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Frames and Concept Types

Applications in Language and Philosophy

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Preface

The contributions to this volume are a selection of papers presented at the "Concept Types and Frames in Language, Cognition, and Science" (CTF) conferences held at the Heinrich Heine University Düsseldorf, Germany, since 2007. The conference series was originally initiated by the research unit FOR 600 "Functional concepts and frames" and is funded by the Deutsche Forschungsgemeinschaft DFG (German Research Foundation). The series is meanwhile continued by the Collaborative Research Centre 991 (CRC 991) "The Structure of Representations in Language, Cognition, and Science" located at the Heinrich Heine University. The research center brings together scholars from linguistics, computational linguistics, psycholinguistics, philosophy of mind, and philosophy of science and aims at developing a general theory of frame representations which can be applied across disciplines.

We are very grateful to all who made the CTF conferences a success. We thank the invited speakers, the presenters, and those who attended the conferences for the lively discussions; the conference organizing committees and their assistants who helped to run the events smoothly; and, last but not least, the reviewers whose insightful comments were much appreciated. Finally, neither the conferences nor this book would have been possible without the financial support of the DFG, for which we express our gratitude.

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Part I
Introduction to Frames and Concept Types

Chapter 1
General Introduction

Thomas Gamerschlag, Doris Gerland, Rainer Osswald, and Wiebke Petersen

The topic of this volume is the investigation of frame representations and their relations to concept types. Frames are cognitively founded and formally explored devices for representing knowledge about objects and categories by means of attributes and their values. They offer a flexible and expressive way of representing concepts of different types in language, philosophy and science at different levels of detail and at different stages of processing and development. This interdisciplinary volume presents approaches to frames and concept types from the perspective of linguistics and philosophy of science.

1.1 Frames and Concept Types in Language and Science

Inspired by the work of F. C. Bartlett, Marvin Minsky and others, frames have drawn considerable interest in the 1970s and 1980s as a common model across disciplines for representing semantic and conceptual knowledge. The collection on "Frames, Fields, and Contrasts" edited by Lehrer and Kittay (1992) provides a good overview on the state-of-the-art of that time. Notably, this collection includes articles by scholars such as Lawrence Barsalou, Charles Fillmore and Ray Jackendoff, among others. These interdisciplinary efforts have since then been abandoned to a certain extent in favor of more specialized investigations within the different scientific disciplines. For example, frame theory is the basis of most of the specification languages for ontology building used in the context of the semantic web. These languages draw on logics (e.g. Description Logics, Sorted Feature Logic) that grew

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out of knowledge representation languages (e.g. KL-ONE) originally developed to formalize frame representations. In computational linguistics, frames appear as feature structures in unification-based grammar formalisms such as Lexical Functional Grammar (Bresnan 2001) and Head-Driven Phrase Structure Grammar (Pollard and Sag 1994). In linguistic semantics, Fillmore has put his frame semantics program into practice with the FrameNet project (Fillmore et al. 2003; Fillmore and Baker 2010), which, however, only employs flat, non-recursive frame structures in its current implementation. It is a central goal of the present collection to revive the interdisciplinary investigation of concepts and frames and to emphasize the potential richness of frame representations, which has been restricted in the more specialized developments due to technical and practical considerations.

1.1.1 Types and Goals of Frame Representations

In his extensive compendium on frame semantics, Busse (2012, p. 550ff) draws a distinction between *predicative frames* and *concept frames*. Predicative frames are understood as frame structures whose primary purpose is the representation of events and states of affairs in terms of their situation types and the participants involved. Fillmore's (1982) frame-semantic approach and its manifestation in the FrameNet project is considered as a prototypical example for the use of predicative frames, since, according to Busse, the main purpose of semantic frames in FrameNet lies in the description of *semantic valency*. This view is in line with the characterization given by Fillmore (2007, p. 129), who describes the FrameNet project as being "dedicated to producing valency descriptions of frame-bearing lexical units, in both semantic and syntactic terms" (see also Osswald and Van Valin, this volume). Consider the classical example sentence in (1):

(1) *Brutus stabbed Caesar in the back with a knife.*

Within FrameNet, situations of the type described by (1) are represented by means of the frame Cause_harm, which comes with the semantic roles (or 'frame elements') Agent, Victim, Body_part, and Instrument, among others. The basic idea is that the main verb of (1) evokes the frame Cause_harm and that the remaining constituents are realizations of (some of) the semantic roles associated with the frame, as indicated in Fig. 1.1.[1]

[1]The analysis is based on the FrameNet online database as of January 2013. While (1) is not an actual corpus example of FrameNet, there are analogous examples in the database such as *Unemployed Martin Lewis of Trinity Close in the town, stabbed Trevor Lampett in the chest with a 10 inch kitchen knife.*

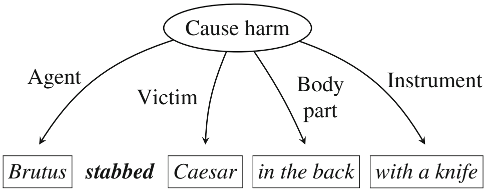


Fig. 1.1 Frame analysis of (1) along the lines of FrameNet

Viewing frames of this type as 'predicative' emphasizes the fact that the root node of the frame is associated with the central predicate of the represented expression, while the arguments of the predicate are bound by the semantic roles of the frame.[2]

The given frame-semantic representation resembles to a certain extent the basic scheme of Neo-Davidsonian approaches to event semantics, with the label of the root node taken as a one-place predicate of events and the semantic roles as two-place predicates relating events to participants (cf. Parsons 1990, 1995). A straightforward translation of Fig. 1.1 along these lines would give rise to a formula like (2).

(2) ∃e(Cause_harm(e) ∧ Agent(e, Brutus) ∧ Victim(e, Caesar) ∧ Body_part(e, back) ∧ Instrument(e, knife))

There are several issues with this representation. For one thing, the formula shows the coarse-grained sortal characterization of event types in FrameNet. The fact that the described event is a stabbing event is not captured at all. This deficiency could simply be remedied by specializing the event predicate 'Cause_harm' to 'Stabbing'. Another, more problematic aspect is the role predicate 'Body_part'. It seems odd at best to regard the back of Caesar as the body part of the stabbing event. The back in question is rather a body part of Caesar. In fact, the informal definition of the 'Cause_harm' frame in FrameNet correctly speaks about "the body part of the victim". The problematic representation in (2) is thus a mere consequence of the Procrustean implementation of frames in FrameNet. A more appropriate frame representation would include a characterization of the body part as a mereological part of the victim, and it would furthermore represent the resulting location of the instrument expressed by the preposition *in*, which is also missing in (2).

While the focus of predicative frames is on binding together the participants of states of affairs, concept frames are primarily concerned with representing the attributes and properties of an entity. Frame structures of this type are closely related to the modeling of categories and they are mostly expressed by nominal expressions (Busse, *ibid*.). For instance, the concept frame for *bottle* comes with attributes such as WEIGHT, VOLUME, and PURPOSE (see Fig. 1.4 below). Concept frames are fully compatible with Barsalou's (1992) proposal, who regards frames as a general format for the representation of categories. Frames in the sense of Barsalou are recursive

[2]For the moment, we put aside the distinction between the formal arguments of a predicate and the syntactic arguments and adjuncts of a verb. FrameNet draws a distinction between "core" and "non-core" roles in order to single out the roles that contribute to the core meaning of the frame.

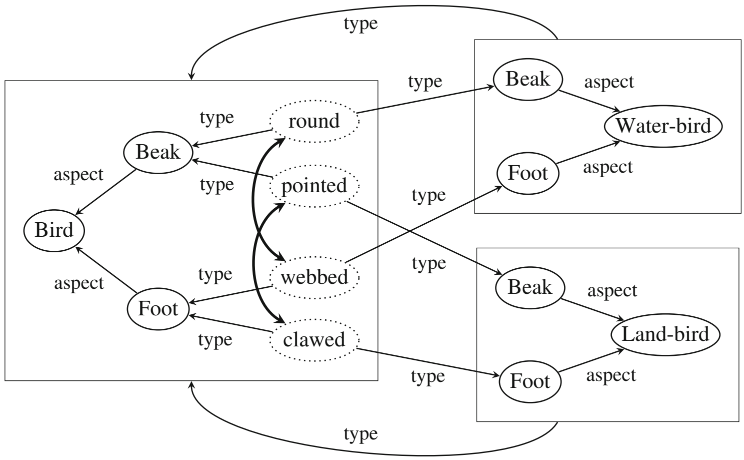


Fig. 1.2 Frame representation of Ray's taxonomy after Chen (2002) in the guise of Barsalou (1992)

attribute-value structures with structural invariants and constraints. They have been introduced as extensions of simple feature list representations in order to overcome the limitations of the latter. As emphasized by Barsalou and Hale (1993), the move from feature lists to frame structures is orthogonal to extensions of feature list models such as prototype theory (cf., e.g., Rosch and Mervis 1975), which tries to take into account the observation that certain objects of a category are more representative of the category than others. The same can be said of the relation between concept frames and Gärdenfors' (2000) conceptual space approach. The main advantage of switching from feature lists to frames is the representation of structural information and structural constraints. The addition of recursion and constraints does not prevent us, in principle, from introducing weighted attributes, similarity measures on values, and the like. But it seems fair to say that it is still an open issue how to reconcile structure and compositionality with gradual membership and family resemblance – a question to which neither prototype theory nor the theory of conceptual spaces has provided a fully satisfying answer so far (pace Kamp and Partee 1995; see also Gleitman et al. 2012).

Inspired by the work of Barsalou, frames have been adopted for the modeling of concepts in various domains. A particularly interesting case is the modeling of conceptual changes in science as elaborated, for instance, by Andersen et al. (2006); see also Part B of the present volume. The following example from Chen (2002) is concerned with the development of avian taxonomy from the seventeenth century onwards. Figure 1.2 shows a partial frame representation of the concept of 'bird' and its subdivision into water birds and land birds based on the taxonomy proposed by John Ray in 1678. The representation follows closely the original notation of Barsalou (1992, p. 52) for representing taxonomies, not the slightly simplified variant given in Chen (2002, p. 5); see Zenker (this volume) for the latter version.

In Barsalou's graphical notation, attributes are treated as *aspects* of concepts while attribute values are characterized as *types* of attributes. The subordination relation between the bird concept and its sub-concepts is explicitly represented by the 'type' relation. The double-headed arrows indicate co-occurrence relations between attribute values.

The basic observation that underlies Ray's taxonomy is that birds fall into two distinct classes and that the membership in these classes is determined by a combination of beak type and foot type: Birds with round beak and webbed feet are water birds and birds with pointed beak and clawed feet are land birds. The co-occurrence relations imply an incompatibility of round beak and clawed feet, and of pointed beak and webbed feet. Chen shows how Ray's taxonomy underwent several changes due to new empirical findings, and he argues that these revisions of the scientific concept of bird and its subordinate concepts can be nicely explained with reference to changes in the respective frame representations (cf. Zenker, this volume). For instance, the discovery of a new type of bird in South America which has webbed feet and a pointed beak revealed that one of the assumed co-occurrence relations had been invalid. As a consequence, the taxonomy was revised and refined by taking into account additional morphological features of birds. The advent of Darwin's theory of evolution led eventually to a further, more drastic revision of the classification system in putting more emphasis on genealogically relevant anatomical features. By making explicit in this way the role of the attributes involved in establishing and changing scientific concepts, frames have proven to be a useful tool for philosophers of science.

It is illustrative to compare the frame representation of Fig. 1.2, which follows the notational conventions of Barsalou (1992), with an equivalent attribute-value representation along the lines of the formalisms employed for unification-based grammars such as HPSG (Pollard and Sag 1994) and for the representation of linguistic data in general (cf. Osswald 2012). In contrast to Barsalou's inspiring but informal synopsis, these formalisms build on elaborate mathematical and logical foundations (cf. Carpenter 1992; Rounds 1997). Figure 1.3 sketches how the frame information expressed in Fig. 1.2 can be formally described in terms of type declarations. Such declarations specify which types subsume which others, which attributes are appropriate for structures of a given type, and which values are admissible for a given attribute. In addition, more complex implicational attribute-value constraints can be defined. As specified in the figure, the type 'bird' comes with the attributes BEAK and FOOT, for which values of type 'beak' and 'foot' are admissible, respectively. (Note that these value restrictions simply express that the beak of a bird is a beak and that the foot of a bird is a foot; cf. Sect. 1.1.2 on the dual interpretation of attributes as types.) The two trees in the upper line of the figure indicate that the type 'beak' has the subtypes 'round' and 'pointed' and the type 'foot' has the subtypes 'webbed' and 'clawed'. Together with the two bi-implicational constraints, the given declarations induce the taxonomy shown in the upper right of the figure, with the newly introduced types 'water-bird' and 'land-bird'. Figure 1.3 also gives graph representations of the three bird frames with attributes depicted not as nodes as in Fig. 1.2 but as arcs, which is the standard representation throughout this

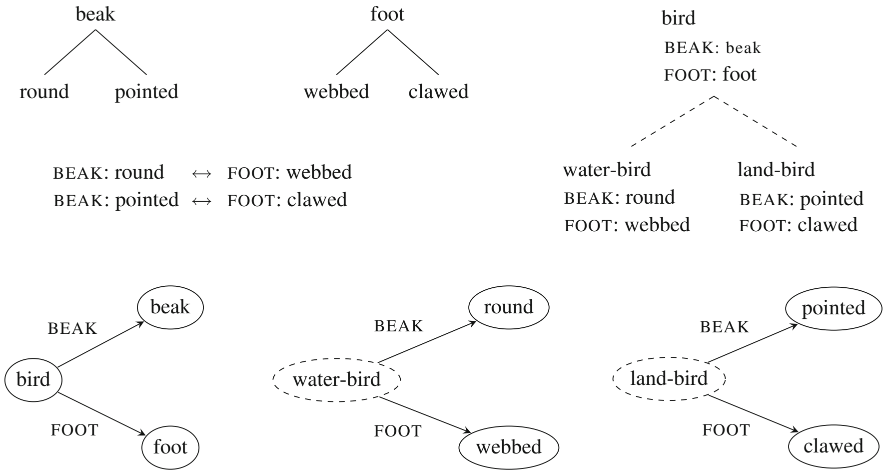


Fig. 1.3 Type declarations, co-occurrence restrictions, and induced inheritance hierarchy

volume. At closer inspection, the type declarations reveal some deficiencies of the original frame representation since, strictly speaking, 'round' and 'pointed' are better seen as values of an attribute FORM associated with 'beak', than as subtypes of 'beak'. A similar argument applies to 'webbed' and 'clawed'.

Let us return to the distinction of different kinds of frames introduced at the beginning of this section. Predicative frames have been loosely associated with verbs, and concept frames were said to be expressed mainly by nouns. However, it should be kept in mind that the linguistic categories 'verb' and 'noun' play only a secondary role in this distinction. Verbs can easily be nominalized and the FrameNet frame sketched in Fig. 1.1 would apply to the nominal expression *the stabbing of Caesar by Brutus* as well. The crucial point of the proposed distinction seems rather to be the representation of inherent attributes in concept frames and the resulting fine discrimination between related concepts. For instance, the fact that bottles have a neck and a body and are typically used as containers for liquids sets them off from other kinds of containers such as baskets, bowls, and boxes. Predicative frames of the type employed in FrameNet, on the other hand, do not allow for such a fine discrimination. The expression *Brutus smacked Caesar on the back with his hand* would get the same frame analysis as (1) as far as the specific activity is concerned. Simply introducing specific event types such as 'stabbing' and 'smacking' would not resolve the matter since type distinctions have no explanatory value *per se*. In order to explain the differences between stabbings and smackings, one needs to identify the relevant attributes and components of the respective event concepts. For example, differences in the way in which the active participant acts on the affected participant can explain why it makes more sense to say *Brutus smacked Caesar against the wall* than *Brutus stabbed Caesar against the wall*, that is, why a caused motion context is fairly natural for *smack* but much less so for *stab*. Generally speaking, the task in question is similar to componential analysis, a

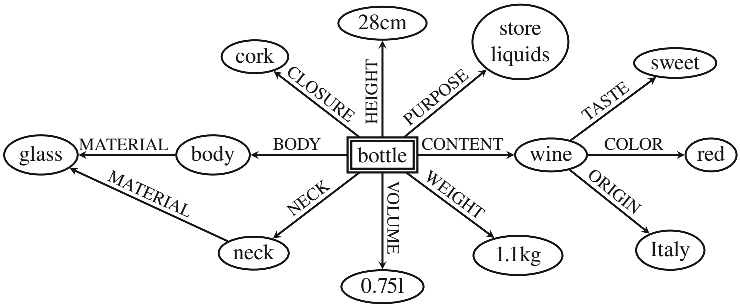


Fig. 1.4 Simplified frame for *bottle of Italian red wine*

method which, in its basic form, dates back at least to the work of Louis Hjelmslev (cf. Lyons 1977, Chap. 9). Boas (2008) proposes to combine componential analysis with Fillmore's frame semantics. Bergen and Chang (2005), by comparison, aim at a more explicit representation of event-internal components by means of frame-like structures. Similar goals are pursued by Osswald and Van Valin (this volume).

The foregoing discussion shows that the adequate modeling of events and states of affairs by means of frames calls for a combination of predicative frames and concept frames. Participant roles are just one kind of characteristics. The sub-eventual structure matters too, as do manner-related attributes of various sorts. But the synthesis of predicative frames and concept frames is not only relevant to event and situation frames. The binding of participants can be necessary for concept frames as well. For example, the content of a bottle can be regarded as a component of the bottle concept, and on the linguistic level, the content is typically expressed by an *of*-phrase like in *a bottle of wine*. The need for representing arguments within concept frames is even more evident in the case of functional concepts such as 'mother' (cf. Petersen and Osswald, this volume).

1.1.2 Types of Frame Attributes

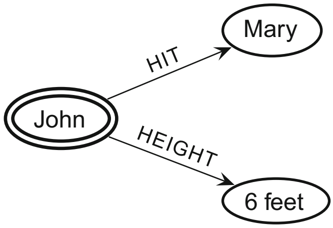
Frames are descriptions of categories and individual objects in terms of recursive attribute-value structures with the attributes representing the properties which characterize a category or an individual object. Attributes can be conceived as functional relations since they assign unique values to objects. Attribute values are concrete or underspecified specifications which are represented by potentially complex frames themselves. It is this recursive structure that makes frames flexible enough to represent information with any desired level of detail. By way of illustration, consider the concept of a bottle filled with Italian red wine and closed with a cork. A simplified frame of this concept can be depicted by a graph as in Fig. 1.4.

The example in Fig. 1.4 shows that the attributes constituting a frame can be of a diverse nature: First, there are attributes such as VOLUME, HEIGHT and WEIGHT which can be called 'dimensions' since they assign an abstract value to the object. The values of dimensions are abstract in that they are not concrete objects in themselves. Rather, they are properties out of a range of mutually exclusive alternative properties. The part attribute is another type of attribute, which assigns unique parts to the possessor. For a complex object, its composition in terms of constitutive parts is a central aspect of description. Terms for parts figure in mereological frames such as anatomical frames and frames which capture the design of artifacts. The respective attributes take values that are on a par with the whole regarding complexity and concreteness, but they are not independent objects. In the frame of the bottle, attributes of this type are, for example, BODY, NECK and CLOSURE which identify the parts a bottle consists of. A third type of attribute assigns to the referent another independently existing object which is related to the referent in a one-to-one relation. In the bottle frame, the CONTENT attribute is an instance of this type of attribute. The PURPOSE attribute is yet another type of attribute which specifies what is usually done with the referent of the frame. In this case, the value of the PURPOSE attribute states that a bottle is used for storing a liquid. For a discussion of similar distinctions of attribute types see Guarino (2009).

Since frames are recursive structures, attribute values are frames themselves and can be specified further by attributes. The value of an attribute like CONTENT, for example, may itself be a complex attribute-value structure. This is the case with a value like 'wine', which is characterized by attributes such as TASTE, COLOR and ORIGIN. The expressiveness of frames does not only result from their recursive structure but also from their potential to reveal shared structures. For instance, the attributes BODY and NECK both exhibit the attribute MATERIAL with a value 'glass.' The fact that the body and the neck of the bottle are made of the same material is expressed in the frame graph by the two MATERIAL-arcs pointing to the same node.

The expressiveness of frames which results from the possibility to express recursive structures, to address substructures by attribute paths, and to flexibly add additional attribute-value specifications, is considered to be one of their main advantages over pure logical formalisms based on First Order Logic. However, frames share with these formalisms some problems already discussed in Woods (1975). Woods devotes his well-known "What's in a link" article to the discussion of common inappropriate uses of semantic networks, i.e. attribute-value formalisms, and the question of the minimal requirements an appropriate frame attribute (or 'link' in his terminology) has to fulfill. He illustrates the problem of allowing attributes to be unrestricted arbitrary binary relations by the frame-like structure shown in Fig. 1.5. Although *height* and *hit* can be logically represented by two-place predicates, the ontological status of the link established between John and 6 ft and between John and Mary differs fundamentally. The expression 6 ft specifies a value along the HEIGHT dimension of John while HIT refers to a hitting event which establishes its own event frame along the lines of the one depicted in Fig. 1.1. From

Fig. 1.5 Frame containing different types of relations (Woods 1975, p. 54)



Woods' remarks one can extract a linguistic test to identify attributes (ibd., p. 53): Y is a value of the attribute A of X if we can say that *Y is the A of X*. While it is appropriate to say that 6 ft is the height of John, one cannot say that Mary is the hit of John. Rather Mary is the patient or victim in a hitting event of which John is the agent. The strategy to implement Woods' test pursued within this volume is to require attributes to express many-to-one, i.e. functional, relations which are usually expressed by nouns. In natural language, attributes correspond to functional nouns, which frequently occur in definite and possessive contexts: *Y is* ***the*** *A* ***of*** *X* (see Sect. 1.1.3).

A second problem is that frame-based formalisms usually force a radical choice between attributes and types as both sets are considered to be disjoint and formally unrelated. One consequence of this choice is that it is common that the same label is used in frame representations to address a type and an attribute (e.g., label 'neck' in Fig. 1.4 or label 'beak' in Fig. 1.3). Naturally, our intention while constructing the bottle-frame in Fig. 1.4 was to express that the neck of the bottle is a neck. However by using the label 'neck' once for the attribute NECK and once for the type 'neck', we have formally created two descriptional primitives which would be unrelated to each other in most frame languages. Guarino (1992) accounts for the systematic relationship between such an attribute and its corresponding type by distinguishing between the denotational and the relational interpretations of concepts that express binary relations. While the relational interpretation refers to the expressed relation itself (that is in the case of 'neck' the binary relation between things and their necks), the denotational interpretation refers to the range of such a relation (that is the set of all necks). Presupposing that attributes are labeled by functional concepts, Petersen (2007) develops a frame account in which there exists for each attribute a unique type corresponding to the value range of the attribute function. As attributes can be identified by their range types, it is from a formal viewpoint sufficient to consider attributes as special kinds of types that have an additional relational interpretation as a function (cf. Petersen and Gamerschlag, this volume). Thereby, one no longer needs to introduce two distinct primitives for functional concepts like for 'neck' in Fig. 1.4. The ontological commitments behind this modeling convention reflect Barsalou's view on attributes and value types: "Attributes are concepts that represent aspects of a category's members, and values are subordinate concepts of attributes" (Barsalou 1992, p. 43).

Table 1.1 Four basic concept types

	Non-unique reference	Unique reference
Non-relational	Sortal concepts: 'dog', 'house', 'verb'	Individual concepts: 'pope', 'sun', 'Mary'
Relational	Proper relational concepts: 'friend', 'son', 'part'	Functional concepts: 'father', 'age', 'meaning'

1.1.3 Concept Types, Attributes, and Functional Nouns

Frames decompose concepts into attributes, which are functional relations between objects and attribute values. Attributes thus correspond to functional concepts, which are characterized by (i) inherent relationality and (ii) inherent uniqueness, i.e., for each attribute there is exactly one value at a time. Based on the idea that concepts in natural language belong to different basic types, Löbner (2011) proposes the system of four basic concept types (Table 1.1), which results from defining inherent relationality and inherent uniqueness as binary features.

The distinction between non-relational and relational concepts, which was already argued for by Frege (1892) and Behaghel (1923) and later elaborated on by Montague (1970), differentiates sortal concepts such as 'dog' or 'stone' from relational concepts such as 'friend' or 'son' in that the latter require an additional argument for reference. Sortal concepts, named as such by Strawson (1959), classify objects into sorts; relational concepts describe objects in relation to another object. Formally, this distinction corresponds to the differentiation between one-place and two-place predicates (cf. Partee 1986; De Bruin and Scha 1988; Löbner 1985; Barker 1995). Löbner (1985) extends the classical distinction between sortal and relational concepts by the distinction between inherently unique and inherently non-unique reference of concepts. The outcome is the cross-classification of four concept types in Table 1.1, which differ with respect to their referential properties. Like non-unique concepts, i.e. sortal and relational concepts, unique concepts can be differentiated with respect to the number of arguments involved: individual concepts such as 'pope' and 'sun' refer to unique referents without requiring an additional argument, whereas functional concepts such as 'father (of someone)' and 'age (of someone)' depend on an additional argument for identifying a referent. Among the different concept types, functional concepts are of particular interest since they directly correspond to attributes in frames and therefore play a central role not only in linguistics but in conceptual and theoretical evolution in general.

The four-way concept classification can be immediately turned into a noun classification in which each noun is characterized with respect to the concept type it corresponds to. Thus, concepts such as 'pope' and 'father' correspond to individual and functional nouns in natural language. Individual and functional nouns are inherently unique in the sense that the number of possible referents is restricted to one in a given context. By contrast, for sortal nouns such as *dog* and relational nouns such as *friend* the number of possible referents is unrestricted. Relational and functional nouns are inherently relational and require the specification of an additional argument for reference. As argued by Löbner (2011), the referential properties influence the way nouns are used grammatically: In accordance with their inherent relationality, functional and relational nouns can be regarded as predisposed for a possessive use. Due to their inherent uniqueness, individual and functional nouns exhibit a predisposition for a definite use. Hence, functional nouns which can be considered as double marked with respect to their referential properties, have a predisposition for both definite and possessive use (cf. Horn and Kimm, this volume, for a statistical test of Löbner's hypothesis). However, many nouns are polysemous, thus a noun represents a certain type only with respect to a given lexical reading: *teacher* for example has both a sortal reading (in the sense of a job title) and a relational reading (in the sense of 'teacher of someone').

Each noun type has – according to the referential properties – a predisposition for a certain kind of determination, the so-called "congruent determination" (Löbner 2011, p. 360). Reciprocally, the kinds of determination have input requirements which lead to a predisposition for a certain noun type (Löbner 2011, p. 290). Definite articles for example require inherently unique nouns and inherently unique nouns have a predisposition for definite articles. However, nouns are often used incongruently, i.e. with a determiner they are not predisposed for. This kind of incongruency is enabled by a type shift (cf. Löbner 2011 for a detailed description of type shifts).

This way, the noun types are directly connected with two intensively discussed phenomena concerning nouns: definiteness marking on the one hand and the expression of possession on the other. For the latter, the so-called alienability distinction (Chappell and McGregor 1996; Heine 1997) can be seen as reflecting the distinction between inherently relational and inherently non-relational concepts grammatically (Gerland and Horn 2010; Löbner 2011). Languages exhibiting an alienability split use different constructions depending on the inherent (non-) relationality of the possessed noun. As Seiler (1983) points out, for inalienable possession (i.e. with inherently relational nouns) the morphological specification of the possessor is always closer to the possessum noun reflecting the closer conceptual relation between the two entities. For definiteness the distribution of definite articles and the use of two definite articles in some regional varieties of German reflect the distinction between inherently unique and non-unique nouns (cf. Ortmann, this volume, for a detailed analyses).

1.2 Contributions

The hypothesis that frames are not just an arbitrary format of representation but essential to human cognition is central to the majority of linguistic and philosophical contributions in this volume. Many of the papers also make ample use of frame representations, which – due to their expressive power – turn out as an efficient analytical tool for a wide range of phenomena. The first two contributions prepare the stage for the papers in this volume.

Sebastian Löbner's paper "Evidence for Frames from Human Language" starts out with two strong claims bundled together as the "Frame Hypothesis": (i) there is a common format for all representations in the human cognitive system and (ii) this format is frames in the sense of Barsalou's. Löbner argues that in addition to evidence from cognitive psychology there is also evidence from different levels of natural language which corroborates the Frame Hypothesis. In support of this claim, he discusses a number of universal uniqueness constraints which apply at the level of syntax and semantic composition. As a further corroboration of the Frame Hypothesis, he explores the development of abstract attributes in lexical semantics.

Frank Zenker investigates the applicability of the frame model to the analysis of scientific change in his paper "From Features via Frames to Spaces: Modeling Scientific Conceptual Change without Incommensurability or Aprioricity". Based on a discussion of various examples of taxonomic change, he reviews the capacity of the frame model. He discusses its origins in feature list models and then compares it to the alternative approach of conceptual spaces with a particular focus on the problem of the incommensurability of scientific paradigms. Since the structural invariants and constraints of frames naturally result from the geometry of the conceptual space, Zenker characterizes the conceptual spaces model as the most powerful model into which frames can easily be translated. However, he also concludes that the conceptual spaces approach may turn out to be too powerful in capturing taxonomic knowledge and that the choice of one model over the other may well be guided by the particular purpose.

1.2.1 Frame Analysis of Changes in Scientific Concepts

Following Zenker's introductory paper, the contributions from the philosophy of science presented in this section apply frame representations in a number of case studies of paradigm change in natural science. In particular, they make use of the structuring potential of frames in representing the components of the theories of combustion, of heat and of light, by means of attributes which, for instance, capture theory-specific assumptions on the chemical reactions involved in combustion, the expansion of matter due to heat, or the taxonomies built upon different concepts of light. The resulting frame representations are characterized by a high degree of transparency and explicitness which allow for a systematic comparison of different accounts of the same phenomenon.

In their paper "Reconstructing Scientific Theory Change by Means of Frames", **Ioannis Votsis** and **Gerhard Schurz** address the applicability of frames to the analysis of different approaches to the phenomena of combustion and heat. They first compare the phlogiston and the oxygen theory as two successive theories of combustion and then discuss the transition from the caloric theory to the kinetic theory of heat. It turns out that frames are particularly apt for a comparison of scientific theories since they allow for a systematic decomposition of the theories into attribute-value pairs. For example, the different explanations theories offer for phenomena such as calcination and salification and the thermal expansion, contraction and stability of bodies are translated into frame representations which permit a direct comparison of the essential ingredients of each account. The resulting frame representations of the phlogiston versus oxygen theory of combustion and the caloric versus kinetic theory of heat then help to reveal structural correspondence relations, which can be regarded as invariances in the sense of structural realism.

Xiang Chen's paper "Interests in Conceptual Changes: A Frame Analysis" is based on the assumption that problem solving is driven by interest and that science is essentially problem solving. Chen investigates how the interests of particular scientists affected the replacement of the particle theory by the wave theory of light at the beginning of the nineteenth century. He argues that this process was to a large degree determined by the weight that proponents of the theories gave to specific attributes in the overall conception of these theories due to their specific interests. According to Chen the phenomenon of attribute weighting is best captured in the frame models of cognitive science since they allow for explicit reference to attributes. In particular, scientific attribute weighting is linked to Barsalou's analysis of ad hoc concepts which are constructed to achieve goals defined by interests. In spite of the important role of interest, Chen concludes that interests alone are not decisive for changes in scientific theory.

1.2.2 Event Frames and Lexical Decomposition

The next two contributions are concerned with the semantic representation of verb-based event descriptions. They investigate the semantic decomposition of verb meaning in terms of event frames and inferential relations, respectively. The common assumption of both contributions is that predicative role frames in the sense introduced in Sect. 1.1.1 need to be extended, be it for a detailed analysis of the syntax-semantics interface or for employing them to draw inferences in textual entailment tasks. Such an extension needs to take into account the inherent structure of an event, including the representation of causal relations and resultant states. As indicated at the close of Sect. 1.1.1, frame representations do allow the reconciliation of predicative structure and a more detailed conceptual decomposition.

In their paper "FrameNet, Frame Structure, and the Syntax-Semantics Interface", **Rainer Osswald** and **Robert D. Van Valin, Jr.** take a close look at the Berkeley FrameNet project, which aims at implementing Fillmore's notion of frame semantics. Osswald and Van Valin critically examine to what extent the FrameNet approach in its present form can cope with its underlying goal of giving rise to an empirically grounded theory of the syntax-semantics interface. Based on a detailed study of verbs of cutting and separation and of the representation of events and results in FrameNet, they observe a certain lack of systematicity in the specification of frames and frame relations. For instance, the FrameNet frame 'Cutting' covers only ‘cut apart’ scenarios but not ‘cut off’ scenarios, and the only frame which covers the latter event type is ‘Cause_harm’. The authors ascribe issues of this kind to the expectation that a system of frames can be developed on a data-driven, purely bottom-up account. As an alternative, the authors argue for a richer frame representation which takes into account the decompositional structure of an event in a systematic way.

Decomposing the meaning of event descriptions is also the central topic of “The Deep Lexical Semantics of Event Words” by **Jerry Hobbs** and **Niloofar Montazeri**. The authors begin with the observation that predicative frames like those of FrameNet provide a first approximation of what constitutes a situation type. Their approach of “deep lexical semantics” aims at decomposing such situation descriptions into more primitive elements, and at formalizing the interrelation between these elements by logical axioms. The overall goal is a formal theory of event components which includes general notions such as causation and change of state, but also elements derived from specific word senses. Such a theory can provide generalizations over event types in that closely related predicative frames can be characterized by similar sets of axioms. More importantly, the theory allows one to draw inferences between event descriptions and thus to build systems for textual entailment and natural language understanding in general, which is the main motivation behind Hobbs’ and Montazeri’s approach. As a basis for deriving the elements and axioms of their theory of word meaning, the authors build on CoreWordNet, a compilation of the most frequent and central concepts in English found within the WordNet database (Fellbaum 1998).

1.2.3 Properties, Frame Attributes and Adjectives

While the papers in the preceding section deal with the representation of complex events referred to by dynamic verbs, the articles in this section are concerned with adjectives and stative verbs which lack internal temporal structure. Expressions of this type isolate particular object properties which translate into single frame attributes. For example, the adjectives *blue* and *young* denote values of the attributes COLOR and AGE, respectively. Likewise, stative verbs of perception such as *sound* and *feel* (*like*) encode the attributes SOUND and TOUCH the values of which are specified by adjectival complements such as *creaky* and *soft*, respectively. From a methodological point of view, lexemes of this kind are particularly interesting since they can be regarded as basic expressions which contribute the individual building blocks of frames. However, as becomes evident in the papers of this section, the straightforward translatability into single frame attributes is not always available since it is given only for a subset of the lexical items under discussion and also depends on their particular use.

The contribution of **Matthias Hartung** and **Anette Frank** “Distinguishing Properties and Relations in the Denotation of Adjectives: An Empirical Investigation” is concerned with the corpus-based classification of attributive adjectives into property-denoting (*blue*, *comfortable*) and relational types (*economic*, *political*). The study is motivated by the fact that the modifiers of a noun can help to reveal information about the attributes of the denoted entity and of its relation to other entities, which can be employed for ontology learning from corpora. Hartung and Frank describe two studies on the corpus-based distinction between adjective types, one with human annotators and one with automatic classifiers. The human annotation task shows that the distinction between property-denoting and relational adjectives is fairly reliable with respect to inter-annotator agreement, while a further sub-classification of property-denoting adjectives into "basic" (*blue*) and "event-related" (*comfortable*) ones is not feasible. Moreover, the two-way distinction between properties and relations is shown to be learnable by an automatic classifier that uses contextual features.

In their contribution "Why Chocolate Eggs can Taste Old but not Oval: A Frame-Theoretic Analysis of Inferential Evidentials" **Wiebke Petersen** and **Thomas Gamerschlag** analyze perception verbs such as *taste (of)* and *look (like)*, which select an adjectival complement. In addition to the basic sensory use as in *taste bitter* and *feel soft*, perception verbs of this type often allow for a derived inferential use as in *taste old* and *feel expensive* in which the adjectival complement denotes a quality which is inferred by means of some sense-specific property indicated by the verb. Starting from the assumption that perception verbs of this type can be decomposed into single sense-specific frame attributes such as SOUND, TASTE, and SMELL, Gamerschlag and Petersen argue that a proper analysis of the inferential use necessarily involves reference to frame attributes, since this use is semantically well-formed only if the adjective specifies a value of an attribute which is inferable from the attribute encoded by the verb such as TASTE → AGE and TOUCH → PRICE. Technically, this kind of inferability is modeled as an inference structure defined on a type structure which represents the general knowledge of object properties. In addition, the authors assume that admissible inferential uses are distinguished from inadmissible uses by two constraints which operate on the type and inference structures.

1.2.4 Frames in Concept Composition

The papers of this section investigate the compositional meaning of two kinds of complex nouns: nominal possessive constructions and nominal compounds. Both approaches are formulated in terms of frames, building on Löbner's claim of the cognitive adequacy of Barsalou frames. They derive the meaning of the complex nouns by means of different operations on the frames contributed by the parts of the construction in focus. As a general approach to the meaning of various subtypes of noun compounds Schulzek applies a frame transformation which relocates the central node of a frame thereby changing its referent. By contrast, Petersen and Osswald's approach to possessive constructions does not involve shifts of this type but rather applies unification of the frames contributed by the head noun and the possessor noun in order to capture the process of argument saturation. Both accounts benefit from the specific structural properties of frames which facilitate the analysis of the composition of complex nouns in a "topographical" manner.

Daniel Schulzek applies Barsalou frames to the analysis of the meaning of complex nouns. In his paper "A Frame Approach to Metonymical Processes in some Common Types of German Word Formation", Schulzek analyses a broad range of nominal word formation phenomena, including possessive compounds such as *Lockenkopf* '(curls-head) curly head', synthetic compounds such as *Klavierspieler* 'piano player' and root compounds such as *Suppenlöffel* 'soup spoon'. Arguing that the meaning of these complex nouns is the result of metonymic shifts, Schulzek presents an approach in which the complex concepts that underlie these metonymic shifts are represented by frames. Metonymy is then captured by a frame transformation which shifts the central node of the frame to another node linked to it. Moreover, his account excludes non-admissible shifts by a frame constraint which demands that the two nodes involved in the frame transformation be connected by a bidirectional link.

In their paper "Concept Composition in Frames – Focusing on Genitive Constructions", **Wiebke Petersen** and **Tanja Osswald** offer a frame analysis of nominal possessive constructions such as *the age of John* and *friend of Mary* in which a noun is complemented by a genitive NP. Based on the distinction of the four different concept types for nouns proposed in Löbner (2011), they assume that a possessor argument appears with functional and true relational nouns and discuss the composition in possessive constructions in terms of frames. They show that the saturation of the possessor argument can be analyzed as the unification of the argument node of the relational frame with the central node of the possessor frame. Furthermore, they introduce an interpretation of frames in predicate logic which allows for a formalization of frame composition. They also address the question of how frames can aid in deriving the different kinds of relations expressed by genitive constructions (e.g. ownership, kinship and part-of relations).

1.2.5 Nominal Concept Types and Determination

The contributions in this section deal with Löbner's (2011) system of concept types (cf. Sect. 1.1.3) and the grammatical phenomena related to the linguistic expression of these different types. The expression of unique reference is closely related to definiteness marking. The conditions under which definiteness markers occur have been discussed extensively in the linguistics literature. The first three papers in this section contribute to this discussion from different perspectives. The last paper investigates the question of whether the four noun types corresponding to the concept types characteristically occur in specific grammatical constructions which reflect their referential properties. In this way, the paper considers not only definiteness marking but also possession as an instance of determination.

Doris Gerland analyzes markers which usually indicate possession but also occur as definite articles. In her paper "Definitely not possessed? Possessive suffixes with Definiteness Marking Function", she explores the phenomenon of the so-called non-possessive use of possessive suffixes in Uralic languages. Showing that there is not enough evidence to consider the definiteness marking function of the suffixes as a result of a classical grammaticalization pathway, she proposes to analyze suffixes of this type as relational suffixes which have two functions: (i) linking the referent of the marked noun to (extra-)linguistic discourse and (ii) characterizing the referent of the noun as unique within this discourse. The conceptual noun type in the sense of Löbner (2011) and the respective context are identified as factors determining whether the suffix is interpreted as a marker of possession or as a marker of definiteness. This assumption is supported by examples from different text collections of Uralic languages.

The paper "Definite Article Asymmetries and Concept Types: Semantic and Pragmatic Uniqueness" by **Albert Ortmann** presents a typological approach to definiteness which analyzes the co-occurrence of inherently (non-)unique nouns and the definite article. Ortmann explores a number of different languages with respect to definite article asymmetries, instances of which are the use versus non-use of definite articles or article splits in languages with two definite articles such as Dutch, Swedish and some variants of German. Ortmann identifies two kinds of article splits, both reflecting Löbner's (1985) distinction between pragmatic (i.e. inherently non-unique) and semantic (i.e. inherently unique) definiteness. The splits follow a concept hierarchy (the 'scale of uniqueness') that is defined by the narrowness in the choice of possible referents. The cross-linguistic variation in the use of definite articles can thus be captured in terms of spreading along the concept hierarchy. This variation amends Löbner's (2011) scale of uniqueness and refines the distinction between inherently unique and non-unique concepts.

In her paper "The Indefiniteness of Definiteness", **Barbara Abbott** discusses the difficulties involved in establishing criteria for definiteness and the question of whether existing characterizations of this notion are able to capture its essence. She compares several traditional accounts which rely on criteria such as familiarity in the sense of Heim (1982), strength and uniqueness. She argues that some types of NPs, such as universally quantified NPs, partitives, possessive NPs and specific indefinites, raise issues concerning definiteness even though they do not belong to the group traditionally classified as definite NP (such as proper names, definite descriptions, demonstrative descriptions, and pronouns). Abbott concludes that although Russell's uniqueness characteristic holds up well against the other accounts, the use of a single definiteness criterion is not sufficient.

The paper by **Christian Horn** and **Nicolas Kimm** analyzes definiteness and possession as linguistic expressions of the referential properties of noun types. In their paper "Nominal Concept Types in German Fictional Texts" they pursue the question of whether Löbner's (2011) assumption of the predisposed use of concept types is corroborated statistically, i.e. whether the referential properties of concept types are reflected by a small set of morphosyntactic features that are observable on the linguistic surface. In their corpus study, they use a manually annotated collection of German texts. Their statistical analysis shows that relational nouns (i.e. relational and functional nouns) occur more often in possessive constructions than non-relational (i.e. sortal and individual) nouns. Within the group of relational nouns, functional nouns show a higher percentage for definite and singular use than relational nouns which are not functional. The results of the investigation support the system of the four different concept types.

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Chapter 2
Evidence for Frames from Human Language

Sebastian Löbner

Abstract The point of departure of this paper is the hypothesis that there is a general format common to all representations in the human cognitive system. There is evidence from cognitive psychology that this might be frames in the sense of Barsalou's. The aim of the paper is an exploration of the consequences of this assumption for natural language. Does natural language provide evidence in favor of Barsalou frames being the general format of representations in human cognition? The paper discusses two levels of representation of linguistic gestures: syntactic structure and meaning. The first part deals with syntactic structure and compositional meaning. It is argued that specific universal uniqueness constraints on the syntactic and semantic structure of complex linguistic gestures provide positive evidence for the assumption. The second part investigates lexical semantics, in particular the emergence of abstract attribute vocabulary. Observations in this field, too, corroborate the hypothesis.

Keywords Frames • Cognition • Natural language • Syntactic structure compositional meaning

2.1 Hypotheses

This paper adopts a strong hypothesis on human cognition:

H1 The human cognitive system operates with a single general format of representations.

Bold as it is, this hypothesis is certainly very attractive. It opens up perspectives for investigating the basic structure of cognitive representations in humans.

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Given the obvious diversity of representations to be dealt with, the hypothesis is certainly controversial. It is, however, a reasonable point of departure. Of course, the assumption is only attractive if it comes with a hypothetical concrete model of this general format. Such a model has to fulfill two requirements: (i) It must be sufficiently expressive to capture the diversity of representations which the human cognitive system is to be assumed to employ. (ii) The model must be sufficiently precise and restrictive in order to be testable.

The hypothesis has fundamental implications for cognitive psychology and neuroscience, for the philosophy of mind, for linguistics, for the philosophy of science, and for information and computer science.

Barsalou (1992a, b, 1999; Barsalou and Hale 1993) assumes that such a general format exists and provides limited experimental evidence.[1] According to Barsalou, the general structure of representations is some version of frames. Barsalou frames are sufficiently restrictive to be testable, and his frame model appears capable of being extended to a wide range of different types of representations. We adopt Barsalou's view as a second hypothesis:

H2 If the human cognitive system operates with one general format of representations, this format is essentially Barsalou frames.

In the following I will refer to Barsalou frames just as 'frames' and to the combination of hypotheses H1 and H2 as the 'Frame Hypothesis'. If the Frame Hypothesis is correct, it applies in particular to cognitive linguistic representations such as lexical entries including lexical meanings, or the grammatical structure and the meaning of complex expressions. Therefore, the investigation of linguistic structures can be used as evidence for testing the Frame Hypothesis. The discussion in this paper will be restricted to syntactic and semantic representations. It will be argued that analysis of the structure of linguistic representations as assumed by linguistic theory essentially supports the hypothesis for the realm of syntactic and semantic representations. Whether or not the hypothesis extends to other levels of linguistic representations or to nonlinguistic representations, is beyond the scope of his paper. The argument is based on the following uncontroversial assumptions:

A1 Human languages are behavioral systems of conventionalized gestures.

a. There is a system of lexical gestures.
b. Following rules of grammar, language producers are able to form complex linguistic gestures out of lexical gestures ...
c. ... in a way that enables language recipients to recognize their structure.

A2 Conventionalized linguistic gestures, lexical or complex, have meanings.

a. The meanings of lexical gestures are stored in the cognitive system.
b. The meanings of complex gestures are computed by the cognitive system.

[1]See Barsalou (1992a) and Barsalou and Hale (1993) for a comparison of the frame approach to other theories of categorization and concept structure.

c. The meanings of complex linguistic gestures can be computed from the structure of the complex gesture and the meanings of the lexical gestures it is composed of.

A2c is a formulation of the principle of compositionality in a very general form (cf. Janssen 1997).

Combining the Frame Hypothesis with these assumptions on human language yields the following conclusions:

C The following linguistic items are represented in the human mind as frames:

a. Lexical linguistic gestures,
b. Meanings of lexical linguistic gestures,
c. Complex linguistic gestures,
d. Meanings of complex linguistic gestures.

Ca and Cb follow from the simple fact that lexical linguistic gestures and their meanings are permanently stored and represented in human cognitive systems. Complex gestures and their meanings are normally not stored permanently, but mental representations of them are generated by the human cognitive system, and hence bound to exhibit the general format of representations. In what follows, we will elaborate on the conclusions Cc (Sect. 2.3), Cd (Sect. 2.4.3), and Cb (Sects. 2.4.1 and 2.5). Elaborating on conclusion Ca would involve going into the phonological and morphological structure of lexical linguistic gestures which will not be done here.

It will be argued that the observable structures of linguistic gestures and meanings actually do provide evidence for a common structure of representation, and that this structure is essentially frames in the sense of Barsalou (1992a, b, 1999).

2.2 Barsalou Frames

2.2.1 The Structure of Frames

In Barsalou (1992a, b), frames are introduced as recursive attribute-value structures with added constraints. A Barsalou frame represents a referent in terms of its attributes, their values, attributes of these values, their respective values, etc. The recursive aggregate of attributes and values constitutes the information about the referent. Barsalou frames are essentially parameterized descriptions. In this article, the notion of frames introduced in Barsalou (1992a, b) is in fact construed in a certain sense which elaborates the original notion in several ways (cf. Petersen 2007; Löbner 2012; Sect. 4). The elaborations include two major points: (1) the attributes are assumed to be strictly functional; (2) Barsalou's approach is extended to different types of concepts. The first assumption is in accordance with all of Barsalou's examples (as well as with his intentions, p.c.). The extension to different

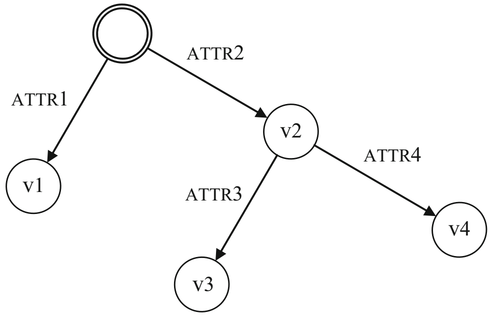


Fig. 2.1 Barsalou frame graph

types of concepts is mandatory if one wants to apply Barsalou's frame model to the lexical meanings of different logical types of expressions such as proper names, relational or functional nouns, or verbs with varying numbers of arguments.[2] The assumption of functional attributes is of central importance for the discussion here; the generalization of the frame approach to different types of concepts matters insofar as functional nouns and concepts will play an important role in Sect. 2.5.3. The essential elements of Barsalou frames are **attributes.** Attributes are functions:

– Attributes assign to every possessor[3] of appropriate type a unique **value** of a certain type; for example, the attribute COLOR_OF[4] assigns possible color values to the objects of the type 'visible [monochrome] object'.
– Value specifications may be more or less specific, but at the most specific level of description, the value is uniquely determined.
– Attributes and their values are constrained and correlated by various types of **constraints**, such as value restrictions for single attributes, or value covariation of pairs of attributes.

Barsalou frames can be represented in several ways. One mode of representation is recursive attribute-value matrices such as those used in HPSG[5] and other formalisms. We prefer directed graphs. Nodes represent objects and values of attributes; labeled arcs represent attributes. There is a distinguished central node that represents the referent of the frame. For a sortal concept, the central node is a source within the graph: all other nodes can be reached from the central node via an arc or a series of arcs; the central node itself does not have an ingoing node, i.e., it is not the value of an attribute. A simple abstract frame structure is given in Fig. 2.1.

[2]See Löbner (2011: Sect. 2) for the distinction of sortal, individual, relational, and functional nouns and concepts, and Petersen (2007) for the different frame structures applying to the representation of these types of concepts.

[3]The argument of an attribute will be referred to as its 'possessor'.

[4]Attribute terms will be written in small capitals.

[5]Head-Driven Phrase Structure Grammar, initiated by Pollard and Sag (1994).

The topmost node with the double line is the central node. Two attributes, ATTR1 and ATTR2 assign the values v1 and v2 respectively to the referent represented by the central node. The value v2 of the second attribute carries two attributes of its own, ATTR3 and ATTR4, which take the values v3 and v4, respectively. Constraints are not represented in this type of graph.

Barsalou himself uses a different graph notation for frames. In his graphs, attributes, too, are represented by nodes. We prefer the graph representation introduced here because it is less complex and corresponds more directly to the conceptual structure of frames.[6]

2.2.2 Uniqueness Conditions

What is essential to a representation in frame format is a set of three uniqueness conditions. These apply independently of the mode of representation chosen for Barsalou frames:

UR ***Unique frame referent***
All attributes and subattributes recursively relate to one and the same referent. (For the graph representation, there is exactly one node, the central node, such that every other node can be reached from it via a chain of one or more attribute arcs.)

UV ***Unique values***
Attributes are partial functions: Every attribute assigns to every possible possessor exactly one value.[7]

UA ***Unique attributes***
Every attribute is applied to a given possessor in a frame structure only once. (All attributes assigned to a given possessor are mutually different.)

UR requires that frames form a coherent whole in a particular way. In terms of the graph representation of frames, UR excludes the possibility that a frame graph may contain subgraphs which are not connected to one another. Rather, frame graphs have a source node. Condition UR is restricted to sortal frames, as opposed to individual, relational, or functional frames. For the latter types of frames,

[6]The graph representation used here implements the principal distinction between attributes and their arguments and values. This distinction is essential; see Petersen (2007) and Löbner (2012: Sect. 4.1) for discussion of this aspect of frame theory and for a comparison of Barsalou's graphs and those used here.

[7]Notwithstanding underspecification. Underspecification leaves room for alternative specifications. For example, the value of the attribute COLOR may be specified not only as, say, 'green', but also as 'warm', 'pleasant', 'sickening', 'stylish', etc. This does not contradict the condition that the attribute takes one particular color as value; rather, these alternative descriptions represent different underspecific predications about the value of the attribute. The values may be complex: for example, a vector of coordinates (see Sect. 2.3.4 on multidimensional spatial case).

UR has to be modified accordingly. These types of frames can be represented by connected graphs, too, but the central node is not a source node (see Petersen 2007 for the structure of nonsortal frames.) For all types of concepts, frames are coherent networks of possessors, attributes, and their values, and have a distinguished node that represents the referent of the whole frame. The discussion of linguistic frames in this article will be confined to sortal frames.

UV is essential. It rules out networks in which (at least some) ‘attributes’ are nonfunctional relations relating possessors to correlates. For example, UV precludes that in a frame for a person attributes labeled ‘CHILD’, ‘PROPERTY’, or ‘IS A’ would relate children, properties, or superordinates to that person.

UA is a natural consequence of condition UV. If the same attribute were specified more than once for a certain possessor in a frame, its instances would have to return an identical value, resulting in a redundant representation. UA does not preclude multiple occurrences of the same attribute for different possessors in one frame: in a frame graph, arcs with identical label may originate from different nodes.

Obviously, a recursive representation in terms of functional attributes and the values they return represents a frame in Barsalou’s sense if and only if these three conditions are met. Therefore these uniqueness conditions will be used in the following argument. We will first turn to syntactic structures, discussing the question as to whether they can be considered to fulfill the three uniqueness conditions (Sect. 2.3). The second part of the paper will deal with the meaning of complex (Sect. 2.4) and lexical (Sect. 2.5) linguistic gestures.

2.3 Syntactic Structure

This section will discuss the basic aspects of syntactic structure, rather than any theoretical frameworks.[8] These aspects are constituent structure (Sect. 2.3.1), dependency structure (Sect. 2.3.2), grammatical functions (Sect. 2.3.3), and grammatical features (Sect. 2.3.4). In this section, the discussion will be restricted to syntactic structure as it can be assessed by purely syntactic means. There seem to be languages for which grammatical structure cannot be settled on the basis of syntactic configurations (constituent structure or dependencies) alone. They have been termed “nonconfigurational”.[9] The issue of the autonomy of syntax will be discussed in Sect. 2.4.4.

[8]As this article is not exclusively aimed at linguists, the discussion of syntax and semantics will include the explanation of basic notions in linguistic theory. The discussion is essentially based on Van Valin (2001).

[9]See Pensalfini (2004, p. 362ff) for an overview.

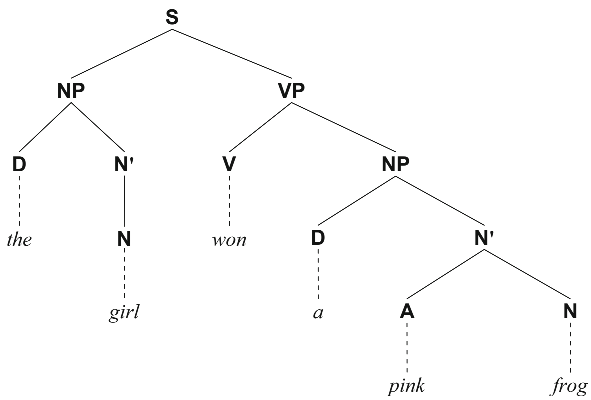


Fig. 2.2 Conventional phrase structure tree diagram of the sentence *the girl won a pink frog*

2.3.1 Constituent Structure

Most approaches to the syntax of natural language – including traditional grammar – are based on constituency: a complex linguistic gesture, specifically a sentence, is analyzed in terms of constituents which may be recursively embedded in one another. Constituents are not just arbitrary substrings of the complex gesture, but constitutive parts with a distinctive function and a certain degree of independence. Van Valin (2001) gives three criteria for constituency. (i) Substitution: "only a constituent can be replaced by another element, usually a pro-form"; (ii) Permutation: "a constituent may occur in different positions in a sentence, while retaining its structural unity". (iii) Coordination: "only constituents may be linked, usually by coordinate conjunction, to form a coordinate structure" (quotes from Van Valin 2001, pp. 111, 112, 113, respectively).

Consider an unsophisticated constituent structure such as the one represented by the phrase structure tree in Fig. 2.2. The sentence S consists of two immediate constituents, NP and VP, the subject and the predicate of the sentence in more traditional terms. These immediate constituents are again analyzed into their immediate constituents, and so on, down to the terminal elements which represent the lexical realizations of the constituents. Expressions and their immediate constituents are traditionally referred to as mothers and their daughters. The representation follows the basic assumptions of X-bar syntax (Jackendoff 1977), a particular framework of constituency theory which is adopted in a large variety of syntactic theories. In X-bar theory, the same types of daughters have to be assigned consistently to the same types of mothers. This is the reason why in the subject NP the article is not immediately attached to the noun N, but to an intermediate N' ('N-bar') constituent. N' is the type of constituent that can, but need not, have an adjective sister, as is the case with the object NP.

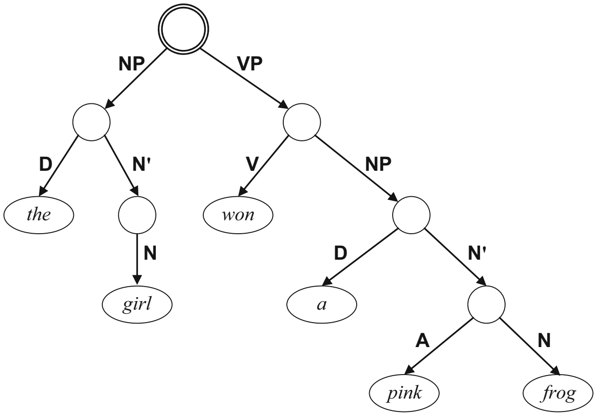


Fig. 2.3 Mereological subframe representing constituent structure

Phrase structure trees and constituency frame graphs. Phrase structure trees can be transformed into directed labeled graphs by applying the following steps:

1. The topmost mother node is marked as the central node.
2. All daughters in the tree, except for the terminal lexical ones, are replaced by nodes.
3. The lines that connect mother nodes to daughter nodes are replaced by arcs which lead from mothers to daughters.
4. Each category label that forms a daughter node in the tree is turned into a label on the arc that leads to the daughter.
5. The terminal nodes of the tree are turned into value specifications of the nodes from which they expand.

The result of applying these transformations to the tree in Fig. 2.2 is given in Fig. 2.3. This is a frame graph. It represents the mereological structure of the complex linguistic gesture. It is to be read as follows. The referent of the constituent structure graph is the whole sentence.[10] It has two parts: the NP *the girl* and the VP *won a pink frog*. NP [OF] and VP [OF] are attributes of sentences, just as HEAD [OF] and STOMACH [OF] are attributes of (bodies) of persons and other creatures. Analogously, the other attributes in the lower parts of the frame are mereological attributes: "D" stands for the attribute DETERMINER [OF] of an NP node, "N'" for the "N' [OF]" attribute, and so on. The terminal nodes of the phrase structure tree are not constituents of their immediate mother nodes; for example, *girl* is not a constituent of N, rather it *is* the N. In the frame graph, they are the values of those mereological attributes which correspond to minimal parts. Thus, *girl* is the value of

[10]The information that the referent is of type "S" is dropped. This is of no detriment since the category label S within the phrase structure is arbitrary and redundant. The fact that the whole complex is a sentence merely follows from its constituent structure.

the N of the N' of the [subject] NP of the sentence, and *pink* is the A of the N' of the [direct object] NP of the VP of the sentence. Since the frame is a mereology, all parts of the same constituent add up to the constituent as a whole. For example, *pink* is the A of *pink frog*, which is the N' of *a pink frog*, which is the NP of *won a pink frog* which is the VP of *the girl won a pink frog*. In this way, the values of those attributes which do not carry a specification entry in their value node are determined. Note that a mere phrase structure frame does not depict the order of its elements. All arcs just denote immediate constituency. Usually, phrase structure trees are arranged, and read, in the way that the terminal nodes appear in their actual order. However, for frame graphs, the spatial arrangement is of no significance, except, of course, for the nodes-and-arcs topology itself.

Uniqueness properties of phrase structures. When phrase structures are construed as constituency frames, the three uniqueness conditions take the following form:

UR_C Unique referent:
There is a unique mother of the whole construction.
UV_C Unique value:
Constituents are unique. Final daughters have unique realizations.
UA_C Unique attributes:
For every mother, all daughters are of mutually different types.

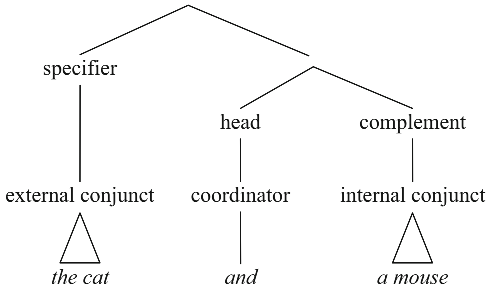
Are these conditions fulfilled in general? Condition UR_C is uncontroversial, though not trivial. It ensures that a constituent structure describes the composition of a complex linguistic gesture as a single coherent whole with a hierarchical structure. The condition excludes structures with two or more independent mothers, for example ⋀⋀ shaped constituent structures with two independent mothers sharing a daughter. It excludes cyclic structures without a source node, and it excludes representations that fall apart into disjoint subgraphs.

Condition UV_C is unproblematic. It rules out the possibility that there is more than one realization for one constituent.

Condition UA_C excludes structures with mothers that have two or more daughters of the same type. There are three types of constructions that, at a first look, might cause trouble: paratactic conjunction,[11] multiple modifiers, and clauses with more than one verb argument in so-called nonconfigurational languages. The analysis of coordination and multiple modification in terms of constituency can be considered settled in syntactic theory. The results comply with UA_C. Constructions with multiple modifiers of the same type, such as [AAAN], can be shown to have a recursively embedded constituent structure [A[A[A N]]] (see Van Valin

[11] Stassen (2000) observes that there are two universal types of languages, which he calls AND-languages and WITH-languages. They differ in the way in which they construct those cases where English would use a conjunction of two NPs. AND-languages combine two NPs in a paratactic coordinating structure, e.g., *Ken and Jo*, while WITH-languages use asymmetric, hypotactic constructions such as *Ken with Jo*. Obviously it is only the AND-languages which provide a potential problem with respect to UA_C.

Fig. 2.4 Constituent structure of coordination (Following Zhang 2009, p. 242)



2001, p. 126). As to paratactic conjunctions, the state-of-the-art analysis considers conjunctions as asymmetrical constructions with binary branching. For example, Zhang (2009, p. 242) argues for the general constituent structure in Fig. 2.4.[12]

So-called nonconfigurational languages (Chomsky 1981) lack a VP in the clause. In a simplistic view, in these languages clauses with transitive or ditransitive verbs have two or three NP sisters to the verb: $[_S$ NP NP (NP) V]. This problem in respect to UA_C will be discussed later.

More recent applications of X-bar theory, e.g., Minimalist Syntax (Chomsky 1995), assume a principle of general binary branching: a mother has either one or two daughters, and two daughters are inevitably of different type. Constituents are distinguished in general functional terms such as 'specifier', 'modifier', 'complement', and 'head'. If this principle is recognized, UA_C is obviously fulfilled. Independently, we note that UA_C is by and large achieved by the distinction of types of constituents which differ in function – both within the constituent structure and semantically – such as 'NP' or 'VP'. Thus, syntactic mereology is intrinsically interwoven with functional properties of the parts.

Mereological frames in general. Mereological systems are a very common type of structure in human cognition. One prominent example is the anatomical frame of the human body. We also have mereological concepts for complex artifacts and other objects. The items in a mereology are not just arbitrary portions of the whole, but parts with a constitutive function and a certain degree of independence. Often such mereologies contain what we perceive as multiple parts. Going back to our example of the human body, this would include all those parts of which there are two or more, such as fingers, teeth, or bones. Artifacts, too, may have multiple parts such as the wheels, seats, or doors of a car, the keys of a piano, the leaves of a book, etc. Multiple parts are multiple by virtue of the fact that they share crucial functional and sortal characteristics. Yet their individual function differs. The right ear does not have the same function as the left ear, as each ear perceives a different share of the environmental soundscape, each key of a piano (if properly tuned) produces a different tone, each page of a book may have different content, and so on.

[12]The general constituent structure is quoted from Zhang; the bottom row is added for illustration. Triangles are used in constituent trees as abbreviations for subtrees of unanalyzed phrasal constituents.

Generally, if mereologies are modeled as Barsalou frames, the existence of multiple parts seems to contradict the uniqueness condition UA (all attributes of the same possessor, i.e., parts of the whole, are of different types) or the functional character of attributes (UV). This problem, however, can be dealt with. Part of the solution consists in recognizing that the terms and notions for multiple parts are superordinates of terms and notions for unique parts. The superordinates can, at least in principle, be disambiguated into, say, LEFT EYE, INDEX FINGER, TIBIA, etc. instead of just 'eye', 'finger', 'bone', respectively. Thus, a mereological frame for the human hand would exhibit attributes such as THUMB, INDEX FINGER, MIDDLE FINGER, etc. instead of five equal generalized (pseudo-)attributes 'finger'. In order to comply with condition UA, one has to take care that such generalized terms for mereological attributes are barred from mereological frames. For cognitive representations it appears natural to assume that, despite the naturalness of notions such as 'finger', the cognitive representation of a human body would not represent the five fingers of the hand indiscriminately as just five equal parts.

In addition to employing unique part terms, there is a second method of disambiguation. Multiple parts for which there is a superordinate nonfunctional term may be distinguished by their structural context and/or their relative position. Different bones are placed in a different (and unique) anatomical context, the wheels or doors of a car are in different relative positions, the leaves of a book are numbered sequentially, etc. Accordingly, the mereological frame can be superimposed with a frame for a certain configuration. Barsalou (1999, pp. 590–593) illustrates the integration of frames with relational configurations.

Applied to mereological syntactic frames, we observe the same principles. Constituents are parts of the whole with a certain degree of independence. Also, types of constituents are distinguished and categorized in terms of their function. If, for certain constructions, the syntactic functional distinctions should be insufficient for complying with UA_C, there are other means of distinction. Word order can be used for disambiguation in the same way as relative position in anatomical frames. Further possibilities will be discussed in Sect. 2.4.4.

Summary on constituent structure. At this point, we can fix the following:

- With the preliminary exception of clauses in nonconfigurational languages, constituent structures can be considered frames in terms of mereological attributes.
- Parts of speech and complex form classes are value types of particular mereological attributes.

It should be noted that the terms for constituent attributes and for the types of values they take are homonymous: for example, the attribute NP [OF] takes values of the type NP.[13]

[13]The ambivalence is systematic for attribute terms: the functional attribute term *color* [*of*] corresponds to the sortal term [*a*] *color* for possible values of this attribute. See Löbner (2011: Sect. 5.2) with reference to Guarino (1992).

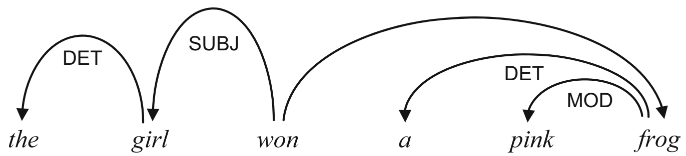
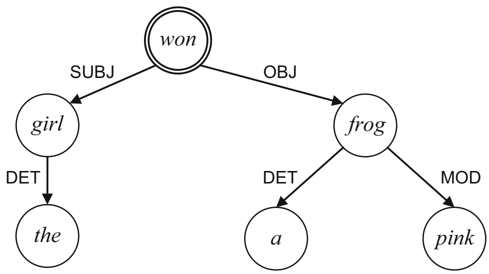


Fig. 2.5 Dependency diagram

Fig. 2.6 Dependency frame



2.3.2 Dependency Structure

A second structural aspect of complex linguistic gestures is dependency relations. A dependency relation holds between two words of which one is the 'head' and the other a 'dependent'. For example, in the English noun phrase *a pink frog*, the noun *frog* is a head with two dependents, the adjective *pink* and the determiner *a*. Heads and dependents are co-occurring expressions, not necessarily adjacent. The head is the "dominant element which is the primary determinant of the properties of the arrangement". Heads "select their dependents and may determine their morphosyntactic and other properties" (both quotes Van Valin 2001, p. 87). Dependencies are usually depicted by means of dependency diagrams such as in Fig. 2.5. The arcs lead from heads to their dependents. Dependency diagrams essentially *are* just frame diagrams, if the highest head is marked as the referent node of the frame (Fig. 2.6); the diagrams in Figs. 2.5 and 2.6 are isomorphic. The dependents are assigned to their heads by functions termed 'subject', 'object', 'modifier', 'determiner', etc. Dependency theory distinguishes different types of dependencies, but this aspect can be neglected here.

The uniqueness issues are parallel to those of constituent structures.

UR_D Unique referent:
There is exactly one element which is a head and not a dependent. All other elements of the structure are ultimately dependent on this element.

UV_D Unique value:
Dependents of a type are unique.

UA_D Unique attributes:
For every head all its dependents are of mutually different types.

Conditions UR_D and UV_D are as unproblematic for dependency structures as they are for constituent structures. Analogous problems arise for UA_D, with the same types of constructions. In the theories of dependency, the treatment of coordinate conjunction and multiple modification is apparently settled as it is in theories of constituent structure. Again, the only type of construction that may provide a problem is that of clauses in nonconfigurational languages.

2.3.3 Grammatical Functions

All theories of syntax agree that basic grammatical functions[14] – such as subject, direct object, indirect object – are of central significance to the syntax of natural language. The classical notions of the grammatical functions are such that a clause can have only one subject, direct object, or indirect object. Thus, the basic understanding is that the following uniqueness conditions hold for grammatical functions:

UV_G Unique value
Grammatical functions receive unique realizations.

UA_G Unique attributes
A clause can contain a grammatical function at most once.

Since grammatical functions are immediately built into dependency structures, the issue of UA for grammatical functions coincides with UA for dependency structures. For constituent structure, the issue is less simple. The problem raises its head for the first time with the question of ‘configurationality’: is the category of VP universal? Does every clause have a constituent of this type? If a language has a VP in its clause structure, the subject can be syntactically defined as the sister to VP, and direct and indirect object as two different constituents within the VP. But if not, the structural distinction of the basic grammatical functions is less obvious. In terms of constituent structure, one might end up with a flat clause structure with two or three argument NP sisters to the verb with equal status. Thus, the problem of UA for grammatical functions is immediately linked to the problem of UA for constituent structures.

There are two fundamental questions: (i) What are the criteria in terms of constituent structure for determining particular grammatical functions? (ii) Given the typological diversity of languages, are these grammatical functions of universal significance? Do all languages have subjects, direct objects, and indirect objects? If not, are there alternative sets of basic grammatical functions for certain types of languages?

[14] Some scholars, including Van Valin (2001), use the term ‘grammatical relations’ rather than ‘grammatical functions’. I prefer to talk of grammatical functions because notions such as ‘subject’ are functional concepts.

As to the first question, there are certain clusters of grammatical properties in terms of encoding and syntactic behavior which allow a morphosyntactic definition of the basic grammatical functions (Van Valin 2001: Sect. 2.2). Typically, in a given language, not all properties apply. Thus, the grammatical functions will only be implemented to a certain degree of typicality.[15]

As to the second question, the answer is negative. First, there are languages which lack grammatical functions. Van Valin (2005, p. 89ff) discusses the case of the Indonesian language Acehnese. In this language, the structure of the clause is not defined in terms of 'subject', 'direct object', etc., but consistently in terms of semantic roles like 'actor' and 'undergoer' (see Sect. 2.4.1 below). Those languages that do exhibit a set of grammatical functions differ in which ones they have. According to Van Valin (2001: Sect. 2.3), there are types of languages for which different sets of grammatical functions are relevant, for example, languages with ergative syntax, where the basic syntactic functions are 'absolutive' and 'ergative' rather than subject and direct object.[16]

With respect to grammatical functions, it does not matter for the Frame Hypothesis if all languages have a set of grammatical functions and if all that have share the same set. The Frame Hypothesis does not include the assumption that any particular attributes in syntactic frames are universal. What does, however, matter directly is whether or not particular grammatical functions can occur more than once within a single clause. Van Valin (2001, p. 70ff) discusses examples where this may indeed be considered to apply. One example is the Philippine language Tagalog. Philippine languages provide considerable problems for general grammatical theories and their analysis is highly controversial. One characteristic trait is a system of voices (like the active and passive voice in English) which enables focussing on each of several arguments and adjuncts[17] of the verb. The argument or adjunct which is singled out by voice will be marked with a special case marker *ang*, usually termed 'nominative' in the literature (Schachter and Otanes 1982); all other arguments receive either a case marker *ng* called 'genitive', or a dative case marker, while adjuncts, e.g., locatives, will bear semantically more specific case marking. According to the bundle of syntactic subject criteria, there are two types of NPs in Tagalog sentences

[15]"Even though there do not seem to be universally valid properties which subjects and direct objects each possess exclusively," Van Valin (2001, p. 69) summarizes, "there are enough constructions to provide tests which should enable a linguist to identify these grammatical relations in many languages. Relations which appear to be rather straightforward in familiar Indo-European languages turn out to be much more varied and problematic when a wider range of languages is examined."

[16]The notion of 'ergative' corresponds to the notion of subject, but only for sentences with transitive verbs; subjects of intransitive verbs are subsumed with objects of transitive verbs under the notion 'absolutive'. Van Valin (2001: 77f) discusses the Australian language Mparntwe Arrernte as an example for syntactic ergativity.

[17]The distinction between arguments and adjuncts does not matter much in this paper. Usually, arguments of a verb are those participants which are necessary components of the verb concept. Adjuncts are optional components such as instruments, location of the action, aims, etc. See Van Valin (2001, pp. 92–95) for criteria and problems of the distinction.

which qualify for subjects: NPs marked with nominative and NPs denoting the 'actor' argument (roughly what would be the subject argument for English verbs in active voice.) For example, only the actor argument can be the antecedent of reflexives, independently of the voice of the verb which may single out a different NP as nominative. The nominative NP, on the other hand, is the only NP which can be the head of a relative clause. Plus it is the NP the verb agrees with, by virtue of its voice. This situation leads to the possibility of sentences which have one subject with respect to one set of criteria in addition to another subject with respect to other criteria. Clearly, however, the two "subjects" in such cases do not play the same role in the sentence, as they denote different arguments of the verb. These cases do not invalidate the $\mathrm{UA_G}$ condition for Philippine languages. Rather they provide evidence that for languages like Tagalog the basic grammatical functions must be defined differently.

2.3.4 Grammatical Features

Grammatical features play an important part in indicating syntactic structure. It is a striking fact that grammatical features such as gender, number, person, case, tense, aspect, or mood can be assigned to a constituent only once. If feature markings are organized in inflectional paradigms, their once-only quality is immediately grammaticalized. Paradigms such as a case paradigm for nouns or a person paradigm for verbs consist of a closed set of alternative forms. Usually these alternative forms are formed by a particular set of morphemes in a unique morphological position. The unique position allows for exactly one marking of the feature value: one morpheme that specifies person, one for tense, one for case, etc. In rare cases, feature markings can be complex, or stacked; see below.

Most grammatical features have a semantic function such as indicating the number of cases which an NP refers to (grammatical number), being a member of a certain class out of mutually exclusive classes (gender or nominal classifiers), reference to a period of time out of a set of separate time intervals (tense), and analogously for other features. For such features, the values they take are usually incompatible alternatives: reference is to either one or two or more cases; time reference relates either to the past or to the present or to the future; grammatical person indicates either the speaker or the addressee or neither, and so on. As a consequence, there are not only no morphological positions for multiple value assignments of these features, but also the result would be semantically contradictory. All this indicates that grammatical features are in fact attributes in the frame of the linguistic gestures they belong to:

$\mathrm{UV_F}$ Unique value
Values of grammatical features are unique.

$\mathrm{UA_F}$ Unique attributes
A linguistic gesture carries a grammatical feature only once.

There are some grammatical features for which the semantic argument does not apply. These include grammatical case, and grammatical gender in languages with obligatory gender distinction such as French, Russian, or German. Grammatical gender in these languages usually coincides with natural sex if the referent of the noun carries sex and the noun meaning specifies it, but in all other cases gender assignment is by and large semantically void. Thus, semantics would not bar double gender marking. As it happens, the languages mentioned all have inherent gender for nouns; there is no way of explicitly marking gender, gender is just lexicalized (uniquely, apart from a few exceptions of nonsystematic variation). But even if gender were marked explicitly as in many cases in Spanish or Italian, there will never be double markings of gender.

UA_F does not exclude that a feature of a linguistic gesture be marked more than once for the same value. In fact, the realization of feature markings is a complex morphosyntactic phenomenon. For example in the German NP *ein schöner Garten* ('a beautiful garden', nominative), the noun is inherently masculine, but does not carry a gender marker, while gender is marked by the forms of the article and the adjective; case and number are relevant for the forms of all three NP constituents.[18] UV_F does not exclude underspecification and syncretism.

The uniqueness conditions for grammatical features provide significant constraints on grammars of human languages. The constraints will be briefly illustrated for the features number, tense, and case.

Number. From a semantic point of view, explicit specification of a grammatical feature in many cases indicates a semantic operation on the meaning of the carrier, e.g., a shift in time reference (tense) or a change in the number of instances a predication is to be applied to (grammatical number). For certain communicative ends one might want to be able to express an iteration of such semantic operations. For example, explicit plural can be analyzed roughly as serving the expression of reference to a group of instances rather than to a single instance. Condition UA_F restricts the expression of plurality by the means of grammatical feature marking to one level of group formation. Explicit expression of reference to a group of groups is beyond the functional scope of grammar. Consider the following examples:

(1) a. *The students gathered in their classroom.*
    b. *The students gathered in their classrooms.*

The collective plural in (1a) indicates that the predication 'gathered in their classroom' applies to a multitude of students as a whole. The singular form of *classroom* forces the reading that there is one group of students all of whom gathered in one classroom. In (1b), *classrooms* is plural, yielding a predication about a group of groups of students, each group gathering in one out of a group of classrooms. Thus, both *students* and *their* in (1b) have a group-of-groups, or double plural,

[18] For one recent theory of morphosyntactic rules of feature markings, see the framework of Distributed Morphology (Halle and Marantz 1993).

reading.[19] However, there is no way of morphologically indicating double plural on the noun (**studentses*) and there is no double-plural third person pronoun. Corbett (2000, p. 36f) reports very rare cases of 'composed', i.e., stacked number plurals, e.g., in Breton, but these seem to be extremely rare and restricted to very few exceptions.[20] Thus, as a very strong tendency, grammatical number cannot be functionally stacked.[21]

Tense. Similarly, it is easy to conceive of situations where semantically stacked tenses such as past of past, past of future, future of past, or future of future are involved. While such situations can be explicitly expressed in many cases, they are not expressed by double tense marking on verbs or other tense-marked predicators. Options like those in (2) for past of past expression by double tense marking do not seem to exist:

(2)	a. English	*went-*	**ed*		vs.	*had*	*gone*		
		go.PAST-	PAST			have.PAST	go.PARTICIPLE		
	b. Japanese	*tabe-*	*ta-*	**ta*	vs.	*tabe-*	*te i-*	*ta*	
		eat-	PAST-	PAST		eat-	PERFECT	PAST	

The available means of expressing stacked time reference, such as pluperfects, future 2, or future in the past, seem to never involve double tense marking on the same stem. Note that the correct forms in (2) contain only one tense marking; the form glossed PERFECT is not a tense marker, but an aspect form.

Case. Grammatical case clearly displays the same picture if case morphology forms a closed paradigm as in Russian, Latin, or German. Languages with agglutinative case marking may allow for more than one case morpheme on one noun. Multiple case morphemes are of two types: complex case and stacked case. Complex case consists in marking one case by a series of more than one case morpheme. For example, in Northeast Caucasian Daghestanian languages, there is a set of basic local case affixes (expressing 'in', 'on', 'at', 'behind', 'under', etc.) which can be optionally combined with an affix that specifies a direction. This gives rise to a triad of case variants: essive (absence of motion), allative (motion towards), and

[19]See Löbner (2000, p. 247ff.) for a discussion of such level-2 plural predications, also called 'superplurals' cf. e.g., Linnebo and Nicolas (2008).

[20]Interestingly, Corbett (2000, p. 36) does mention a case of stacked number marking of the kind ruled out here: a double plural marking on Breton 'child' indicating a reference to a group of groups of children: *bugal-e-où* = child-PL-PL; "The first formation," he remarks, "is highly irregular, and the second is a common one. The possibility of composing plural on plural is not freely available."

[21]Cases of functional plural-of-plural and similar stacking must be distinguished from double morphological feature marking with the functional effect of simple plural. For instance the irregular Dutch plural form *kinderen* of *kind* ('child') is based on a former plural *kind-er* (the same form as in the German cognate *Kind*, plural *Kind-er*) to which the general regular Dutch plural suffix *-en* is added. Semantically, the form just functions as a simple plural.

ablative (motion away from).[22] Such complex case markings are not instances of multiple specifications of the same feature, but rather complex specifications of one multidimensional spatial case that consists of a component specifying a spatial region of an object of reference plus a relative direction towards or away from it.[23]

Case stacking occurs as so-called 'Suffixaufnahme' (Plank 1995; Moravcsik 1995). A typical example is the following from the Australian language Gumbaynggir, quoted from Moravcsik (1995, p. 458).

(3) *ba:ba- gu junyu- gundi- yu*
father- ERG child- GEN- ERG
'the child's father (ergative)'

The NP *junyu-gundi-yu* carries an internal case marker that marks it as the possessor phrase for the relational noun *ba:ba*; in addition, both nouns carry ergative case marking. Such structures do not violate condition UA for the attribute CASE: the genitive case morpheme *-gundi* marks *junyu*___ as genitive, while the two ergative morphemes mark the whole NP *ba:ba-*___*junyu-gundi*___ as ergative – both on the head *ba:ba* and the possessor NP. Thus the CASE attribute that takes the value 'genitive' is an attribute of the possessor NP only, while the CASE attribute that takes the value 'ergative' is an attribute of the latter's mother.

Summary on grammatical features. Given these observations, we are entitled to conclude that grammatical features can be construed as attributes in structural frames. These attributes can be added to phrase structure frames or to dependency frames. Figure 2.7 illustrates the latter option by adding the attributes NUMBER and TENSE to appropriate nodes in the dependency frame of Fig. 2.6. From this point of view, it appears problematic to treat grammatical features and their expression as constituents as is done in Government-Binding Theory (Chomsky 1981) or Minimalist Syntax (Chomsky 1995). Rather a treatment appears adequate along the lines adopted in LFG[24] or HPSG, where features are treated as attributes.

2.3.5 Conclusion on Grammatical Structure

Among the aspects of grammar discussed in this section, it is grammatical features that provide the strongest evidence for a cognitive representation of grammatical structure in the form of frames. The Frame Hypothesis explains severe restrictions imposed on the expressiveness of grammatical feature markings. For constituency,

[22]Comrie and Polinsky (1998) discuss the complex case systems of the Daghestanian languages Tabasaran and Tsez.

[23]Spatial case may exhibit up to four dimensions; see Creissels (2011) for a survey of multidimensional spatial case systems.

[24]Lexical-Functional Grammar, see Bresnan (2000).

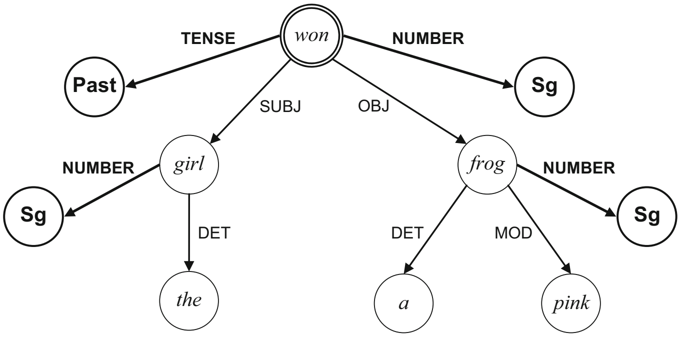


Fig. 2.7 Dependency frame with grammatical features

dependency structure, and grammatical functions the conclusion is this: the Frame Hypothesis is in agreement with basic grammatical structures both in terms of constituent structure and of dependencies. It is also in agreement with the assumption that syntactic functions are unique within a clause – if they are properly defined. The only problematic cases are provided by the clause structure of nonconfigurational languages. Still, there are two ways of reconciling that which we know about constituency, dependency, and grammatical functions with the Frame Hypothesis:

I. Impose UA as a general restriction on constituent structures, dependency structures, and sets of basic grammatical functions, and gain a strong structural constraint which is externally motivated by the Frame Hypothesis. Similar accounts do exist in several versions. For constituent structure, syntactic approaches adopting X-bar theory with binary branching apply this constraint in an even stronger version by admitting at most two daughters for one mother, and necessarily different types of daughters for the same mother. This constraint, however, was never externally motivated, except for, maybe, general principles such as simplicity and uniformity.

II. Alternatively, one can keep to those variants of analysis which for certain constructions prefer flat structures with more than one daughter, or dependent, of the same type. Still, there are two ways to comply with the Frame Hypothesis.

   (a) One may read the corresponding quasiframe structures such as [$_S$ NP NP V] as containing generalized attribute labels to be properly disambiguated. The corresponding structures would then actually be frames, although with underspecified, or generalized, attribute labels. They could be turned into proper frames by using more specific, functional attributes, sacrificing certain generalizations.

   (b) One might recognize that these framelike structures actually are incomplete frames. Neither constituent structure nor dependency structure alone is all there is to grammatical structure. This would mean acknowledging that purely syntactic criteria do not fully determine the grammatical structure of a sentence. Nonfunctional attributes, i.e., nonunique elements in constituent or dependency structure, would have to be disambiguated by adding further, nonsyntactic attributes in order to comply with UA. From the point of view of the cognitive representation of complex linguistic gestures, this step is harmless. Full representations will not be restricted to abstract constituent or dependency structure, but will necessarily also capture the semantic properties of its constituents. In order to comply with the Frame Hypothesis, one only has to verify that the total representation of grammatical structure is a Barsalou frame. We will return to this option in Sect. 2.4.4.

2.4 Frames and Meaning

2.4.1 Verb Case Frames and Semantic Roles

The most "framish" elements of language are certainly verbs with their case frames. A one-place or more-place verb opens a case frame in terms of its arguments and their respective semantic, or 'thematic', roles. Optional adjunct roles can be added. Case frames have a central element, representing the situation expressed, and a certain number of case roles corresponding to the arguments and adjuncts of the verb (Fillmore 1968). The cases are functional: they assign to each instance of the situation expressed by the verb a unique agent, theme, goal, etc. Each role can occur at most once in a case frame. Thus, Fillmorean case frames clearly fulfill the three uniqueness conditions. Note that UR here is even stronger than the general condition, since case frames are usually conceived of as flat, nonrecursive structures.[25]

UR_{CF} Unique referent:
All case attributes immediately relate to the referent of the frame.

UV_{CF} Unique value:
Case attributes take unique participants as values.

UA_{CF} Unique attributes:
All case attributes are different.[26]

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[25]For a theory with recursive case frame embedding see the Localist Case Grammar in Anderson (1977) and Ostler (1980).

[26]Chomky's 'theta criterion' explicitly states UA for case frames; using the term 'θ-role' for Fillmorean case: "Each argument bears one and only one θ-role, and each θ-role is assigned to one and only one argument." (Chomsky 1981, p. 36) Arguments are values of case attributes; an argument is assigned a θ-role if it is the value of the corresponding θ-attribute. The first conjunct of the θ-criterion states a different condition. In terms of the frame approach it means that different attributes of the same verb cannot share their value. This would constitute a fourth uniqueness condition: if x is the value of some attribute of a possessor p, then there is exactly one attribute of p such that x is the value of that attribute. The condition seems plausible for constituents and dependents – one and the same expression apparently cannot be two constituents or dependents of the same mother or head. Whether it holds for frames in general, is a question far beyond the scope

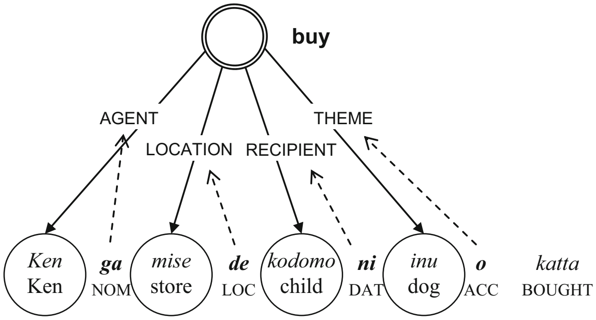

Fig. 2.8 Case frame and linking of the sentence in (4)

Linking theories describe how case frames are related to syntactic structures.[27] The relation is particularly direct for languages such as Japanese which mark every possible argument and adjunct of a verb with a different case marker:

(4) Japanese

Ken	*ga*	*mise*	*de*	*kodomo*	*ni*	*inu*	*o*	*katta*
Ken	NOM	shop	LOC	child	DAT	dog	ACC	bought.PST

'Ken bought the child a dog at the shop'

In this sentence, the verb *kau* 'buy' is used for a four-place predication with the arguments and adjuncts agent, recipient, theme, location marked by the case particles *ga* (nominative), *ni* (dative), *o* (accusative), and *de* (locative), respectively. The grammar of Japanese immediately indicates the different arguments in the case frame by particular case markers. Not only does the case frame provide a set of mutually different argument roles, but in addition to this, two arguments are (almost) never marked with the same case particle in Japanese.[28] Figure 2.8 has the case frame for this four-place use of *kau* 'buy' superimposed on the sentence in (4).

The interaction of case frames with syntax takes us back to the UA issue for constituent and dependency structures. Japanese has been considered a

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of this paper. Note that UR the uniqueness conditions do not rule out that a node in a frame may be the value of more than one attribute. This is perfectly admissible if we are talking about attributes of different nodes. For example, attributes can be composed: HAIR is an attribute of people, COLOR is an attribute of the hair of people, whence HAIR COLOR is an attribute of people. The color of the hair of a person is thus, even necessarily, at the same time the value of the attribute COLOR of the hair of the person and the value of the attribute HAIR COLOR of the person.

[27] See Van Valin (2005) for a linking theory in the framework of Role and Reference Grammar.

[28] There are very few exceptions: *ni* may mark dative case as well as a location; the accusative marker *o* can also be used to mark the path argument of a verb of locomotion.

nonconfigurational language (Chomsky 1981, p. 128f).[29] From this point of view, the clause structure of the sentence in (4) would have more than one NP sister to the verb. The locative NP can be exempted as an adjunct, but still three argument NPs would remain. Japanese allows a disambiguation of the three constituents as NP_{ga}, NP_{o}, and NP_{ni}, in order to comply with UA_{C}. This is possible as a general solution for Japanese because basic clauses, with very few systematic exceptions, cannot have more than one occurrence of the same case particle. For other nonconfigurational languages, this solution for the UA_{C} problem is not available. For example, in Tagalog more than one argument of a verb can be marked with the default case genitive (Schachter and Otanes 1982). Consider the Tagalog equivalent of (4). In Tagalog, case particles precede the noun; BV marks benefactive voice. Due to the choice of benefactive voice, the recipient NP receives nominative case. The genitive marking is different for NPs denoting persons, but both *ni* and *ng* are genitive case markers.

(5) Tagalog (Anja Latrouite, p.c.)

i-	*b <in>*	*i∼*	*bili*	*ni*	*Ken*	*ng*	*aso*	*ang*	*bata*	*sa*	*tindahan.*
BV-	<Realis>	IPFV	buy	GEN	Ken	GEN	dog	NOM	child	DAT	shop
				AGENT		THEME		RECIPIENT		LOCATION	

Semantically the three roles of agent, theme, and recipient are different, but they may receive identical case marking. They differ grammatically in corresponding to different voices, but the applicability of a particular voice, again depends on the semantic role. Thus, in order to disambiguate argument NPs in Tagalog, one would have to make use of semantic properties of the NPs.

UA_{CF} imposes nontrivial restrictions on natural languages. There are certain verbs which have two arguments that logically play the same role in the verb concept: symmetric, or reciprocal, verbs such as *meet*, *struggle (with)*, *marry*, *differ (from)*, etc. The UA condition on case frames forces these verbs to be constructed either with two arguments of different types or with one complex argument:

(6) a. *Lucy*$_{\text{AGENT}}$ *married Joe*$_{\text{PATIENT}}$ equivalently: *Joe*$_{\text{AGENT}}$ *married Lucy*$_{\text{PATIENT}}$
b. (*Lucy and Joe*)$_{\text{AGENT}}$ *married*

2.4.2 Verb Meanings and Case Frames

Case frames cannot be equated with lexical frames for verbs. Rather they constitute an interface between lexical verb meanings and grammar. A language may have

[29] Chomsky's (1981) claim has been successfully challenged by various authors (cf. references in Farmer 1989, p. 249); Japanese is now considered a configurational language with comparatively free word order resulting from the possibility of so-called scrambling (Pensalfini 2004, p. 362). Independently of the discussion within the generativist camp, the cases of Japanese, and Tagalog (see below), are discussed here in order to deal with a possible argument against the assumption of UA in syntax.

hundreds, if not thousands, of verbs with the same case frame. Therefore, case frames obviously do not exhaust verb meanings. Also case frames do not represent aspectual characteristics of the situation expressed as they lack any representation of temporal or causal characteristics of the situation. So far, we know little about the composition of verb meanings beyond comparatively general structures like those introduced in Dowty (1979), Jackendoff (1990), or Pustejovsky (1995).

It must be assumed that verb meanings, if they are frames, are not just enriched case frames. Let me illustrate the problem with just one example. A verb expressing movement of x from A to B would have a flat case frame with three argument roles, THEME (or AGENT) X, SOURCE A, and GOAL B. These three ingredients of the moving event are, however, not on a par and independent of each other as the flat structure of the corresponding case frame suggests. Rather they are linked by the event of moving as follows: the source of the movement is the location of the theme of the movement before the event, and the goal of the movement is the location of the theme of the movement after the event (t_1 is the time when the movement starts, t_2 when it ends):

(7) Dependencies of the roles in a case frame of a verb of movement

SOURCE(e) = LOCATION(AGENT(e), t_1)

GOAL(e) = LOCATION(AGENT(e), t_2)

Thus, a frame for this type of event requires a recursive attribute structure. In addition, the concept will have to represent a change in time of the value of the location attribute of the theme argument: this change constitutes the event expressed.

For the following it will be assumed that for verbs and other predicate expressions there is some regular mapping of the lexical meaning frames ('lexical frames' for short) to the corresponding case frames. It will be assumed that the lexical frames of one-place or more-place predicate expressions (such as verbs, nouns, and adjectives) contain certain nodes marked as empty arguments. The mapping renders the empty nodes in the lexical frame as open arguments in the case frame, where these arguments are distinguished as different semantic roles. Thus, there is not only a linking mechanism that maps case frames to syntactic structures, but also, preceding it, a mechanism that maps lexical frames to case frames.

2.4.3 Sentence Meaning

Due to the principle of compositionality, the meanings of basic clauses can be constructed as frames based on frame-format syntactic structure, where syntactic structure can be defined either in terms of constituency or in terms of dependency. The constitutive parts of both types of structure will be referred to just as 'elements' of the sentence. A regular complex linguistic gesture and its elements are assigned meanings, from the lexical elements up to the whole complex. The frame representation of meaning requires just one attribute: MEANING. The uniqueness conditions yield the following requirements for frames representing syntactic structures with their compositional meaning:

UR_M Unique referent:
There is a meaning assignment for the highest element.
UA_M Unique attributes:
There is only one meaning assignment for each element.
UV_M Unique value:
A meaning assignment assigns only one meaning.

Compositional meaning and constituent structure. Common theories of composition such as those deriving from Montague Grammar (Montague 1970) are essentially based on constituent structure. Lexical constituents are assigned a meaning in their lexical entry. We will not bother here with the problem of lexical polysemy. Rather, it is assumed that polysemy gives rise to multiple lexical entries with different meaning specifications yet identical form. Thus, UA_M is secured for lexical meaning. Syntax defines the rules for combining constituents into more complex gestures, while corresponding rules of semantic composition specify the way in which the meaning of the whole is computed from the meanings of the constituents. If we adopt the Frame Hypothesis, cognitive representations of lexemes contain an attribute MEANING (along with several other attributes such as PHONOLOGICAL FORM, PART OF SPEECH, GENDER, etc.). Complex expressions are assigned a value of their meaning attribute as the result of compositional interpretation.

Let me illustrate the mechanism of semantic composition in terms of frames, based on constituent structure, with a very simple example. Of course, a frame-based theory of semantic composition requires more than this. A meaning attribute, represented by the dotted arcs, is added to each constituent in Fig. 2.9. To enhance readability, the attribute label 'MEANING' is omitted on these arcs. For the sake of simplicity we treat the lowest constituents as lexical, disregarding possible specifiers and modifiers of the NPs and the V. They are simply assigned their lexical meanings as values of their meaning attributes. In accordance with the Frame Hypothesis, it is assumed that the lexical meanings are themselves frames. The little arrows spreading from the three central nodes of the lexical frames symbolize individual attributes in these frames, i.e., attributes of the subject argument, the object argument, and the event referred to. These attributes may be elaborated recursively. The lexical verb frame contains empty values for the agent and theme arguments of the verb, represented by smaller black nodes. Let us assume that the interface between lexicon and syntax produces these two argument attributes in order to enable the verb frame to figure in the clause. Although these two nodes are empty, they carry type information since the case attributes for the given type of event impose selectional restrictions on the respective possible values, i.e., the arguments of the verb. For example, the THEME attribute of *drink* would define a different type of value than the THEME attribute of *eat*.

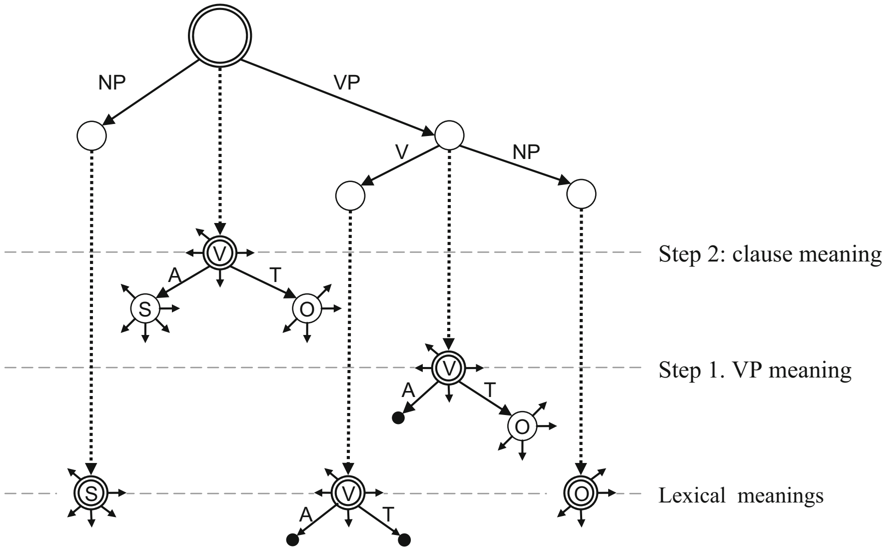

Fig. 2.9 Constituent frame with meaning attributes and values for lexical meanings

The VP and the clause receive meanings in the next two steps. The composition rules require combining the V meaning and the object NP meaning into one, as the constituents themselves combine to form one complex constituent. One of the basic ways of combining meanings is functional application, or argument saturation. This is what applies to the verb meaning and the object NP meaning by unifying the central node of the object NP meaning with the value of the attribute T(HEME) in the verb meaning frame. The resulting meaning frame retains the central node of the verb meaning frame, while the central node of the object NP meaning frame loses its status. Thereby, the resulting meaning frame complies with UR. This VP meaning frame is the value of the meaning attribute of the VP constituent. In the second step, the VP meaning frame combines by unification with the subject NP meaning frame, yielding the value of the meaning assignment of the whole clause. The meaning of a clause is a complex frame that integrates the lexical meanings of the three lexical elements of the sentence into a single frame.

In the total frame in Fig. 2.9, each constituent of the sentence has a meaning assigned to it. The whole structure is a well-formed frame. It contains the phrase structure frame and five meaning frames as subframes. Of course, this representation is redundant. When the human brain processes such a clause, it will certainly "forget" all meaning assignments except the one for the whole clause. Any model of semantic processing would probably understand the three levels of meaning assignment indicated here as subsequent phases of frame formation.

Compositional meaning and dependency structures. Alternatively, semantic composition can be built on the dependency structure of a clause, and this alternative

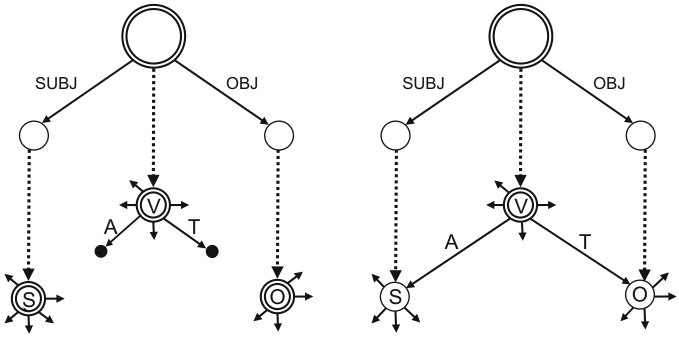

Fig. 2.10 Dependency structure with meanings

is in fact simpler and more elegant than the one just illustrated. The same basic type of clause has the dependency structure displayed in the left part of Fig. 2.10, with the same lexical frames assigned as meanings to its elements, the verb, the subject, and the object. Composition rules for dependencies can be generally described as requiring that the meaning frame of the dependent is to be incorporated into the meaning frame of the head, where rules of linking specify where and how the dependent is to be incorporated into the frame of the head. Incorporation of the dependent frame into the head frame does not change the central node of the head and makes the central node of the dependent lose its status.

In one step, the object NP meaning frame is incorporated into the verb meaning frame by inserting it as the value node of the THEME attribute of the verb meaning frame; in another step, the subject NP meaning frame is integrated. The result is a frame that is composed of two isomorphic subframes that represent the dependency structure and the structured meaning of the clause. The elements of the clause are each related to their respective meanings. However, these meanings are now meanings in the clausal context: the meaning of the subject is modified by the additional condition that it is the value of the AGENT attribute of the event referred to with the verb, and analogously for the meaning of the object NP. The right frame in Fig. 2.10 is free of the redundancies of the resulting frame in Fig. 2.9. From this perspective, it appears more attractive to base composition on dependency rather than constituency.

2.4.4 Configurationality and the Autonomy of Syntactic Structure

The issue of compositional meaning takes us back to the UA problem with syntactic structure. Assume that, for some reason or other, in a certain language different NP arguments, i.e., different grammatical functions cannot be distinguished on merely syntactic grounds. How can a sentence be assigned a structure in accordance with UA? The problem can be solved easily if the language is like Japanese in that different semantic roles are consistently marked with specific morphological markers. All it takes is a theory of linking which describes the regularities of marking semantic roles with certain case affixes or by other means, for example word order. While such a theory is possible for every language, linking still might not provide enough evidence for determining semantic roles because different roles might be linked in the same way. This is illustrated by the example of Tagalog where, for example, agent and patient may receive the same case marking if the verb is neither in actor nor in undergoer voice.[30] A similar case arises in languages without case marking and with a certain degree of free word order. Consider the following examples from Lakhota (Robert D. Van Valin, p.c.). Lakhota has no case marking on the NP argument terms, rather there are infixes within the verb stem that indicate person, number and semantic role (in this case actor and undergoer) of the external NPs; the infixes for 3rd person singular actor and undergoer are morphologically zero, i.e., equal. Articles are postponed.

(8) a. *hokšíla ki wíŋyaŋ ki waŋ-Ø-Ø-yáŋke*
boy the woman the see < 3sgA-3sgU>
'the boy saw the woman' *or* 'the woman saw the boy'

b. *hokšíla ki thípi ki waŋ-Ø-Ø-yáŋke*
boy the house the see < 3sgA-3sgU>
'the boy saw the house'

c. *thípi ki hokšíla ki waŋ-Ø-Ø-yáŋke*
house the boy the see < 3sgA-3sgU>
'the boy saw the house'

Lakhota allows for both word orders, actor–undergoer (which is unmarked) and undergoer– actor. The case of (8b, 8c) shows that the question as to who sees what cannot be settled syntactically. What makes disambiguation possible in certain cases are the selectional restrictions of the verb 'see' which rule out that the see-er be a house (unless *thípi ki* is shifted by metonymy or metaphor to refer to a person). In the case of (8a) even this is impossible; the sentence does not allow the distinction of actor and undergoer. However – and this is a crucial observation – the sentence will not be construed as merely indifferent as to who sees whom. It would not be taken to mean "there was some seeing event that involved a woman and a boy, one seeing and the other being seen". Rather the sentence will always be interpreted as referring to a seeing event with one unique see-er and one unique object seen (not excluding, but also not expressing, a situation of two persons mutually seeing each other). It is construed as ambiguous, not as neutral. This can only be explained if one assumes that the interpretation of such a sentence forces the construction of a structural representation which complies with UA for the two NPs. When

[30] 'Actor' and 'undergoer' are more general semantic 'macroroles' comprising 'agent' and 'patient', respectively (see Van Valin 2001, pp. 22–33).

there is no grammatical or semantic indication available for the distinction of the two NPs, one will look for contextual or world knowledge for disambiguation, because of UA_M for the sentence. And if this, too, fails one will be stuck with two alternative structural representations of the sentence – each of which complies with the uniqueness conditions.

In any event, if a syntactic structure receives its semantic interpretation, on whatever grounds, its elements are linked to the case attributes in the verb meaning frame. For example, for the structures in Figs. 2.9 and 2.10, the following relations result for the two NPs[31]:

(9) a. Constituent structure: MEANING(NP(clause)) = AGENT(MEANING(clause))
MEANING(NP(VP(clause)))=
THEME(MEANING(clause))
b. Dependency structure: MEANING(SUBJ(verb)) = AGENT(MEANING(verb))
MEANING(OBJ(verb)) = THEME(MEANING(verb))

The problem with equal elements in flat structures for nonconfigurational languages can then be resolved by using these relations to the semantic structure for disambiguation. Due to UA for case frames, no verb has equal cases in its frame. Therefore, any NP in a clause will be associated with a different case role. Thus, UA can be ensured for basic constituency and dependency structure of clauses, although possibly at the price of the autonomy of syntax.

2.4.5 Frame Semantics Versus Model-Theoretic Semantics

A frame approach to natural language semantics has two advantages over model-theoretic semantics, the dominant paradigm in sentence semantics. First, according to the frame approach, compositional meanings of complex gestures preserve, accumulate, and configure all the information given by the meanings of the elements of the complex. In this respect it differs fundamentally from the truth-functional approach taken in model-theoretic semantics. There, composition is basically modeled as the application of functions to appropriate arguments. Looking merely at the result, there is no way of knowing where it was computed from; the meanings of the parts are not recoverable from the meaning of the whole. Consequently, model-theoretic semantics does not capture meaning differences between logically equivalent expressions with different meanings, such as *the bottle is half empty* vs. *the bottle is half full*, or *today is Tuesday* vs. *yesterday was Monday*.[32]

[31] Note that due to the isomorphic structure of dependencies and meanings in the clause, the relation in the case of dependency structure is more straightforward. See Debusmann and Kuhlmann (2009) on this and other general aspects of dependency grammars.

[32] See Löbner (2013, Sects. 7.6 and 13.5) for discussion.

This problem with model-theoretic semantics has been addressed by constructing 'structured' meanings and propositions in various ways (see King 2008 for a survey). One type of solutions (e.g., Cresswell 1985; Soames 1987) defines meanings of complex linguistic expressions as tuples of their component meanings, just keeping the component meanings apart instead of letting them operate on each other. This type of approach fails to provide an explicit explanation of how the semantic constituents combine to form the compositional meaning of the complex expression. King (1996) proposes considering compositional meanings as a complex of component meanings related to each other by the syntactic relations among their respective expressions. The former approach is obviously deficient, while the latter fails to properly distinguish the levels of expression and meaning. The frame approach sketched here obviously solves these problems.

The second advantage of the frame semantics approach is its potential of linking linguistic semantics to cognitive psychology. Model-theoretic semantics does not provide a link to cognition. By modeling meanings in terms of reference and truth conditions, model-theoretical semantics abstracts away from the cognitive level of concepts. This type of approach captures the logical properties of sentences, but not the way in which these properties result from the meanings of linguistic expressions.

2.5 Meanings of Argument Terms and the Evolution of Abstract Attribute Vocabulary

2.5.1 A Simplified Model of Reference and Linguistic Communication

The discussion of the meanings of argument terms[33] will be restricted to argument terms in basic clauses; these are NPs or PPs, i.e., essentially nominal. Argument types such as propositions would require embedding of clauses. Let us start the discussion from a consideration of a simplified model of reference and communication when a typical argument term is used. The model is depicted in Fig. 2.11. Assume a person P (the eventual producer of an utterance) has seen a tiger and wants to refer to the tiger in an utterance which she addresses to some other person R, the recipient, who speaks the same language. Let us assume that the expression for tigers is phonetically [hu]. Perceiving the tiger, P's cognitive system produces a cognitive representation of the animal. According to the Frame Hypothesis, the representation of this individual tiger is some frame. Whatever the representation of the meaning of the word [hu] in P's mind, it may be a much leaner representation of a tiger than the representation of the individual tiger P saw; the lexical meaning may lack a lot of details of the individual tiger's representation. Wanting to communicate reference to

[33] In this section, 'argument term' is to be understood as also including adjunct terms.

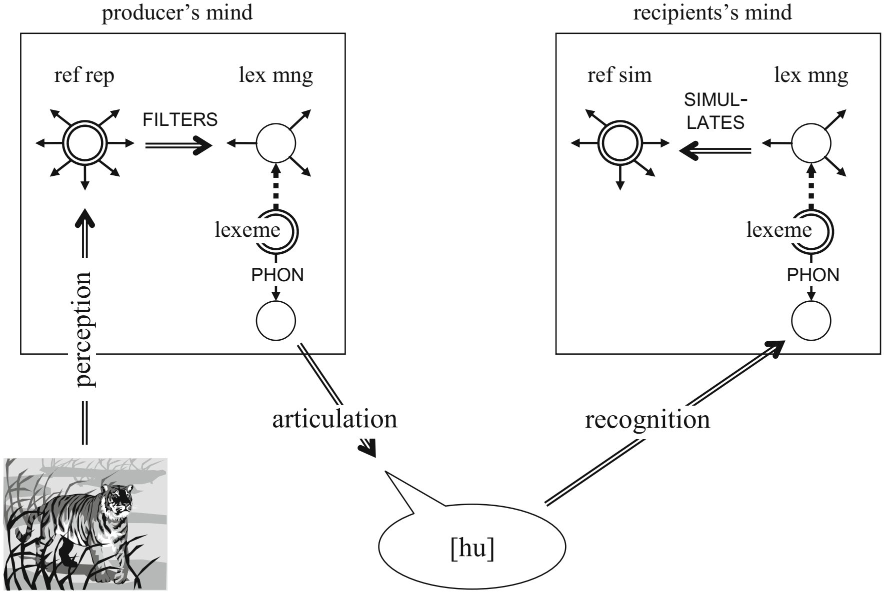

Fig. 2.11 A simplified model of reference and communication (*ref rep* = referent representation, *lex mng* lexical meaning, *ref sim* referent simulation)

that tiger, P will strip the representation of the individual tiger she saw from context-bound details and will search in her mental lexicon for an appropriate entry. An entry will be appropriate if its meaning is compatible with the representation of the tiger she saw and sufficiently specific as to convey enough information. Let us assume that the word [hu] satisfies the communicational needs of P. In Fig. 2.11 the lexical entry is incompletely represented with two attributes, MEANING (indicated by the dotted arc) and PHON[ETIC FORM]. P proceeds from the meaning of the lexical entry to its phonetic form and produces an utterance addressed to R which contains an articulation of the phonetic form [hu]. R, hearing the utterance, recognizes the phonetic form as that of her lexical 'tiger' entry and activates its meaning. The communication is semantically successful, as regards the reference to a tiger, if this is what happens in the mind of R. Based on this meaning and on additional contextual and experiential knowledge, R will construct an individual simulation of a tiger.[34] This is the communicative result of P's utterance. The simulation in R's mind need not match P's original impression. However, what is required to match, at least roughly, are the cognitive representations of the phonetic form [hu] and of its meaning 'tiger'.

[34]Cf. Barsalou (1999) on simulations, Barsalou (2003) on the cognitive interaction of language and simulation.

2.5.2 Meanings of Argument Terms

The most common types of argument terms have no arguments themselves. Therefore, the defining attributes in their meaning frames and the specification of their values remains implicit in verbal communication. (When dealing with, say, transitive verbs we at least know that they have two specific participant attributes.)

In order to secure successful common reference, the meanings of the lexical gestures need to be synchronized in the speech community. There are basically three strategies facilitating shared reference for nominal argument terms:

- **Concrete common nouns**
  Terms with rich meanings where the *exact* match of all meaning components does not matter,
- **Proper names**
  Terms that refer to individual, fixed objects by virtue of some convention in the speech community,
- **Indexicals**
  Terms for which reference in a given context of utterance is fixed by demonstration.

Indexical terms are primarily used for unique (definite) reference to objects which are given with the context of utterance, such as the speech participants, the location where the utterance takes place, objects present at the location, or the time of the utterance and related times. The meanings of indexicals are conceptually lean, for example, ‘the producer of this utterance’ for first person singular pronouns. The conceptual information about the referent in a given context is drawn from contextual, extralinguistic knowledge. Indexicals provide positive evidence for the Frame Hypothesis insofar as their reference can be considered to be based on a frame model of utterances: speaker, addressee, time of utterance, or location of utterance all constitute the values of functional attributes of utterances, in fact case frames in a frame for speaking to someone.

Proper names do not have much conceptual content either. They are used for fixed reference to entities which are established in a wider, permanent context, such as individual persons, animals, geographical landmarks, etc. The lexical meaning of a proper name like *Liz* is a lean concept, approximately, ‘the object with NAME ›Liz‹’.[35] The meaning of a proper name is not to be confused with the general knowledge about the object so named. Proper names, if analyzed in this way, provide evidence for the significance of a NAME attribute in frames for certain types of individual objects.

In the following, we will focus on the strategy of common nouns. Synchronization of the meanings of common nouns takes place in the course of language acquisition as well as in verbal communication in general. The acquisition of the

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[35] See Löbner (2011, Sect. 2.3) for a discussion of the meaning of proper names.

meanings of common nouns is either based on ostension or on verbal explanation. Ostension is by no means deterministic. If I point to a cat and tell a child: "This is a cat," the child has to recognize what it is that my pointing aims to single out. If the child manages to realize that it is the cat which I meant to refer to, it is left with the problem of determining the intended categorization. According to the findings of developmental psychology, several assumptions and predispositions constrain and underlie the successful process of meaning induction from reference (Markman 1989). One such constraint is the preference of 'basic level' categorization[36] which fixes a certain, medium level of concept formation that is tied to human action and behavior. Hypothesizing the basic level of categorization when shown a cat, the child will not categorize it as just an animal, or a furry thing, nor as a particular breed of cats, a cat with exactly this pattern of stripes in its fur, etc. It will categorize it in a way which is specific enough to exclude other animal categories of the same level for which the child already knows the linguistic terms. But even so, the concept which the child is going to assign as a lexical meaning to the phonetic string heard is far from precisely determined.

Further restrictions that will guide the learner are the 'whole object assumption' and the 'taxonomic assumption'. The language learner will assume that the referent of the ostension is the whole object rather than parts or properties of it; and he or she will assume that the word to be learned is a term for objects of a particular *kind* (Markman 1989: Sect. 2). Even given these constraints, much room is left for fixing a lexical meaning. The child may include conceptual elements irrelevant for the lexical meaning or may fail to include relevant meaning elements, in particular such that cannot be derived from mere perception.

The method of verbal explanation is not much more precise. Since language users do not consciously know the content of lexical meanings, they can only give explanations in terms of other unexplained expressions the meanings of which may be known to the learner, more or less accurately. Imprecision of the defining concepts will be inherited by the new concept.

Thus, it is obvious that the tradition of lexical meanings of concrete common nouns is not a process that propagates precise concepts. Consequently, the individual lexical concepts of the members of a speech community will vary to some degree. When people in a speech community have experiential knowledge of, say, tigers and communicate about them using a certain lexical expression, they will have individual notions of tigers on the one hand, and theories of the notion of tigers shared in the language community, on the other. Language users know what they themselves know about tigers and they know which part of their knowledge of tigers can be shared by others. Thus, it will be the concept that language users assume is being used by the others which they themselves will assign as the lexical meaning

[36]The basic level theory goes back to experiments reported in Rosch et al. (1976). See Markman (1989: Sect. 4) for the role of basic level categorization in cognitive development.

to an expression.[37] As long as the members of a speech community have roughly similar theories about the commonly used meaning of the tiger word, reference to tigers will function in that community.

In the course of language development and language evolution, there are factors which will exert pressure towards more precision and more generality of lexical meanings. Language communities may grow, and with them the range and degree of individual variation of lexical meanings. The range of experience will grow, and with it the diversity of samples to be covered by existing lexical terms. Such developments will result in more general meanings for concrete common nouns. The supposed common denominator of lexical meaning will become leaner. In terms of the frame approach to concepts, this means that certain attributes in a lexical frame will receive more general value specifications or will be dropped altogether. By this process, lexical meanings will gradually approximate the bare logical minimum. For example, a child will form a concept for the denotation of the word 'bird' on the basis of encounters with exemplar birds, with pictures of birds, etc. This will result in a concept which ascribes birds certain attributes such as having wings, being able to fly, and maybe further attributes which are accidentally shared by the exemplars she happens to encounter. Later, she will learn that there is a broader variety of birds, in terms of color, size, shape, and behavior. She will remove certain restrictions from her bird frame. Eventually she will have to cope with the fact that there are also atypical birds such as penguins or ostriches. At some stage, there will remain a hard core of necessary attribute-value information and constraints in the ultimate educated adult bird frame.[38]

Another process of language change is the growth and differentiation of the lexicon. A growing number of terms will evolve that are more specific than basic level terms. While basic level concepts differ in a large number of attributes, their subordinates are differentiated by only few additional semantic conditions. For example, 'dog' is a basic level concept comprising a great number of properties that distinguish dogs from the members of other basic level animal categories. The subordinate 'bitch', however, only adds a sex specification, while 'Golden Retriever' would add a handful of other conditions.

The growth of the lexicon and the growth of speech communities, as well as other factors like language contact will eventually lead to the necessity of negotiating meanings more precisely. This can be done implicitly, for example, by way of communicating reference. But eventually it will become necessary to be able to

[37]Therefore, lexical meaning is based on a generalized theory of mind (see Carruthers and Smith 1996) about the mental lexicons of the other members of the speech community.

[38]Two questions will not be discussed in this connection. The first concerns the relation between world knowledge frames and lexical meaning frames. I have argued elsewhere (Löbner 2013: Sect. 11.6) that lexical meaning frames are necessarily leaner than world knowledge frames; for a recent review see Kelter & Kaup (2012), in particular Sect. 6. The second question concerns the relationship of prototypes to world knowledge frames on the one hand and lexical meaning frames on the other; see Barsalou (1992b, pp. 47–50) on world knowledge frames and prototypes, and Löbner (2013: Sect. 11.5) on lexical meanings and prototypes.

communicate about meaning components. If the Frame Hypothesis is correct, these components are attributes. Consequently, what a speech community may develop sooner or later is attribute vocabulary: terms for attributes and terms for the values which attributes take.

Terms for attributes are functional nouns: nouns that are relational (attributes are attributes *of* something) and inherently unique (attributes are functional).[39] This combination is nothing to be expected in an early stage vocabulary. Likely types of argument terms such as common nouns or proper names are not relational. Proper names and indexicals are inherently unique, but this alone does not make up the sort of expression needed for denoting attributes. In what follows, we will first take a look at different semantic types of attribute terms (Sect. 2.5.3) and then discuss developments in which attributes in lexical meanings may get eventually isolated and later named and lexicalized (Sects. 2.5.4 and 2.5.5).

The discussion in this subsection has been mixing observations from language acquisition with aspects of language evolution. It may be assumed that both processes follow similar lines. Children learn concrete nouns, proper names, and somewhat later indexical expressions earlier than more general and abstract vocabulary, in particular abstract attribute vocabulary. For example, they will learn color terms earlier than they will learn the term ‘color’. Analogously, languages acquire more general and abstract vocabulary only later in their history. This can be clearly seen from the fact that such vocabulary very often is recruited derivationally from existing vocabulary or borrowed from other languages. Just take a glimpse at abstract attribute terms in English:

(10) a. Native root terms: *name*, *shape*, *speed*
b. Native derivatives: *length*, *height*, *breadth*, *width*, *depth*, *meaning*, *weight*
c. Nonnative terms: *color*, *form*, *size*, *quality*, *quantity*, *temperature*, *price*, *sex*, *age*

It is very hard to find any native root terms at all in English. *Name* appears to be the only genuine original one. The terms s*hape* and *speed* underwent a series of semantic shifts before they took on the modern attribute meanings.

There appear to be languages which lack abstract attribute vocabulary almost completely (e.g., Lakhota, according to Van Valin, p.c.). Even in European languages, the evolution of abstract attribute vocabulary apparently has taken place only in modern times.[40]

[39] See Löbner (2011: Sect. 2) for extensive discussion of types of nouns, Löbner (1998, p. 5; 2012, Sect. 4.2) for the connection between functional nouns and frames.

[40] For example, Middle High German of about 1,200 seems to widely lack abstract functional concepts with inanimate possessors, such as ‘value’, ‘size’, or ‘quality’. The 100,000 word poem ‘Tristan’ by Gottfried von Strassburg from around 1200 does not contain a single such noun (personal reading).

The direction of conceptual development is therefore one from structurally complex concepts to simpler ones. This is not as paradoxical as it might seem.[41] Concept formation, including the formation of concrete lexical concepts, is based on perceptual representations (Barsalou 1999). Perception yields very complex representations which are connected with other complex faculties of human cognition such as agency and emotions. Thus, one major type of cognitive achievement is the reduction of the complexity of representations.

2.5.3 Types of Attributes and Attribute Terms

Attributes in Barsalou frames can be distinguished in terms of the types of values they take.[42] Major attribute types are the following:

M Mereological attributes for constitutive parts of the referent, e.g., body parts: HEAD, BODY.

R Role attributes for correlates of the referent, e.g., kin attributes such as MOTHER, HUSBAND, or attributes such as BOSS, OWNER, SUCCESSOR, etc.

D Abstract dimensional attributes such as SHAPE, SIZE, COLOR, TEMPERATURE, WEIGHT, MEANING, FUNCTION, or NAME.

The frames used in Sects. 2.3 and 2.4 illustrate all three kinds of attributes: attributes such as VP in constituent frames are of type M; attributes in dependency frames are of type R; the meaning attribute and attributes for grammatical features are of type D.

Type M attributes in mereological frames of concrete objects have concrete objects as their possessor and take concrete, though not independent, objects as values. The relationship between the possessor and the values of its mereological attributes is bidirectionally one-to-one: a given part can belong to only one whole (notwithstanding transitivity of the belong-to relation), and due to UA a given whole has a given part only once. For concrete objects, at least the external parts can be referred to by ostension. However, their categorization is dispreferred due to the whole-object constraint. The latter corresponds to the cognitive problem that categorization requires cues for individuating the part within the whole, singling it out in order to establish a certain degree of relatively independent existence.

Type R attributes in everyday life also take concrete values. For example, the value of the attribute MOTHER is a concrete person. Unlike mereological attributes, role attributes are not bidirectionally one-to-one (e.g., different persons can have the same mother, but not the same womb). However, although the values of role attributes, i.e., the occupants of the roles, are concrete and of independent existence,

[41] Cf. Werning's notion, and discussion, of what he terms the "complex first paradox" (Werning 2010).

[42] For basic ontological distinctions of types of attributes, see Guarino (1992).

it is impossible to illustrate the meaning of a role term by just pointing to an instance. The notion of ‘mother’ can only be grasped if some abstract causal or social relation is recognized. The taxonomic assumption mentioned above is a barrier to this type of categorization, since it leads to the induction of a sortal rather than a relational concept.

Type D attributes, or ‘D-attributes’ for short, have abstract reference. They take values, but the values do not exist independently of the possessors. Different possessors can have equal values for the same D-attribute, e.g. they may be the same size, color, price, or age. Obviously, ostension without further explanation cannot be used for teaching the meaning of a D-attribute term. If I point to a ball, saying “this is red,” it is by no means evident that I refer to the color of the ball rather than to its shape, temperature, or weight. Grasping the meaning of a term for a D-attribute or its value requires the isolation of this aspect of categorization, i.e., abstraction from all other attributes which the possessor may exhibit.

Thus, it is increasingly challenging to establish reference and meaning of attribute terms for M, R, and D type attributes, respectively. This is in accordance with the data from language acquisition as well as historical lexicology. As to D-attribute terms, in particular D-attribute nouns, the question arises as to how they emerge at all. Using nouns such as *weight*, *temperature*, or *shape* as referential terms and as argument terms for verbs is far away from the prototypical use of nouns and verbs. In the next subsection I will outline possible steps in the lexical and semantic emergence of D-attribute nouns.

2.5.4 Semantic Isolation of Abstract Attributes

2.5.4.1 Step I: Gross Attribute Isolation

Suppose the nominal lexicon is restricted to concrete sortal nouns (disregarding proper names or indexicals, which do not matter in this connection). A first step of cognitively getting hold of a certain D-attribute might involve establishing pairs of lexical opposites which differ with respect to the value of this attribute. Probably all languages will have different nouns for females and males, such as Japanese *otoko* (‘male, man’) vs. *onna* (‘female, woman’), and maybe not all, but many, may have different terms for adults and children, like Japanese *otona* (‘adult’) vs. *kodomo* (‘child’). Having different terms for females and males, does not necessarily mean that the D-attribute SEX is semantically isolated. There are many concomitant differences between males and females. Therefore the distinction will first be conceived of as relating to a bundle of attributes. The bundle may be eventually reduced to a considerably smaller number of attributes, if and when the distinction is extended to other domains, e.g., by establishing opposing terms for male and female animals. Analogous considerations apply to the adult vs. child opposition. If a language has several pairs of opposites for female vs. male or child vs. adult, it can be considered to have some semantic grasp of the underlying attributes SEX and DEVELOPMENTAL STAGE, but this grasp is not necessarily very precise. The respective attributes may still be bundled with others.

2.5.4.2 Step II: Value Specification for an Implicit Attribute

In a second step of lexical evolution, expressions might arise for the values that certain D-attributes take. Still, there may be no term for the attribute itself. For any D-attribute there is a whole range of possible values. Therefore, if terms for the values of a certain D-attribute arise, they will not denote the whole range of possible values, but rather certain marked cases. Very often, this will result in lexical fields of two or more terms for the same dimension. Examples are systems of color terms, systems of numerals, quality terms (e.g., for 'good' and 'bad'), size terms, or terms for other D-attributes such as *long/short*, *heavy/light*, *fast/slow*, *high/low,* etc. In his comparative study, Dixon (1977) investigated which terms for properties and dimension values actually do occur as adjectives or other parts of speech in a sample of 17 unrelated languages. Focusing on adjectives, he states that there are many languages with a small closed class of adjectives, from 8 (Igbo, Niger-Congo), 12 (Hausa, Chadic), up to several hundred in Japanese. Adjectives, it appears, are a word class denoting prototypically values of certain attributes. "The AGE, DIMENSION, VALUE, and COLOUR types are likely to belong to the adjective class, however small it is."[43] Such adjectives relate to a single attribute, but the relation is implicit. They do not (yet) serve to denote the attribute as such. The attribute may be implicitly specified with more or less precision. Adjectives for 'good' and 'bad' are very vague with respect to the criterion of evaluation. 'Big' and 'small' may apply to more than one spatial dimension of physical objects. As to color terms, cases are reported where the 'color' term also includes other dimensions such as being glossy or wet.[44] But as a tendency, the degree of conceptual isolation of the underlying attribute is much higher than with opposing common nouns.

2.5.4.3 Step III: Grasping the Range of an Isolated Attribute

The third step will for the first time provide expressions that relate to a dimension as such. In a preparatory stage, a language will have pairs of antonyms relating to the

[43] Dixon (1977, p. 36). The types AGE and COLOUR are obviously related to the respective D-attributes. The type DIMENSION is defined as comprising, for English, the adjectives "*big*, *large*; *little*, *small*; *long*, *short*; *wide*, *narrow*; *thick*, *fat*, *thin*, and just a few more items" (p. 31). These, too, directly relate to specific D-attributes. VALUE adjectives correspond to the D-attributes WORTH, VALUE, QUALITY and include "*good, bad* and a few more items [. . .]" (p. 31).

[44] See the discussion in Levinson (2001).

same dimension such as expressions for ‘big’ and ‘small’ or for ‘good’ and ‘bad’.[45] Pairs of antonyms not only relate to the same dimension, but by denoting two opposite extremes on a scale of possible values, they jointly define the dimension as such by spanning a large range of possible values.[46] The members of such pairs of opposition typically divide the scale in a vague and context-dependent way. As a natural consequence, languages will evolve constructions for comparative predications, such as ‘x is bigger than y’.[47,48] In a comparative construction, the gradable adjectives are stripped of any fixation of the value on the scale. A statement expressing ‘x is bigger than y’ by using a predicative term for being big, may be true independently of whether x is big or small taken for its own. This use of the term ‘big’ is applicable throughout the whole scale. The same holds for other constructions such as superlative or equative. A further important construction of this type is questions of the type ‘how big is x’.

Although in these constructions the predicative expression such as ‘big’ relates to the whole range of possible values of an attribute, it cannot be used as a term for referring to the attribute as such. This requires a noun that denotes the D-attribute.

2.5.4.4 Step IV: Functional Nouns for the Attribute as Such

Functional nouns for D-attributes appear to emerge very late. In German and other languages, numerous D-attribute nouns are derived from adjectives, thus indicating that steps II and III are the historical basis of the development (cf. (10b) for English). There are hardly any historically genuine D-attribute terms. One rare exception is functional nouns for the attribute NAME. Apparently the isolation of the abstract attribute NAME was necessary for metalinguistic communication. A look into the etymology of other abstract functional concepts reveals that they are semantically and/or morphologically derived. For example, the meaning of German *Farbe* (‘color’) derives from the meaning ‘paint’ (which *Farbe* still possesses along

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[45] According to Dixon, even very small adjective repertories contain pairs of antonyms. For example, the eight adjectives in Igbo mean ‘large’, ‘small’, ‘new’, ‘old’, ‘black/dark’, ‘white/light’, ‘good’, and ‘bad’ (Dixon 177: 20f).

[46] The discussion will focus on scalar dimensions from now on. Similar considerations apply to terms for values of nonscalar dimensions. For example, the research into color terms (cf. Berlin and Kay 1969 and subsequent work) shows that most languages do not just have isolated color terms, but always systems of color terms that more or less cover the whole space of visible colors.

[47] Bierwisch (1987: 150ff/1989: 123ff), following Sapir (1944: 93f), argues that even the positive use of dimensional adjectives is essentially a comparative. I do not endorse this analysis (Löbner 1990: Ch. 8), but argue similarly that predication with dimensional adjectives involves the comparison of higher with lower degrees on a scale.

[48] Comparative constructions may be grammaticalized to varying degrees. For example, a language might express ‘x is bigger than y’ by two sentences ‘x is big, y is small’ or ‘y is not big, x is big’ (Stassen 1985: 44f). The latter variant shows that all it takes to cognitively span the underlying scale is negation of a scalar adjective.

Table 2.1 Patterns of emergence of abstract attribute terms

	Specific value predicate term		Property term	Value question predication	Attribute term
English	*big*		*bigness*	*how big*	*size*
German	*groß*		*Größe*	*wie groß*	*Größe*
	‘big’		‘bigness’	‘how big’	‘size’
Dutch	*veel*		[*veelheid*]	*hoe veel*	*hoeveelheid*
	‘much’		‘muchhood’	‘how much’	‘howmuchhood’
Chinese	長	短			長 短
	cháng	*duǎn*			*chángduǎn*
	‘long’	‘short’			‘longshort’

with the abstract meaning). The word *temperature* and its parallels in French, German and other languages acquired the present meaning only in modern times. Its original meaning was the same as that of *temperament*: ‘mixture’.

Deadjectival D-attribute terms exhibit crosslinguistic patterns that provide insight into their evolution (Table 2.1). De-adjectival nouns often start out with a meaning denoting the property of being “ADJ”, i.e., the property of x if ‘x is ADJ’ is true. As a rule, for the negative members of antonymy pairs (i.e., *small* out of *big* vs. *small*), the derived noun only has this interpretation (Bierwisch1987, p. 110). In this reading, de-adjectival nouns are not attribute terms. Only readings that can be roughly paraphrased with an interrogative clause ‘how ADJ x is’ can be used as terms for the attribute as such. The Dutch term *hoeveelheid* ‘how-much-hood’ is interesting in deriving directly from the question construction. The example shows that the cognitive derivation of the attribute term from this type of question is at least plausible enough to be accepted as a lexicalized derivation.[49]

If a noun is available that denotes an abstract attribute as such, it can be used for predications relating to changes of its value or to the determination of it:

(11) a. *The temperature of the cooling water* is rising
b. *They are not able to* determine *the temperature of the cooling water*

Constructions like these require an adaptation of verb vocabulary or of verb constructions. For example, the intensional use of *rise* in (11a) requires a metaphor, and the predication in (11b) involves a ‘concealed question’ interpretation of the object NP.[50]

In addition to nouns denoting D-attributes, there is a second option for neutral reference to a D-attribute, namely static dimensional (or attribute) verbs. Instead of

[49]The pattern displayed in *hoeveelheid* is not productive in Dutch. There is only one parallel: *hoedanigheid* (‘quality’, lit. ‘how-done-ness’). Probably both are loan translations of Latin *quantitas* and *qualitas*, respectively. *Quantitas* is a noun derived from an interrogative adjective *quantus* ‘how much’; *qualitas* is the same type of derivation from the interrogative adjective *qualis* ‘of what kind’.

[50]See Löbner 1979: Ch. 3, 2012: Sect. 3.4, for a discussion of the relevant constructions.

using the attribute noun *price* for specifying the price of something in (12a), one could use the stative verb *cost* (12b).

(12) a. D-attribute noun: *the* price *of the car is 499 Euro*
b. D-attribute verb: *the car* costs *499 Euro*

The functional potential provided by a stative D-attribute verb is, however, much more restricted than that of a corresponding noun. With a stative D-attribute verb, only one type of predication about the attribute becomes available: the specification of its value for a particular object. By contrast, a D-attribute noun opens up the possibility of using it as an argument term for a wide range of predications by verbs. Predications such as those in (11) cannot be equivalently expressed by using a stative D-attribute verb. This is probably the reason why this class of verbs is much less frequent than D-attribute nouns.

2.5.5 Lexical Tinkering with Abstract Attribute Vocabulary

There are two remarkable observations concerning the emergence of abstract attribute vocabulary. The first is that abstract vocabulary comes about at all, against all odds of learnability and grammar. It is far more difficult to teach and acquire attribute vocabulary than concrete common nouns. A look at functional nouns and the constructions they occur in shows that they constitute a special and marked type of nouns. Their lexical recruitment requires several steps of derivation, and even when they are available, an appropriate repertory of verbs and constructions needs to be developed.

The second observation is that there is a remarkable lack of systematic patterns of word formation in the course of the development lined out above. There are, of course, systematic means of forming pairs of expressions in sex opposition or deriving antonyms from given adjectives by adding negative affixes like *un-important*, *in-efficient*, *a-modal*. However, the core cases which represent the original stages are characterized by morphologically unrelated pairs such as *girl* vs. *boy*, *big* vs. *small*, *size* vs. *big*, etc.[51] This appears to indicate that the respective vocabulary was either semantically adjusted to yield the oppositions or, in other cases, recruited from wherever something grossly appropriate was available or derivable. Borrowing a term from evolution theory, the evolution of abstract attribute vocabulary is a case of heavy ‘evolutionary tinkering’[52] – innovative use of various *given* material for meeting novel purposes. For an illustration of the point, consider the vocabulary for

[51] See also the antonym pairs for six languages in Dixon (1977, pp. 21–23); there is not a single pair of antonyms which are morphologically related.

[52] The notion goes back to the seminal article Jacob (1977).

dealing with the attribute PRICE in German; the emerging picture in other languages would be very similar. At least four different, and originally unrelated word stems are immediately semantically related to this D-attribute in (13).

(13)	Stem	Meaning	History
	teuer$_{\text{A}}$	‘expensive’	Cognate of English *dear*; original meaning: ‘dear’, ‘precious’
	billig$_{\text{A}}$	‘cheap’	Original meaning: ‘adequate’, ‘appropriate’
	kosten$_{\text{V}}$	‘cost’	Loan from middle French *couster*, *coster* (now *coûter*), from Latin *constare* ‘cost’
	Preis$_{\text{N}}$	‘price’	Loan from middle French *prise*, from Latin *pretium* ‘price, value, money’; compare English *price*, *prize*, *praise*, *precious* of the same origin

The adjectives relating to the attribute PRICE are originally not only morphologically unrelated, but also semantically not attuned to each other. The original meaning of *teuer* is more generally ‘of high value’. The meaning ‘expensive’ is the result of a restriction to the commercial value of goods. The antonym *billig* originally means ‘acceptable’, ‘appropriate’, ‘adequate’; the meaning ‘cheap’ results from a metonymy which transfers the property of being an appropriate price to the possessor, resulting in the property of being *of* an appropriate price. Later on, *billig* acquired a derived meaning ‘of low quality, worthless’ (as did *cheap* in a parallel development). In order to avoid this interpretation, *billig* is nowadays often replaced by the more recent expression *preiswert* (lit. ‘worth its price’, from *Preis* ‘price’ and *wert*$_{\text{A}}$ ‘worth’) which now functions as an antonym of ‘expensive’. Note that the original meaning of *billig* ‘adequate (in price)’ displays the same kind of concept. The verb *kosten* was borrowed from French *coster*, now *coûter*, as late as in medieval times (Grimm). The original meaning and use was more concrete: the construction was [þx_{NOM} *kost-* y_{ACC} z_{ACC}ÿ], where x is the thing to be paid, y is the payer and z the price (e.g., *der Urlaub kostet mich 2000 Euro*, lit. ‘the vacation costs me 2000 euros’). This alternant of the verb is less stative and less abstract. Finally, the functional noun *Preis* is another loan from medieval French. Along with the D-attribute meaning ‘price’ it carries the meaning ‘prize’ or ‘premium’ as well as ‘praise$_{\text{N}}$’ (obsolete); the derived verb *preis-en* ‘praise’ with the same stem is only related to the meaning ‘praise’.

The example shows how vocabulary eventually falls in place in the conceptual paradigm of abstract attributes: antonymous adjectives for high and low values on the scale, a functional noun for the attribute as such and a stative dimensional verb for predications about the value the attribute takes. All this, however, is only the result of a long and complex historical process.

Both observations, the fact that D-attribute vocabulary exists at all, and the massive lexical tinkering in the respective vocabulary, show that there must be some driving force behind the development. The cognitive structure in terms of frame attributes is first; the emergence of frame vocabulary results from an a posteriori convergence of cognitive structure and the vocabulary of the languages we use.

2.6 Conclusion

The review of the grammatical structure and meanings of linguistic gestures offers positive evidence for the assumption that cognitive representations of linguistic gestures exhibit the essential structural properties of Barsalou frames described in Sect. 2.2. For the part of language as a subsystem of human cognition, this provides evidence for the Frame Hypothesis: there is a uniform structure of representations in human cognition, and this structure is essentially Barsalou frames.

This corroboration of the Frame Hypothesis opens important perspectives, for linguistics, for cognitive psychology, and for the relationship between both.

Applied to linguistics, the Frame Hypothesis entails that there is a uniform structure of representations for all levels of linguistic description, including phonetics, phonology, morphology, syntax, semantics, and pragmatics. At present, the respective subdisciplines of linguistics all apply representations of different structures. There are only few approaches, among them HPSG, which try to apply a uniform format of representation to syntax, semantics, morphology, and phonology. Not accidentally, it appears, HPSG uses framelike representations. Tree representations are used in many linguistic theories for representing the composition of complex linguistic gestures not only in syntax, but also in morphology and phonology. As was demonstrated in Sect. 2.3.1, such trees are essentially mereological frames. Classical structuralism introduced features for the distinction of sounds, parts of speech, and meanings. Feature sets are not frames (see the discussion in Barsalou and Hale 1993), but features can be considered specifying the value of an implicit attribute. For example, the feature +[FEMALE] implicitly relates to the attribute SEX, or the phonetic feature [–VOICE] to the attribute VOICING.

The assumption that the same structure underlies cognitive representations of linguistic gestures at all levels of description would provide a very strong constraint on linguistic theory. Such a constraint would be extremely productive and innovative, since the subdisciplines of linguistics would have a reason and a common perspective for cooperating to a degree never envisaged before. Applied to linguistic theory, the Frame Hypothesis first of all means that syntax, semantics, morphology, and phonology are not separate modules of the language faculty, at least not in terms of the structure of representations they use. This is not to deny that each level has a *certain* degree of autonomy, resulting from its particular constraints and its connection to other cognitive faculties. For example, syntax is bound to produce linear structures of phonetic strings, phonology is grounded in phonetic articulation and auditory perception, semantics is connected with cognitive faculties such as perception, categorization, reasoning, and memory.

For cognitive psychology, the recognition of the fact that the cognitive representations of form and meaning of linguistic gestures instantiate the general format of representations in human cognition could lead to a much more intensive consideration of the findings of linguistic analysis. No area of cognition has received such an amount of scientific attention and understanding as language has in more than 2,000 years of theories on the structure of language(s). If there is a uniform structure of human cognitive representations of linguistic gestures, cognitive psychology can learn about the structure of cognitive representations, their potential and their constraints, from linguistic research into grammar(s) and meaning.

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Chapter 3
From Features via Frames to Spaces: Modeling Scientific Conceptual Change Without Incommensurability or Aprioricity

Frank Zenker

Abstract The (dynamic) frame model, originating in artificial intelligence and cognitive psychology, has recently been applied to change-phenomena traditionally studied within history and philosophy of science. Its application purpose is to account for episodes of conceptual dynamics in the empirical sciences (allegedly) suggestive of incommensurability as evidenced by "ruptures" in the symbolic forms of historically successive empirical theories with similar classes of applications. This article reviews the frame model and traces its development from the feature list model. Drawing on extant literature, examples of frame-reconstructed taxonomic change are presented. This occurs for purposes of comparison with an alternative tool, conceptual spaces. The main claim is that conceptual spaces save the merits of the frame model and provide a powerful model for conceptual change in scientific knowledge, since distinctions arising in measurement theory are native to the model. It is suggested how incommensurability as incomparability of theoretical frameworks might be avoided (thus coming *on par* with a key-result of applying frames). Moreover, as non(inter-)translatability of world-views, it need not to be treated as a genuine problem of conceptual representation. The status of laws *vis à vis* their dimensional bases as well as diachronic similarity measures are (inconclusively) discussed.

Keywords Dimension • Measurement • Natural law • Scientific change • Symbolic representation

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3.1 Introduction

Starting with Minsky (1975) and more widely recognized since Barsalou's (1992) work, (dynamic) *frames* are a rather well-accepted tool for modeling conceptual knowledge. Beginning with the predecessor model, the *feature list* (Sect. 3.2), we trace its development into the (dynamic) frame model (Sect. 3.2.1) by summarizing frame-reconstructed episodes of taxonomic change (Sect. 3.2.2) as paradigmatic examples of recent application within history and philosophy of science (Sect. 3.3) addressing the 'incommensurability of frameworks/world-views' from a cognitive historical perspective (Sect. 3.3.1). We hold that a frame is a sophisticated feature list, serving to support the claim that historically successive taxonomies are comparable, but criticize that the frame model seems to yield little insight beyond taxonomic change. Introducing *conceptual spaces* as an alternative model (Sect. 3.4), dimensions (Sect. 3.4.1), their combinations (Sect. 3.4.2), how to recover frames (Sect. 3.5) by analogue expressions (Sect. 3.5.1), the notion of 'similarity as geometric distance' across diachronically varying spaces (Sect. 3.5.2) and the status of scientific laws (Sect. 3.6) are discussed.

3.2 Feature Lists

Its origins in Aristotelian philosophy (Taylor 2003), the feature list model may count as the most entrenched and, at the same time, the most outdated tool for reconstructing conceptual knowledge. Paradigmatically instantiated by taxonomic knowledge (e.g. in biology), Kuukkanen usefully summarizes the classical view by three assumptions:

> (1) [T]he representation of a concept is a summary description of an entire class of instances that fall under it; (2) the features that represent a concept are singly necessary and jointly sufficient to define that concept; and (3) features are nested in subset relations, i.e. if a concept C is a subset of concept Y, the defining features of Y are nested in those of C. For this reason, features are sometimes referred to as defining or essential. (Kuukkanen 2006, p. 88)

On the classical view, combinations of binary features (or attributes) define a thing which falls under (or instantiates) a concept, *if and only if* the features are present in (or true of) the thing. Features are rendered in natural language, normally by nouns or adjectives. As a classical example: MAN may be analyzed as [+ biped, + rational, + animal]. As a discrimination issue, problems arise upon observing that a Para-Olympic athlete may fail to instantiate MAN—which is somewhat absurd. However, short of throwing individually necessary and jointly sufficient features over board, the problem is not easily remedied.

The model's distinct merit is found in worlds cut along patterns generated by features. The choice of features may always be viewed as a matter of convention, particular conventions as contingent upon contexts. For instance, to categorize *champagne*, *vodka*, *fruit juice* and *soda water*, why not borrow from chemistry and use: [+/−C_6] alcohol, [+/−CO_2] carbon-dioxide.

Barsalou and Hale (1993) demonstrate that, as representations of conceptual knowledge, feature lists contain rich relational information, primarily with respect to *truth* (attributes count as true or false of a thing). Secondly, whatever a feature names, if true of the thing, will name one of its *aspects*. Thirdly, as set-members, a concept's defining features obey the logical relation of *conjunction*, just as several concepts obey *exclusive disjunction*. Fourthly, *contingent* relational information may be read off the feature list, allowing strict or probabilistic predictions, e.g., "Consumers of items in the + C6 category (likely) need a designated driver." Finally, nesting of concepts accounts for the *analytic* character of "A bachelor is a man," because BACHELOR, when analyzed as [+ man], [− married], is subordinate to MAN.

Exemplar and (weighed) prototype models are mathematical refinements of the feature list model, seeking to remedy the absurdity of the Para-Olympic example, above. At least in part, they are also motivated by empirical investigation into human categorization (Labov 1973; Rosch et al. 1976), strongly suggesting that we do not, invariably across contexts, categorize via necessary and sufficient features. Whether all models operate at the *symbolic* level, i.e., presuppose an explicit language, may be debated. At any rate, refined models "remain grounded" in feature lists, but abandon the strictness by which (possibly weighed) presence projects into category-membership. Thus, in principle, considerations of similarity (rather than identity) may govern concept boundaries (see Barsalou and Hale 1993, pp. 103–124).

> [A] few principled components underlie the feature list representation across a wide variety of categorization models. All of these representations use binary features, with some allowing continuous values under a binary interpretation. Relationally, all of these representations integrate features with various relations, including 'aspect', 'truth', 'and', 'or', 'compensates', 'implies', and 'predicts'. All of the feature list representations that we have considered are built up from this small set of components. (Barsalou and Hale 1993, p. 123)

The above-cited relations give rise to the *frame-account of concepts* which will be introduced below. Generally, one may say that the frame-model also qualifies as an *extension* of the traditional feature list. This extension is reached by allowing non-binary features (e.g., large, medium, small) and relations of constraint and invariance.

3.2.1 From Feature Lists to Simple and Recursive Frames

In support of the claim that a frame model is a sophisticated extension of a feature lists, consider that, when (i) suspending the additional functions introduced by frames and (ii) constraining attribute-values to binary options, the frame model *collapses* into the feature list model, rather than some model analogous to feature lists. This should become clear when appreciating that, step-wise, frames may be generated from feature lists.

The first step beyond feature lists requires understanding a feature as the *value* of some *attribute*. For example, [+ blue], [+ green] are values of the attribute ‘color’ and [+ long], [+ round] are values of the attribute ‘shape’. The additional structure (over that of feature lists) consists in a *set* of values being used to define an attribute. The second step is taken by minding that the values of a particular attribute may be non-binary. Thus, an additional relation (which a feature list model does not allow to represent) is that between an attribute and its value(s), called the ‘type’-relation (informally: the ‘is-a relation’), e.g., ‘square’ is a type of shape, ‘blue’ is a color, etc. The third step is to understand attributes as exhibiting *structural invariants* which “specify relations between attributes that *do not vary often* across instances of a concept” (Barsalou and Hale 1993, p. 125, italics added), while *constraints* form relations between attribute values “which instead *vary widely* across the instances of a concept” (ibid. 125, italics added). In sum, we reach the notion of a *simple frame*, defined as “a co-occurring set of multi-valued attributes that are integrated by structural invariants” (ibid. 126).

Constraints hold across values and “produce systematic variability in attribute values” (Barsalou 1992, p. 37), e.g., a comparatively massive person (relative to height) will likely not be skinny. Together with invariants, constraints generate structure for the purpose of representing a concept(−instance)—giving rise to the notion ‘frame-pattern’—and play an important role in reconstructing scientific conceptual change (see Sect. 3.5.1).

The advantage of frames over feature lists is that “the addition of ‘attribute-value relations’ and ‘structural invariants’ increases their expressiveness substantially” (ibid. 127), because we are provided with means by which to model both stable and variable relations across attributes and values. One may then regard the representation of a concept to proceed *primarily* via structural invariants and constraints. Structural invariants tell you which attributes (are likely to) “collect” or “bind” into a concept, constrained values identify concept instances.

In a final step, by recursion, one allows the components used in conceptual representation (*attributes*, *values*, *structural invariants* and *constraints*) to be represented not by words, but by frames. “[T]his recursive process can continue indefinitely, with the components of these more specific frames being represented in turn by frames themselves” (ibid. 133). Where conceptual knowledge includes not just things, but also relations (e.g., ‘is a part of’ or ‘requires’), again, frames are employed recursively. Generally, “[a]t any level of analysis, for any frame component, there is always the potential to note new variability across exemplars of the component and capture it in a still more specific frame” (ibid. 134). Thus, there is no principled limit to finding new attributes, “simply by noting variance across the component’s exemplars and representing this variance with a new attribute-value structure” (ibid. 133f.).

Which attributes to include in a frame will normally be a result of querying subjects. It is assumed that the choice of attributes is always influenced by “goals, experience and intuitive theories” (Barsalou 1992, p. 34). Hence, the examples of frame-representations discussed in the literature count as *partial* representations. This also holds for event frames (aka. *scripts*), which are sequential adaptations

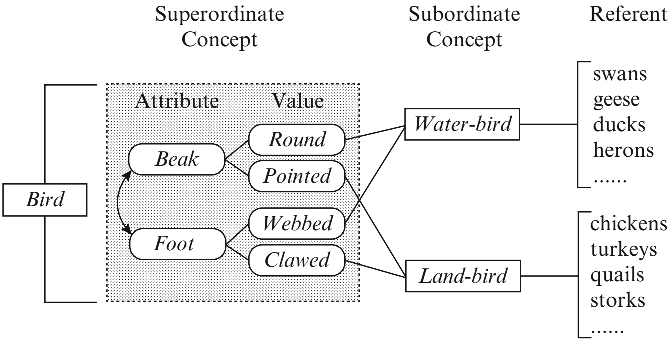

Fig. 3.1 Partial frame for Ray's (1678) concept of bird (Chen 2002)

of the object-frames discussed here. In the scientific case, the identification of attributes, values, etc. will be based on the (historical) material under study.

3.2.2 Motivated Conceptual Change

To appreciate the frame model, a simple example may be helpful. Based on Chen (2002), it comes from ornithology, does without iteration, and employs binary features.

> In the late 18th century, ornithologists discovered a strange creature from South America by the common name of 'screamer' ... . A peculiar feature of screamers is that they have webbed feet like ducks but a pointed beak like chickens. The combination of these two features, which were supposed to be incompatible according to the Ray taxonomy, caused confusion. The constraint between *foot* and *beak* in the Ray taxonomy required that these two attributes be used together in classification. Thus, the discovery of screamers immediately generated problems, because ornithologists did not know how screamers should be classified according to the cluster of *foot* and *beak*. Eventually, this anomaly forced them to alter the frame of *bird* and the associated taxonomy, because it made a very important constraint relation between *foot* and *beak* invalid. (Chen 2002, p. 7)

The diagrams below are partial frame representations of the earlier taxonomy by Ray (1678) in Fig. 3.1 and of the revised taxonomy by Sundevall (1889) in Fig. 3.2. Ray uses the attributes *beak* (values: round or pointed) and *foot* (webbed or clawed), connected by a structural invariant (double-headed arrow), to distinguish WATER and LAND-BIRD (Chen 2002, p. 5).[1]

[1]"In the Ray taxonomy, for example, the attributes *beak* and *foot* are not independent. There are correlations between the value of *beak* and that of *foot*: webbed feet are usually associated with a round beak, and clawed feet with a pointed beak. These are physical constraints imposed by nature: webbed feet and round beaks are adapted to the environment in which water-birds live, but clawed feet and pointed beaks would be a hindrance in water. Because of these constraint relations, the attributes *beak* and *foot* must be used together as a cluster in classification" (Chen 2002, p. 6).

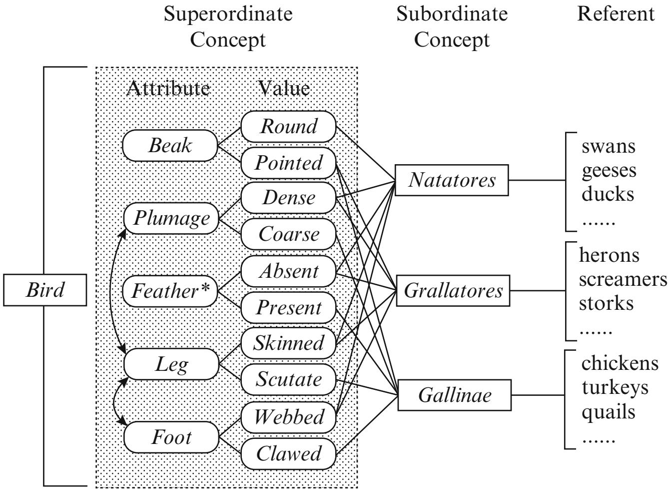

Fig. 3.2 Partial frame for Sundevall's (1889) concept of bird (Chen 2002)

Here, constraints are thought to be *imposed by* structural invariants, functioning as follows:

> [D]ue to the constraints between the value sets, some (. . .) property combinations are conceptually impossible, such as *round beak* with *clawed foot* and *point beak* with *webbed foot*. The results are only two property combinations (*round beak* with *webbed foot* and *pointed beak* with *clawed foot*), which form two subordinate concepts—*water-bird* and *land-bird*. In this way, the frame specifies the contrastive relations between the two subordinate concepts. (Chen 2002, p. 6)

Compare Fig. 3.1, then, with Sundevall's taxonomy (Fig. 3.2).

The transition between the representations in Figs. 3.1 and 3.2 amounts to a redefinition of the concept BIRD. To a frame-theorist, the point of this example is that it allows reconstructing change to a scientific taxonomy as a *motivated revision*.

> Sundevall's *bird* no longer entails a constraint relation between *beak* and *foot*; instead, new constraint relations are formed between *foot* and *plumage*, as well as between *foot* and *leg covering*. [T]hese are physical constraints imposed by nature, resulting from the adaptation to the environment. The new superordinate concept inevitably alters the taxonomy by expanding the conceptual field at the subordinate level. (Chen 2002, p. 8)

Now contrast Fig. 3.2 with the yet later taxonomy by Gadow (1892) in Fig. 3.3, the transition to which might be seen to instantiate a *more radical* shift than the transition from Ray's to Sundevall's, because "Darwin discovered that species are not constant, and therefore affinity among species must be founded on their common origin" (Chen 2002, p. 12).[2] Add to this that Gadow's taxonomy was developed in

[2]"Influenced by Darwin's evolutionary theory, ornithologists realized that many morphological characters used as classification standards in previous taxonomies were arbitrary, and they began to search for new classification criteria that could display the origins of birds" (Chen 2002, p. 12).

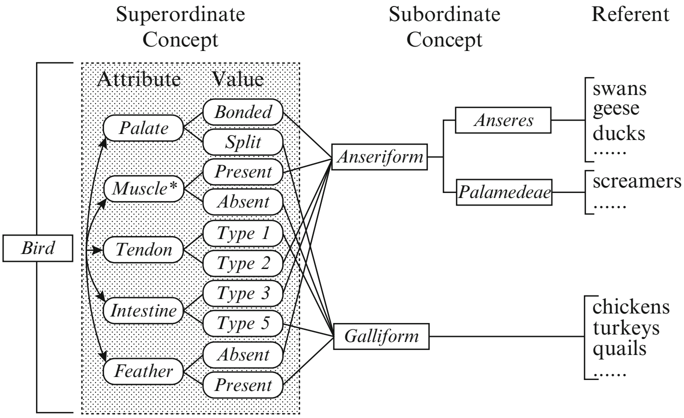

Fig. 3.3 Partial frame for Gadow's (1892) concept of bird (Chen 2002)

response to Sundevall's having "emphasized the dissimilarities between screamers and waterfowl" (ibid. 12), rather than their similarities.

Except for the attribute 'feathering arrangement', Gadow's taxonomy employs attributes designating radically different morphological features from those shown in Figs. 3.1 and 3.2. Moreover, all attributes are connected by "Darwin-motivated" constraints. What remains constant over the three taxonomies is the use of body parts. These can be motivated by their cognitive salience (Tversky and Hemenway 1984, see Chen 2002, p. 16f.).

3.3 Frames in the History and Philosophy of Science

As an exercise in history and philosophy of science, reconstructing taxonomies as partial frames, then contrasting them, is carried out with regard to Kuhn's (1970) incommensurability of taxonomies. A frame-reconstruction is said to provide some form of comparability.

> We have (...) seen taxonomic change like the one from the Sundevall system to the Gadow system, where the two taxonomies were incommensurable and no compatible lexical structures existed. But with the help of frame representations that expose the internal structures of the superordinate concepts involved in the taxonomic change, we find that the attribute lists embedded in these two incommensurable taxonomies remained compatible. (Chen 2002, p. 18)

Chen's claim is twofold: Firstly, the frame method facilitates a representation by which one may explain why the Sundevall and the Gadow taxonomy are incommensurable, in the sense that this pair violates Kuhn's 'no overlap principle' for kind terms (Kuhn 1993; Chen 1997).[3] The principle is rendered as: "[C]oncepts belonging to the same subordinate group cannot overlap in their referents" by Barker et al. (2003, p. 226).

Secondly, a more important claim is raised: In developing a consensus on the superiority of Gadow's taxonomy (which reportedly relied on more than 40 classification criteria and was based on rich empirical evidence) over that of Sundevall, the community of ornithologist *could* chose rationally, because—or so the reconstructive method is said to support—both Gadov's and Sundevall's criteria were spatial features (body parts). Contrary to the incomparability-interpretation of 'incommensurable'—which the mature Kuhn rejected (Chen 1997; Kuhn 1983; Hoyningen-Huene 1993)—, criteria could have been rationally compared.

> [T]he compatible attribute lists, rooted in the preference for body parts, or more general, the preference for spatial features in attribute selection, could have functioned as a cognitive platform for the rational comparison of the Sundevall and the Gadow systems and resulted in the quick and smooth taxonomic change. (Chen 2002, p. 18)

The frame model shows: Allegedly incommensurable taxonomies may cut nature along different, but spatial features. Such cuts need not result in rationally incomparable taxonomies, although violating Kuhn's no-overlap principle. Frame analysis thus has a potential use in "making good on history." This is meant as follows: Historical transitions that *prima facie* support the incommensurability thesis (because the comparison of taxonomies appears to undercut choice-rationality) *may*—namely upon comparing them as frame reconstructions—be reconciled with standard maxims of choice rational action, e.g., the mini-max principle. This result, Chen suggests, draws on a distinctly *cognitive* platform for rational comparison.

> [T]axonomic change is rooted deeply in the cognitive mechanisms behind the processes of classification and concept representation. These cognitive mechanisms determine the process of mutual understanding and rational comparison during taxonomic change. In fact, the cognitive platforms for rational comparison identified in our historical cases, that is, compatible contrast sets and attribute lists, were the products of such cognitive mechanisms as the relational assumptions adopted in classification and the preference for body parts developed in concept representation. (Chen 2002, p. 19)

[3] "Consequently, communication obstacles were bound to occur between the followers of the two systems. The followers of the Ray taxonomy, for example, would regard 'grallatores' from the Sundevall taxonomy as incommensurable, because they could not find an equivalent native term with referents that do not overlap those of the foreign one. Both 'water-bird' and 'land-bird' from the old taxonomy overlap 'grallatores,' which includes water-birds like herons as well as landbirds like storks. On the other hand, the followers of the Sundevall taxonomy would regard 'water-bird' from the Ray taxonomy as confusing, because they could not find an equivalent native term without violating the non-overlap principle. Sundevall's 'natatores' overlaps Ray's 'waterbird'; specifically, the former is included by the latter, but they are not in species-genus relations" (Chen 2002, p. 9).

Further applications of the frame model to scientific change are found, among others, in Andersen et al. (1996), Andersen and Nersessian (2000), Chen et al. (1998), Chen (2003, 2005), Chen and Barker (2000), and the book-length Andersen et al. (2006). Next to taxonomic change, cases range from the wave vs. the particle theory of light over astronomy and nuclear physics to the transition from Maxwell's to Einstein's conception of electro-dynamic action.

The last example is briefly discussed in Sect. 3.6. First, we turn to the critical reception of applications of the frame account within the history and philosophy of science.

3.3.1 Incomparability, Non-Translatability and the Cognitive Historical Approach

In a recent review of Andersen et al. (2006), who prefer the term 'dynamic frame', Thagard (2009, p. 844) points out: "[A]lthough the attribute-value account of representation continues to be influential, there are several other approaches that suggest that the dynamic frame account of concepts used by Andersen, Barker and Chen is at best incomplete and at worst seriously inaccurate." Exclusive use of the frame-model risks recycling an outdated model. To what extent computer-implemented connectionist models, e.g., Thagard's (1999) ECHO, have "broken free" from feature lists is a matter of debate. As computing power has increased exponentially, such models easily appear to have become more powerful. At any rate, Thagard (2009, p. 845) favors *multi-modal* conceptual representation over frames.

In an earlier review, Stanford (2008) observes that—although (presumably) fine for descriptive purposes—frames do in no good sense improve our understanding of incommensurable world-views as cognitive phenomena.

> [T]he tools imported from contemporary cognitive science prove more effective in describing central aspects of Kuhn's account of science than in explaining how they arise or how we respond to them. The feeling one gets is of being engaged in something of an extended translation exercise. If we are willing to follow the authors in embracing Barsalou's 'dynamic-frames' theory of concepts, our reward is a description in the terms of that theory of what a Kuhnian anomaly would be, what incommensurability would be, what revolutionary science would be, and so on. This may indeed show that contemporary cognitive science is capable of countenancing Kuhnian cognitive phenomena, but it does not do much to deepen our understanding of their causes or consequences. (Stanford 2008, p. 116)

A slightly more drastic consequence might obtain. By employing frames, incommensurability as incomparability of world-views is seemingly reconstructed away, while incommensurability as non-(inter)translatability of world-views is reconstructively confirmed. The undeniable fact seems to be: Using a frame-model, one inevitably reaches a state of representation at which a rational comparison of the conceptual structure of two (or more) 'views of the world' consists in nothing but a comparison of two (partial) frames. This allows tracing the requisite constraint violation and observing if/how anomalies are resolved in a different frame (or not).

One may use this fact in at least two ways. One option, presumably preferred by Stanford, is to object that applying the frame-model does not yield insight into the genesis and the effects of incommensurable world views: Frames merely facilitate a different view on the non-translatability-side of the problem. This much then would speak against what Nersessian (1995) dubbed the 'cognitive historical approach'.

> [S]tarting from the Kuhnian idea that a particular phenomenon is an anomaly because its existence is not permitted by a given scientific concept, the further information that, in dynamic frames terms, anomaly is a matter of a phenomenon's properties violating a concept's constraints on the assignment of values to attributes, or that the anomaly might be resolved by revising such constraints, seems to add little explanatory insight or power to Kuhn's original proposal. (Stanford 2008, p. 116)

A second option is to undercut Stanford's conclusion and argue: Because the cognitive historical reconstruction renders allegedly incommensurable transitions between taxonomies rationally comparable, incommensurability as incomparability is *false* as a claim on the cognitive representation of concepts. And one might continue: *If* insights into causes and effects of the incommensurability of world-views are needed, then—as far as a cognitive account of conceptual representation is concerned—, such insights might just as well lie outside of it.

In pursuing this option, one suggests that causes and effects of this phenomenon (which, on the view ascribed to Stanford, is not captured by the frame-model in an enlightening way) are located altogether beyond issues of conceptual representation. Instead, incommensurability as non-(inter)translatability of world-views (and communication breakdown) may be straightforwardly explained by human imperfection. One might cite psychological deficits, in the sense of having remained, or become, unable to adopt (and switch between) different views, or as strong, perhaps quasi-religious biases, in the sense of no longer considering, e.g., that claims to *one* ultimate ontology ('final description of the world') may be dogmatic, or group-sociological/institutional, in the sense that actors are rationally uncompelled to consider alternatives while investing in, or after having profited from, a particular research program.

This option may not sit well with everybody. *Vis à vis* the comparability claim, which can be supported by the frame-model, I find it hard to resist. *If* comparability can be secured, translatability is a less pressing issue. I take the frame model to support that, as a thesis on the rational incomparability of conceptual structures, incommensurability is a false claim. As a claim on the non-(inter-)translatability of world-views, the plausibility of incommensurability can—largely, though perhaps not entirely—be accounted for by drawing on factors other than those pertaining to conceptual representation.

For a more upbeat review of Andersen et al. (2006), see Botteril (2007).

3.4 Conceptual Spaces

The expressive power that frames gain over feature lists, while notable, remains meager. In support of this claim, frames will now be compared to *conceptual spaces* (Gärdenfors 2000). The latter appears (to me) to be more useful in application to scientific concepts, as it incorporates the measurement theoretic considerations underlying *nominal*, *ordinal*, *interval*, and *ratio scales*. It should therefore sit much better with the intuitions of working scientists. From the point of view of conceptual spaces, reference to *only one* empirical world is of lesser importance; ontological finality is not implied, nor precluded. Whether a measurement structure "picks out" a 'real structure' is rather not a pressing question (see Sect. 3.6).

Conceptual spaces provide a *geometric* and *topological* account of concept representation. An assumption which seems basic to the frame model—namely: concepts must be represented in symbols—, is discarded. Rather, information is modeled at a level *between* the symbolic and the subconceptual one. So, symbolic forms such as the laws of mathematical physics are not seen as representing concepts, but as specifying 'mathematical relational structures'.

Past Stevens' (1946) influential work (to which the above classification of differentially informative measurement scales goes back), in "mature" measurement theory, mathematical relational structures are normally understood as being embeddable into empirical relational structures, i.e., principally projectable into an ultimate ontology (structures may therefore be called *real*). Stevens did not, in any detail, treat conditions that empirical structures should satisfy (Diez 1997a, p. 180). However, from a conceptual spaces point of view, this is fine. After all, the dimensions postulated in a conceptual space aren't "out there" either.

Importantly, some mathematical relational structures are claimed to be *constitutive* of empirical relational structures or (methodologically) a priori (Friedman 2001). This Neo-Kantian aspect is briefly taken up in Sect. 3.5. Now follows a non-technical summary of conceptual spaces. Rigorous treatments are Aisbett and Gibbon (2001) or Adams and Raubal (2009).

3.4.1 Dimensions

A conceptual space is built up from a number of quality dimensions. Examples include *temperature*, *weight*, *brightness*, *pitch,* as well as the three ordinary spatial dimensions (*height*, *width*, *depth*). Moreover, we find quality dimensions of an abstract non-sensory character, e.g., *mass*, *force*, *energy*, introduced by science. The notion of a dimension may be taken literally. Each quality dimension is assumed to be endowed with *geometrical* structures.

Fig. 3.4 The weight dimension

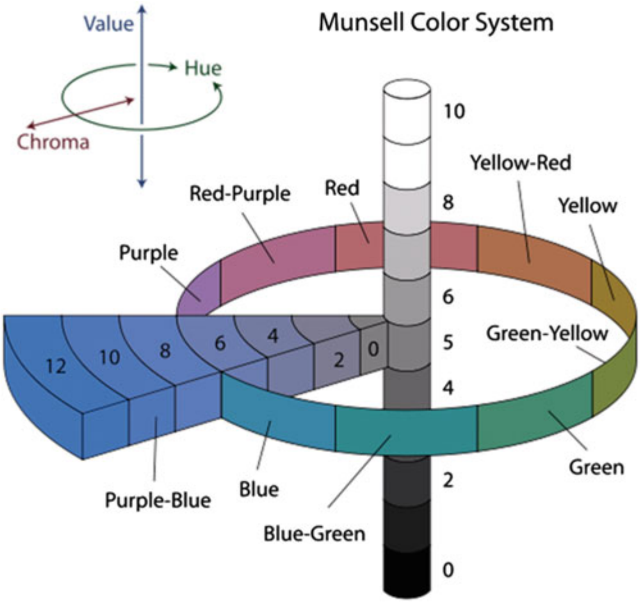

Fig. 3.5 The Munsell color system (Image reference: http://en.wikipedia.org/wiki/File:Munsell-system.svg (*public domain*))

Figure 3.4 illustrates the weight-dimension (one-dimensional with a zero point). It is isomorphic to the half-line of the non-negative numbers. That there are no negative weights is a basic constraint commonly made in science.

Far from trivial, the non-negativity of the weight dimension is a historical contingency. As an *ad hoc* assumption, the fire-substance *phlogiston* (a theoretical entity) was assumed to have negative weight, in the late eighteenth century giving way to the *oxygen* account (McCann 1978).

As a second example, following Munsell (1915), the cognitive representation of color can be described by three dimensions (Fig. 3.5). The first is *hue*, represented by the familiar color circle (red via yellow to green, blue and back to red). The topological structure of this dimension is different from the dimensions representing time or weight (both isomorphic to the real line). The second psychological dimension of color is *saturation* (or chromaticity), ranging from grey (zero color intensity) to increasingly greater intensities. This dimension is isomorphic to an interval of the real line. The third dimension is *brightness* that varies from white to black and is thus a linear dimension with end points.

Together, these three dimensions, one with circular and two with linear structure, constitute the color domain which is a subspace of our perceptual conceptual space. This domain is often illustrated by the so-called *color spindle* (two cones attached at their bases). Brightness is shown on the vertical axis. Saturation is represented as the distance from the centre of the spindle. Finally, hue is represented by the positions along the perimeter of the central circle. The circle at the center of the spindle is tilted so that the distance between yellow and white is smaller than the distance between blue and white.

3.4.2 Combinations

A *conceptual space* can now be defined as a collection of quality dimensions. However, the dimensions of a conceptual space should not be seen as totally independent. Rather, they are *correlated* in various ways since the properties of the objects modeled in the space co-vary. For example, in the domain of fruits the ripeness and the color dimensions co-vary.

It is not possible to give a complete list of the quality dimensions that make up the conceptual spaces of humans. Some of these dimensions seem to be *innate* and to some extent “hardwired” (e.g. color, pitch, force, and probably ordinary space). Others are presumably *learned*, yet others are introduced by science.

In modeling a scientific concept, the requisite dimensions have to be identified and the respective values, i.e., a *metric* (see Berka 1983, p. 93), must be assigned. If it is not possible to assign a value on one dimension without also assigning a value on another, then the dimensions are said to be *integral*; otherwise they are called *separable*. For instance, an object cannot be given a brightness value without also giving it a hue; the pitch of a sound always goes along with its loudness. In Newtonian mechanics, an object is fully described only when it is assigned values on eight dimensions: 3-D space, 1-D time, 3-D force, 1-D mass.[4]

On this distinction, the notion of a *domain* can be defined as a set of integral dimensions separable from all other dimensions. More precisely, domains C and D are separable in a theory, if the transformations of the dimensions in C do not involve dimensions from D. For example, until the rise of relativity theories in physics, the three spatial dimensions were separable from the time dimension. So, the spatial coordinates x, y, z are separable from t (the time coordinate) in Galilean, but not in Lorentz transformations. Moreover, *mass* is separable from everything else in Newton’s theory, but no longer separable from *energy* in special relativity.

As the criterion for identifying a domain, we propose the independence of the respective measurement procedures (Diez 1997a, p. 183f.). For example, in

[4]Since $F = ma$ holds, some values can be inferred, e.g., for the three force dimensions.

classical mechanics, the measurement of distance and duration (trigonometry and chronometry) are independent, as light signals are tacitly assumed to propagate instantaneously rather than at finite speed.

For criticism, primarily as to the necessity of positing such spaces, see Decock (2006).

3.5 Frames Recovered in Conceptual Spaces

A comparison between frames and conceptual spaces for cases of taxonomic knowledge is straightforward. It consists of transposing the terminology of the former into that of the latter model. The notions *attribute*, *value*, *structural invariance* and *constraint* (see Sect. 3.2) can be provided with analogues. Our claim is that frames can be recovered rather easily within the conceptual spaces model. In particular, the structural invariants and constraints of a frame arise naturally from the geometry of the conceptual space (e.g., category membership is principally a matter of occupying regions of a space).

Using one or the other modeling tool may be regarded a matter of convenience and thus related to the complexity of a representation. To model taxonomic knowledge, conceptual spaces appear over-powerful. Alternatively, representing knowledge with binary features is under-complex. In Sect. 3.6, we discuss limits of frame representations.

3.5.1 Analogue Expressions

An 'attribute' corresponds to a single 'dimension' or to combinations thereof. For example, each color can be represented as a sub-region of the space spanned by the three dimensions *hue*, *saturation* and *brightness*, rather than by natural language color terms (see Sect. 3.4).

The 'value' of an attribute corresponds to a point or to an interval on one or several dimensions. The metric of the dimensions will mimic the attributes' values. For example, on the assumption of being an equal distance apart, the values 'large', 'medium' and 'small' of the attribute 'size' will yield an interval (else an ordinal) scale. Unlike the conceptual spaces model – where "being-in-between" is meaningful by virtue of the dimensions' geometric properties –, nothing in the frame model *represents*, in a motivated way, that 'medium' is between 'large' and 'small'. Model users know as much, the model does not.

The purpose of a 'constraint' is to rule out (or make unlikely) some among logically many attribute-value combinations. Constraints result from the particular selection of attribute values that define a subordinate category. To mimic this in conceptual spaces, where instances of a concept are represented as points or vectors in an *n*-dimensional space, one may speak of sub-regions of a conceptual space being empty (or comparatively unpopulated).

The notion 'structural invariance' corresponds to a correlation of dimensions. This means no more than that a number of dimensions represent jointly. In the frame-model, structural invariants have been interpreted to represent *synthetic* a priori knowledge, i.e., knowledge about the empirical world which originates in a (taxonomic) structure not based in experience, but constitutive of it. For example, structural invariants are claimed to account for such *synthetic* a priori knowledge claims as: "There are no [normal] birds with legs that attach to their necks" (Barker et al. 2003, p. 225f.). Denial of this claim may lead a hearer to the assumption that a speaker does not understand the concept BIRD. The *synthetic* a priori status of such knowledge can, in principle, be saved in conceptual spaces, assuming that one has somehow identified it. At the same time, it is unclear (to me) if singling out some (and not other) elements as *synthetic* a priori is helpful or necessary.

An influential attempt at securing an important sense of 'rational' across scientific changes is Friedman's (2002, 2008) Neo-Kantian account, where theoretical principles may be identified as *methodological* a priori propositions, e.g., 'Space is (not) Euclidian'. Such principles are said to enable the measurement-experiences expressible within a given theoretical framework by means of laws (e.g., the law of gravitation). His tri-partition separates (i) empirical laws, (ii) constitutively a priori principles making these laws possible, and (iii) philosophical meta-paradigms which "provide a basis for mutual communication (. . .) between otherwise incommensurable (and therefore non-intertranslatable) scientific paradigms" (2002, p. 189).

The meta-paradigmatic level seems to primarily serve the purpose of leaving the historical dynamics of a priori principles rationally discussable. This level in hand, Friedman can easily accept symbolic disruptiveness (aka. symbolic non-continuity) at level (ii). However, it is unclear what besides avoiding, in a principled way, a possible communication breakdown between scientists applying different frameworks (world-views) may be cited in support of Friedman's conception. See also Howard (2009) and the brief discussion in Sect. 3.3.1.

3.5.2 Similarity as Distance

Reconsider Sundevall's taxonomy (Fig. 3.2). The attributes and their values in brackets are:

Beak (round, pointed)
Plumage (course, dense)
Feather (absent, present)
Leg (skinned, scutate)
Foot (webbed, clawed)

Table 3.1 Comparison of dimensions in Sundevall's taxonomy

Natarotes	BE-*ro*, PL-de, FE-ab, LE-sk, FO-we	Swans, geese, ducks
Grallatores	BE-po, PL-de, FE-ab, LE-sk, FO-we	Herons, screamers, storks
Gallinae	BE-po, PL-*co*, FE-pr, LE-*sc*, FO-*cl*	Chickens, turkeys, quails

We treat each attribute as a dimension. All values are binary, so each dimension gives rise to a "scale with two ranks." In Table 3.1, capital letters abbreviate attributes, lower case letters values. This yields five integral dimensions at ordinal level.

Note that *Natarotes* and *Grallatores* are *similar* up to the beak-dimension (BE-ro vs. BE-po). This similarity remains rather hidden in the frame-model, but is immediate in a feature list or a conceptual space. Moreover, in a frame and a feature list model, it is not clear how to measure—by virtue of the tool—the comparative distance between *Natarotes*, *Grallatores* and *Gallinae*. In the idiom of conceptual spaces, the *Gallinae* region is maximally distant from the *Natarotes* region, as it differs on four dimensions from *Grallatores*. That this distance cannot be expressed more informatively is a result of employing binary features. Note that, when expressing taxonomic difference as distance, conceptual spaces have implicitly been applied.

In Gadow's taxonomy (Fig. 3.3), since the attribute (dimension) *feather* is retained with identical values, one may describe the change from Sundevall's to Gadow's taxonomy as a replacement or revision of four dimensions (*cum* invariants and constraints). This yields a *trivial,* but correct reconstruction of conceptual change. Such is easier to accept when incommensurability of world-views is not seen as a problem of representation (see Sect. 3.3.1).

The partial frame of Gadow's new taxonomy features five dimensions, not all of which take binary values. One may therefore say that complexity (as measured by the number and scale-strength of dimensions) is not constant. Gadow uses four *new* dimensions. Featuring also one region less, in this respect, his taxonomy is simpler than Sundevall's. On the other hand, the types of *intestines* (Type 3 and 5) suggest that complexity increased. The same seems to hold for the *tendon* dimension. *Prima facie*, these still constitute ordinal scales.

Generally, by defining change-operations on the dimensions and their mode of combination, the conceptual spaces model may also be applied dynamically. In increasing order of severity of revision, these are: (i) addition/deletion of laws, (ii) change in scale, (iii) change in integrality/separation of dimensions, (iv) change in importance (or salience) of dimensions, (v) addition/deletion of dimensions (see Gärdenfors and Zenker 2010, 2013 for examples).

A more informative reconstruction might employ the comparative distance between taxonomic items (pre- vs. post-change). Thus, relative distance between reconstitutions of dimensional points within (regions of) spaces would measure if, e.g., screamers have become *more* similar to ducks (or not). *Severity of scientific change* then comes out as 'distance between spaces', i.e., as a function of the above change operations and a distance measure.

Below, we exploit this idea, offering it as a promising mode of addressing the (alleged) incommensurability of theoretical frameworks. We view scientific laws as symbolic expression of constraints on conceptual spaces. On this view, historical transitions to new spaces are in principle always *continuously* reconstructable, leaving no room for incommensurability in a cognitive account of scientific conceptual knowledge representation.

3.6 Scientific Laws as Constraints on Dimensions

Frame representations almost exclusively use natural language. Attributes and values are ultimately linguistic entities. This may be fine when representing changes in taxonomic knowledge. That taxonomies mostly employ binary features may be motivated historically: "better tools" were not available. The foundations for a theory of measurement (in the modern sense) arise only with Helmholtz (1887), are provided with (some say, insufficient) systematizion by Stevens (1946), and developed by Krantz et al. (1971/1989/1990). For an overview and the caveat in Steven's work, see Diez (1997a, b), Hand (2004).

When dimensions are fine grained, we approach scientifically exact measurement. Here, shortcomings in the information conveyed by the frame model's attribute-value structure may be observed, suggesting a revision of this model. If attribute values are not bi-, but *n*-ary, any attempt at modeling ordering relations with frames presumably incurs a revision towards conceptual spaces. When representing a scientific concept (and, eventually, the conceptual space spanned by an empirical theory), e.g., in physics, dimensions tend to be *ratio-scales*. One will want to make sense of the fact that empirical theories and their (mathematical) laws depend on and give rise to measurement results at this level of scale. In brief, frames seem under equipped to represent conceptual knowledge beyond the taxonomic level.

Moreover, it is easily overlooked that one may attempt to motivate the *symbolic* character of scientific laws by virtue of the representational tool. Thus, Andersen and Nersessian (2000) clearly state they "believe that [frame] analysis can be extended to represent the similarity class of problem situations for *nomic* concepts" (ibid. 230), i.e., those obeying law-like generalizations. In their electromagnetism example (Fig. 3.6), the Lorentz force-treatment is distinguished from the electromotive force-treatment; "frame-style", the attributes *conductor*, *ether* and *magnet* (values: *moving* or *at rest*) are coordinated to the respective force laws. Their symbolic forms differ strikingly—and implausibly so, as the application situation is identical. (In modern terms, applications pertain to the *relative* motion of a magnet *vis à vis* that of a conductor.) Recall that, "in Maxwellian electrodynamics, although the resultant electromagnetic induction is the same whether it is the magnet or the conductor that is moving and the other at rest, these are interpreted as two *different kinds* of problem situations" (ibid. 237, italics added). The point of their example is: Suspending the attribute *ether*, Einstein's revision of Maxwell's electrodynamics removed a "total overlap" (ibid.) between the two treatments.

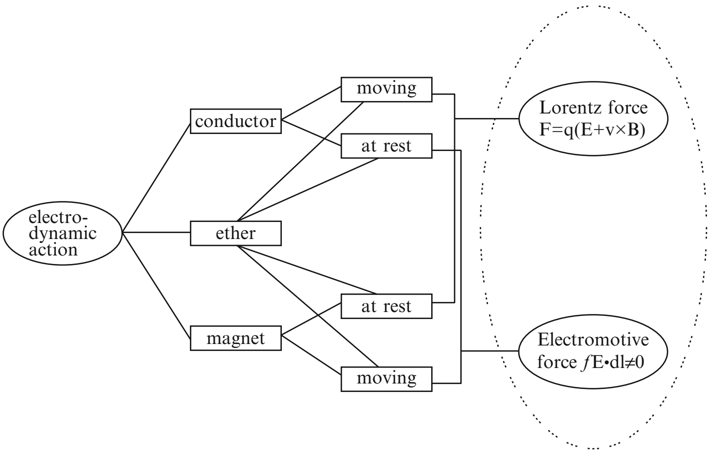

Fig. 3.6 Partial frame for Maxwellian 'electrodynamic action' Andersen and Nersessian (2000, p. S238)

In Andersen and Nersessian's use of frames, laws are appended, rather than motivated by the frame structure. It therefore seems (to me) that frames apply to scientific laws *without* providing insight into their status as symbolic generalizations. Strikingly different formulae, which evidence the "symbolic rupture" (allegedly incurred) in *radical* scientific change, can also be viewed as the symbolic expressions of constraints holding over different conceptual spaces. In fact, scientific laws may be viewed as *nothing but* the symbolic forms of constraints on some space. Note that ontological qualms in theory change may also be explicated with respect to the dimensions of an empirical theory—one need not pin this to the laws or the axioms.

This move no doubt demotes the importance of laws in scientific change *vis à vis* the dominant view (e.g., Dorato 2005). On the dominant view, for instance, any continuity of mathematical structure achieved by limiting case reduction (see Batterman 2003)—which, following Worrall (1989), structural realists tend to cite as strong evidence in disfavor of incommensurability claims—, would no longer be exclusively a matter of laws. Instead, once one characterizes empirical theories *primarily* through identifying the scale-type of the dimensions—or, more contemporaneously, the admissible transformation of a scale (see Diez 1997b)—and their modes of combinations (integral vs. separable), 'continuity in scientific change' denotes the continuous generation of one conceptual space into another.

Questioning the assumption that the rationality of a scientific change is inherently a symbolic matter (i.e., has to be demonstrated *in symbols*), then, one may motivate the claim that conceptual spaces provide a model for scientific change (across various disciplines), without yielding incommensurability or incurring a priori notions. In this sense, the assumption that a conceptual space is not (an) intrinsically symbolic (model) is indispensable.

To represent scientific concepts, theories in which they occur as well as their dynamics, similarity measures over *diachronically* related spaces appear promising. How such measures are to be defined, is open to discussion. Extant treatments of conceptual dynamics project (or transform) conceptual spaces according to contexts which, in the widest sense, vary *synchronically*, e.g., spatial environmental features under day and night conditions (Raubal 2004). The change operations (Sect. 3.5.2) and the definition of a domain may serve in providing the building blocks for such diachronic similarity measures.

3.7 Conclusion

It should be stressed that, with the exception of saying something meaningful on the status of symbolic generalizations, the frame model is presumably applicable whenever the conceptual spaces model it. Alas, the latter gains in applicability to concepts which are based on and give rise to exact measurement. Having reviewed the development of feature lists into the frame account of conceptual representation, and having moreover shown how to recover frames in conceptual spaces, one may conclude that the latter model gains its advantages, because key notions of modern measurement theory are *native* to it. Conversely, any attempt to achieve this within the frame model will (very likely) look just like a conceptual space.

Distinct correspondences between frames and conceptual spaces were pointed out. Moreover, it was suggested that using one or the other model is also a matter of convenience. For taxonomic knowledge, for example, conceptual spaces appear over-complex. Importantly, whenever the question is raised if—through a change in taxonomy—items have become more (or less) similar, it should be admitted that one implicitly uses the conceptual spaces model. After all, neither frames nor feature lists provide a notion of difference as geometric distance.

Consequently, future work should concern definitions of distance measures across diachronically varying spaces. No measure was defined, but the building blocks pointed out.

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Part II
Frame Analysis of Changes in Scientific Concepts

Chapter 4
Reconstructing Scientific Theory Change by Means of Frames

Gerhard Schurz and Ioannis Votsis

Abstract This paper has two aims. The first is to show the usefulness and intuitiveness of frame theory in reconstructing scientific classification systems. The second is to employ such reconstructions in order to make headway in the scientific realism debate and, more specifically, in the question concerning scientific theory change. Two case studies are utilised with the second aim in mind. The first concerns the transition from the phlogiston theory to the oxygen theory of combustion, while the second concerns the transition from the caloric theory to the kinetic theory of heat. Frame-theoretic reconstructions of these theories reveal substantial structural continuities across theory change. This outcome supports a structural realist view of science, according to which successful scientific theories reveal only structural features of the unobservable world.

Keywords Frames • Scientific classification system • Structural realism • Theory change

4.1 Introduction

This paper has two aims. The first is to show the usefulness and intuitiveness of frame theory in reconstructing scientific classification systems. The second is to employ such reconstructions in order to make headway in the scientific realism debate and, more specifically, in the question concerning scientific theory change. Two case studies are utilised with the second aim in mind. The first concerns the transition from the phlogiston theory to the oxygen theory of combustion, while the second concerns the transition from the caloric theory to the kinetic theory of

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heat. Frame-theoretic reconstructions of these theories reveal substantial structural continuities across theory change. This outcome supports a structural realist view of science, according to which successful scientific theories reveal only structural features of the unobservable world.

4.2 Frames and Scientific Classification

A frame represents a super-ordinate category (henceforth: 'super-category') and therefore its corresponding concept by a recursive system of functional attributes. Systems are recursive because attributes and even the values of attributes are themselves concepts and may therefore be analysed into further frames. We call collections of such nested frames 'nets'. It should be obvious that frames and nets of frames define systems of classification for the objects of the underlying categories. This makes frames an excellent tool for the investigation of the conceptual systems of scientific theories and their respective ontologies (cf. Chen and Barker 2000; Chen 2003).

Figures 4.1 and 4.2 illustrate how frame-theory can be used to represent biological classifications. The frames exhibit many of the trademark features of frame-theoretic representations, features that are particularly apt at capturing the subtleties of scientific classification (see Petersen 2007). In what follows, we consider nine noteworthy features.

The first feature worth mentioning has already been mentioned. It is the recursive character of frames, illustrated in both Figs. 4.1 and 4.2 by the fact that certain

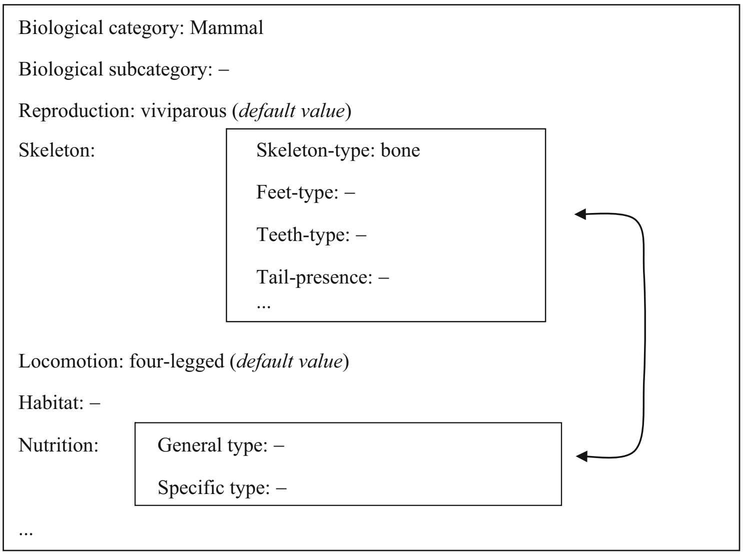

Fig. 4.1 Partial frame for the biological super-category "mammal"

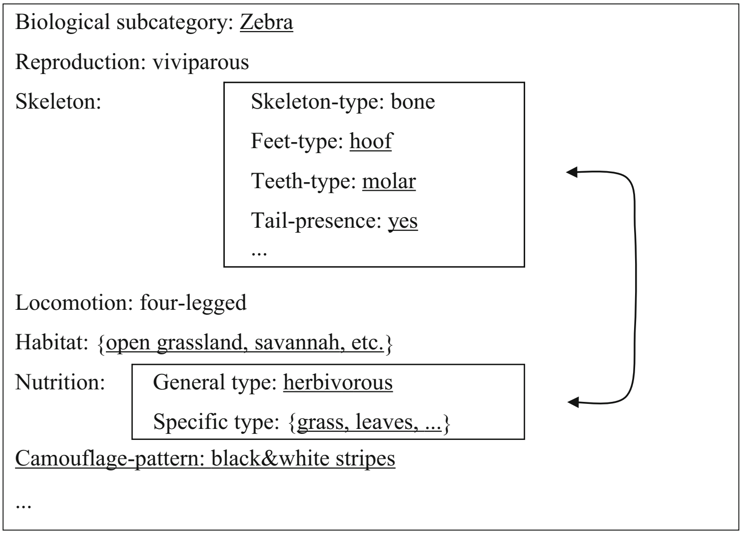

Fig. 4.2 Partial frame for the subcategory "zebra". New values instantiated by the zebra-frame are underlined

attributes correspond to (nested) frames. For example, the attribute "skeleton type" is also a frame, possessing its own attributes.

The second feature worth noting is that when representing super-categories the values of most attributes in the frame are not specified. This is illustrated by Fig. 4.1 which is a frame for the super-category mammal. Values are specified in the frames of the sub-categories. Thus, the frame for the sub-category zebra (i.e. Fig. 4.2) contains values for all the remaining mammal-attributes. Sometimes sub-categories leave some attributes uninstantiated. These attributes get instantiated in sub-categories further down the hierarchy.

This brings us to the third noteworthy feature. Frames may contain incomplete information regarding their target category. For example, not all attributes belonging to a category may be known. Such frames are called 'partial'. In science we often do not have the complete story regarding a classification system. So the ability to represent incomplete information in terms of partial frames is one of frame theory's strengths.

The fourth feature of note is that some values are there by default. This is the case with the value "viviparous" of the attribute "reproduction" in Fig. 4.1. It is a default value because most species of mammals are viviparous – they give birth to live young. Platypuses are mammals but are oviparous – they lay eggs. Default values become fixed lower down the hierarchy of frames, e.g. the value "viviparous" is fixed in the zebra-frame.

The fifth noteworthy feature is the type of constraints available. In both figures there is a constraint between the values of attributes "general type of nutrition" and "teeth-type", indicated by the double-edged arrow. In this case the constraint is a non-strict empirical correlation (or uncertain biological law): herbivorous nutrition correlates well with (but does not necessitate) molar teeth; carnivorous nutrition correlates well with (but does not necessitate) fang teeth, etc. Some constraints are strict, others are non-strict. Moreover, some constraints are synthetic (i.e. empirical), while others are analytic (i.e. they hold purely by virtue of the meaning of the concepts they relate).

The sixth feature worth noting also concerns types of constraints. In the paragraph above the constraints hold between the values of different attributes. These are called 'value-value' constraints. There are also 'value-attribute' constraints. Thus the value "zebra" for the biological sub-category brings with it the attribute "camouflage-pattern". Moreover, there are 'attribute-attribute' constraints. Thus the attribute "specific type of nutrition" goes hand in hand with the attribute "general type of nutrition".

Number seven in our list of notable features is that sub-category frames sometimes contain attributes not found in the frames of their respective super-categories. Thus in the zebra-frame the attribute "camouflage-pattern" is new.

The eighth noteworthy feature concerns how attributes ought to be understood. An attribute is not a property but a space of possible properties that belong to the same dimension. The simplest dimension is binary. For example, the attribute "tail-presence" takes either 'yes' or 'no' as values. Other more complex dimensions, e.g. real-valued ones, abound in science and can be accommodated within frame-theoretic reconstructions.

The ninth and final feature we make note of is that sometimes an attribute can take more than one value at the same time. For example, the attribute "habitat" in Fig. 4.2 has more than one value assigned to it for the simple reason that zebras can be found in different habitats.

The problem with the biological classifications in Figs. 4.1 and 4.2 is that they have low to moderate *systematic power*. This notion captures the degree to which all the values of a given frame are determined by the values of a few core attributes. Closely connected to systematic power is the notion of *diagnostic efficiency*. This captures the idea of how easy it is to diagnose whether an object belongs to a given category. Take the zebra-frame again. The values of the sub-frame "skeleton" do not determine many of the values of the other attributes. For example, hoofed animals need not live in open grassland or the savannah, as they can also be found living in mountainous terrain. This deficiency in systematic power also impairs the frame's diagnostic efficiency. An example of a frame with an extremely high systematic power and diagnostic efficiency is that of the periodic table of elements in chemistry – see Fig. 4.3. The atomic number – and if we are also interested in nuclear stability and decay properties also the mass number – determines all further attributes and their values. This determination takes the form of a strictly general value-attribute and value-value constraint.

In sum, we hope to have made clear how frame theory's central features facilitate the representation of scientific classifications in intuitive ways. It is now time to apply frame-theory to a central problem in the philosophy of science, namely that of the scientific realism debate and, in particular, the question of theory change.

Chemical category: Element
Chemical subcategory: – [Name of element]
Atomic number (= number of protons): –
Mass number (= number of protons and neutrons): –
Various further attributes, all strictly determined by atomic (and mass) number, e.g.:
Melting point: –
Boiling point: –
Electronegativity: –
Character: (metallic or semi-metallic or non-metallic): –
If metallic character: solubility in different kinds of acids;
If non-metallic character: solubility in different kinds of bases; etc.

Fig. 4.3 Partial frame for the periodic table – the values of all additional attributes are determined by atomic (and mass) number

4.3 Scientific Realism and the Question of Theory Change

There are different kinds of realists and anti-realists. What most realists agree on is that theories with enough predictive and explanatorily success entail true, or at least partially true, claims about the observable and the unobservable world.[1,2] Anti-realists deny this claim. They typically argue that it is not the case or at least that we cannot know whether scientific theories contain true or partially true statements. One of the arguments employed by anti-realists is that from the pessimistic meta-induction (PMI). According to this argument, the history of science supplies ample evidence against realism in the form of past successful theories that are now considered false and whose central theoretical terms refer to nothing. In other words, the argument questions the reliability of inductive inferences from explanatory and predictive success to truth or partial truth and to referential success. The PMI thus directly challenges the realists' no miracles argument (NMA). According to this latter argument, the predictive and explanatory success of theories is not a consequence of an exceedingly lucky series of coincidences but rather a consequence of such theories truthfully uncovering aspects of the observable and the unobservable worlds. The PMI also challenges a widespread expectation amongst realists, namely that successive and successful scientific theories converge towards the truth.

[1]Following van Fraassen (1980), unobservables are understood as those objects, phenomena or events that we can only detect with instruments, i.e. never with our unaided senses.

[2]Realists often disagree on where to place the cut-off point concerning how much success a theory needs in order to entail true or partially true claims about the unobservable world. One popular criterion is the ability to make novel predictions, though even here there is considerable controversy – see Worrall (2002).

Most realists take the challenges issued by the PMI seriously and attempt to make sense of the historical record of science without sacrificing their adherence to the central tenets of realism. One important observation the realists made early on is that not all parts of a successful theory play an indispensable role in its success. For this reason not all parts are equally well-confirmed. Indeed some parts lack confirmation altogether. There is thus no reason for the realist to worry about the abandonment of such parts in the wake of scientific revolutions. What the realist should worry about is whether the well-confirmed parts survive. So long as they do, at least in some limit form, the realist has nothing to fear from the PMI. Even the convergence claim can be saved albeit in a more refined guise: If successful theories that supersede each other are to converge towards (or at least get closer to) a true description of the (observable and unobservable) world, then some of their claims about the unobservable world are expected to play an indispensable role in the production of at least part of that success and, unless non-rational considerations take precedence, these claims are expected to survive theory change at least in some limit form.[3]

As mentioned above, there are different kinds of realism. We are keen on structural realism, particularly the epistemic variety.[4] According to this view, successful scientific theories cannot reveal more than structural features of the unobservable world. This view separates structural realists from standard scientific realists as the latter put no such restriction on what we can know about unobservables. As a consequence of their view, structural realists expect the historical record to exhibit only structural continuity at the unobservable level. In more detail and largely following Worrall (1989), structural realists hold that scientific revolutions result in the abandonment of specific unobservable posits – in accordance with the PMI – but not of the structure of such posits when it plays an indispensable role for at least part of the success enjoyed by the abandoned theory – in accordance with the NMA. In the sections that follow we test this claim against two cases of theory change: (1) the transition from the phlogiston theory to the oxygen theory of combustion and (2) the transition from the caloric theory to the kinetic theory of heat.

Before we turn our attention to these case studies it is worth saying a few words on what it is that we hope to achieve with frame theory in this debate. Our investigation employs frame theory because it enables us to make explicit the inner structure of scientific concepts in an intuitive manner. Concepts belonging to distinct scientific theories can be compared with relative ease to find out whether, and, if so to what extent, any continuity between them exists. This ability is particularly valuable for the debate at hand since, as we just saw, a lot hangs on whether successive scientific theories exhibit continuities, what form these continuities take, whether the continuities are highly correlated with the successes of those theories and what is the best explanation for these correlations.

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[3]For the notion of survival or correspondence in a limit form see Redhead (2001).

[4]For a comprehensive critical survey of the literature on structural realism see Frigg and Votsis (2011).

4.4 The Phlogiston-Oxygen Case

The theory of phlogiston goes back to Johann Becher and Georg Stahl – the latter coined the term 'phlogiston' – and was developed, among others by Henry Cavendish and Joseph Priestley (cf. McCann 1978, Chap. 2). According to this theory, combustible substances contain phlogiston, which is the bearer of combustibility. When combustion, calcination or roasting of a substance *X* takes place, *X* delivers its phlogiston as a hot flame or an evaporating inflammable gas, leaving behind a dephlogisticated substance-specific residual (a so-called 'calx'). This process is called *dephlogistication*, and the inverted process *phlogistication*. It is widely known today that the theory of phlogiston had difficulty explaining a number of phenomena – in Kuhnian terms it faced a number of anomalies (see Kuhn 1962). What is not so widely known is that it enjoyed some non-negligible measure of success in that it was able to predict and to some extent explain what would happen to metals during certain conditions we now associate with oxidation and salification as well as what would happen during the inverse of such processes – what we now associate with the retransformation of metal calxes into pure metals (cf. Carrier 2004; Schurz 2004, 2009).

Rivalling the theory of phlogiston was the oxygen theory of combustion and calcination developed in the 1780s by Antoine Lavoisier. The generalised form of this theory is now part of modern chemistry. According to Lavoisier's oxygen theory, combustion or calcination of a substance *X* consists in the oxidation of *X*, i.e. in modern terms its forming a polarized bond with oxygen. In the generalized oxidation theory, the oxidizing substance need not be oxygen but it must be strongly electronegative, e.g. a halogen. Thus, according to the modern oxygen theory, the *oxidation* of a substance *X* consists in the formation of a polarized bond between *X* and an electronegative substance *Y*, in which the *X*-atoms become electropositive and donate electrons to their electronegative neighbour-atoms of type *Y*. The inversion of this chemical process is called *reduction*.

The assumption of a special bearer of combustibility was recognized by advocates of the oxygen theory to be explanatorily superfluous. Phlogiston simply does not exist. But how can we then explain the empirical success the phlogiston theory enjoyed at the time? In Schurz (2009) it is argued that the theoretical term "phlogiston" was empirically underdetermined. The theoretical expressions which performed the empirically relevant work for the theory of phlogiston and thus were not empirically underdetermined were phlogistication and dephlogistication. These concepts of the theory of phlogiston stand in the following correspondence relations with some of the central concepts of modern chemistry: (C_1) Dephlogistication of a substance *X* corresponds (and hence implicitly refers) to the donation of electrons of *X*-atoms to the bonding partner in the formation of a polarized or ionic chemical bond. (C_2) Phlogistication of *X* corresponds (and hence implicitly refers) to the acceptance of electrons from the bonding partner by positively charged *Y*-ions in the breaking of a polarized or ionic chemical bond. The two correspondence relations explain the empirical success of the theory of phlogiston. Moreover, they

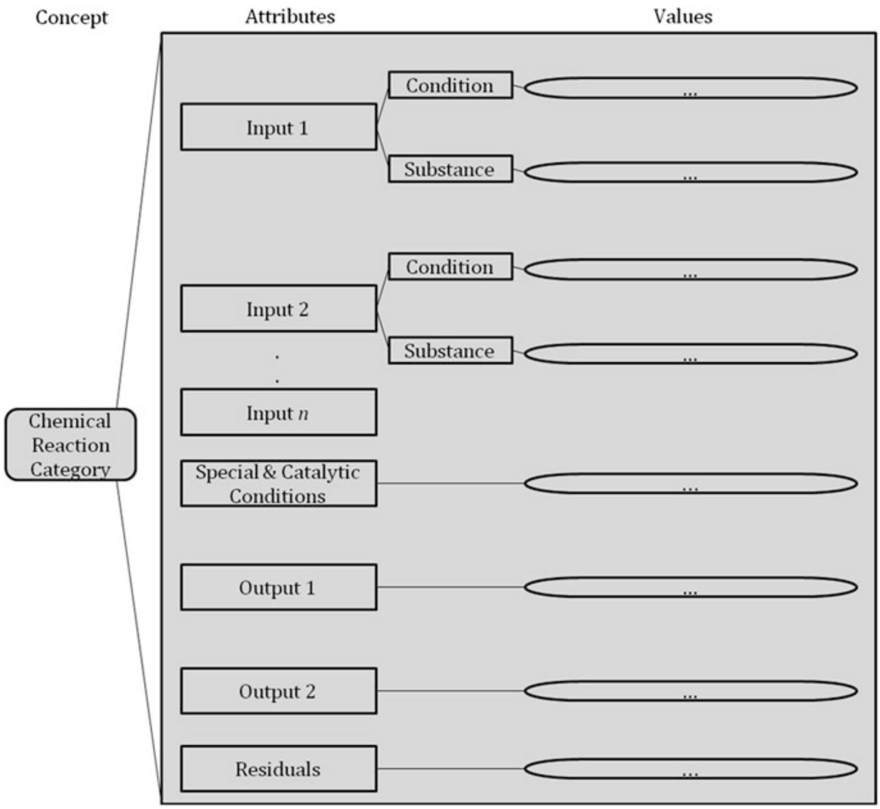

Fig. 4.4 Partial frame for chemical reactions. The *dotted* elliptic fields indicate that a number of values can be given to these attributes

support a structural realist view of science. This is because the structural form of the theoretical expressions that produce the empirical success enjoyed by the theory of phlogiston survived into the generalised oxygen theory.[5]

In order to reconstruct the structural correspondence between the theory of phlogiston and the generalised oxygen theory in a frame-theoretic manner, we have to first develop a general frame for chemical reactions – see Fig. 4.4. Roughly speaking, a chemical reaction consists of one or two input substances under certain conditions, which have to do with the substances as well as the circumstances of the reactions, together with one or two output substances and possibly some residuals. Two constraints govern chemical reaction frames. First, the chemical *law of equal proportions* requires that for all atoms (elements) of kind *i* involved in the reaction,

[5]See also Ladyman (2011) for another structural realist account of the phlogiston-oxygen theory transition.

the number of moles of atom i among the input substances equals the number of moles of atom i among the output substances. Second, the *reaction-inversion principle*, according to which for every reaction, there exists one and only one inverse reaction.

At this point it is worth pointing out that the reaction-inversion principle is important for the development of frame theory itself. This is so because to properly represent the principle requires an inter-frame constraint as opposed to the intra-frame constraints discussed in Sect. 4.2. The principle thus demonstrates the need for extending the theory of frames to a theory of nets of frames where all sorts of relations between frames are expressible. We expect to discover many more such relations in our application of the theory of frames to case studies such as the current one.

Interestingly, the rough understanding of chemical reactions according to the proposed frame, together with its intra- and inter-theoretic constraints, was accepted by both phlogiston and oxygen theorists and experimentalists. This shows how frame-theory can be useful in revealing the hidden common principles shared by otherwise ontologically rival theories. What was different in the two theories was not the general understanding of chemical reactions, but the theoretical decomposition of the empirically given substances, i.e. the stuff both parties in the debate agreed was being tested regardless of their descriptions of them. In particular, what was understood as pure in one theory was understood as compound in the other theory, and vice versa. The different theoretical decomposition of substances concerned the following major chemical reactions: the calcination (or roasting) of metals, the salification (i.e. salt-formation) of metals through their dissolution in acids and the inversion of these two processes.

The schemata below represent four chemical reaction types as analysed by each of the two theories. Underlining indicates inter-theoretic correspondences. Substances which are underlined in the same way indicate the different theoretical decomposition each theory attributed to the same empirically given substance. For example, the pure chemical substance metal was understood as a non-compound by the oxygen theory, but as a compound, namely metal calx and phlogiston, by the phlogiston theory. Henceforth, "Phlog" stands for "pure phlogiston". "X–Y" stands for a combination of X and Y" – for example, "Phlog-Air" stands for "phlogisticated air" while "Ash-Phlog" for "combination of ash and phlogiston". The symbol "↑" indicates that the substance is an evaporating gas. The symbols "+" ("−") designate electropositivity and electronegativity respectively. Items in brackets denote residuals. Finally, "H" stands for "hydrogen".

Calcination of metals:

Oxygen theory: $\underline{\text{Metal}} + \text{Oxygen} \rightarrow \underline{\underline{\text{Metal}^{+} - \text{Oxide}^{-}}}$ [+ HotAir ↑]
Phlogiston theory: Metal (= $\underline{\text{MetCalx}-\text{Phlog}}$) + Pure Heat → $\underline{\underline{\text{MetCalx}}}$ +Phlog − Air ↑

Salt-formation of metals in acids:

Oxygen theory: Metal + $H^{+} - X^{-}$ (=Acid) → $\text{Metal}^{+} - X^{-}$ (=Salt) + Hydrogen (H_2)↑

Phlogiston theory: MetCalx–Phlog + Acid → MetCalx−Acid (=Salt) + Phlog (inflammable air)↑

Inversion of calcinations – reduction with coal:

Oxygen theory: $\text{Metal}^{+} - \text{Oxide}^{-}$ + Coal → Metal + $\text{Coal}^{+} - \text{Oxide}^{-}$↑ [+Ash]

Phlogiston theory: MetCalx + Coal (=Ash – Phlog) → Metal + Ash [+ Phlog−Air]↑

Inversion of salt-formation:

Oxygen theory: $\text{Metal}^{+} - \text{Oxide}^{-}$ + Hydrogen → Metal + Water (= $\text{Hydrogen}^{+} - \text{Oxide}^{-}$)

Phlogiston theory: MetCalx + Phlog [+ Water-in-Air]) → Metal [+ Water-in-Air]↑

Note that the identification of phlogiston with 'inflammable air' (i.e. hydrogen) does not hold in all domains. Moreover, we do not claim here that the theory of phlogiston worked well across the board. For example, it failed to explain why after combustion the weight of some substances increased instead of decreasing. Attempted explanations were based on wildly ad-hoc assumptions, e.g. postulating that phlogiston had negative weight. Nevertheless, the theory of phlogiston was empirically successful with respect to the domains of oxidation and salification of metals as well as the retransformation of metal calxes into pure metals. Lavoisier's oxygen theory surpassed the success of its rival. Even so, it also had problems of its own. For example, Lavoisier assumed that salt-formation of metals in acids is always due to the presence of oxygen, whereas in actual fact oxygen is contained only in some acids.

We can now express the correspondence relations between the two theories by means of special chemical reaction frames. Consider first the calcination and salification frame of Fig. 4.5. Here the oxygen theory's condition of being electropositive but in neutral-bond translates into the phlogiston theory's condition of being rich in phlogiston. Acid is primitive in phlogiston theory but consists of hydrogen ions plus a negative oxydans in oxygen theory. Metal is primitive in oxygen theory but analysed as metal calx-plus-phlogiston in phlogiston theory (as explained above). In the case of calcination, the theory of phlogiston does not require a second input substance, but merely pure heat because the phlogiston is already contained in the first input substance. In the case of salt-formation, acid is the second input substance in both theories. In spite of the differences, we hope that the correspondence relations are clear for all to see. If, from the point of view of one theory, one or more input conditions and one or more input substances lead to a given output, then the same relation holds between the corresponding input conditions, input substances and output of the other theory.

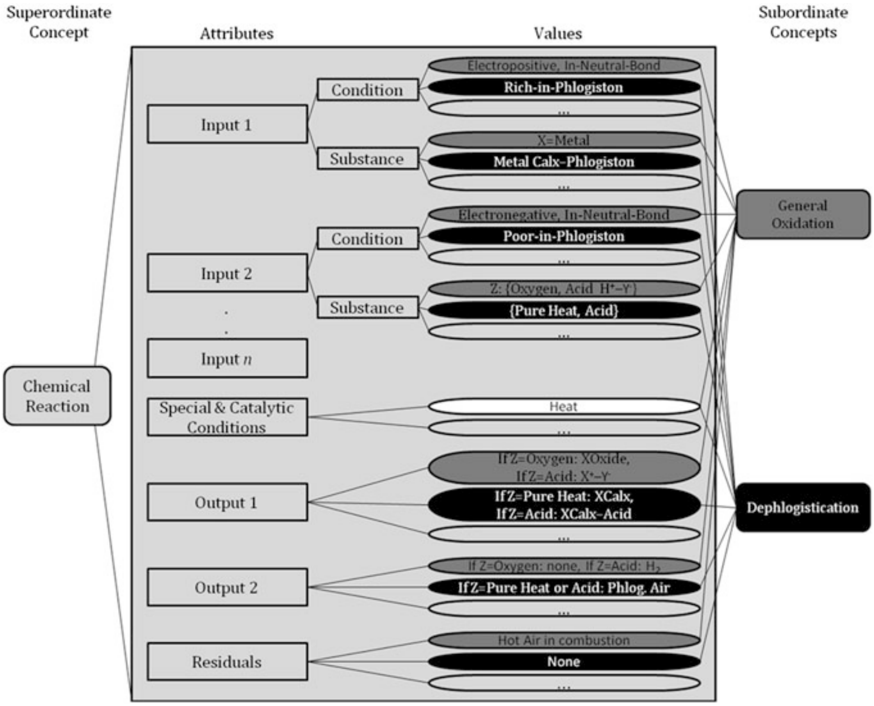

Fig. 4.5 Partial chemical reaction frame for the processes of calcination and salification. For expediency both the concept of dephlogistication and the corresponding concept of general oxidation are represented in one frame. The elliptic fields in *black* indicate the values of the subordinate concept of dephlogistication in phlogiston theory; the elliptic fields in *dark grey* indicate the values of the corresponding subordinate concept of general oxidation in general oxidation theory; the one *white* elliptic field indicates a default value associated with both subordinate concepts; the *dotted* elliptic fields indicate the possibility of more values

The inverted processes of calcination and salification are displayed in the frame of Fig. 4.6. Here, the different analysis of the residuals of the reactions is of special interest: ash, which is a residual for oxygen theory, is a proper output substance for phlogiston theory, while water, which is a residual for phlogiston theory, is a proper output substance for oxygen theory. As before, there are clear correspondence relations. If one or more input conditions and one or more input substances lead to a given output according to one theory, then the same relation holds between the corresponding input conditions, input substances and output of the other theory.

The frames in Figs. 4.5 and 4.6 show us in an intuitive way where the two competing theories converge and where they diverge. The message we hope is clear. Despite the divergence found in the different values each theory assigns to the inputs, outputs and residuals of the aforementioned chemical reactions, there is undeniably substantial convergence at the structural level. The case of the transition from the phlogiston to the oxygen theory of combustion thus seems to tell in favour of structural realism. Let us now turn to the other case.

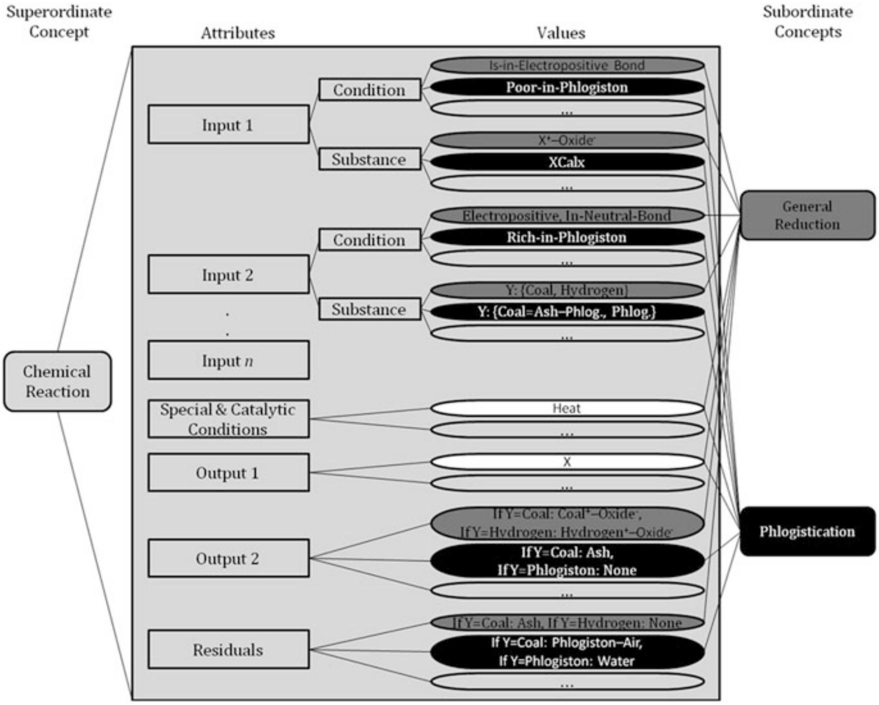

Fig. 4.6 Partial chemical reaction frame for the inverse processes. Once again for expediency both the concept of phlogistication and the corresponding concept of general reduction are represented in one frame. The elliptic fields in *black* indicate the values of the subordinate concept of phlogistication in phlogiston theory; the elliptic fields in *dark grey* indicate the values of the corresponding subordinate concept of general reduction in general oxidation theory; the two *white* elliptic fields indicate default values associated with both subordinate concepts; the *dotted* elliptic fields indicate the possibility of more values

4.5 The Caloric-Kinetic Case

The first sophisticated theory of heat was the caloric theory, developed chiefly by Antoine Lavoisier late in the eighteenth century.[6] Heat, according to this theory, is a kind of material substance that is imperceptible, or, nearly so, depending on the version of the theory advocated. Dubbed ‘caloric’, this substance was thought to be an elastic fluid that flows from warmer to colder bodies. Its particles were subject to two forces, one repulsive and holding between caloric particles, the other attractive and holding between caloric particles and particles of ordinary matter. Arguably, the caloric theory enjoyed some success in explaining and/or predicting phenomena. It

[6]The material in this section (including all the figures) is a reformulated version of material found in Votsis and Schurz (2012). For more details please consult that publication.

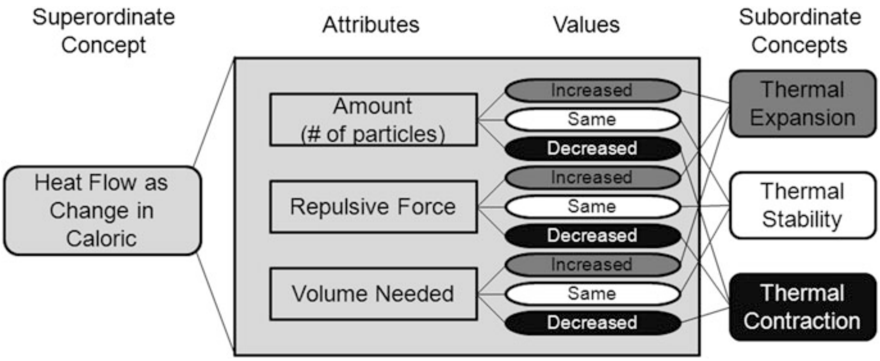

Fig. 4.7 Partial frame for heat flow as change in caloric. This frame illustrates the caloric explanation of thermal expansion, contraction and stability in terms of changes in the amount of caloric. Different shades indicate that the instantiated values correspond to different sub-ordinate concepts

was eventually displaced by the kinetic theory. The latter conceived of heat not as a material substance but in terms of the motion of particles of ordinary matter. Today we continue to understand heat in terms of motion but this idea has been further refined so that we now speak of heat as a kind, or instance, of kinetic energy.

In this section we consider two successes attributed to the caloric theory, namely (i) the explanation that matter expands by heating and contracts by cooling and (ii) the postulation of a special kind of heat, i.e. latent heat, to account for phase transitions. As explained earlier, for structural realism to gain support in this case, it must be shown that (i) and (ii) survived into the kinetic conception of heat. Moreover, it must be shown that the production of these successes was dependent on theoretical posits, the structure of which also survived. In what follows we consider each of these in turn.

The caloricists explained the thermal expansion, contraction and stability of bodies in largely intuitive terms. Expansion, they argued, ensues when caloric particles are added to a body. Since caloric particles repulse each other, the more such particles a body contains the more they push against the body's boundaries leading to an increase in its volume. Contraction ensues when caloric particles are removed. Less caloric particles mean less pushing against the body's boundaries and hence a decrease in volume. As you would have thought, a body is thermally stable when no caloric particles are added or taken away since the repulsive force between caloric particles already present in the body remains the same (see Fig. 4.7).

Explaining thermal expansion, contraction and stability is an ability that the kinetic theory of heat also possesses. Its theorists argue that an increase in a body's kinetic energy increases its internal pressure. In the case of solids, this is because of an increase in the amplitude of vibration of the atoms, thereby resulting in an increase in the average distance required between neighbouring atoms. In the case of gases, this is because of an increase in the velocity of the freely moving atoms or

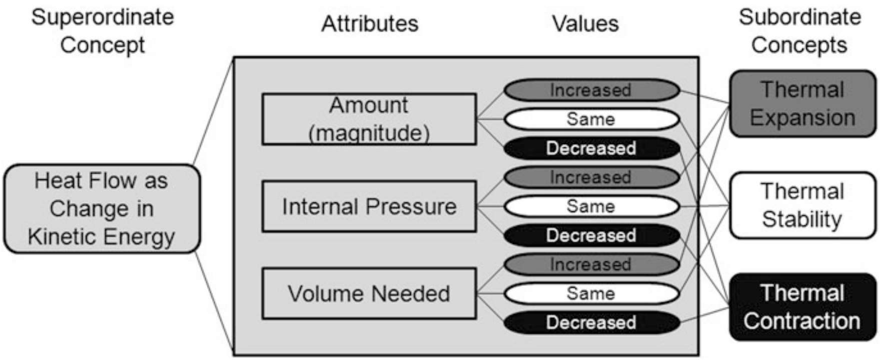

Fig. 4.8 Partial frame for heat flow as change in kinetic energy. This frame illustrates the kinetic explanation of thermal expansion, contraction and stability in terms of changes in the amount of kinetic energy. Different shades indicate that the instantiated values correspond to different subordinate concepts

molecules, thereby resulting in more frequent and more violent collisions with the body's boundaries than before. The result in both cases is an increase in the body's volume, i.e. an expansion. Contraction can be effected by decreasing the amount of kinetic energy present in a body, thereby leading to a decrease of internal pressure and hence to a decrease of the volume needed by those molecules. It will come as no surprise that stability emerges simply by maintaining the amount of kinetic energy contained in a body (see Fig. 4.8).[7]

The two explanations employ radically different conceptions of heat. Even so, they share the same structure. As the amount of caloric particles/kinetic energy in a body increases/decreases/remains the same, the repulsive force/internal pressure of that body increases/decreases/remains the same and that leads to (an) increase/decrease/no change in that body's volume. In other words, the concepts of "heat flow as change in caloric" and "heat flow as change in kinetic energy" are structurally identical in virtue of the correspondence relations that hold between their attributes and values. Thus, to the extent that the caloric explanation of such phenomena amounts to a genuine success, it is a success that survives into the kinetic theory, and, moreover, it can be accounted for in terms congenial to the structural realist viewpoint. The structure of the two explanations is identical save for the fact that the ontological posits of the predecessor theory, i.e. the caloric particles and the caloric's repulsive force, get replaced by those of the successor theory, i.e. kinetic energy and internal pressure. This is exactly what structural realism asserts ought to happen in the history of science. We may thus reasonably conclude that (i) lends credence to structural realism.

[7]Frames higher up the hierarchy for both the caloric and the kinetic theory can be found in Votsis and Schurz (2012). These include the general frames for "heat as caloric" and "heat as kinetic energy".

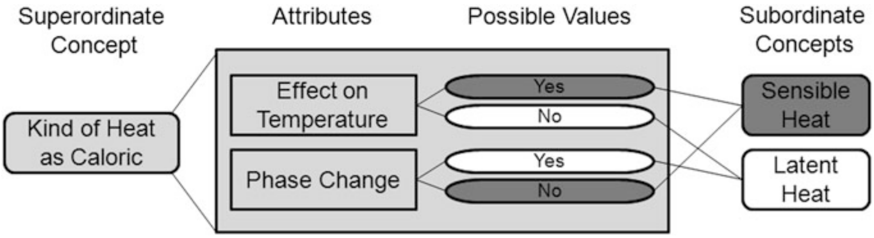

Fig. 4.9 Partial frame for kind of heat as caloric. This frame illustrates the caloric account of phase transition phenomena. Different shades indicate how the instantiated values correspond to the two subordinate concepts

Take next the postulation that a special kind of heat plays a pivotal role in phase transitions. Phenomena concerning phase transitions, e.g. melting, freezing and evaporation, were known for centuries. It was not until the eighteenth century, however, that a peculiar sort of phenomenon was recorded. Joseph Black, an experimentalist and renowned caloricist, observed that when ice melts through the application of heat the temperature of both ice and melted water remains the same. This contradicted the commonly accepted wisdom at the time that adding heat always raises the temperature of a body. In need of an explanation, Black posited that heat can exist not only in a sensible but also in a latent form, i.e. a form unable to influence instruments like thermometers (see Fig. 4.9). He reasoned that during melting the caloric being added to ice is converted from its sensible to its latent form. The latent caloric present in the melted water could then be converted back into its sensible form under the inverse process of freezing. The upshot of this explanation was that it saved the idea that the caloric is a conserved quantity, for any losses in the amount of sensible caloric a given physical system possessed could be accounted for by corresponding gains in the amount of latent caloric. That is, the quantity being conserved was total (sensible and latent) caloric.

Black's distinction between latent and sensible forms of heat has survived into the modern kinetic conception of heat. According to this conception, during phase transitions the temperature of the given physical system remains invariant but latent heat, now understood as a form of energy, is added to or taken away from the system. In the experiment just mentioned, when sensible heat, i.e. kinetic energy, is introduced into ice it does not increase the average kinetic energy of its molecules, i.e. their temperature, but rather acts so as to break up the bonds between those molecules, the result of which is melted water. As with caloric, this heat is not lost but converted into a latent form, namely potential energy, which is stored in the water and is capable of being released when water undergoes freezing (see Fig. 4.10).

Both explanations share structure at the observable level, namely the regularity that a system undergoing a phase transition maintains a constant temperature despite the addition or subtraction of heat. Beyond this observable level, there is also some structure sharing regarding the unobservable mechanism underpinning such

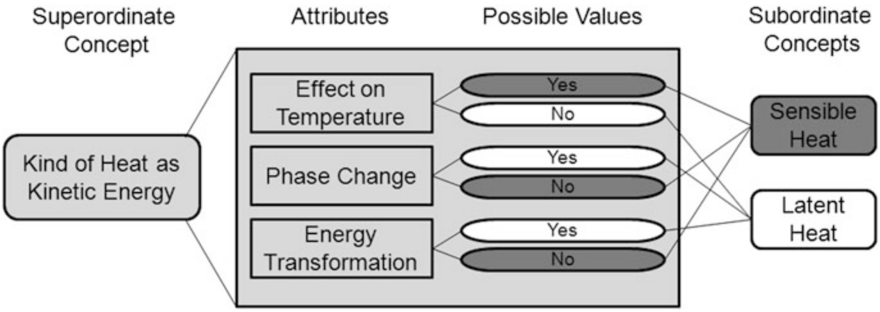

Fig. 4.10 Partial frame for kind of heat as kinetic energy. This frame illustrates the kinetic account of phase transition phenomena. Different shades indicate how the instantiated values correspond to the two subordinate concepts

phenomena. Although no details of this mechanism were given by Black or his fellow caloricists, they at least identified the need for a new unobservable posit, i.e. latent heat, to help them come to grips with the said phenomena. The kinetic theory adopts this unobservable posit and places it in the context of a mechanism that is well understood and independently confirmed, e.g. in terms of how the aggregate state of a body depends on molecular bonds and of what is required for these to break down.[8] The resulting structure convergence is modest, but it is convergence nonetheless. The upshot, once more, is that to the extent that the caloric theory enjoyed some success in explaining phase transitions that success is encoded in structural claims that survived into the kinetic theory of heat.

4.6 Conclusion

The two case studies provide some support for structural realism. Aside from this, they stand testimony to the usefulness of frame theory in finding plausible answers to problems in the philosophy of science. At the same time, our examples show how frame-theory itself can be sharpened and further developed by its application to this field.

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[8]Of course if structural realism is correct then we should only believe in the structural form of the mechanism posited by the kinetic theory.

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Chapter 5
Interests in Conceptual Changes: A Frame Analysis

Xiang Chen

Abstract In this article, I analyze how interests affect the results of scientific change through concept representation and categorization. I first review two models offered by cognitive psychology, which use frames as the representational structure to account for how interests actually affect concept representation and categorization. I then use a historical case from nineteenth-century optics to illustrate how the interests of historical figures influenced their concept representations, then their classifications and finally the results of their theory appraisal. I conclude that the impact of interests on science is constrained by the states of the world and interests alone can never decide the results of scientific change.

Keywords Conceptual changes • Scientific changes • Frame analysis

5.1 Introduction

As a typical problem-solving activity, scientific research is interest-driven, beginning with a selection of a goal and then an assessment to see what must be changed to achieve the goal (Newell and Simon 1972). Thus, interests of individual scientists and scientific communities affect what scientific research ought to achieve and how science should evolve.

Among scholars of science studies, there are two assessments to the roles of interests in the development of science. Sociologists of science in general highly value the importance of interests. They believe that interests of a scientific community are fully responsible for the results of scientific change. Since all

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interests are socially structured, ultimately social interests, rather than the state of the empirical world, determine the development of science (Barnes and MacKenzie 1979).

Philosophers of science, however, are much less enthusiastic to the discussion of interests. They trend to downplay the roles of interests in science, because they are afraid that acknowledging the impact of interests on scientific development would eliminate the role of the empirical world in knowledge production and ultimately deny science as a rational enterprise. When philosophers of science discuss the roles of interests, they carefully define the type of interest that can legitimately play a role in the development of science. Personal and social interests are off the list. They only accept a small number of epistemic interests, such as increasing empirical knowledge (Hempel 1979), providing explanation (Popper 1975), and reaching approximation to the truth (Newton-Smith 1981).

Despite their differences, both the sociological and the philosophical approaches toward interests are built on an assumption that the impact of interests on science is subjective, reflecting solely the desires of people and not constrained by the state of the empirical world. This assumption, however, overestimates the role of interests in scientific change. In this article, I analyze how interests affect the results of scientific change through concept representation and categorization. In the following sections, I first review two models offered by cognitive psychology, which use frames as the representational structure to account for how interests affect concept representation and categorization. I then use a historical case from nineteenth-century optics further to illustrate how differences in concept representations resulted in different taxonomies and eventually different judgments in theory appraisal. I conclude that the roles of interests in concept representation and categorization are far less decisive than what many people believe, and that the impact of interests is not entirely subjective because it is always constrained by the state of the empirical world.

5.2 Interests and Attribute Weights

One way to learn the precise roles of interests in concept representation is to analyze the process of concept combination. Our understanding of the meaning of a concept may not be the same due to different purposes or interests. For example, to those who are watching their weights, their interest to lose weights would modify their concept of food and the related taxonomy of foods – foods are either “appropriate on a diet” or “inappropriate on a diet.” These interest-modified concepts are roughly identical to such adjective-noun conjunctions as ‘low-calorie foods’ and ‘high-calorie foods.’ Hence, it is reasonable to assume that the way that interests modify a concept is similar to the process of forming adjective-noun conjunctions, where an adjective modifies the meaning of a noun to form a new composite concept.

Smith and his cooperators offered a detailed account, a selective modification model, to explain how people combine adjectives and nouns to form composite concepts (Smith et al. 1988). To begin with, this selective modification model requires a frame representation of concepts. A frame is a set of multi-valued attributes integrated by structural relations. Thought highlighting the hierarchical relations between attributes and values, the structural connections between attributes, the constraints between value sets, and attribute weighting, a frame representation can reveal the complexity of intraconceptual relations within a concept.

The frame for the concept of *apple*, for example, has a list of three attributes: *color*, *shape*, and *texture*, which are properties shared by all exemplars of *apple*. Associated with each attribute is a set of values; for example, *red*, *green* and *brown* are the values associated with the attribute *color*, *round*, *square* and *cylinder* with *shape*, and *smooth*, *rough* and *bumpy* with *texture*. Features in the value list are activated selectively to represent the prototype of a specific subordinate concept. For example, a typical apple is an object whose value for *color* is *red, shape* is *round*, and *texture* is *smooth*.

The frame representation uses attribute weighting to indicate the salience of each attribute. Attribute weighting indicates how useful each attribute is in discriminating instances of the concept from instances of contrasting concepts. Consider the frame for *apple*. Since *color* is the most useful attribute in discriminating apples from non-apples, it is given the highest score, and *shape* and *texture* are given lower scores.

Smith also includes indication of the salience of each relevant value. When people are asked to verify whether a property is true of a particular concept, they usually respond faster and more reliable to properties that belong to the prototypes. Because the prototype of *apple* is red, people are faster and more accurate at deciding whether "apples are red" than "apples are green." Thus, *red* is a most salient value and is assigned the highest score, while *green* and *brown* are lower.

The selective modification model assumes that adjective and noun concepts play different and asymmetrical roles in the process of concept combination. Specifically, nouns offer the basic frames to be operated on and adjectives function as modifiers by selecting and changing the corresponding attribute and values in the noun concepts. Consider a process through which *red* and *apple* are combined to form an adjective-noun conjunction – *red apple* (Fig. 5.1). To begin with, the adjective *red* selects the corresponding attribute in the noun, which is *color*. Then, for the selected attribute, there is an increase in the salience of the value given by the adjective. The score of *red* in *color* increases by getting all the scores from other values under the same attribute. The salience of the corresponding value increases because the change from *apple* to *red apple* signals a change in the prototype –*red* is more representative to *red apple* than to *apple*. Furthermore, there is also an increase in the salience of such selected attribute as *color*. This is because there is a change in the perceived contrast class of the concept. As *apple* is changed to *red apple*, the contrast class is also changed from *orange* to *green apple*. In this way, *color* becomes the only discriminating attribute for categorization.

The selective modification model illustrates a possible mechanism to explain how interests affect concept representation. When people try to comprehend a subject,

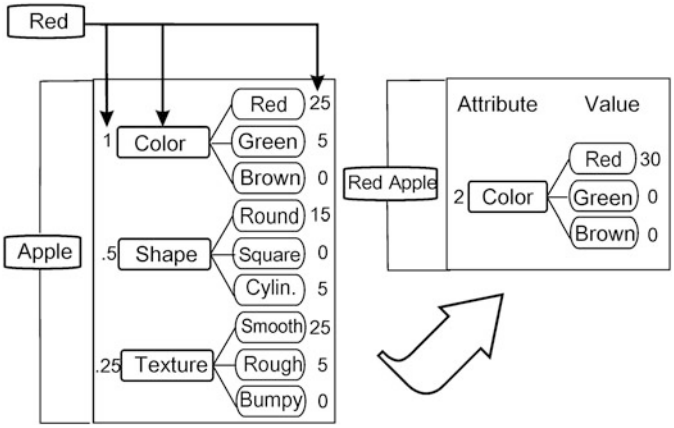

Fig. 5.1 The process of concept combination (Reproduced from Smith et al. (1988))

they always focus on certain aspects of it according to their interests. In the process of conceptualization, they tend to give extra weights to attributes corresponding to their interests, and form an interest-modified concept. Such an interest-modified concept can subsequently change the classification of the field. Many similarity-based models of categorization allow for selective weighting of features, which are equivalent to stretching or shrinking some dimensions of the similarity space. In the process of categorization, those features with extra weights usually cause attention and become classification standards.

5.3 Interests and Optimal Values

We often construct concepts while making plans to achieve goals. Many of these constructed concepts are ad hoc in the sense that they are derived in an offhanded manner to achieve current interests. This process of making concepts in the fly is top-down and creative. Experience from exemplar learning appears irrelevant for ad hoc concepts because little experience with exemplars is necessary. Unlike common taxonomic concepts in which prototypes are represented by central tendency, prototypes of ad hoc concepts are represented by ideals that arise from reasoning with respect to interests (Barsalou 1983). Frequently, these ideals do not really exist; for example, the ideal for *foods to eat on a diet* is *zero calories*.

Barsalou performed an exploratory study to examine how people construct ad hoc concepts to make plans (Barsalou 1991). In the study, Barsalou asked the subjects to describe the processes of planning interest-driven activities, such as taking a trip, making a purchase, repairing a tool, and attending a social gathering. By analyzing the subjects' protocols, Barsalou identified a general procedure for constructing ad hoc concepts to fulfill interests.

Barsalou's analysis also requires a frame representation of concepts. To plan a familiar type of interest-driven activities such as a vacation, people usually first retrieve from their memory a general frame for it. Barsalou found that the subjects' representation of *vacation* contains six attributes: *actors*, *departure time*, *location*, *activity*, *cost*, and *thing to take as gifts*. Among them, some can be further analyzed to form a cluster of attributes at a secondary level. For example, *location* includes a group of specific attributes such as *hemisphere*, *terrain*, *climate*, *scenery* and *popularity*.

After a general frame is available, people begin to instantiate its attributes, that is, to adopt specific values for the attributes. Instantiation is the primary activity of planning, and the results of instantiation, that is, which value is selected for a particular attribute, are determined by the interests that people set up for the planned activity. Specifically, interests set up ideals in the process of instantiation. For example, if to save money is the interest, then the ideal for *cost* would be *zero*, and if to reward myself after receiving the bonus is the interest, then the ideal for *departure time* would be *immediate*. These ideals are specific characteristics that exemplars of *vocation* should have in order to achieve the interests.

Once an ideal is established, it guides the selection of values for the related attribute. They should contain an optimal value that is close or identical to the ideal, and several others that are at various distances from the ideal; for example, when *zero cost* is the ideal, the value set of *cost* should include a lowest possible number as the most desirable value and several others at various distances from *zero cost*. Sometimes, when people highly value an interest, they could further emphasize the optimal value, and regard others from the same value set as equally undesirable. As the result, the value set could have a dichotomous structure, with only a desirable and an undesirable value; for example, when the interest to reward myself after receiving the bonus is very important, the optimal value of *departure time* could be *within days*, and all other values of longer time frames could be simply grouped together under *later*. This is a process of optimization, in which values approximate to ideals set up by the interests are selected.

Figure 5.2 illustrates the process of optimization in constructing *vacation*. First, the interests of privacy and aesthetic enjoyment establish the ideals for *popularity* and *scenery*, and select *minimally popular* and *maximally beautiful* as the optimal values. Similarly, the interests to receive immediate reward and to learn a snow sport select *July* and *skiing* as the most desirable values for *departure time* and *activity*.

After we select the optimal values for some attributes through optimization, these optimal values would impose constraints on the selections of values for other attributes, because concepts must be coherent with compatible value selections. For example, if one has decided that the desirable value of *activity* is *snow skiing*, then one cannot select just any location to instantiate *vocation*. No meaningful concepts can be formed on incompatible values between *activity* and *location*. In this way, the optimal values for *activity* and *departure time* impose constraints on the selections of values for *hemisphere*, *terrain* and *climate*.

Barsalou's analysis illustrates another mechanism to explain how interests affect concept representation. People construct ad hoc concepts to achieve goals defined

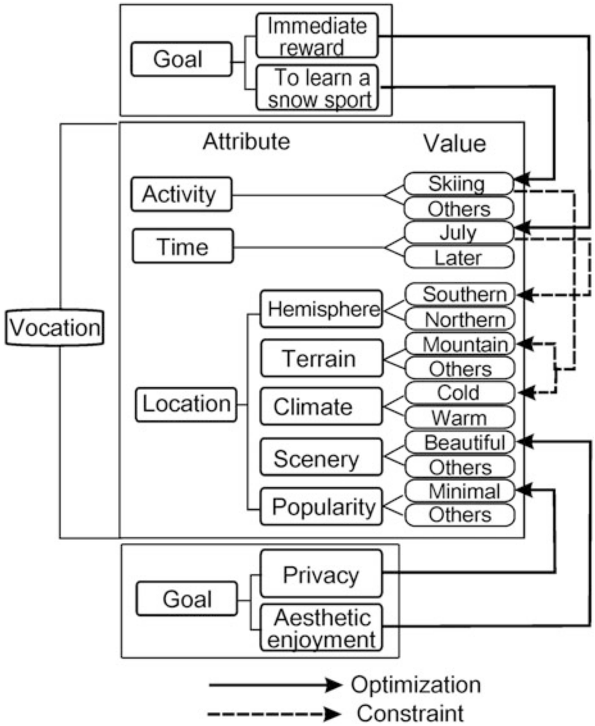

Fig. 5.2 Reconstructing vocation through optimization (Reproduced from Barsalou (1991))

by interests. In this process, interests set up ideas and instantiate a concept through optimizing values and imposing constraints. Constructing concepts in this way would also change the classification of the field. Because we construct ad hoc concepts to reflect interests, instances of ad hoc concepts do not appear to share correlated properties. For example, instances of *things to take from one's home during a fire* may include very different objects such as children, dogs, stereos and blankets (Barsalou 1983). Taxonomies of ad hoc concepts frequently violate the correlational structure of the real world to such a degree that they are no longer accountable by changing the weights of attributes.

The process of optimization also predicts that taxonomies of ad hoc concepts could have a unique structure. Consider the number of possible subordinate concepts under *vacation* without the impact of interests. With six attributes, each having two values or more, there are at least 64 possible property combinations ($2 \times 2 \times 2 \times 2 \times 2 \times 2$), and therefore at least 64 possible subordinate concepts. However, the process of optimization significantly reduces the number of possible subordinate concepts. First, optimization may generate dichotomous values through highlighting the most desirable ones and treating all others as undesirable. Furthermore, optimal values can impose constraints to the selections of values for other attributes. Consequently, interests generate many conceptual gaps in the taxonomic structure; that is, many subcategories of an ad hoc concept do not exist. In some extreme cases where all attributes are either optimized or constrained so that they have only a preferred value, the number of the subcategories could be reduced to one.

5.4 Interests and Theory Appraisal

The optical revolution – the conceptual change from the particle to the wave theory of light in the early nineteenth century – was a good example to illustrate how scientists' interests affected the results of a scientific revolution. Historical studies have indicated that changes of classification systems preconditioned the optical revolution: only after taxonomic changes did the superiority of the wave theory became compelling (Chen 1995). Through this historical episode, we can learn how the communal interests of historical figures first influenced their concepts of *light*, then their classifications of optical phenomena, and finally their judgments of the two rival theories.

On the eve of the optical revolution, the dominant taxonomy was a system built upon the particle concept of *light*. According to the particle tradition, light consists of a sequence of rapidly moving particles susceptible to attractive and repulsive forces defined by the laws of mechanics. Thus the particle concept of *light* contained four attributes: *force* (*attractive* or *repulsive*), *velocity* (*changed* or *unchanged*), *size* (*small* or *large*) and *side* (*orderly* or *random*). Among them, *force* was given the highest weight, because, from the Newtonian point of view, mechanical forces are the causes of all optical phenomena.

Such a concept of *light* defined the taxonomy, which divided optical phenomena into eight categories: *reflection*, *refraction*, *dispersion*, *diffraction*, *Newton's rings*, *double refraction*, *polarization*, and *absorption* (Brewster 1831). This taxonomy highlighted the defects of the wave theory. Because the wave theory could not account for dispersion and absorption but its rival could, there was no reason to replace the particle theory with the wave theory (Brewster 1832).

In 1827, John Herschel introduced a new concept of *light*. Herschel began his optical research as a believer of the particle theory, but he was convinced by the successes of Fresnel's wave theory in the early 1820s. Around 1824, Herschel wrote a comprehensive review essay to introduce Fresnel's wave account to the Britain audience (Herschel 1827). The main purpose of this essay was to present the conceptual framework of Fresnel's account and eventually to revitalize the wave tradition in Britain.

In the early nineteenth century, most supporters of the wave tradition believed that light consists of disturbances in a medium called ether. To describe the motion of a periodic disturbance, they needed four parameters according to the wave equation: *velocity*, *amplitude*, *wavelength*, and *phase difference*. All optical phenomena were supposed to be explained in terms of these four parameters, and no reference to *force* was necessary.

These four wave parameters became the attributes in Herschel's concept of *light*. Herschel gave *wavelength* the highest weight, because it was the only attribute that could represent the typical characters of waves. Both the particle and the wave theories defined *velocity* in the same way, and there were significant similarities between *amplitude* in the wave framework and *size* in the particle framework because both defined intensity of light. In theory, *phase difference* was a unique wave attribute, but Herschel did not understand this notion correctly. He failed to complete the conceptual change from *side* to *phase difference* and continued to adopt the former to represent polarization (Chen 2003). With the interest to revitalize the wave theory in Britain, it was logical for Herschel to emphasize *wavelength* as the key character of light.

Without *force* as a classification standard, it became unnecessary to separate *reflection* from *refraction* – they were just changes of direction. *Dispersion* and *absorption* should belong to the same category, called *chromatics* by Herschel, because both were interactions between light and matters. *Double refraction* was no longer an independent category but under *polarized light*, because what kind of force involved was no longer considered. At the same time, since *wavelength* was assigned the highest weight, phenomena associated with this attribute should be separated and highlighted. In the context of the early nineteenth century, they were the phenomena of interference, diffraction and the Newton's rings. Thus, Herschel formed a new category *interference* to cover these phenomena. At a result, Herschel's concept of *light* generated a taxonomy with four subordinate categories: *direction of light*, *chromatics*, *interference*, and *polarized light*.

Theory appraisal under this taxonomy was in favor of the wave theory. The wave theory was superior because it could successfully explain three major categories except *chromatics*, while its rival failed in two major categories (*interference* and *polarization*). However, Herschel's taxonomy continued to highlight the wave theory's failure in dispersion. When Herschel evaluated the two rival theories, he developed a preference for the wave theory, but he was reluctant to embrace it completely. The explanatory success of the particle theory in dispersion and absorption, which represented an important category, led him to believe that the particle theory was still valuable. In a rather long period after he established his preference for the wave theory, Herschel did not believe that the particle theory should be totally abandoned.

In his report presented to the British Association in 1834, Lloyd introduced another concept of *light* (Lloyd 1834). At the beginning of the 1830s, wave theorists in Britain were under pressure. On the one hand, Brewster used the particle taxonomy as the framework to highlight the difficulties of the wave theory. On the other hand, Herschel continued to believe that the particle theory should not be abandoned. To complete the revolutionary change in optics, wave theorists in Britain had a strong interest in demonstrating the necessity of replacing the particle with the wave theory. Such a general interest was set in the unique context where polarization had become the most exciting research subject in optics. Between the 1810s and the 1820s, a large number of novel phenomena related to polarization was found. The wave theory in general was successful in accounting for polarization, while the particle theory remained cumbersome in this field. Thus, Lloyd adopted a specific tactics to achieve the general interests of the wave camp, that is, he wanted to highlight the wave theory's successes in polarization.

Lloyd's concept of *light* originated from Fresnel's account of polarization. According to Fresnel, the differences between polarized and unpolarized light consisted in the phase difference and the amplitude ratio of the two perpendicular components of the light beam: the two perpendicular components of polarized light always have a fixed phase difference and a fixed amplitude ratio. Thus, polarization could be represented by two attributes: *amplitude ratio* and *phase difference*. To demonstrate the superiority of the wave theory in polarization, Lloyd built an ad hoc concept through a process of optimization, in which the interest of highlighting the wave theory's successes in polarization sets up the ideal of *light*. Given the specific interest, polarized light became the ideal exemplar of *light* in order to demonstrate the superiority of the wave theory. This ideal further determined the value sets of the attributes *amplitude ratio* and *phase difference*. Instead of taking continuous values, they have a dichotomous structure. For *phase difference*, *stable phase difference* is desirable and *unstable phase difference* is undesirable; for *amplitude ratio*, *stable ratio* is desirable and *unstable ratio* undesirable.

Lloyd's concept of *light* generated a taxonomy with a unique dichotomous structure. Lloyd's taxonomy first classified all optical phenomena solely in terms of their states of polarization. *Polarized light* and *unpolarized light* were the only two major categories, and many categories treated as major in other systems, such as *reflection*, *dispersion*, and *diffraction*, now became subcategories, or even sub-subcategories. This taxonomy violated the correlational relations between optical phenomena, with categories cut across the correlational structure of the environment. Instances of *polarized light*, which included propagation and color, did not appear to share correlated properties; instead, they shared many correlated properties with entities in the other category.

Under this new taxonomy, Lloyd was able to make persuasive arguments that the community should abandon the particle theory and adopt the wave theory immediately. By listing the wave theory's successes in both major and secondary categories, Lloyd showed its superiority over the particle theory. Under his system, the wave theory was able to have a total control of one of the two major categories – *polarized light*, in which the particle theory experienced tremendous difficulties. In the other major category – *unpolarized light*, the wave theory had demonstrated its superiority in such secondary categories as *propagation of light and interference*, *diffraction*, and *colors of thin plates*, while the particle theory had no currency at all. At the same time, Lloyd was able to deal with the difficulties of the wave theory. Lloyd admitted that dispersion was the most formidable obstacle to the theory. However, under his dichotomous taxonomy, the troublesome cases of dispersion and absorption became third-level categories. Here, the tacit argument was that dispersion and absorption were no longer relevant to theory appraisal.

5.5 Conclusion

Interests impose genuine and profound impact in concept representation and categorization. Cognitive psychology has provided explanatory frameworks for us to understand how interests actually affect the processes of concept representation and categorization. According to the selective modification model, for example, interests affect the result of concept representation by changing the salience of related attributes and values, as exemplified by the concept of *light* adopted by Herschel on the eve of the optical revolution. According to the studies of ad hoc concepts, interests alter the result of concept representation through a process of optimization and constraint, as demonstrated by the concept of *light* that Lloyd adopted during the optical revolution. With different concept representations, we construct different taxonomies, since classification standards come from superordinate concepts. With different classifications, we make different theory appraisals. The historical example from nineteenth-century optics substantiates the cognitive accounts of the mechanisms that underlie the interest-driven process of classification and verify the role of interests in scientific change in general.

However, the role of interests in the process of concept representation is far less subjective than what had been described by many sociologists and philosophers of science. In representation, people cannot freely modify or construct concepts solely according to their interests. They do not have the freedom to frame a concept out of subjective contemplation, nor can they make purely subjective and arbitrary selections among various possibilities. How interests affect representation is not a purely subjective process, because it is still constrained by the states of the world.

In the process described by the selective modification model, for example, interests can alter the representation of a concept by changing the salience of certain attributes and the weights of certain values under the selected attributes. However, people cannot arbitrarily select and highlight certain attributes or values solely according to their interests. A certain interest can select and modify only those relevant attributes and values, and whether an attribute or a value is relevant is defined by the states of the world. For example, when Herschel modified the concept of *light* according to his interests of introducing the wave theory to the British audience, he had no choice but selecting and highlighting the attribute *wavelength* because this attribute was the only one that reflected the unique features of the wave theory. Furthermore, people cannot increase the salience of attributes and values arbitrarily. They can only increase the scores of attributes and values to degrees consistent with the states of the world. For example, no matter how strong the interest to lose weight is, one can only increase the salience of *low calorie* by combining all the scores from other values under the attribute of *calorie*. Impact of interests on representation is always limited to directions and ranges permissible by the states of the world.

In the process of constructing ad hoc concepts, the impact of interests is extensive, spreading to every attribute through constraints, and interests can select values that do not even exist through optimization. However, the role of interests is still not arbitrary. Interests can establish ideals through optimization, but only those ideals consistent with the environment are accepted. For example, an interest to learn a snow sport in planning a vacation would not establish an ideal of *snow diving*, which is something physically impossible. Similarly, when an interest imposes constraints, it is effective only when causal connections indeed exist between related attributes. The interest to ski in July can restrict the value of *hemisphere* but not that of *popularity*, because there are causal connections between activities in a certain season and geographical locations defined by the physical structure of the earth, but there are no possible causal links between the former and the density of population. Most importantly, though interests have comprehensive influences on concept representation, they do not create concepts. The impact of interests is limited to filling in the details for a frame that has been retrieved from memory and accepted as the starting point of constructing an ad hoc concept. When Lloyd constructed a new concept of *light* according to the interest of highlighting the wave theory's successes in polarization, he used the existing frame for *light* from the wave tradition as the starting point. Through optimizing values and imposing constraints, Lloyd changed the values of two attributes. But the processes of optimization and constraint did not alter the existing list of attributes and the structural relations among them. Experiences based on similarity observations continued to function as a foundation for Lloyd to create a new concept.

The limited and non-arbitrary role of interests in concept representation is consistent with findings regarding perceptually based information in categorization. Cognitive studies have found that observations at the perceptual level frequently interfere with categorization, despite theories having defined them as irrelevant. A classical example is the so-called Stroop interference. When subjects were asked to name the color of a word printed with colored ink, the speed and accuracy of their judgments were affected if the word was the name of a conflicting color, such as the word "red" printed with blue ink – the observations of words interfered with the judgments of colors despite clear instructions (Stroop 1935). Similar evidence also comes from studies of the impact of prior episodes in categorization, where subjects were found to be influenced by observations learned in the training phase, even though they were told specifically to ignore these previous observations and to follow a set of different rules (Allen and Brooks 1991). Thus, even within the limited domain where they are effective, interests are not dominant. Observations at the perceptual level and information about the states of the world continue to influence the processes of representation and categorization, regardless of whether they are consistent with the expectations of interests.

Thus, interests alone never decide the results and directions of scientific change. The concern that acknowledging the role of interests in scientific change would deny science as a rational enterprise overestimates the impact of interests. Such an overestimation originates from a faulty representational method that threats concepts as atomic entities, examining merely the connections between concepts and the relationships between concepts and their referents. Without considering the internal structure of concepts, how exactly interests affect concept representation remains unclear. By using the frame model to illustrate the internal structure of concepts, we learn in which ways interests affect scientific change. We learn that the impact of interests is localized, limited to specific components of a concept, and that the internal structure of a concept as a whole continues to reflect the state of the world. The impact of interests on science is conditioned and constrained by the states of the world. Thus, acknowledging the role of interests in scientific change does not imply that science is no longer a rational enterprise.

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Part III
Event Frames and Lexical Decomposition

Chapter 6
FrameNet, Frame Structure, and the Syntax-Semantics Interface

Rainer Osswald and Robert D. Van Valin Jr.

Abstract The Berkeley FrameNet project aims at implementing Fillmore's Frame Semantics program on a broad empirical basis. The syntactic environments of words in corpora are systematically aligned with the semantic frames evoked by the words. It is Fillmore's vision that such a collection of valency data can pave the way for an empirically grounded theory of the syntax-semantics interface. In this article, we examine to what extent this goal can be achieved by the FrameNet approach in its present form. We take a close look at verbs of cutting and separation and at the representation of events and results in the latest FrameNet version. Our investigation reveals a certain lack of systematicity in the definition of frames and frame relations, which may hinder the derivation of linking generalizations. This situation seems to be partly due to the expectation that a system of frames can be developed on a data-driven, purely bottom-up account. As a possible solution, we argue for a richer frame representation which systematically takes into account the inner structure of an event and thereby inherently captures structural relations between frames.

Keywords Syntax-semantics-interface • FrameNet • Relations between frames • Structure of frames

6.1 Introduction

In the context of lexical semantics, the notion of frame is mostly associated with the research program known as Frame Semantics initiated by Charles Fillmore (1982). Its basic idea is that words, in each of their senses, are linked to frames, which are schematic cognitive structures that represent a speaker's knowledge of the described

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situation or state of affairs. An important part of the program is to study in detail how the components of the frames are expressed in the morphosyntactic environment of the word. To this end, the relationships between word senses and lexico-syntactic patterns are systematically recorded, and each of these patterns has its components indexed with specific parts of the associated frame (Fillmore and Atkins 1992).

Frame Semantics has been put into practice in the Berkeley FrameNet project (Fillmore et al. 2003, Fillmore and Baker 2010). The main goal of FrameNet is to systematically collect syntactic and semantic valency patterns based on extensive corpus annotation. In this respect, the focus of the project is first and foremost descriptive. But the project has also an important "inventive" part in providing appropriate frames for the annotation. While there are a number of guidelines for introducing frames based on identifying groups of semantically related words (Ruppenhofer et al. 2010, Chap. 2), there is no explicated framework of semantic analysis for the specification of more abstract frames and frame-to-frame relations. We will see below that many inconsistencies in FrameNet's frame structure may be attributed to this lack of a general top-down strategy.

Fillmore (2007) characterizes the FrameNet project as an empirical investigation into the interplay between lexical semantics and morphosyntactic realization. As with any scientific investigation, the point is not only to sample as much data as possible but also to look for regularities and generalizations, that is, for a theory that explains the data. The theory in question is a theory about argument linking and the syntax-semantics interface of lexico-syntactic constructions. In fact, Fillmore has the vision that Frame Semantics as implemented in FrameNet can provide a basis for deriving linking generalizations. The underlying assumption is that FrameNet will ultimately be equipped with an elaborate frame hierarchy and that linking generalizations can then be formulated in terms of abstract frames for action, change, causation, and the like.

We will critically examine whether Fillmore's vision is supported by the present architecture of FrameNet.[1] A crucial problem turns out to be the relative lack of systematicity in semantic analysis. We provide evidence for this claim by revealing various deficiencies in the frame representation of causation and inchoation and of events and changes in general, and in the representation of verbs of cutting and separation. We sketch how a more explicit decompositional approach to frame semantics could potentially overcome many of these problems. In particular, we argue that the internal structure of an event or state of affairs should be reflected within the frame representation itself. We will also point out that FrameNet's current restriction to associating frames with lexical items may run into difficulties even for elementary constructional variations.

[1]It is worth mentioning that FrameNet has gained some popularity among computational linguists as a lexical semantic resource in systems for textual inference and the like. This is not surprising in view of the fact that most current natural language understanding systems combine various, often statistically trained processing components and are in need of any kind of information about lexical semantic classes and possible paraphrases.

All FrameNet data discussed in the following are taken from FrameNet Version 1.5 of September 21, 2010, which includes more than 1,000 frames, almost 12,000 word senses (lexical units), and over 8,000 instances of frame-to-frame relations. We speak of 'FN 1.5', if we refer to this specific release, and of 'FrameNet', if we mean the project in general. A word of caution: We are fully aware that an intermediary release of an ongoing large-scale project like FrameNet inevitably shows gaps and inconsistencies.[2] We therefore try to distinguish between temporary issues that can easily be remedied during the next revision cycle and potential inherent problems of the approach itself. Despite its shortcomings, we regard the FrameNet project as an important contribution to developing an empirically grounded theory of lexical semantics and linking. And, of course, the present study would not have been possible without the generous policy of the FrameNet group to make their data publicly available.

6.2 Frame Semantics and FrameNet

6.2.1 From Case Frames to Frame Semantics

Fillmore's (1968) early 'case grammar' approach builds on the concept of *case frames*, whose underlying idea was to characterize the valency of verbs by a small set of semantic roles from which the syntactic valency can be predicted by general rules. In later writings, Fillmore conceded that this approach falls short in several respects (cf. Fillmore 2003). For one thing, it turned out to be difficult, if not impossible, to come up with a stable inventory of semantic case roles together with reliable criteria for assigning them to the participants of the situation described by a verb or any other valency bearing lexical item. Another issue is the unique role assignment in cases of complex event descriptions like (1), where *the ball* is both the Goal of the 'hitting' component and the Theme of the 'go-over' component.

(1) Peter knocked the ball over the fence.

As a consequence, the notion of frame laid out in his *Frame Semantics* approach (Fillmore 1982) aims at a much broader and deeper conceptual-semantic description of lexical items than provided by course-grained semantic role frames. *Frames* in this context are to be understood as "schematic representation[s] of speakers' knowledge of the situations or states of affairs that underlie the meanings of lexical items" (Fillmore 2007, p. 130) or as "situation types for which the language

[2]A good part of the FrameNet data has been gathered by full text annotation (Ruppenhofer et al. 2013), which is a particularly demanding and, hence, error-prone task.

has provided special expressive means" (Fillmore and Baker 2010, p. 321).[3] The program of Frame Semantics has been elaborated in a series of detailed case studies on the meaning and use of individual verbs and narrow verb classes (cf., e.g., Fillmore and Atkins 1992). Although these studies emphasized the correlation of particular lexical meanings with specific morphosyntactic patterns, they did not aim at an explanatory account of the relation between (morpho-)syntax and semantics. In particular, no attempt has been made to derive generalizations on this interaction that go beyond the discussion of selected examples.

6.2.2 The FrameNet Project

The FrameNet project, which started in the late 1990s, is intended as a broad coverage, corpus-based implementation of the Frame Semantics program (Fillmore et al. 2003, Fillmore and Baker 2010). According to Fillmore (2007, p. 129), the project's main focus is on valency descriptions in syntactic and semantic terms, that is, on exploring the correlation between lexical semantics and syntactic argument realization:

> The FrameNet project is dedicated to producing valency descriptions of frame-bearing *lexical units* (LUs), in both semantic and syntactic terms, and it bases this work on attestations of word usage taken from a very large digital corpus. The semantic descriptors of each valency pattern are taken from frame-specific semantic role names (called *frame elements*), and the syntactic terms are taken from a restricted set of grammatical function names and a detailed set of phrase types.

Frames in the context of FrameNet are thus plain semantic role frames, similar to the earlier case frames, except that there is no universal role inventory anymore since the semantic roles are specific with respect to the frame they belong to.

6.2.2.1 The Specification of Frames in FrameNet

The description of a frame in the FrameNet database includes the following components: the name of the frame; an informal definition of the situation the frame is supposed to represent; the set of semantic roles (*frame elements*) associated with the frame, subdivided into *core* and *non-core* elements; and the corresponding word senses (*lexical units*) that evoke the frame. Core roles are those which are "necessary to the central meaning of the frame" (Fillmore 2007, p. 133). Non-core roles are subdivided into *peripheral* and *extrathematic* elements. Peripheral roles mark notions such as time, place, manner, means, and the like. They are not unique

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[3]Similarly, Fillmore and Baker (2010, p. 317): "In Frame Semantics, the meaning dimension is expressed in terms of the cognitive structures (frames) that shape speakers' understanding of linguistic expressions."

Table 6.1 Partial description of the Cutting frame in FN 1.5

Cutting

Definition: An [Agent] cuts an [Item] into [Pieces] using an [Instrument] (which may or may not be expressed).

Core frame elements:

Agent	The [Agent] is the person cutting the [Item] into [Pieces].	
Item	The item which is being cut into [Pieces].	
Pieces	The [Pieces] are the parts of the original [Item] which are the result of the slicing.	

Non-core frame elements:

Instrument	The [Instrument] with which the [Item] is being cut into [Pieces].	
Manner	[Manner] in which the [Item] is being cut into [Pieces].	
Result	The [Result] of the [Item] being sliced into [Pieces].	(extrathematic)
In addition: Means, Purpose, Place, Time		

Lexical units: *carve*, *chop*, *cube*, *cut*, *dice*, *fillet*, *mince*, *pare*, *slice*

to a frame but can modify any frame of the appropriate type. Extrathematic roles are used to annotate a "word or phrase which can be thought of as introducing a new frame, rather filling out the details of the frame evoked by the head" (Fillmore 2007, *ibid.*). An example of an extrathematic role is Depictive, which is used to mark depictive secondary predicates. Furthermore, FrameNet allows the characterization of "role fillers" by semantic types.

Table 6.1 shows part of the specification of the Cutting frame, which is evoked by (appropriate senses of) the verbs *cut*, *chop*, etc. The element Result is the only extrathematic role among the non-core elements. Some of the frame elements carry semantic types, which are not shown in the Figure. For example, Agent and Instrument are typed as Sentient and Physical_entity, respectively.

6.2.2.2 Annotation Scheme

One of the goals of FrameNet is to provide all lexical units of a frame with a representative set of corpus-based example sentences, which are annotated both syntactically and semantically. The semantic annotation consists basically in the assignment of frame elements to constituents of the example sentences. The syntactic annotation comprises a phrasal and a functional level. The phrasal level employs fairly standard phrase type markers (NP, PP, AVP, etc.; cf. Atkins et al. 2003), while the functional level uses grammatical functions such as External, Object, and Dependent.

The sentences in (2) are corpus examples from FN 1.5 that are associated with the lexical unit *slice* of the frame Cutting.

(2) a. Slice the cake lengthwise into two halves, to give two long, thin cakes.
b. Slice the onions fairly fine.
c. The frozen brain is [...] sliced sequentially into very thin sections.

The annotation report for sentence (2a) is shown in (3). CNI stands for 'constructional null instantiation', which indicates that the core role Agent is omitted on syntactic grounds, here, because of the imperative.[4]

(3)

	Item	Manner	Pieces	Purpose	Agent
Slice	the cake	lengthwise	into two halves,	to give two long, thin cakes.	CNI
	NP	AVP	PP[into]	VPto	
	Obj	Dep	Dep	Dep	

6.2.2.3 Frame-to-Frame Relations

FrameNet frames are not isolated units but are related to each other in various ways. FrameNet employs eight different types of relations between frames, of which seven are relevant to the present study. They fall into three groups (Fillmore and Baker 2010): generalization relations (inherits from, is perspective on, uses), event structure relations (is subframe of, precedes), and "systematic" relations (is causative of, is inchoative of).[5]

Inheritance is the strongest relation between frames. If a frame (the *child* frame) inherits from another frame (the *parent* frame) then all frame elements (semantic roles) of the parent frame occur as frame elements of the child frame, possibly under a different name. The possible difference in naming reflects the fact that FrameNet assumes frame-specific semantic roles. In the case of inheritance, the semantic type of the child is a subtype of the parent, and the same condition holds for all role filler types. For example, the frame Cutting inherits from the frame Intentionally_affect, with the Item element of Cutting bound to the Patient element of Intentionally_affect and all other element names kept equal. And the frame Commerce_buy inherits from Getting, with the roles Buyer, Goods, and Seller bound to Recipient, Theme, and Source, respectively. Figure 6.1 shows a simplified representation of these examples, with only some of the core roles listed. Frames are depicted as attribute-value matrices and co-indexing indicates the correspondence between roles.

[4]The FrameNet annotations identify two further types of omissions of core frame elements, called *definite* and *indefinite null instantiations*; cf. Fillmore (1986).

[5]The eighth relation is the 'See also' relation, which is used for cross-referencing purposes.

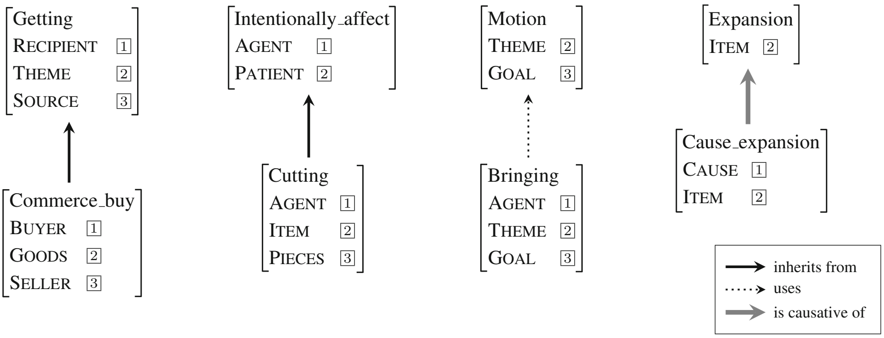


Fig. 6.1 Simplified examples of frame-to-frame relations in FN 1.5

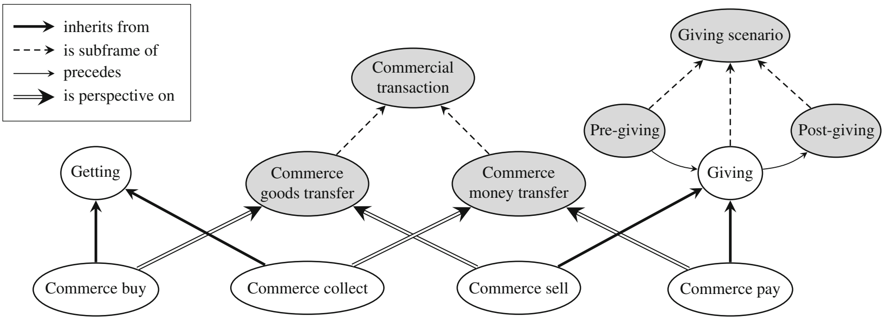


Fig. 6.2 Commercial transaction in FrameNet (*shaded nodes* indicate non-lexical frames)

The 'is perspective on' relation implements the ideas of profiling and figure/ground distinction.[6] A widely discussed example in the FrameNet literature is the commercial transaction scenario, where buying and selling are regarded as taking different perspectives on the transfer of goods, while paying and collecting take different perspectives on the transfer of money[7]; see Fig. 6.2. Frames that have perspectives are often abstract or *non-lexical* in that they are not directly evoked by lexical units but via one of their perspective-taking frames.

The 'uses' relation is defined somewhat vaguely. According to Ruppenhofer et al. (2010, p. 78), this relation "is used almost exclusively for cases in which a part of the scene evoked by the Child refers to the Parent frame", Fillmore and Petruck (2003, p. 361) describe it as a "relation like Inheritance, but less strictly defined", and Fillmore and Baker (2010, p. 330) posit that the child frame "depends upon

[6]Cf. Fillmore et al. (2001, p. 16): "Profiling [. . .] is the presentation of the foregrounded part of a frame [. . .] which figures centrally in the semantic interpretation of the sentence within which the frame is evoked."

[7]But see Van Valin (1999, p. 387), where it is argued that *buy* and *sell* are not simple shifts of perspective.

background knowledge provided by the parent frame" and that some but not all of the core roles of the parent must correspond to roles of the child frame. For instance, the frames Bringing and Removing use the frame Motion with the Agent role of Bringing and Removing not bound to any role of Motion, while the roles Theme, Goal, Path, and several others have direct correspondents (cf. Fig. 6.1).

The 'is subframe of' relation holds between a pair of frames if the first frame represents a subevent of the (complex) event represented by the second frame. Figure 6.2 shows two instances of subframe structures. The frame Commercial_transaction has the subframes Commerce_goods_transfer and Commerce_money_transfer. Apparently, there is no clear temporal precedence between the events denoted by these two subframes. This is different for the subframes of the Giving_scenario frame. They represent a temporal succession of states and events, which is indicated by the 'precedes' relation.[8] Note that it remains unclear how exactly "subevent" in the subframe definition differs from "part of the scene" in the 'uses' definition.

The 'is inchoative of' and 'is causative of' relations, finally, hold between pairs of frames of which the first denotes respectively the inchoative and the causative of the event denoted by the second frame. For instance, the frame Cause_expansion is causative of the frame Expansion, and Becoming_detached is inchoative of Being_detached. The two relations will be discussed in more detail in Sect. 6.3.2.[9]

6.2.3 Frame Semantics and Linking Generalizations

Fillmore's early case frame approach was a proposal to explain the morphosyntactic realization of a verb's arguments in terms of general semantic characteristics of the verb. Because of the problems mentioned in Sect. 6.2.1, Fillmore abandoned the idea of universal case roles in favor of his Frame Semantics program with its richer notion of lexical meaning and its dedication to a broad coverage of realization patterns. Exploring the regularities of the interaction between lexical semantics and morphosyntax nevertheless continues to be an essential goal of the program, and thus also one of the FrameNet project. Accordingly, Fillmore (2007, p. 157) assumes that FrameNet can give rise to linking generalizations if abstract frames and frame-to-frame relations are appropriately defined:

> The structure of the system of frame-to-frame relations is set up, but the details have not been completed as of this writing. *Many FrameNet frames are elaborations of more*

[8] Although not shown in Fig. 6.2, the Getting frame is part of a similar change scenario. The easiest way to get an overview of the frame relations in FrameNet is to use the FrameGrapher tool available at the project website http://framenet.icsi.berkeley.edu. (Note that the online version might differ from the FN 1.5 release discussed here.)

[9] For a more formal analysis of the FrameNet relations in terms of logical axioms see Scheffczyk et al. (2010) and Ovchinnikova et al. (2010).

> *abstract schemas of change, action, movement, experience, causation, etc., and the roles found in these are the ones that figure in linking generalizations;* many of the more refined frames can be seen as perspectives on the more abstract frames, in the way that buying is a subtype of getting, selling and paying are kinds of giving, etc. Generalizations based on inferences about who possesses what before and after the transaction depend on the roles in the commercial transaction; *generalizations about how syntactic roles are assigned to the arguments depend on the more abstract inherited schemas.* [emphasis added][10]

Fillmore and Baker (2010, pp. 332f) illustrate this idea with an example from the commercial transaction scenario shown in Fig. 6.2. They argue that the verbs *buy* and *collect* are used with the preposition *from* because "buying and collecting are getting," and that *sell* and *pay* allow the dative alternation because "selling and paying are giving." That is, the fact that Commerce_buy and Commerce_collect inherit from Getting is employed to explain the respective realizations of the Seller and the Buyer by a *from*-PP. A glance at Commerce_collect in FN 1.5 shows some of the complications this proposal is faced with in practice. The Commerce_collect frame has the units *bill*, *charge*, and *collect* (of which only *charge* is annotated). Neither *bill* nor *charge* allow the "getting-from" pattern – simply because none of them is a getting verb. Billing and charging have to do with communicating the demand for money to the buyer. Hence, *bill* and *charge* are more like verbs of giving and, in fact, *charge* allows the dative alternation. What we have encountered here is a defect in FN 1.5 but not necessarily one in FrameNet. The problem can be remedied by removing *bill* and *charge* from Commerce_collect, thereby keeping the inheritance from Getting. Now, what to do with *bill* and *charge*? Clearly, these verbs should evoke some frame in the commercial transaction domain. But the frame system shown in Fig. 6.2 is not subtle enough to cover the respective component of a commercial transaction, which could roughly be described as "assigning debt of payment." This discussion illustrates that while frame inheritance might indeed give rise to linking generalizations, the approach is very sensitive to the adequate specification of frames and frame-to-frame relations.

6.3 The Representation of Events and States

6.3.1 Events and Changes

According to Fillmore and Baker (2010, p. 331), FrameNet adopts, for the most part, a "simple three-state model of event structure, with a pre-state, a central change, and a post-state," of which "typically, only the central, changing part of the event is

[10] In an earlier, more programmatic publication on the FrameNet project, one of its central goals is described as follows: "As much as possible, we wish to show that the particular valence profiles of individual words can often be best understood with reference to the multiple frames which enter into their semantic structure." (Fillmore and Atkins 1998).

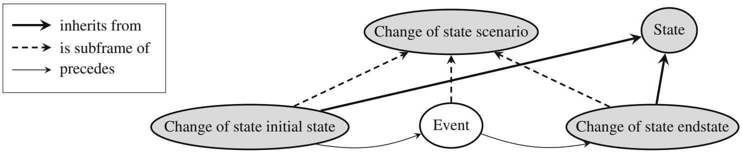


Fig. 6.3 FN 1.5 top level event structure (*shaded nodes* indicate non-lexical frames)

profiled, and, hence lexicalized." We have seen this structure in Fig. 6.2 instantiated by the Giving_scenario frame and its subframes. Its abstract correlate is shown in Fig. 6.3. The precise interpretation of this frame-to-frame structure in terms of the represented situation types raises a number of questions. Does the structure in Fig. 6.3 imply that each situation of type Event is necessarily part of a situation of type Change_of_state_scenario? If yes, then this property should somehow be reflected in the definition of the Event frame. According to the FN 1.5 definition shown in Table 6.2, nothing seems to be required of situations of type Event except that something happens; that is, situations of this type are dynamic, not static. Correspondingly, the associated verb units are general verbs of occurrence such as *happen* and *take place*.

There are basically two ways of conceiving the Event frame in its relation to change of state scenarios. On one interpretation, the frame covers all kinds of dynamic situations, including processes and activities like motion in place (*rotate*, *vibrate*) and directed perception (*watch*, *listen*), which are usually not regarded as changes of state in the proper sense. On a second, more restrictive interpretation, any situation of type Event involves a *conceptually salient* change, typically manifested on one of the participants.[11] The two options should give rise to different sets of frames that inherit from Event. The direct inheritance daughters of Event in FN 1.5 are shown in (4).

(4) Becoming, Birth, Ceasing_to_be, Change_of_consistency, Coming_to_believe, Eventive_affecting, Experience_bodily_harm, Getting, Go_into_shape, Intentionally_act, Misdeed, Process_end, Process_pause, Process_resume, Process_start, Process_stop, Rotting, Transitive_action, Waking_up.[12]

The first thing to notice about this list is its heterogeneity. We can ascribe this to the fact that FrameNet is still under construction, and presumably also to the lack of an elaborate and precise guideline on how to organize the frame inheritance hierarchy. As to the question of whether Event subsumes all sorts of events or only changes of state, the frames listed in (4) give a mixed impression. The wide interpretation of Event is supported by the fact that Intentionally_act is inherited by

[11] Note that it is not the physicalistic notion of change which is relevant here. In the physical sense, progression of time is always accompanied by changes of state.

[12] As of January 25th, 2012, the frames Motion and Objective_Influence have been added to this list.

Table 6.2 Definitions of general situation frames in FN 1.5, with associated verb and noun units

Event: An [Event] takes place at a [Place] and [Time].

go on, *happen*, *occur*, *take place*, *transpire*; *development*, *event*

State: An [Entity] persists in a stable situation called a [State].

(Non-lexical)

Change_of_state_scenario: This frame denotes simple [Event]s in which an [Entity] punctually or continually changes in the direction of the Endstate.

(Non-lexical)

Change_of_state_endstate: The endstate of a simple event X-schema.[13]

(Non-lexical)

Becoming: An [Entity] ends up in a [Final_state] or [Final_category] which it was not in before.

become, *end up*, *form*, *get*, *go*, *grow*, *turn*

Process: This frame describes a complex event which lasts some amount of time, consisting of a beginning stage, a stage where the process is ongoing, and a finish or end. In some cases the process may pause, and then possibly resume.

process (N)

Activity: This is an abstract frame for durative activities, in which the [Agent] enters an ongoing state of the [Activity], remains in this state for some [Duration] of [Time], and leaves this state either by finishing or by stopping. The [Agent]'s [Activity] should be intentional.

(Non-lexical)

Intentionally_act: This is an abstract frame for acts performed by sentient beings. It exists mostly for FE inheritance.

act, *carry out*, *conduct*, *do*, *engage*, *execute*; *action*, *activity*, *act*, *actor*, *agent*, *doing*, *measures*, *move*, *perform*, *step*

Perception_active (*watch*, *listen*) and Practice (*practice*, *rehearse*), both of which do not count as proper change of state frames in the sense discussed above. On the other hand, the frame Process_continue (*go on*, *proceed*) is not included in the list (nor subsumed by one of its members) and neither is Moving_in_place (*rotate*, *vibrate*). Moreover, there are obvious cases of change of state frames such as Undergo_change (*change*, *turn*) and Change_of_phase (*freeze*, *melt*) which do not inherit from Event. In sum, FN 1.5 provides no coherent picture about how dynamic situations are to be distinguished with respect to their change-of-state character. It is also indicative that the frame Process and its inheritance daughter Activity are not systematically employed for structuring the inheritance hierarchy. And the same is true of the frame Becoming, which is inherited by a single frame only, namely, Absorb_heat.

The foregoing shortcomings of the FN 1.5 frame hierarchy may be remediable to some extent by a thorough revision and extension of the frame-to-frame inheritance

[13] 'X-schema' is short for 'executing schema'; cf., e.g., Chang et al. (2002)

relations.[14] For instance, if the Event frame is to be conceived of as covering all kinds of dynamic situations, then it seems reasonable to require that every frame representing a dynamic situation type inherits (directly or indirectly) from Event. In this case, the above observations that some dynamic situations are not subsumed by Event would simply be due to missing inheritance relations which remain to be added to the database. The frames Process, Activity, Change_of_state_scenario, etc. would then all inherit from Event. But the question as to whether there is a distinction between event frames that inherently encode a goal or result and those which do not still needs to be answered. Put differently, is the telic/atelic distinction, or a more refined Aktionsart classification, part of the representation of situation types in FrameNet? Whatever the answer is, there should be clear criteria for deciding whether a given situation type is subsumed by, say, Process, Change_of_state_scenario, or none of the two. In fact, there are good reasons to have Aktionsart distinctions represented in FrameNet because of their relevance both for natural language reasoning (Im and Pustejovsky 2010) and for formulating generalizations about the syntax-semantics interface (Van Valin 2005).[15]

6.3.2 Causatives and Inchoatives

The names of about 30 frames in FN 1.5 start with ‘Cause’. They range from general frames like Cause_change (with lexical units *alter*, *change*, *convert*, *modify*, *turn*, etc.) to fairly specific ones like Cause_to_wake and Cause_to_be_dry. As to be expected, many of these “cause” frames are causatives of other frames; e.g., Cause_change is causative of Undergo_change (*change*, *shift*, *turn*, etc.). Further causative pairs are listed in Table 6.3. The verbs in the right column occur in both frames, that is, they undergo the causative-inchoative alternation. A number of the “Cause frames” are not causatives of other frames, even if there are clear candidates available. For example, there is no ‘is causative of’ relation between the frames Cause_to_wake and Waking_up. Also, one would expect that the frames Cause_change and Undergo_change are somehow related to – if not inherited by – more specific frames such as Cause_change_of_phase and Change_of_phase, respectively, which is not the case. As to inchoatives, there are transparent chains from causative to inchoative to result state as illustrated by the following examples:

[14]The frame-to-frame relations in the FrameNet database are subject to continuous revision; cf. Petruck et al. (2004).

[15]It is worth mentioning that the foundational upper-level ontology DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering; cf. Gangemi et al. 2002), which is used by Ovchinnikova et al. (2010) in their ontological analysis of FrameNet, basically follows Vendler’s (1957) Aktionsart typology in subdividing situations (“perdurants”) into events and statives, events further into accomplishments and achievements, and statives into states and processes.

Table 6.3 Some causative-inchoative pairs in FN 1.5, together with alternating verb units

Cause_change	Undergo_change	*change*, *turn*
Cause_change_position_on_a_scale	Change_position_on_a_scale	*grow*, *increase*
Cause_temperature_change	Inchoative_change_of_temperature	*cool*, *heat*, *warm*
Cause_change_of_phase	Change_of_phase	*freeze*, *liquefy*, *melt*
Cause_change_of_consistency	Change_of_consistency	*clot*, *harden*, *thicken*
Cause_expansion	Expansion	*grow*, *lengthen*
Cause_to_move_in_place	Moving_in_place	*rotate*, *spin*, *vibrate*
Cause_fluidic_motion	Fluidic_motion	*drip*, *splash*
Attaching	Inchoative_attaching	*attach*, *stick*
Detaching	Becoming_detached	*detach*, *unhook*
Cause_to_amalgamate	Amalgamation	*fuse*, *meld*, *unify*
Separating	Becoming_separated	*separate*, *split*

(5) a. Attaching, Inchoative_attaching, Being_attached
b. Cause_temperature_change, Inchoative_change_of_temperature, Temperature
c. Cause_change_position_on_a_scale, Change_position_on_a_scale, Position_on_a_scale

But it also happens that the inchoative frame is missing in the chain: Cause_to_be_dry is causative of Being_dry and the frame Becoming_dry is not related to either of the them (cf. Table 6.4 and the discussion in Sect. 6.3.3 below).

As in the case of event inheritance discussed in the previous section, one might argue that the foregoing deficiencies could be easily remedied without changing the present set-up of the FrameNet project by successively adding missing frames and frame-to-frame relations and by eliminating inconsistencies. The point we want to make is that this task could strongly profit from a systematic decompositional analysis of event frames. Notice that decompositional structure is already captured in FN 1.5, to some extent, by the naming of the frames. Several names of the causative frames listed in Table 6.3 are regularly built from the names of their inchoative correlates by adding the prefix 'Cause'. However, there is obviously no general convention for naming frames – compare, e.g., Inchoative_attaching vs. Becoming_detached. While naming is, in principle, irrelevant to the content of FrameNet, a consistent naming convention would help to avoid many of the deficiencies of the 'is causative of' and 'is inchoative of' frame-to-frame relations mentioned above. Whether one of these relations holds between two frames could then be deduced from the names of the frames. Also, cases like Becoming_dry being not related to Being_dry would not occur. One of the arguments in favor of a decompositional frame analysis is thus the inherent support for organizing the frame hierarchy in a systematic way. A second argument, to be sketched in Sect. 6.3.3 below, is the role the decompositional structure can play in deriving linking generalizations.

A more intricate issue for the systematic treatment of causation and inchoation turns up with the Change_of_phase frame and its associates. As shown in Fig. 6.4,

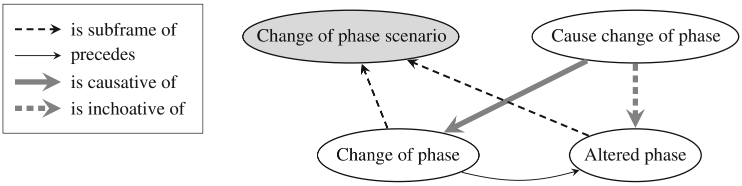


Fig. 6.4 FrameNet frames representing changes of phase

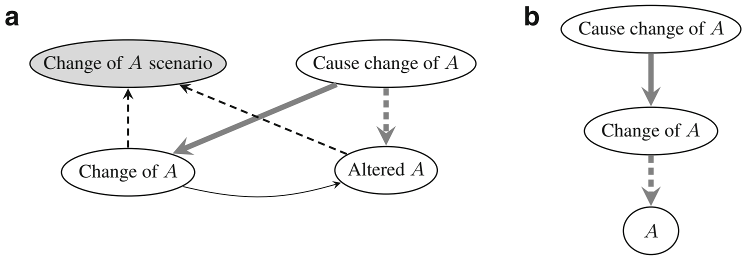


Fig. 6.5 Different FN 1.5 representations of the causation/inchoation/state pattern

Table 6.4 Definitions of FN 1.5 frames of drying, with associated verb and adjective units

Cause_to_be_dry: An [Agent] causes a [Dryee] (...) to become dry. ...	
	anhydrate, *dehumidify*, *dehydrate*, *desiccate*, *dry off*, *dry out*, *dry up*, *dry*
Becoming_dry: An [Entity] loses moisture with the outcome of being in a dry state.	
	dehydrate, *dry up*, *dry*, *exsiccate*
Being_dry: An [Item] is in a state of dryness.	
	dehydrated, *desiccated*, *dry*, *parched*, *waterless*

the causative frame is inchoative of the frame Altered_phase (*frozen*, *liquefied*, *melted*, etc.), which is preceded by the frame Change_of_phase, and there is an additional "scenario frame" with Change_of_phase and Altered_phase as subframes. Figure 6.5a depicts the general structure behind Fig. 6.4, namely the change of an object with respect to an attribute A – here, the object's phase or state of matter. By comparison, the corresponding case of the attribute temperature (5b) follows basically the pattern shown in Fig. 6.5b. The state characterizations in (a) and (b) differ substantially: States of affairs of type 'A' are about an entity having its attribute A specified to a certain value. For instance, the Temperature frame has the adjective units *cold*, *hot*, *warm*, etc., which can be used to characterize the temperature of an entity, either in pre-nominal position or in a copula construction. States of affairs of type 'Altered A', by contrast, depend on a previous alteration event. If applied to temperature, the respective "Altered temperature" frame would presumably cover the participles *cooled*, *heated*, and *warmed*. The frame structure shown in Figs. 6.4 and 6.5a conceives of the resulting state as being a part of a change of state scenario in much the same way as outlined by the general event model in Fig. 6.3. The question, then, is whether all change of state frames are sought to be systematically paired with corresponding result state frames and, even more crucially, how these result frames are related to their event-independent counterparts, if existent.[16] That is, should FrameNet provide different state frames for *dried* and *dry*, *warmed* and *warm*, or *liquefied* and *liquid*, respectively?[17] In the following section, we will argue that these issues can be resolved, up to a point, by representing the components of an event type within the frame itself.

6.3.3 Toward a Decompositional Frame Semantics

Many current theories of the syntax-semantics interface rely on semantic decomposition.[18] Almost all of these proposals involve relatively shallow, term-based decompositions. Two notational variants of such a decomposition of causative *dry* are shown in (6), formulated along the lines of Van Valin and LaPolla (1997) and Rappaport Hovav and Levin (1998), respectively.

(6) a. $[\mathbf{do}(x, \varnothing)]$ CAUSE [BECOME $\mathbf{dry}(y)$]

b. [x ACT] CAUSE [BECOME [y ⟨*DRY*⟩]]

Decompositional representations of this type try to make explicit the semantic factors that play a role in argument realization, including causal and aspectual factors as well as notions such as volitionality and the like. Many theories of linking are based on semantic decompositions of this sort. For example, the linking theory of Van Valin and LaPolla (1997) regards specific and generalized semantic roles as derived notions that can be defined on the basis of the structural positions in the decompositional representations. In this approach, the generalized roles Actor and Undergoer play a key role in explaining the linking of arguments to their morphosyntactic realization.

As discussed in the previous section, a naming convention for frames is a simple but limited method of capturing the sub-eventual structure of a situation. A more attractive and more sophisticated option is to represent the structure within

[16]This distinction is similar to that between resultant states and target states proposed by Parsons (1990).

[17]The online version of the FrameNet database of January 25th, 2012, has Altered_phase renamed to Substance_by_phase, with the adjectives *gaseous* and *liquid* and the nouns *gas* and *liquid* added, among others. The basic dichotomy between the two structures shown in Fig. 6.5 nevertheless persists (not to mention the additional problem that the new name suggests that the frame should inherit from Substance and thereby from Physical_entity, which seems fully at odds with the structure shown in Fig. 6.4).

[18]See Levin and Rappaport Hovav (2005) for an overview.

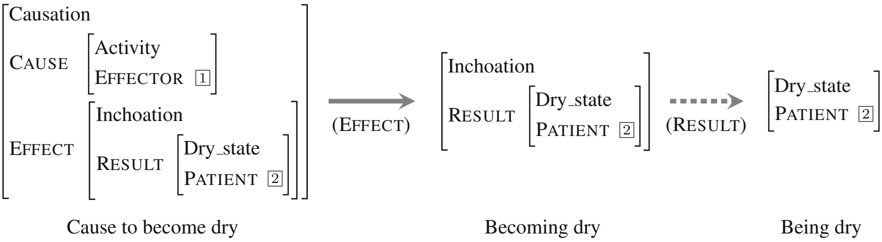


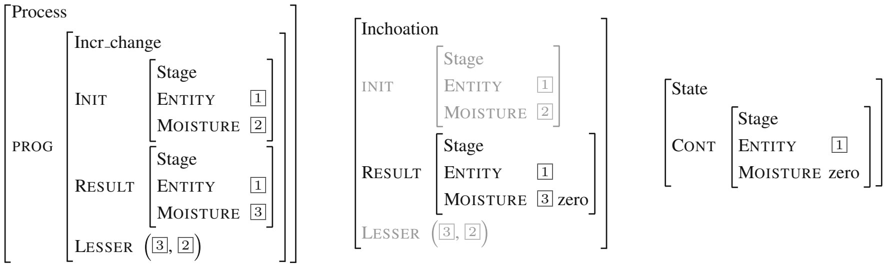
Fig. 6.6 Frame-based event structure decomposition of causative and inchoative *dry*

the frame itself. Doing this means to move from the plain role frames used in FrameNet to more complex frame structures which allow the embedding of one frame in another. Term-based decompositional representations of the kind shown in (6) offer a first blueprint of how to proceed. For example, the primitive one-place state predicate **dry** can be reinterpreted as a basic state frame Dry_state with a role Patient, whose filler corresponds to the argument of the predicate; see the attribute-value matrix on the right of Fig. 6.6. The BECOME **dry**(y) term can be taken as an Inchoation frame whose attribute Result is filled by the Dry_state frame; see the matrix in the middle of the figure. Finally, the overall CAUSE term of (6) corresponds to a frame Causation with attributes Cause and Effect, which are filled with the Activity and Inchoation subframes, respectively, as depicted on the left of Fig. 6.6. The resulting decompositional frames are related to each other by virtue of their inner structure. Compact frame names such as 'Cause_to_become_dry' can now be introduced as abbreviations for complex frame structures, or, on a more formal basis, as elements of a type hierarchy associated with complex attribute-value declarations.[19] The frame-specific roles of FrameNet, which have their purpose, e.g., in easing the annotation task, can be reintroduced as shortcuts for attribute paths of the decompositional frame structures. For example, the role Dryee can be defined as the concatenated path Effect|Result|Patient of the Cause_to_become_dry frame.[20]

The transformation of standard decompositional schemas into frame structures is only a first step in developing an elaborate frame semantics. Term-based decompositions like the ones in (6) are usually rather limited in representing information about, e.g., attributes of participants or other implicit components of a situation. Frames in the general sense of Barsalou (1992), or of Fillmore (1982) for that matter, are more expressive in this respect. As an example, consider again the representations for *dry* given in Fig. 6.6 and the respective FN 1.5 frames listed in Table 6.4. None of the frame structures in Fig. 6.6 captures the actual process the "patient" undergoes during drying. Unlike pure change of state verbs such as *break*, which are non-specific about how the resulting state is achieved,

[19] E.g., along the lines of Carpenter (1992).

[20] Introducing specific semantic roles this way is similar to defining them in terms of positions in decompositional structures as proposed by Van Valin and LaPolla (1997, Chap. 3).



Becoming drier Becoming dry Being dry

Fig. 6.7 Representation of (non-causative) atelic, telic, and stative *dry*

deadjectival *degree achievement* verbs (Dowty 1979) like *dry*, *darken*, and *cool* allow an atelic interpretation which profiles the change process without entailing the result denoted by the base adjective. The different readings can be triggered by temporal adverbials: *dry for an hour* means to get drier and drier within that hour without necessarily being dry afterwards, *dry in an hour* implies a resulting dryness.

The decompositional Becoming_dry frame of Fig. 6.6 is a plain change of state frame whose result state is dryness. Similarly, the definition of the corresponding FN 1.5 frame shown in Table 6.4 entails the resulting dryness of the undergoer. Both frames do not cover the situation where an entity gets drier without becoming dry.[21] As to the process of drying, the definition in Table 6.4 mentions the loss of moisture, which, however, has no consequences for the semantic content of the FrameNet frame. Decrease of moisture, or increase of dryness for that matter, is in fact the core characteristics of the process of drying. The general pattern behind this type of process is that an entity undergoes a change with respect to the value of one of its attributes, here, the degree of moisture or dryness. More precisely, the change in question is either an increase or a decrease of that value on an ordered scale.[22] An appropriate semantic representation of this situation type should therefore take into account the respective attribute of the undergoer and the ordering of its possible values. Figure 6.7 indicates how this can be achieved within a frame-based account. The basic component of these frames is the instantaneous "moisture stage" of an entity, which can be conceived of as a snap-shot of the entity having a certain degree of moisture.[23] Stages provide a natural way to model changes of attribute values. The atelic interpretation of *dry* can be analyzed as a process whose progression (PROG) consists of an ongoing incremental change between two stages of the undergoer of which the second has a lesser degree of moisture than the first. The

[21] Notice that this could lead to faulty inferences, given that the missing inchoative relation between Becoming_dry and Being_dry is added.

[22] See Kearns (2007) and Kennedy and Levin (2008) for detailed analyses of the relation between attributes, scales, and scalar change.

[23] Cf. Bittner and Donnelly (2004) and Sider (2001) on the stage view of objects.

corresponding frame structure on the left of Fig. 6.7 employs a relational constraint LESSER between moisture values. The telic, inchoative interpretation depicted in the middle of the Figure resembles the inchoative frame of Fig. 6.6.[24] The stative interpretation of *dry* is then represented by the situation type in which the stages of the entity in question are constant with respect to their degree of moisture, which is 'zero' in this case; see the frame on the right of Fig. 6.7.

At first glance, it might appear that the proposal described here leads to a multiplication of frames. This is true insofar as we think it important to keep track of the differences between processes and accomplishments in the frame representations of situation types. This distinction is relevant to the understanding of the syntax-semantics interface as well as for drawing correct inferences. If something is not necessarily dry after having dried for an hour then an automatic reasoning system should not come to a different conclusion. On the other hand, it is important to notice that the frame structures in Fig. 6.7 are not tailored for specific verbs but represent fairly general situation schemata. The only verb specific meaning components are the moisture attribute and its associated value scale, both of which are determined by the adjectival root of the verb. If we abstract from these components then the frame on the left of the figure is about situations where an entity undergoes a continuous change with respect to the value of one of its (scalar) attributes such that the value decreases on the scale in question. The situation type encoded by the frame in the middle of the figure differs in that the minimal value on the attribute scale is reached and the exact course of the change not specified. The event structure schemas of both frames are clearly relevant to other degree achievement verbs as well. Moreover, the two frames are systematically related to each other. Hence, if one wants to speak of frame multiplication at all, then it should be in the sense of a more thorough account of the combinatorial potential of elementary event structure components. Another objection could be that the above distinction between the process and the accomplishment interpretations of *dry* is not part of lexical semantics but should be modeled in terms of aspectual coercion or the like. A first reply is that at least the current FrameNet annotation would not allow such a "post processing" since *in* and *for* adverbials are both annotated as Duration. More crucial is the question of what to count as a frame evoking unit, especially from a cross-linguistic perspective. For example, the Australian aboriginal language Mparntwe Arrernte encodes the distinction between the process and the accomplishment interpretation of degree achievement verbs like *cool* by means of process and result affixes (Van Valin 2005, pp. 43f). If some languages encode Aktionsart operators as bound morphemes while others do not, the focus on word units as frame-bearing elements may run into serious problems when it comes to language comparison.[25]

[24]The shaded INIT and LESSER components are redundant if changes of state are always assumed to have an initial stage different from the result stage and if 'zero' is the minimal value of the degree of moisture scale.

[25]It remains to be seen whether the recent initiative of including frame bearing constructions into FrameNet (Fillmore et al. 2012) will be able to resolve these issues.

6.4 Case Study: Verbs of Cutting and Fragmentation

Verbs of cutting and fragmentation provide a good touchstone for lexical semantic representation and linking. They have been studied widely with respect to differences in their argument realization options and varying lexicalization patterns across languages (Guerssel et al. 1985, Mairal Usón and Faber 2002, Majid et al. 2007). Cut-verbs have also been discussed with respect to the controversial thesis of a manner/result complementarity in lexical encoding (Bohnemeyer 2007, Rappaport Hovav and Levin 2010).

The verb *cut* occurs in FN 1.5 as a lexical unit in the frames listed in Table 6.5. The table also shows a number of verb units associated with these frames. In the following, we are concerned with senses of *cut* that are related to affecting a physical entity by means of a sharp-edged object, resulting in incision and, possibly, separation or fragmentation. Senses of *cut* meeting this constraint occur in the frames Cutting, Removing, Experience_bodily_harm, and Cause_harm, which are marked bold face in Table 6.5.

There are several more senses of *cut*, but missing senses at an intermediate stage of the project are an inevitable consequence of FrameNet's frame-oriented working procedure. For as Fillmore (2007, pp. 139ff) points out, the frame-based exploration of word meanings "pays attention to paraphrase relation and postpones thorough treatment of polysemy structures." An obvious gap among the concrete, object affecting meanings of *cut* is the sense "trim or reduce in length of (grass, hair, etc.) by using a sharp implement" (Oxford Dictionary of English, 2nd ed.). In fact, FN 1.5 seems to have no frame for this scenario since *trim* and *mow* are not covered either. Another missing pattern is *cut a hole into something*.

6.4.1 Cutting and Other Ways of Separation

The core meaning of *cut* is represented by the Cutting frame introduced in Sect. 6.2.2.1 (Table 6.1). Somewhat surprisingly, FN 1.5 provides no annotated

Table 6.5 List of all frames in FN 1.5 with verb unit *cut*

Cause_change_of_position_on_a_scale	*add*, *curtail*, ***cut***, *enhance*, *decrease*, *increase*
Cause_harm	*bash*, *batter*, *bayonet*, *beat*, *boil*, *break*, ***cut***, *elbow*
Change_direction	***cut***, *swing*, *turn*, *veer*
Change_operational_state	*activate*, *boot*, ***cut***, *deactivate*, *turn on*, *turn off*
Cutting	*carve*, *chop*, *cube*, ***cut***, *dice*, *fillet*, *mince*, *pare*, *slice*
Experience_bodily_harm	*break*, *bruise*, *burn*, ***cut***, *graze*, *hit*, *hurt*, *injure*
Intentional_traversing	*ascend*, *climb*, ***cut***, *ford*, *traverse*
Removing	*clear*, ***cut***, *discard*, *disgorge*, *dust*, *empty*, *remove*, *shave*

Table 6.6 Lexical units of Cutting with FN 1.5 sense definitions

cut	divide into pieces with a knife or other sharp implement
slice	cut into slices
cube	cut (food) into small cubes
dice	cut (food) into small cubes
fillet	cut (fish or meat) into fillets
mince	cut up or shred (meat) into very small pieces
chop	cut with repeated sharp, heavy blows of an axe or knife
carve	cut into hard material, sometimes with a carving knife
pare	trim by cutting away the outer edges of

examples for the lexical unit *cut* of Cutting.[26] But the examples for *slice* given in (2) and those for *chop* in (7) do as well.

(7) a. *Chop* [the onions]$_{\text{Item}}$ [finely]$_{\text{Manner}}$.
b. [The animals]$_{\text{Item}}$ are always *chopped* [into small pieces]$_{\text{Pieces}}$

The definition of the frame Cutting presented in Table 6.1 is repeated in (8).

(8) An Agent cuts an Item into Pieces using an Instrument.

One might object that this definition just illustrates schematically a certain use of the verb *cut*. Instead of (8), one would probably expect a typical dictionary definition of *cut* like "divide something into pieces with a knife or other sharp implement," which is, in fact, the sense definition given for the lexical unit *cut* of the Cutting frame. However, the "definition" of a frame is only intended as an informal description that indicates the kind of scenario the frame is supposed to represent. The definition plays no formal role in the FrameNet architecture. That said, we can take (8) as a characterization of the Cutting frame. All lexical units of this frame (except *cut* itself) are described as specific types of cutting. Table 6.6 lists these units together with their FN 1.5 sense definitions. As with frame definitions, the sense definitions of lexical units play no formal role in the FrameNet architecture; they are useful indicators for the human users and, especially, for the annotators. The sense definitions in FrameNet are either taken from the Concise Oxford Dictionary, 10th Edition, or are written by FrameNet editors.

The units *slice* through *chop* conform to the frame definition (8). The first four of them, *slice*, *cube*, *dice*, and *fillet*, have zero-related nouns that characterize the (form of the) resulting pieces. Except for *dice*, this verbal incorporation of the Pieces element is explicitly marked in FN 1.5. The case of *mince* is similar but specifies the size of the resulting pieces, not their form. The definition given for *chop* does not

[26]This is even more surprising in view of the fact that some of the annotated example sentences associated with other verb units of the Cutting frame contain *cut* in the correct sense; witness (9).

mention 'into pieces', but this could be a flaw of the chosen dictionary definition.[27] By contrast, the sense definitions of *carve* and *pare* are not subsumed by (8). None of them indicates that something is cut into pieces.[28] The sense of *pare* that appears in the FN 1.5 examples shown in (9) can be paraphrased as "cut off the outer skin of something", typically used with fruits and vegetables.[29]

(9) a. *Pare* [the mangoes]$_{\text{Item}}$ and cut the flesh away from the pit lengthwise into long slices.
b. Thinly *pare* [the rind from 1 orange]$_{\text{Item}}$ and cut into narrow strips.

In (9), we have actually two distinct lexico-syntactic patterns of *pare*. The direct object of (9a) refers to the entity whose outer skin is cut off; in (9b), the outer skin is expressed by the direct object and the corresponding entity is expressed by the *from*-PP. Note that the FN 1.5 annotation of (9b) mistakenly combines the object NP and the PP to a single constituent. While (9a) could be classified as a "trimming by cutting" scenario, the type of situation expressed in (9b) falls under "cutting off a part from a whole". Neither of the situation types is covered by the Cutting frame as introduced in Table 6.1.

It is striking that neither *hack*, *hew*, *saw*, *snip*, nor *slash* are listed among the units of Cutting, for one easily finds corpus attestations of the pattern *hack/hew/saw/snip/slash sth (in)to pieces* and dictionary definitions typically describe these verbs (in one of their senses) as verbs of cutting. As mentioned before, FrameNet aims at a frame-wise processing of the lexical domain. Hence, one wonders whether these verbs are left out by accident or on purpose. The answer depends on which situation type the Cutting frame is supposed to represent. In view of (8), the situation in question is about cutting-related activities which result in the affected entity being in pieces. With *cut* and *chop* as units of the frame, there seems to be no reason not to include *hack*, *hew*, *saw*, etc. as well.

As mentioned above, definition (8) suggests that the affected item's being in pieces is an essential component of the Cutting frame. More evidence for this conclusion comes from the fact that Pieces is a core element of Cutting. Recall from Sect. 6.2.2.1 that core elements are "necessary to the central meaning of the frame". Hence, no Cutting without Pieces. Situations where someone cuts into an object, or at an object, without separating it are thus not represented by Cutting. But even if the cutting leads to pieces, the situation is not necessarily subsumed by the Cutting frame. Consider situations described by phrases such as *cut a branch off the tree*. Here, a piece is separated from a whole without the whole going to pieces. The definition of the Cutting frame and the lack of appropriate core elements imply that

[27] Consider, e.g., the following two Dictionary definitions for the relevant sense of *chop*: "cut (something) into pieces with repeated sharp blows of an axe or knife" (Oxford Dictionary of English, 2nd ed.); "to cut sth into pieces with a sharp tool such as a knife" (Oxford Advanced Learner's Dictionary).

[28] Note that there is a use of *carve*, as in *he carved the roast into slices*, that conforms to (8).

[29] Of course, only the *pare* clause of the coordination is relevant here.

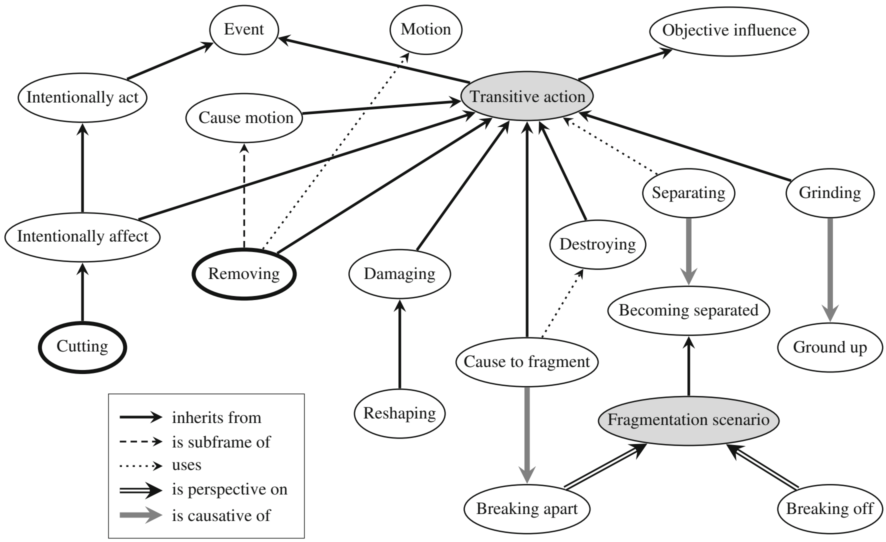


Fig. 6.8 Frames for *cut*, *split*, *break*, *rip*, *shred*, etc. and their interrelation in FN 1.5

the "cutting off" scenario is not within the scope of the Cutting frame (see also the discussion of the interpretation of *pare* in (9b) above).

The given characterization of the Cutting frame raises a number of questions: Should the frame be extended to cover "cutting off" scenarios as well? What about cutting events that result in an incision but do not lead to separation? In which way is Cutting related to other frames of separation and fragmentation? Several FN 1.5 frames are explicitly concerned with fragmentation and separation scenarios. Figure 6.8 gives an overview of these frames and shows how they are related to each other and to the frames Cutting and Removing, both of which have *cut* as a lexical unit. (Shaded nodes represent again non-lexical frames.) The definitions and lexical units of most of these frames are listed in Table 6.7 (with verbs to be discussed in the following in bold-face). Besides Cutting there are two other frames, Cause_to_fragment and Breaking_apart, that have Pieces as a core element. Pieces is bound to Parts in the 'is perspective on' relation between Breaking_apart and Fragmentation_scenario, and Parts is also a core element of the frames Separating and Becoming_separated. The FN 1.5 examples in (10) describe situations where some entity is separated or fragmented into parts or pieces.

(10) a. The young men *split* [the cattle]$_{\text{Whole}}$ [into two groups]$_{\text{Parts}}$ — Separating
b. *Split* [the cake]$_{\text{Whole}}$ [in half]$_{\text{Parts}}$ horizontally — Separating
c. [French flags]$_{\text{Whole\_patient}}$ were *ripped* [in half]$_{\text{Pieces}}$ — Cause_to_fragment
d. *Break* [the carcass]$_{\text{Whole\_patient}}$ [into small pieces]$_{\text{Pieces}}$ — Cause_to_fragment
e. *shredding* [the notes]$_{\text{Whole\_patient}}$ [into little pieces]$_{\text{Pieces}}$. — Cause_to_fragment
f. [thinly]$_{\text{Manner}}$ *shred* [each half]$_{\text{Whole\_patient}}$, using a sharp knife. Cause_to_fragment

Table 6.7 Definitions of FN 1.5 frames related to fragmentation and separation, with selected verb units

Separating: These words refer to separating a [Whole] into [Parts], or separating one part from another. The separation is made by an [Agent] or [Cause] and may be made on the basis of some [Criterion].

bisect, *divide*, *partition*, *part*, *section*, *segment*, *segregate*, *separate*, *sever*, ***split***

Becoming_separated: A [Whole] separates into [Parts], or one part of a whole, called [Part_1], becomes separate from the remaining portion, [Part_2].

divide, *separate*, ***split***

Fragmentation_scenario: A [Whole] fragments or breaks into [Parts], or alternatively a part, [Part_1], breaks off from the rest of the item, called [Part_2].

(Non-lexical)

Breaking_off: A single [Subpart] breaks off from a [Whole].

break, *chip*, *snap*

Breaking_apart: A [Whole] breaks apart into [Pieces], resulting in the loss of the [Whole] (and in most cases, no piece that has a separate function).

break apart, *break down*, ***break***, *fragment*, *shatter*, *snap*, *splinter*

Cause_to_fragment: An [Agent] suddenly and often violently separates the [Whole_patient] into two or more smaller [Pieces], resulting in the [Whole_patient] no longer existing as such.

break apart, *break down*, *break up*, ***break***, *chip*, *cleave*, *dissect*, *dissolve*, *fracture*, *fragment*, *rend*, *rip up*, ***rip***, *rive*, *shatter*, *shiver*, ***shred***, *sliver*, *smash*, *snap*, *splinter*, ***split***, *take apart*, *tear up*, *tear*

Grinding: In this frame a [Grinder] or [Grinding_cause] causes an [Undergoer] to be broken into smaller pieces. A [Result] or [Goal] can be present.

chew, *crumble*, *crunch*, ***crush***, *flake*, *grate*, *grind*, *masticate*, *mill*, *pulverize*, ***shred***

Damaging: An [Agent] affects a [Patient] in such a way that the [Patient] (or some [Subregion] of the [Patient]) ends up in a non-canonical state. Often this non-canonical state is undesirable, ...

chip, *damage*, *deface*, *dent*, *key*, *nick*, *rend*, ***rip***, *sabotage*, *scrape*, *scratch*, *tear*, *vandalise*

Removing: An [Agent] causes a [Theme] to move away from a location, the [Source].

clear, *confiscate*, ***cut***, *discard*, *disgorge*, *drain*, *dust*, *eject*, *eliminate*, *empty*, *excise*, *expel*, *expurgate*, *extract*, *file*, *flush*, *prise*, *purge*, *remove*, *rinse*, ***rip***, *scrape*, *shave*, *snatch*, *strip*, *swipe*, *take*, *tear*, *unload*, *wash*, *withdraw*

g. [thinly]$_{\text{Result}}$ *shred* [each half]$_{\text{Undergoer}}$, using a sharp knife. Grinding
h. *crush* [them]$_{\text{Undergoer}}$ [to bits]$_{\text{Result}}$. Grinding

With the exception of (10a), the verb contexts in (10) are compatible with cut-verbs like *slice* and *chop*. However, generalizations about this similarity in syntagmatic patterning are not supported by the FN 1.5 frame-to-frame structure shown in Fig. 6.8. There is no general representation of the meaning component common to the described scenarios, that is, of the turning of something into pieces. Again, a decompositional analysis could help in this case. The frames

Cause_to_fragment, Grinding, and Cutting are not related to each other, except by their inheritance from Transitive_action, and Separating does not inherit from any frame at all. The Grinding frame, while mentioning "into smaller pieces" in its definition, has no Pieces element but uses the (non-core) Result element for this purpose; cf. example (10h).

The verb *shred* deserves special attention because it is a unit of the frames Grinding and Cause_to_fragment and it is defined as 'tear or cut into shreds' in both cases. There are even a number of sentences annotated by both frames, witness (10f) and (10g). Note that *thinly* is annotated as Manner in (10f) and as Result in (10g). The latter analysis seems adequate if the expression is taken to mean that it is the resulting shreds which are thin. However, FN 1.5 defines the Result element of Grinding as "the shape the Undergoer becomes" and this definition is difficult to reconcile with the foregoing interpretation of (10g) since it is not the Undergoer that becomes thin. This phenomenon is related to the *spurious resultatives* discussed by Washio (1997, pp. 17f), for which *cut the meat thick/thickly* and *tie the laces tight/tightly* are typical examples.[30] The crucial property of this pattern is that the "result" predicates are not applied to the entities denoted by the direct objects but to entities that are not overtly expressed, the slices in *cut the meat* and the knot in *tie the laces*. The lexical semantic constraints that underlie this construction clearly call for a frame semantic analysis that goes beyond plain role frames.

A further issue arises with the use of particles. The adverb *apart* occurs frequently with verbs of separation and fragmentation. The FN 1.5 examples in (11) contain annotated instances of *apart* used as a particle with the verbs *split* and *rip*.

(11)	a.	everything has been *split* $[\text{apart}]_{\text{Result}}$ by erosion.	Separating
	b.	she *ripped* the thing $[\text{apart}]_{\text{Result}}$ with her sharp teeth.	Cause_to_fragment
	c.	somebody got *ripped* $[\text{apart}]_{\text{Pieces}}$ by a diseased ferret	Cause_to_fragment

The annotation of the element Pieces in (11c) seems misguided given the definition of Pieces as "[t]he fragments of the Whole_patient that result from the Agent's action". By comparison, the Result annotations in (11a) and (11b) are adequate since *apart* has the function of a resultative secondary predicate in these constructions.[31] The result of the separation or fragmentation is the object's being in pieces. A good part of the apparent problems with annotating Pieces and Result in FN 1.5 can be attributed to the fact that FrameNet has no means for representing the relationship between an activity and the resulting state of the affected object in a transparent way within a single frame. A different way to cope with particle verb constructions is to treat them as multi-word lexemes. There are a few particle verbs among the lexical units listed in Table 6.7, e.g., *break apart* and *rip up* in Cause_to_fragment.

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[30]The restriction of the adjective to a postverbal position (**thick cut the meat*) does not seem to preclude the resultative interpretation of the preverbal adverb in (10g), but this point may need further investigation.

[31]See also Bolinger (1971, Chap. 6).

However, pursuing this strategy would lead to a proliferation of lexical units paired with a loss of generalization about the constructional behaviour of the base verbs.

It was mentioned above in passing that example (10a) is not compatible with *slice* and *chop*. The reason is that the described situation is not about separating a single physical entity into two or more parts (or pieces) but about dividing a collection of individual entities into subgroups. The Separating frame seems to cover both types of situations while Cause_to_fragment is apparently limited to the first situation type. However, FN 1.5 has no corresponding inheritance relationship between the two frames (see Fig. 6.8). The Separating frame extends Cause_to_fragment in another important aspect: the frame covers not only "split apart" scenarios but also "split off" scenarios[32]:

(12) a. the wind *split* [a bough]$_{\text{Part\_1}}$ [from a tree]$_{\text{Part\_2}}$ Separating
b. we *split* [our business]$_{\text{Part\_1}}$ [from Healthcare]$_{\text{Part\_2}}$ Separating

The dichotomy between "apart" and "off" scenarios has already been discussed above, where we noted that the Cutting frame does not cover "cutting off" scenarios. The Separating frame and, similarly, the frames Becoming_separated and Fragmentation_scenario resolve this dichotomy by providing core elements for both types of situations: Whole and Parts, as well as Part_1 and Part_2.[33] These two pairs of roles are disjoint alternatives in that they cannot occur together. Technically this is enforced in FrameNet by "frame element relations" such as 'exlcude' and 'require' (Ruppenhofer et al. 2010, pp. 21f), which are basically co-occurrence constraints on the set of core elements. A crucial question now is whether the alternatives ought to be accessible by perspectivization. In view of the fact the frame Fragmentation_scenario is perspectivized by Breaking_apart and Breaking_off, the answer seems to be positive. On the other hand, recall from Sect. 6.2 that perspectivization is based on the idea that a situation represented by a neutral, non-perspectivized frame is characterized by all of its perspective-taking frames as well. That is, all "split off" scenarios should be describable as "split apart" scenarios, and vice versa. This condition, however, is most likely untenable for examples such as (12a).

[32]Levin (1993) defines a separate split-verb class with members *break*, *cut*, *hack*, *kick*, *pull*, *rip*, *saw*, *split*, and *tear*, among others. The verbs of this class occur also in other classes such as the break-verbs, the cut-verbs, and the push/pull-verbs. When used as split-verbs, these verbs are said to manifest "an extended sense which might be paraphrased 'separating by V-ing', where 'V' is the basic meaning of the verb" (Levin 1993, pp. 166f). Among the alternation patterns associated with this class is the "*apart* reciprocal alternation" as exemplified by *I broke the twig off (of) the branch* vs. *I broke the twig and the branch apart*. Note that the 'apart' pattern of this alternation requires a collective NP as object. The sentences *I broke the twig apart* and *I cut the twig apart*, by contrast, would count as unrelated evidence for the resultative phrase patterns of the break-verb class and the cut-verb class, respectively. (Cf. Baker and Ruppenhofer (2002) for a comparison between FrameNet frames and Levin's verb classes.)

[33]The FN 1.5 definition of Separating shown in Table 6.7 is deficient in not explicitly mentioning Part_1 and Part_2.

Table 6.8 Definitions of harm frames in FN 1.5 with selected verb units

Cause_harm: The words in this frame describe situations in which an [Agent] or a [Cause] injures a [Victim]. The [Body_part] of the [Victim] which is most directly affected may also be mentioned in the place of the [Victim]. In such cases, the [Victim] is often indicated as a genitive modifier of the [Body_part] ...
bash, *batter*, *bayonet*, *beat*, *belt*, *boil*, *break*, *bruise*, *burn*, *butt*, ***chop***, *claw*, *crush*, *cuff*, ***cut***, *elbow*, *electrocute*, *fracture*, ***gash***, *hammer*, *hit*, *hurt*, *injure*, *jab*, *kick*, *knee*, *knife*, *knock*, *lash*, *poison*, *slap*, ***slice***, *smack*, *smash*, *spear*, *stab*, *stone*, *strike*, *torture*, *wound*
Experience_bodily_harm: An [Experiencer] is involved in a bodily injury to a [Body_part]. (In some cases, no [Body_part] need be indicated.) Often an [Injuring_entity] on which the [Experiencer] injures themselves is mentioned.
abrade, *break*, *bruise*, *burn*, ***cut***, *graze*, *hit*, *hurt*, *injure*, *jam*, *pull*, *scrape*, *smack*, *sprain*, *strain*, *stub*, *sunburn*, *tear*, *twist*

A small number of cutting and fragmentation verbs show up as lexical units of the Removing frame (cf. Table 6.7):

(13) a. he had *ripped* [my wallpaper]$_{\text{Theme}}$ [off my wall]$_{\text{Source}}$ — Removing
b. and *cut* [paintings]$_{\text{Theme}}$ [from their frames]$_{\text{Source}}$ — Removing

Counting these verbs as units of Removing is not unproblematic since contexts like those in (13) are compatible with many other verbs of cutting and fragmentation (cf. (12a)). One might even come to the conclusion that all "off" scenarios can be seen as instances of Removing, which would position the frame high in the inheritance hierarchy.

6.4.2 *Cuts and Other Injuries*

Somewhat surprisingly, the only FN 1.5 attestations of cut-verbs in combination with *off* belong to the frame Cause_harm. Two of the examples are given in (14).

(14) a. the executioner should *cut* [[his]$_{\text{Victim}}$ head]$_{\text{Body\_part}}$ [off]$_{\text{Result}}$ — Cause_harm
b. he *chopped* [[their]$_{\text{Victim}}$ tails]$_{\text{Body\_part}}$ [off]$_{\text{Result}}$ — Cause_harm

The definitions and lexical units of Cause_harm and of the related frame Experience_bodily_harm are shown in Table 6.8 (with cut-verbs in bold-face).

There are good reasons to list the verb *cut* under Experience_bodily_harm because of its specific use in describing situations where you accidentally injure yourself on something sharp (*I cut my finger*, *I cut myself on a broken glass*). Treating cut-verbs like *chop*, *cut*, *gash*, and *slice* as units of the Cause_harm is, however, rather problematic. Nothing about the constructions in (14) is specific to animate beings and their body parts. Cutting off a body part might cause harm to the affected being (if still alive) but this is not part of the meaning of *cut (off)*, in contrast, for instance, to *torture*. Consider example (15), which is annotated under Cause_harm for *cut* and *slice*.

(15) They scalped old men and women, beheaded others, slit throats, *cut* $[\text{out}]_{\text{Result}}$ tongues, *sliced* $[\text{off}]_{\text{Result}}$ ears, and hacked off limbs.

In view of the last clause of (15), it would be consistent to have *hack* in Cause_harm, too. And by a similar argument many other verbs would have to be added as well, including, e.g., *rip*, for tongues can be ripped out and ears can be ripped off and it is probably not difficult to find corpus examples that describe such scenarios.

As discussed above, cutting does not necessarily lead to separation but can result in an incision, or cut for that matter. This type of result, if describable as a damage or wound, seems more in line with the meaning of the Cause_harm frame. We take this as a further argument for a more elaborate frame representation that makes explicit the activities and results involved in the described situations.

6.4.3 Sketch of Reanalysis

As in the case studies presented in earlier sections, the issues we have identified in the domain of cutting and fragmentation verbs fall basically into two categories. On the one hand, there are deficiencies which could be resolved more or less easily within the present set-up of FrameNet. Issues such as the inappropriate inclusion of *pare* in the Cutting frame (cf. Table 6.6) can be simply settled by removing this unit from the frame. Straightening out the frame-to-frame structure shown in Fig. 6.8 is more demanding. This means to clarify, among many other things, how the frame Cause_to_fragment relates to the frames Separating and Fragmentation_scenario and how the distinction between "apart" and "off" scenarios cuts across the various frames discussed. Under the proposal put forward in this article, such a clarification is driven by event structure analysis, which leads to questions like the following: Which of the represented situations types have a causative structure? Which contain an activity or a change of state component? Which types of activities and results should be distinguished in the frame representations? These decisions should be empirically grounded. One such basis is given by FrameNet's annotated sentences, on which the existing frame structure is based in the first place. In addition, explicit Aktionsart tests can be employed such as the insertion of adverbials and appropriate semantic paraphrases and implications (cf. Van Valin 2005, Chap. 2).

The identification of the relevant types of activities and results has to cope with the problem of keeping the right level of granularity. Consider again the distinction between "apart" and "off" scenarios. The "apart" construction, if used with a non-collective noun, implies that the denoted undergoer looses its integrity,

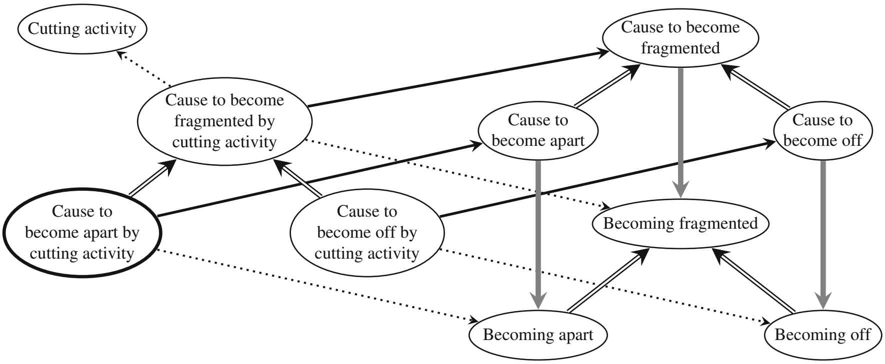

Fig. 6.9 Partial sketch of a frame system for fragmentation scenarios based on event decomposition

while the "off" case has no such implication. There are also clear differences on the morphosyntactic side between the result phrases involved. That is, the distinction in question captures certain regularities of the syntax-semantics interface. Moreover, some verbs can only be used, or have a strong tendency to be used, for one kind of fragmentation scenario but not for the other. For instance, *chip* is almost exclusively used for "off" scenarios while *shatter* is restricted to "apart" scenarios. In sum, there are good reasons to have the "apart"/"off" distinction represented in the domain of frames for fragmentation scenarios.

Suppose that, in addition to the fragmentation frame with its two perspectives,[34] we have accepted a frame for cutting activities. Then, if we allow fragmentation events to be caused, and caused fragmentations to be brought about by cutting activities, the frame system shown in Fig. 6.9 arises. For ease of exposition, the frames are described verbally; their actual decompositional structure is similar to the ones shown in Fig. 6.6. The Cutting frame of FN 1.5 corresponds to the frame on the lower left of the figure. Note that there is now a frame for the *cut/saw/chop off* examples, which is systematically related to the more general "Cause to become off" frame. Note also that there is no causative/inchoative structure for the fragmentation by cutting frames. This fact can be attributed to the additional activity involved.

While this simple example illustrates that frame inheritance can indeed give rise to generalizations about the syntax-semantics interface, it also indicates that the actual burden seem to lie on the identification of appropriate perspective-taking frames. Needless to say that the reanalysis presented in Fig. 6.9 covers only a portion of the frame structure of Fig. 6.8 and that many problems will still have to be solved concerning the precise form of the decompositional frame structures.

[34]For simplicity, we stick to FrameNet's view that "apart" and "off" scenarios are perspectives of fragmentation scenarios, in spite of the problems mentioned in Sect. 6.4.1.

6.5 Conclusion

As stated in the introduction and later in Sect. 6.2.3, it is Fillmore's vision that Frame Semantics as implemented in FrameNet can give rise to linking generalizations if abstract frames for movement, action, change, etc., and appropriate frame-to-frame relations such as inheritance and causation are added in a systematic way. The case studies presented in this article have shown that the FrameNet approach is faced with serious problems in coming up with a consistent and systematic relational system of frames of different degrees of abstraction. As a practical problem, the present set-up of FrameNet with its lexeme-oriented and example-driven definitions of narrow-domain frames is prone to inconsistencies that could hinder the systematic addition of more abstract frames. While a large-scale lexicon building and annotation project is probably not possible without making compromises concerning the depth of modeling, it is important that such compromises, shortcuts and the like are based on a clear vision of how the ideal solution should look like. Otherwise the project's set-up will be entangled in a web of ad-hoc decisions that could hinder if not inhibit the successive improvement and extension of the architecture, with the effect that the linguistically central goal of deriving linking generalizations remains out of reach. It is difficult to build a system of abstract frames on purely empirical grounds, i.e. from the bottom up. The task of building a general account of semantic frames requires a theoretically motivated theory of frame structure in addition to the empirical data. In other words, it is necessary to proceed both from the top down and from the bottom up. To this end, we proposed that a system of decompositional frames which allows the transparent representation of subcomponents of events and of attributes of participants could be an important step toward solving these problems. Such a system could provide an excellent basis for developing an empirically grounded theory of the syntax-semantics interface that combines FrameNet's strong reliance on extensive corpus analysis with typologically motivated insights into lexical semantic classes and their linking properties.

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Chapter 7
The Deep Lexical Semantics of Event Words

Jerry R. Hobbs and Niloofar Montazeri

Abstract We have selected a basic core of about 5,000 synsets in WordNet that are the most frequently used, and we categorized these into 16 broad categories, including, for example, time, space, scalar notions, composite entities, and event structure. We sketched out the structure of some of the underlying abstract core theories of commonsense knowledge, including those for the mentioned areas. These theories explicate the basic predicates in terms of which the most common word senses need to be defined or characterized. We are encoding axioms that link the word senses to the core theories. This may be thought of as a kind of "advanced lexical decomposition", where the "primitives" into which words are "decomposed" are elements in coherently worked-out theories. In this paper we focus on our work on the 450 of these synsets that are concerned with events and their structure.

Keywords Event words • FrameNet • WordNet • Lexical semantics

7.1 Introduction

From the sentence

Russia is blocking oil from entering Ukraine.

we would like to be able to conclude

Oil can not be delivered to Ukraine.

But doing this requires fairly complex inference, because the words "block", "enter", "can", "not" and "deliver" carve up the world in different ways.

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Words describe the world, so if we are going to draw the appropriate inferences in understanding a text, we must have underlying theories of aspects of the world and we must have axioms that link these to words. The frames of FrameNet provide a first approximation of what is needed. They identify the underlying complex situation that the word taps into, and identifies the principal roles that entities fill in that situation. In our work we are trying to push this effort to deeper levels, for example, describing how frame-like situations decompose into more primitive elements and how closely related frames can be characterized by very similar sets of axioms.

We of course wish to handle domain-dependent knowledge in this way. But 70–80 % of the words in most texts, even technical texts, are words in ordinary English used with their ordinary meanings, like "enter" and "deliver". For example, in this paragraph and the previous one, only the words "theories", "axioms", "frame" and possibly "domain-dependent" have been domain-dependent.

Domain-independent words have such wide utility because their basic meanings tend to be very abstract, and they acquire more specific meanings in combination with their context. Therefore, the underlying theories required for explicating the meanings of these words are going to be very abstract.

For example, a core theory of scales will provide axioms involving predicates such as `scale`, `lessThan`, `subscale`, `top`, `bottom`, and `at`. These are abstract notions that apply to partial orderings as diverse as heights, money, and degrees of happiness. Then, at the "lexical periphery" we will be able to define the rather complex word "range" by the following axiom[1]:

```
(forall (x y z)
   (iff (range x y z)
        (exist (s s1 u1 u2)
           (and (scale s)(subscale s1 s)(bottom y s1)(top z s1)
                (member u1 x)(at u1 y)(member u2 x)(at u2 z)
                (forall (u)
                   (if (member u x)
                       (exist (v) (and (in v s1)(at u v))))))))))
```

That is, `x` ranges from `y` to `z` if and only if there is a scale `s` with a subscale `s1` whose bottom is `y` and whose top is `z`, such that some member `u1` of `x` is at `y`, some member `u2` of `x` is at `z`, and every member `u` of `x` is at some point `v` in `s1`.

Many things can be conceptualized as scales, and when this is done, a large vocabulary, including the word "range", becomes available. For example, we can now use and interpret "range" in the sentences

The grades on the midterm ranged from 33 to 96.
The timber wolf ranges from New Mexico to Alberta.
Pat's behavior ranges from barely tolerable to deeply hostile.

[1] In this paper we use a subset of Common Logic (http://common-logic.org/) for the syntax of our notation.

by instantiating `scale` and `at` in different ways. From the axiom and the first sentence, we should be able to answer the questions

Did someone get a 33 on the test? Yes.
Did someone get a 22 on the test? No.
Did someone get a 44 on the test? Maybe.

Similar questions could be answered for the other two sentences.

We can contrast this effort with that of FrameNet. The frame for the verb "range" has slots for the scale, the subscale, the lower and upper bounds, and the set of entities placed along the subscale. This gives us a good starting point, and indeed an examination of the relevant FrameNet frames is the first step in our work on any given word. But these roles are not explicated in FrameNet to the extent that would enable the kinds of inferences we would like to draw. In our work, the roles are anchored in core theories that enable the above inferences.

It would be good if we could learn relevant lexical and world knowledge automatically, and there has been some excellent work in this area (e.g., Pantel and Lin 2002). For example, we can automatically learn the correlation between "married" and "divorced", and maybe we can even learn automatically the corresponding predicate-argument structures and which way the implication goes and with what temporal constraints. But this is a very simple relation to axiomatize in comparison to the "range" axiom. The kinds of knowledge we need are in general much more complex than automatic methods can give us. Moreover, automatic methods do not always yield very reliable results. The word "married" is highly correlated with "divorced" but it is also highly correlated with "murdered".

We are engaged in an enterprise we call "deep lexical semantics", in which we develop various core theories of fundamental commonsense phenomena and define English word senses by means of axioms using predicates explicated in these theories. Among the core theories is a theory of the structure of events, which is the focus of this paper.

If we construct the core theories and the linking axioms manually, we can achieve the desired complexity and reliability. However, it would not be feasible to axiomatize the meanings of 100,000 words manually. But it *is* feasible to axiomatize the meanings of several thousand words manually, and if the words are very common, this would result in a very valuable resource for natural language understanding.

We use textual entailment pairs like the "delivered" example above to test out subsets of related axioms. This process enforces a uniformity in the way axioms are constructed, and also exposes missing inferences in the core theories, as we discuss later in this chapter.

This chapter describes an effort in which a set of very common words somehow related to events and their structure is being linked with underlying core theories. Section 7.2 describes previous work in identifying a "core WordNet" and subsequent efforts to examine and classify the words in various ways. This led to the identification of 446 common words with senses that are primarily focused on events, viewed abstractly. In Sect. 7.3 we describe two aspects of the framework we are working in—the logical form we use, and abductive interpretation and defeasibility. In Sect. 7.4 we describe several of the core theories that are crucial in characterizing event words, including composite entities, scales, change, and causality. In Sect. 7.5 we describe the methodology we use for constructing axioms, deriving from WordNet and FrameNet senses a smaller set of abstract, general "supersenses", encoding axioms for these, and testing them on textual entailment pairs; we give as examples the analyses of several common words. In Sect. 7.6 we look at a specific example to illustrate both the power of the method for textual entailment and the holes in the knowledge base that it exposes. In Sect. 7.7 we address the problem of holes more systematically, specifically asking, for example, what kinds of "pairwise interactions" are possible for core theory predicates like `change` and `cause`.

7.2 Identifying the Core Event Words

WordNet (Miller 1995) contains tens of thousands of synsets referring to highly specific animals, plants, chemical compounds, French mathematicians, and so on. Most of these are rarely relevant to any particular natural language understanding application. To focus on the more central words in English, the Princeton WordNet group has compiled a CoreWordNet,[2] consisting of 4,979 synsets that express frequent and salient concepts. These were selected as follows: First, a list with the most frequent strings from the British National Corpus was automatically compiled and all WordNet synsets for these strings were pulled out. Second, two raters determined which of the senses of these strings expressed "salient" concepts (Boyd-Graber et al. 2006). Only nouns, verbs and adjectives were identified in this effort, but subsequently 322 adverbs were added to the list.

We classified these word senses manually into 16 broad categories, listed here with rough descriptions and lists of sample words in the categories. Word senses are not indicated but should be obvious from the category.

Composite Entities: the structure and function of things made of other things: perfect, empty, relative, secondary, similar, odd, ...

Scales: partial orderings and their fine-grained structure: step, degree, level, intensify, high, major, considerable, ...

Events: concepts involving change and causality: constraint, secure, generate, fix, power, development, ...

Space: spatial properties and relations: inside, top, list, direction, turn, enlarge, long, ...

Time: temporal properties and relations: year, day, summer, recent, old, early, present, then, often, ...

[2]CoreWordNet is downloadable from http://wordnet.cs.princeton.edu/downloads.html.

Cognition: concepts involving mental and emotional states: imagination, horror, rely, remind, matter, estimate, idea, . . .

Communication: concepts involving people communicating with each other: journal, poetry, announcement, gesture, charter, . . .

Persons: concepts involving persons and their relationships and activities: leisure, childhood, glance, cousin, jump, . . .

Microsocial: social phenomena other than communication that would be present in any society regardless of their level of technology: virtue, separate, friendly, married, company, name, . . .

Bio: living things other than humans: oak, shell, lion, eagle, shark, snail, fur, flock, . . .

Geo: geographical, geological and meteorological concepts: storm, moon, pole, world, peak, site, sea, island, . . .

Material World: other aspects of the natural world: smoke, stick, carbon, blue, burn, dry, tough, . . .

Artifacts: physical objects built by humans to fulfill some function: bell, button, van, shelf, machine, film, floor, glass, chair, . . .

Food: concepts involving things that are eaten or drunk: cheese, potato, milk, bread, cake, meat, beer, bake, spoil, . . .

Macrosocial: concepts that depend on a large-scale technological society: architecture, airport, headquarters, prosecution, . . .

Economic: having to do with money and trade: import, money, policy, poverty, profit, venture, owe, . . .

These categories of course have fuzzy boundaries and overlaps, but their purpose is only for grouping together concepts that need to be axiomatized together for coherent theories.

Each of these categories was then given a finer-grained structure. The internal structure of the category of event words is given below, with descriptions and examples of each subcategory.

- **State:** Having to do with an entity being in some state or not: have, remain, lack, still, . . .
- **Change**: involving a change of state:
  - Abstractly: incident, happen
  - A change of real or metaphorical position: enter, return, take, leave, rise, . . .
  - A change in real or metaphorical size or quantity: increase, fall, . . .
  - A change in property: change, become, transition, . . .
  - A change in existence: develop, revival, decay, break, . . .
  - A change in real or metaphorical possession: accumulation, fill, recovery, loss, give, . . .
  - The beginning of a change: source, start, origin, . . .
  - The end of a change: end, target, conclusion, stop, . . .
  - Things happening in the middle of a change: path, variation, repetition, [take a] break, . . .
  - Participant in a change: participant, player, . . .

- **Cause:** having to do with something causing or not causing a change of state:
  - In general: effect, result, make, prevent, so, thereby, ...
  - Causes acting as a barrier: restriction, limit, restraint, ...
  - An absence of causes or barriers: chance, accident, freely, ...
  - Causing a change in position: put, pull, deliver, load, ...
  - Causing a change in existence: develop, create, establish, ...
  - Causing a change in real or metaphorical possession: obtain, deprive, ...
- **Instrumentality:** involving causal factors intermediate between the primary cause and the primary effect: way, method, ability, influence, preparation, help, somehow, ...
- **Process:** A complex of causally related changes of state:
  - The process as a whole: process, routine, work, operational, ...
  - The beginning of the process: undertake, activate, ready, ...
  - The end of the process: settlement, close, finish, ...
  - Things that happen in the middle of a process: trend, steady, postpone, drift, ...
- **Opposition:**
  - Involving factors acting against some causal flow: opposition, conflict, delay, block, bar, ...
  - Involving resistance to opposition: resist, endure, ...
- **Force:** Involving forces acting causally with greater or lesser intensity: power, strong, difficulty, throw, press, ...
- **Functionality:** A notion of functionality with respect to some human agent's goals is superimposed on the causal structure; some outcomes are good and some are bad:
  - Relative to achieving a goal: use, success, improve, safe, ...
  - Relative to failing to achieve a goal: failure, blow, disaster, critical, ...
  - Relative to countering the failure to achieve a goal: survivor, escape, fix, reform, ...

As with the broad categories, these subcategories are intended to group together words that need to be defined or characterized together if a coherent theory is to result.

7.3 Framework

Logical Notation: We use a logical notation in which states and events (eventualities) are reified. Specifically, if the expression `(p x)` says that `p` is true of `x`, then `(p' e x)` says that `e` is the eventuality of `p` being true of `x`. Eventuality `e` may exist in the real world (`Rexist`), in which case `(p x)` holds, or it may only exist in some modal context, in which case that is expressed simply as another property of the possible individual `e`.

The logical form of a sentence is a flat conjunction of existentially quantified positive literals, with about one literal per morpheme. (For example, logical words like "not" and "or" are treated as expressing predications about possible eventualities.) We have developed software[3] to translate Penn TreeBank-style trees (as well as other syntactic formalisms) into this notation. The underlying core theories are expressed as axioms in this notation (Hobbs 1985).

As axiomatized, eventualities are isomorphic to predications, and just as predications have arguments, eventualities have participants. The expression `(arg x e)` says that entity `x` is a participant in or argument of eventuality `e`. We can define a predicate `relatedTo` that holds between two entities `x` and `y` when they are participants in the same eventuality, or equivalently, when they are arguments of the same predication.

We find that reifying states and events as eventualities and treating them as first-class individuals is preferable to employing the event calculus (Gruninger and Menzel 2003, Mueller 1988) which makes a sharp distinction between the two, because language makes no distinction in where they can appear and we can give them a uniform treatment.

Abduction: The interpretation of a text is taken to be the lowest-cost abductive proof of the logical form of the text, given the knowledge base. That is, to interpret a text we prove the logical form, allowing for assumptions at cost, and pick the lowest-cost proof. Factors involved in computing costs include, besides the number of assumptions, the salience of axioms, the plausibility of axioms expressing defeasible knowledge, and consiliance or the degree to which the pervasive implicit redundancy of natural language texts is exploited. We have demonstrated that many interpretation problems are solved as a by-product of finding the lowest-cost proof. This method has been implemented in an abductive theorem-prover called Mini-Tacitus[4] that has been used in a number of applications (Hobbs et al. 1993, Mulkar et al. 2011), and is used in the textual entailment problems described here.

Most commonsense knowledge is defeasible, i.e., it can be defeated. This is represented in our framework by having a unique "et cetera" proposition in the antecedent of Horn clauses that cannot be proved but can be assumed at a cost corresponding to the likeliehood that the conclusion is true. For example, the axiom

```
(forall (x) (if (and (bird x)(etc-i x))(fly x)))
```

would say that if `x` is a bird and other unspecified conditions hold, `(etc-i)`, then `x` flies. No other axioms enable proving `(etc-i x)`, but it can be assumed, and hence participate in the lowest cost proof. The index `i` is unique to this axiom. In this

[3] http://www.rutumulkar.com/download/NL-Pipeline/NL-Pipeline.php.

[4] http://rutumulkar.com/download/TACITUS/tacitus.php.

paper rather than invent new indices for each axiom, we will use the abbreviation `(etc)` to indicate the defeasibility of the rule. (This approach to defeasibility is similar to circumscription McCarthy 1980.)

7.4 Some Core Theories

The enterprise is to link words with core theories. In Sect. 7.2 gave an indication of the words involved in the effort, and a high-level analysis of the concepts needed for defining or characterizing them formally. This section sketches some of the principal core theories, including concepts used in Sect. 7.5.[5] Currently, there are 16 theories defining or characterizing 230 predicates with 380 axioms. The theories differ from other commonsense knowledge bases, such as Cyc (Guha and Lenat 1990) or SUMO (Niles and Pease 2001), primarily in the abstract character and linguistic motivation of the knowledge.

Set Theory: This is axiomatized in a standard fashion, and provides predicates like *setdiff* and $deleteElt$, the latter expressing a relation between a set and the set resulting from deleting an element from it.

Composite Entities: This is a very general theory of things made of other things, one of the most basic notions one can imagine. A composite entity is characterized by a set of components, a set of properties of these components, and a set of relations among the components and between the components and the whole. With this theory we can talk about the structure of an entity by explicating its components and their relations, and we can talk about the environment of an entity by viewing the environment as composite and having the entity among its components. The predicate *partOf* is a very broad notion covering among other relations the *componentOf* relation. We also introduce in this theory the figure-ground relation at which places an external entity "at" some component in a composite entity.

Scales: This theory was mentioned in the introduction. In addition to defining the basic vocabulary for talking about partial orderings, we also explicate monotone-increasing scale-to-scale functions ("the more ... the more ..."), the construction of composite scales, the characterization of qualitatively high and low regions of a scale (related to distributions and functionality), and constraints on vague scales based on associated subsets (e.g., if Pat has all the skills Chris has and then some, Pat is more skilled than Chris, even though such judgments in general are often indeterminate).

Change of State: The two core theories most relevant to this chapter are the theory of change of state and the theory of causality. The predication `(change'`

[5]Descriptions of all the core theories, with axioms, can be found at http://www.isi.edu/~hobbs/csk.html.

e e1 e2) says that e is a change of state whose initial state is e1 and whose final state is e2. The chief properties of change are that there is some entity whose state is undergoing change, that change is defeasibly transitive, that e1 and e2 cannot be the same unless there has been an intermediate state that is different, and that change is consistent with the before relation from our core theory of time. Since many lexical items focus only on the initial or the final state of a change, we introduce for convenience the predications (changeFrom′ e e1) and (changeTo′ e e2), defined in terms of change.

Cause: The chief distinction in our core theory of causality is between the notions of causalComplex and cause. A causal complex includes all the states and events that have to happen or hold in order for the effect to happen. A cause is that contextually relevant element of the causal complex that is somehow central to the effect, whether because it is an action the agent performs, because it is not normally true, or for some other reason. Most of our knowledge about causality is expressed in terms of the predicate cause, rather than in terms of causal complexes, because we rarely if ever know the complete causal complex. Typically planning, explanation, and the interpretation of texts (though not diagnosis) involve reasoning about cause. Among the principal properties of cause are that it is defeasibly transitive, that events defeasibly have causes, and that cause is consistent with before. In addition, in this theory we define such concepts as enable, prevent, help, and obstruct. There are also treatments of attempts, success, failure, ability, and difficulty.

Events: This theory is about how changes of state and causality compose into more complex events, processes and scenarios. It includes definitions of conditional, iterative, cyclic, and periodic events, and is linked with several well-developed ontologies for event structure, e.g., PSL (Bock and Gruninger 2005).

Time: We also have a core theory of time, and the times of states and events can be represented as temporal properties of the reified eventualities. The theory of time has an essential function in axioms for words explicitly referencing time, such as “schedule” and “delay”. But for most of the words we are explicating in this effort, we base our approach to the dynamic aspects of the world on the cognitively more basic theory of change of state. For example, the word “enter” is axiomatized as a change of state from being outside to being inside, and the fact that being outside comes *before* being inside follows from the axiom relating the predicates change and before.

7.5 Analyzing and Axiomatizing Word Senses

Our methodology consists of three steps.

1. Analyze the radial structure of a word’s WordNet and FrameNet senses.
2. Write axioms for the most general senses.
3. Test the axioms on textual entailment pairs.

Our focus in this paper is on words involving the concepts of change of state and causality, or event words, such as “block”, “delay”, “deliver”, “destroy”, “enter”, “escape”, “give”, “have”, “hit”, “manage”, “provide”, “remain”, and “remove”. For each word, we analyze the structure of its WordNet senses. Typically, there will be pairs that differ only in, for example, constraints on their arguments or in that one is inchoative and the other causative. This analysis generally leads to a radial structure indicating how one sense leads by increments, logically and perhaps chronologically, to another word sense (Lakoff 1987). The analysis also leads us to posit “supersenses” that cover two or more WordNet senses. (Frequently, these supersenses correspond to senses in FrameNet (Baker et al. 2003) or VerbNet (Kipper et al. 2006), which tend to be coarser grained; sometimes the desired senses are in WordNet itself.)

“Enter”: For example, for the verb “enter”, three WordNet senses involve a change into a state:

V2: become a participant: “enter a race”
V4: play a part in: “this factor enters into your decision”
V9: set out on an enterprise: “enter a new career”

Call this supersense S1. Two other senses add a causal role to this (S2):

V5: make a record of: “enter the data”
V8: put or introduce into something: “enter a figure into a text”

Two more senses specialize supersense S1 by restricting the target state to be in a physical location (S1.1):

V1: come or go into: “he entered the room”
V6: come on stage: “enter from stage left”

One other sense specializes S1 by restricting the target state to be membership in a group (S1.2).

V3: register formally as a participant or member: “enter a club”

Knowing this radial structure of the senses helps enforce uniformity in the construction of the axioms. If the senses are close, their axioms should be almost the same.

Figure 7.1 shows the radial structure of the senses for the word “enter”, together with the axioms that characterize each sense. A link between two word senses means an incremental change in the axiom for one gives the axiom for the other. For example, the axiom for `enter-S2` says that if `x1` enters `x2` in `x3`, then `x1` causes a change to the eventuality `i1` in which `x2` is in `x3`; and the expanded axiom for `enter-S1.1` states that if `x1` enters `x2`, then there is a change to a state `e1` in which `x1` is in `x2`. So `enter-S2` and `enter-S1.1` are closely related and thus linked together.

Abstraction is a special incremental change where one sense S1.1 specializes another sense S1 either by adding more predicates to or specializing some of the predicates in S1’s axiom. We represent abstractions via arrows pointing from the subsenses to the supersenses. In Fig. 7.1, `enter-S1.1` and `enter-S1.2`

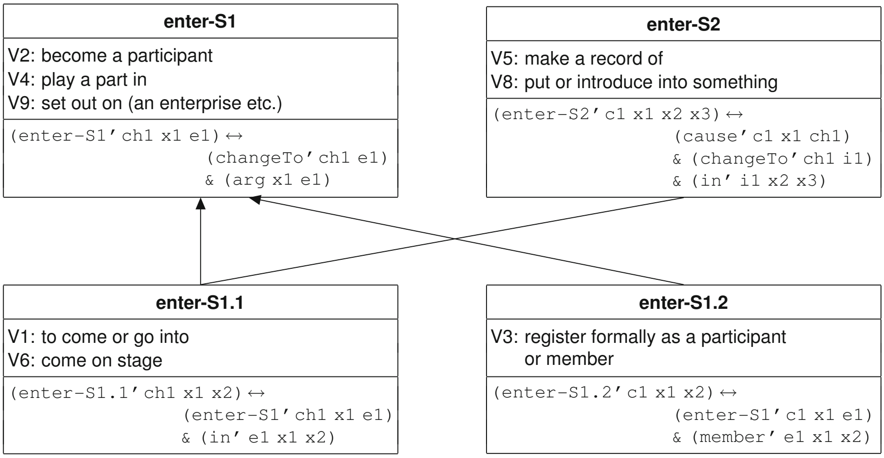

Fig. 7.1 Senses of and axioms for the verb “enter”

both specialize `enter-S1`. The predicate `enter-S1.1` adds an extra predicate describing `e1` as an `in` eventuality and `enter-S1.2` specializes `e1` to membership in `x2`, where `x2` is a group.

“Have”: In WordNet the verb “have” has 19 senses. But they can be grouped into three broad supersenses. In its first supersense, X has Y means that X is in some relation to Y. The WordNet senses this covers are as follows:

V1. a broad sense, including have a son, having a condition hold and having a college degree
V2. having a feature or property, i.e., the property holding of the entity
V3. a sentient being having a feeling or internal property
V4. a person owning a possession
V7. have a person related in some way: “have an assistant”
V9. have left: “have three more chapters to write”
V12. have a disease: “have influenza”
V17. have a score in a game: “have three touchdowns”

The supersense can be characterized by the axiom

```
(forall (x y) (if (have-S1 x y)(relatedTo x y)))
```

(We use S suffixes for supersenses, W or V suffixes for WordNet senses, and F suffixes for FrameNet senses.)

The individual senses are then specializations of the supersense where more domain-specific predicates are explicated in more specialized domains. For example, sense 4 relates to the supersense as follows:

```
(forall (x y) (iff (have-W4 x y)(possess x y)))

(forall (x y) (if (have-W4 x y)(have-S1 x y)))
```

where the predicate `possess` would be explicated in a commonsense theory of economics, relating it to the priveleged use of the object. Similarly, `(have-W3 x y)` links with the supersense but has the restrictions that `x` is sentient and that the `relatedTo` property is the predicate-argument relation between the feeling and its subject.

The second supersense of "have" is "come to be in a relation to". This is our *changeTo* predicate. Thus, the definition of this supersense is

```
(forall (x y)
   (iff (have-S2 x y)
        (exist (e) (and (changeTo e)(have-S1′ e x y)))))
```

The WordNet senses this covers are as follows:

V10. be confronted with: "we have a fine mess"
V11. experience: "the stocks had a fast run-up"
V14. receive something offered: "have this present"
V15. come into possession of: "he had a gift from her"
V16. undergo, e.g., an injury: "he had his arm broken in the fight"
V18. have a baby

In these senses the new relation is initiated but the subject does not necessarily play a causal or agentive role. The particular change involved is specialized in the WordNet senses to a confronting, a receiving, a giving birth, and so on.

The third supersense of "have" is "cause to come to be in a relation to". The axiom defining this is

```
(forall (x y)
   (iff (have-S3 x y)
        (exist (e) (and (cause x e)(have-S2′ e x y)))))
```

The WordNet senses this covers are

V5. cause to move or be in a certain position or condition: "have your car ready"
V6. consume: "have a cup of coffee"
V8. organize: "have a party"
V13. cause to do: "she had him see a doctor"
V19. have sex with

In all these cases the subject initiates the change of state that occurs.

FrameNet has five simple transitive senses for "have". Their associated frames are

1. Have associated
2. Possession
3. Ingestion
4. Inclusion
5. Birth

The first sense corresponds to the first WordNet supersense:

```
(forall (x y) (iff (have-F1 x y)(have-S1 x y)))
```

The second sense is WordNet sense 4.

```
(forall (x y) (iff (have-F2 x y)(have-W4 x y)))
```

The third sense is WordNet sense 6. The fourth sense is the *partOf* relation introduced in Sect. 7.3. It is a specialization of WordNet sense 2.

```
(forall (x y) (iff (have-F4 x y)(partOf x y)))
```

```
(forall (x y) (if (have-F4 x y)(have-W2 x y)))
```

The fifth sense is WordNet sense 18.

By relating the senses in this way, an NLP system capable of inference can tap into both resources, for example, by accessing the WordNet hierarchy or the WordNet glosses expressed as logical axioms (Harabagiu and Moldovan 2000), and by accessing the FrameNet frames, which are very close to axiomatic characterizations of abstract situations (Ovchinnikova et al. 2011). In addition, it allows us to access the core theories explicating predicates like `relatedTo` and `partOf`.

"Remain:" There are four WordNet senses of the verb "remain":

V1. Not change out of a state: "He remained calm."
V2. Not change out of being at a location: "He remained at his post."
V3. Entities in a set remaining after others are removed: "Three problems remain."
V4. A condition remains in a location: "Some smoke remained after the fire was put out."

The first sense is the most general and subsumes the other three. We can characterize it by the axiom

```
(forall (x e)
   (if (remain-W1 x e)(and (arg x e)(not (changeFrom e)))))
```

By the properties of `changeFrom` it follows that `x` is in state `e`. In the second sense, the property `e` of `x` is being in a location.

```
(forall (x e)
   (iff (remain-W2 x e)
        (exist (y) (and (remain-W1 x e)(at' e y)))))
```

The fourth sense is a specialization of the second sense in which the entity `x` that remains is a state or condition.

The third sense is the most interesting to characterize. There is a process that removes elements from a set, and what remains is the set difference between the original and the set of elements that are removed. In this axiom x remains after process e.

```
(forall (x e)
   (iff (remain-W3 x e)
        (exist (y s1 s2 s3)
           (and (remove' e y s2 s1)(setdiff s3 s1 s2)
                (member x s3)))))
```

That is, `x` remains after `e` if and only if `e` is a removal event by some agent `y` of a subset `s2` from `s1`, `s3` is the set difference between `s1` and `s2`, and `x` is a member of `s3`.

There are four FrameNet senses of "remain". The first is the same as WordNet sense 1. The second is the same as WordNet sense 3. The third and fourth are two specializations of WordNet sense 3, one in which the removal process is destructive and one in which it is not.

There are two nominalizations of the verb "remain"—"remainder" and "remains". All of their senses are related to WordNet sense 3. The first WordNet sense of "remainder" is the most general.

```
(forall (x y) (iff (remainder-W1 x e)(remain-W3 x e)))
```

That is, `x` is the remainder after process `e` if and only if `x` remains after `e`. The other three senses result from specialization of the removal process to arithmetic division, arithmetic subtraction, and the purposeful cutting of a piece of cloth.

The supersenses capture the basic topology of the senses they subsume. The extra information that the subsenses convey are typically the types and properties of the arguments, such as being a place or a process, or qualities of the causing event, such as being sudden or forceful.

We are currently only constructing axioms for the most general or abstract senses or supersenses. In this way, although we are missing some of the implications of the more specialized senses, we are capturing the most basic topological structure in the meanings of the words. Moreover, the specialized senses usually tap into some specialized domain that needs to be axiomatized before the axioms for these senses can be written, e.g., ownership for `have-W4`.

In constructing the axioms in the event domain, we are very much informed by the long tradition of work on lexical decomposition in linguistics (e.g., Gruber 1965, Jackendoff 1972). Our work differs from this in that our decompositions are done as logical inferences and not as tree transformations as in the earliest linguistic work, they are not obligatory but only inferences that may or may not be part of the lowest-cost abductive proof, and the "primitives" into which we decompose the words are explicated in theories that enable reasoning about the concepts.

7.6 Textual Entailment

For each set of inferentially related words we construct textual entailment pairs, where the hypothesis (H) intuitively follows from text (T), and use these for testing and evaluation. The person writing the axioms does not know what the pairs are, and the person constructing the pairs does not know what the axioms look like.

The ideal test then is whether given a knowledge base K consisting of all the axioms, H cannot be proven from K alone, but H can be proven from the union of K and the best interpretation of T. This is often too stringent a condition, since H may contain irrelevant material that doesn't follow from T, so an alternative is to determine whether the lowest cost abductive proof of H given K plus T is substantially lower than the lowest cost abductive proof of H given K alone, where "substantially lower" is defined by a threshold that can be trained (Ovchinnikova et al. 2011).

Here we work through an example to illustrate how textual entailment problems are handled in our framework. We assume in this example that lexical disambiguation has been done correctly. With more context, lexical disambiguation should fall out of the best interpretation, but it is unreasonable to expect that in these short examples. In practice we run the examples both with disambiguated and with nondisambiguated predicates. In this example we do not show the costs, although they are used by our system.

Consider the text-hypothesis pair we began with.

T: Russia is blocking oil from entering Ukraine.
H: Oil cannot be delivered to Ukraine.

What we notice in attempting to establish text-hypothesis relations like this after encoding the core theories and the axioms defining the words is that we get tantalizingly close to success, but not quite there, because of missing axioms. In Sect. 7.7 we discuss how this problem can be approached systematically.

The relevant part of the logical form of the text is

```
(and (block-V3' b1 x1 e1)(enter-S2' e1 o1 u1))
```

That is, there is a blocking event `b1` in which Russia `x1` blocks eventuality `e1` from occurring, and `e1` is the eventuality of oil `o1` entering Ukraine `u1`. The `-V3` on `block` indicates that it is the third WordNet sense of the verb "block" and the `-S2` suffix on `enter` indicates that it is the second supersense of "enter".

The relevant part of the logical form of the hypothesis is

```
(and (not' n2 c2) (can-S1' c2 x2 d2) (deliver-S2' d2 x2 o2 u2))
```

That is, `n2` is the eventuality that `c2` is not the case, where `c2` is some `x2`'s being able to do `d2`, where `d2` is `x2`'s delivering oil `o2` to Ukraine `u2`. Note that we don't know yet that the oil and Ukraine in the two sentences are coreferential.

The axiom relating the third verb sense of "block" to the underlying core theories is

```
AX4: (forall (c1 x1 e1)
        (if (block-V3' c1 x1 e1)
            (exist (n1 p1)
               (and (cause' c1 x1 n1)(not' n1 p1)
                    (possible' p1 e1)))))
```

This rule says that for `x1` to block some eventuality `e1` is for `x1` to cause `e1` not to be possible. (In this example, for expositional simplicity, we have allowed the eventuality c1 of blocking be the same as the eventuality of causing, where properly they should be closely related but not identical.)

The other axioms needed in this example are

```
AX1: (forall (c1 e1)
        (if (and (possible' c1 e1)(etc))
            (exist (x1)(can-S1' c1 x1 e1))))

AX2: (forall (d1 x1 c1 r1 x2 x3)
        (if (and (cause' d1 x1 c1)(changeTo' c1 r1)
                 (rel' r1 x2 x3))
            (deliver-S2' d1 x1 x2 x3)))

AX3: (forall (c1 x1 x2)
        (if (enter-S2' c1 x1 x2)
            (exist (i1)(and changeTo' c1 i1)(in' i1 x1 x2))))
```

AX1 says that defeasibly, if an eventuality e1 is possible, then someone can do it. AX2 says that if x1 causes a change to a situation r1 in which x2 is in some relation to x3, then in a very general sense (S2), x1 has delivered x2 to x3. AX3 says that if c1 is the eventuality of x1 entering x2, then c1 is the change into a state i1 in which x1 is in x2.

Starting with the logical form of H as the initial interpretation and applying axioms AX1 and AX2, we get interpretation H1:

```
H1: (and (not' n2 c2) (possible' c2 d2) (cause' d2 x2 c1)
         (changeTo' c1 r1)(rel' r1 o2 u2))
```

At this point we are stuck in our effort to back-chain to T. An axiom is missing, namely, one that says that "in" is a relation between two entities.

```
AX5:  (forall (r1 x1 x2) (if (in' r1 x1 x2)(rel' r1 x1 x2)))
```

Using AX5, we can back-chain from H1 and derive interpretation H2:

```
H2: (and (not' n2 c2)(possible' c2 d2)(cause' d2 x2 c1)
         (changeTo' c1 r1)(in' r1 o2 u2))
```

We can then further back-chain with AX3 to interpretation H3:

```
H3: (and (not' n2 c2)(possible' c2 d2)(cause' d2 x2 c1)
         (enter-S2' c1  o2 u2))
```

Again, we need a missing axiom, AX6, to get closer to the logical form of T:

```
AX6:  (forall (p e1)
         (if (and (possible' p e1)(etc))
             (exist (c x1) (and (possible' p c)
                                (cause' c x1 e1)))))
```

That is, if something is possible, it is possible for something to cause it. Using this axiom, we can derive

```
H4: (and (not' n2 c2)(possible' c2 c1)(enter-S2' c1  o2 u2))
```

The final missing axiom, AX7, says that if x1 causes eventuality c2 not to occur, then c2 doesn't occur.

```
AX7:  (forall (n x1 n1 c2)
          (if (and (cause' n x1 n1)(not' n1 c2))( not' n c2)))
```

Using this we derive interpretation H5.

```
H5: (and (cause' n2 x3 n)(not' n c2)(possible' c2 c1)
          (enter-S2' c1 o2 u2))
```

We can now apply the rule for "block", identifying b1 and n2, x1 and x3, e1 and c1, o1 and o2, and u1 and u2, yielding H6 and establishing the entailment relation between H and T.

```
H6: (and (block-V3' n2 x3 c1)(enter-S2' c1 o2 u2))
```

It may seem at first blush that any new text-hypothesis pair will reveal new axioms that must be encoded, and that therefore it is hopeless ever to achieve completeness in the theories. But a closer examination reveals that the missing axioms all involve relations among the most fundamental predicates, like cause, change, not, and possible. These are axioms that should be a part of the core theories of change and causality. They are not a random collection of facts, any one of which may turn out to be necessary for any given example. Rather we can investigate the possibilities systematically. That investigation is what we describe in the following section.

7.7 Elaborating the Core Theories: Relations Among Fundamental Predicates

For completeness in the core theories, we need to look at pairs of fundamental predicates and ask what relations hold between them, what their composition yields, and for each such axiom whether it is defeasible or indefeasible. The predicates we consider are possible, Rexist, not, cause, changeFrom, and changeTo.

The first type of axiom formulates the relationship between two predicates. For example, the rule relating cause and Rexist is

```
(forall (x e) (if (cause x e)(Rexist e)))
```

That is, if something is caused, then it actually occurs. Other rules of this type are as follows:

```
(forall (x e) (if (Rexist e)(possible e)))

(forall (e) (if (and (Rexist e)(etc))(exist (x)(cause x e))))
```

	(possible′ e2 e3)	**(Rexist′ e2 e3)**	**(not′ e2 e3)**	**(cause′ e2 x2 e3)**	**(changeFrom′ e2 e3)**	**(changeTo′ e2 e3)**
(possible′ e1 e2)	(possible′ e1 e3)	(possible′ e1 e3)		*(possible′ e1 e3)*		*(possible′ e1 e3)*
(Rexist′ e1 e2)	(possible′ e1 e3)	(Rexist′ e1 e3)	(not′ e1 e3)	*(Rexist′ e1 e3)*	*(not′ e1 e3)*	*(Rexist′ e1 e3)*
(not′ e1 e2)	(not′ e1 e3)	(not′ e1 e3)	(Rexist′ e1 e3)	(etc) → (not′ e1 e3)	(Rexist′ e1 e3)	(etc) → (not′ e1 e3)
(cause′ e1 x1 e2)	*(possible′ e1 e3)*	(cause′ e1 x1 e3) *(Rexist′ e1 e3)*	*(not′ e1 e3)*	(cause′ e1 x1 e3) *(Rexist′ e1 e3)*	*(not′ e1 e3)* *(changeFrom′ e1 e3)*	*(cause′ e1 x1 e3)* *(changeTo′ e1 e3)*
(changeFrom′ e1 e2)		(changeFrom′ e1 e3)	(changeTo′ e1 e3) *(Rexist′ e1 e3)*	(etc) → (changeFrom′ e1 e3) *(etc) → (not′ e1 e3)*	*(Rexist′ e1 e3)*	*(etc) → (not′ e1 e3)*
(changeTo′ e1 e2)	*(possible′ e1 e3)*	(changeTo′ e1 e3) *(Rexist′ e1 e3)*	(changeFrom′ e1 e3) *(not′ e1 e3)*	(etc) → (changeTo′ e1 e3) *(Rexist′ e1 e3)* *(cause′ e1 x1 e3)*	*(not′ e1 e3)* *(changeFrom′ e1 e3)*	*(Rexist′ e1 e3)* *(changeTo′ e1 e3)*

Fig. 7.2 Axioms expressing compositions of fundamental predicates

```
(forall (e2)
   (if (changeTo e2)
       (exist (e1)(and (changeFrom e1)(not′ e1 e2)))))

(forall (e1)
   (if (changeFrom e1)
       (exist (e2)(and (changeTo e2)(not′ e2 e1)))))

(forall (e) (if (changeTo e)(Rexist e)))

(forall (e) (if (changeFrom e)(not e)))

(forall (e) (if (and (Rexist e)(etc))(changeTo e)))
```

That is, if something occurs, it is possible and, defeasibly, something causes it. If there is a change to some state obtaining, then there is a change from its not obtaining, and vice versa. If there is a change to something, then it obtains, and if there is a change from something, then it no longer obtains. If some state obtains, then defeasibly there was a change from something else to that state obtaining.

The second type of axiom involves the composition of predicates, and gives us rules of the form

```
(forall (e1 e2 x) (if (and (p′ e1 e2)(q′ e2 x)) (r′ e1 x)))
```

That is, when `p` is applied to `q`, what relation `r` do we get?

Figure 7.2 shows the axioms encoding these compositions. The rows correspond to the `(p′ e1 e2)`'s and the columns correspond to the `(q′ e2 x)`'s, and the cell contains the consequents `(r′ e1 x)`. If the rule is defeasible, the cell indicates that by adding `(etc)` to the antecedent. The consequents in italics are derivable from other rules. For example, in the `possible-possible` cell, the rule says that if it is possible that something is possible, then it is possible. To take a more complex example, the `changeFrom-cause` cell says that if there is a change from some entity causing (or maintaining) a state, then defeasibly there will be a change from that state. So if a glass is released, it will fall.

We have also looked at axioms whose pattern is the converse of those in Fig. 7.2. For example, if something does not hold, then it was not caused.

7.8 Summary

We understand language so well because we know so much, and our computer programs will only approach what we might call "understanding" when they have access to very large knowledge bases. Resources like FrameNet represent a good start on this enterprise, but we need to explicate knowledge at levels of analysis deeper than that provided by FrameNet frames. Much of this knowledge will be of a technical nature and can perhaps be acquired automatically by statistical methods or from learning by reading. But the bulk of the inferences required for understanding natural language discourse involve very basic abstract categories. In the work described here, we have identified the words related to events and their structure, which because of their frequency are most demanding of explication in terms of the inferences they trigger. We have constructed abstract core theories of the principal domains that need to be elaborated in order to express these inferences in a coherent fashion. We presented a methodology for defining or characterizing the meanings of words in terms of the core theories, of evaluating the axioms using textual entailment, and of elaborating the knowledge base by identifying and filling lacunae. Doing this for several thousand of the most common words in English would produce a huge gain in the inferential power of our systems and would be an enterprise approximately equal in scope to the manual construction of other widely used resources such as WordNet and FrameNet. In combination with other knowledge resources, this work should take us a step closer to sophisticated, inference-based natural language understanding.

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Part IV
Properties, Frame Attributes and Adjectives

Chapter 8
Distinguishing Properties and Relations in the Denotation of Adjectives: An Empirical Investigation

Matthias Hartung and Anette Frank

Abstract We empirically investigate the task of classifying adjectives into property-denoting vs. relational types, a distinction that is highly relevant for ontology learning. The feasibility of this task is evaluated in two experiments: (i) a corpus study based on human annotations and (ii) an automatic classification experiment. We observe that token-level annotation of these classes is expensive and difficult. Yet, a careful corpus analysis reveals that adjective classes tend to be stable on the type level, with few occurrences of class shifts observed at the token level. As a consequence, we opt for an automatic classification approach that operates on the type level. Training on heuristically labeled data yields high classification performance on our own data and on a data set compiled from WordNet. Our results indicate that it is feasible to automatically distinguish property-denoting and relational adjectives, even if only small amounts of annotated data are available. A combination of semantic, morphological and shallow syntactic features turns out to be most informative for the task.

Keywords Adjective classification • Properties • Relations • Corpus study

8.1 Introduction

Frames are considered as a fundamental formalism for representing conceptual knowledge in both cognitive science and artificial intelligence. Incorporating attribute-value sets, structural invariants and constraints as their basic components, frame representations provide high expressive power suitable for complex reasoning in various tasks (Barsalou 1992). Nevertheless, frames are no exception to the

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infamous "knowledge acquisition bottleneck", i.e. the fact that manual construction of knowledge resources is extremely time-consuming and notoriously prone to incompleteness (Pinto and Martins 2004, Ciravegna 2000). As a consequence, the last decade has seen numerous attempts to harvest conceptual knowledge automatically from natural language text in the emerging field of *ontology learning* (e.g., Cimiano 2006).

The focus of our own work in ontology learning is on knowledge acquisition from adjective-noun phrases. We argue that, due to their class-constitutive and class-delineating function in language (cf. Kamp 1975), adjectives are a natural choice in order to facilitate *attribute learning* and *relation learning*.

Attribute learning, as initiated by Almuhareb and Poesio (2004) and Almuhareb (2006), aims at learning concept representations in terms of frame-like attribute-value sets from adjective-noun phrases in natural language corpora. For example, from the cooccurrence of a noun and a property-denoting adjective in a phrase such as *red car*, we can infer that (i) members of the concept *car* have an attribute COLOR, (ii) *red* is one of its possible values, and (iii) the particular exemplar being referred to in the phrase has the value *red* for COLOR. In relation learning, the goal is to discover (non-taxonomic) relations between previously established concepts (Buitelaar et al. 2005). For this purpose, relational adjectives provide a valuable source of information. For instance, an adjective-noun phrase such as *agricultural equipment*, being composed of the relational adjective *agricultural* and a noun referring to the concept EQUIPMENT, is indicative of the semantic relation EQUIPMENT *to be used in* AGRICULTURE (Miller 1998).

Adjective-noun phrases as introduced in the examples above are a particularly rich source for both learning tasks, as they abound in natural language and can be easily detected in corpora without the need for deep syntactic analysis. On the downside, the distinction between *property-denoting* and *relational adjectives* is a critical prerequisite in order to determine which adjectives are suitable for either attribute or relation learning and for appropriately encoding the acquired knowledge in formal ontologies.

In the work presented in this chapter, we examine whether the task of automatically distinguishing property-denoting and relational adjectives is feasible in principle. For this purpose, we adopt an adjective classification scheme that separates adjectives into subtypes relevant for ontology learning. This classification scheme is evaluated in two tasks. First, we assess the validity of the scheme in a human annotation task. In a second step, we present a machine learning approach for the automatic classification of adjectives into property-denoting and relational lexical types.

In our annotation experiment, we observe that token-level annotation for adjective types is time-consuming and difficult. At the same time, careful analysis of the annotated corpus reveals that adjective types tend to be stable, with only few occurrences of class shifts observed at the token level. This ability of an adjective to change its class on the token level will be denoted as *class volatility* throughout the paper. A second observation is that features that may be used to separate the two classes in a machine learning approach are essentially type-based, focusing on grammatical properties that are not exhibited by all instances in particular contexts.

These insights suggest a type-based classification approach, similar to previous work in semantic verb classification by Miyao and Tsujii (2009). Based on the observed low class volatility, we use the token-level annotations from our annotated corpus as seeds for the acquisition of a large training set by heuristic instance generation. The classifiers trained on this heuristically annotated set identify property-denoting and relational adjectives with high precision well above the baseline.

8.2 Related Work

Using adjectives for attribute learning has first been proposed by Almuhareb and Poesio (2004) and Cimiano (2006). Cimiano's work on this particular task is based on the investigation of adjective-noun phrases from corpora. For every adjective modifying a noun, its possible attributes are extracted from WordNet (Fellbaum 1998) and associated with the respective noun. As this approach depends on an external lexical resource, it is obviously limited in coverage. Almuhareb (2006) aims at learning this information on a larger scale by means of a pattern-based approach that operates on large web-based corpora. The outcome of his work on this task, however, is considerably affected by the lack of a separation between property-denoting and relational adjectives, such that a large number of adjectives is erroneously identified by his system as denoting a property. Hartung and Frank (2010a) and the present paper concentrate on distinguishing these classes automatically.

In Hartung and Frank (2010b, 2011), we focus on property-denoting adjectives used as modifiers of concepts: Extending the pattern-based approach of Almuhareb (2006), we propose vector space models to uncover the attribute(s) of a given concept that are elicited in the compositional semantics of adjective-noun phrases being composed from a property-denoting adjective and a noun referring to the respective concept.

Classification schemes similar to the one we envisage here have been presented by Boleda (2006) for Catalan and Raskin and Nirenburg (1998) for English. Their goal was the creation of a large-scale adjective lexicon for NLP tasks. The most fundamental difference between the work of Raskin and Nirenburg and ours is that they created their resource manually. In contrast, we aim at automatic classification, as effective automatic methods have the advantage that they can be applied to novel, specialized domains and possibly to other languages. Boleda (2006) made use of clustering techniques to automatically establish adjective classes in Catalan. She obtained various sets of clusters that were evaluated against a human-annotated gold standard, yielding up to 73 % accuracy.[1] Since our aim is the targeted acquisition and classification of adjectives for the purpose of ontology learning, we opt for a classification approach that allows us to pre-specify (and possibly refine and extend) appropriate target classes for concept learning – which is not possible within a clustering approach.

Finally, Amoia and Gardent (2008) present a (manual) classification of adjectives that relies on logical properties of adjectives in the tradition of Montague (1974). While this perspective is orthogonal to our work, their work might be useful to supplement our approach by providing further adjective classes that may be sorted out as being neither property-denoting nor relational.

Methodologically, our approach is related to a great body of work in automatic verb classification (e.g., Miyao and Tsujii 2009), going back to the empirical work of Levin (1993). Although in this field the number of target classes is by far greater and aimed at a conceptual semantic classification, the common denominator between verb semantic classes and the adjective classes considered here is that certain properties on the type level are constitutive for class membership, while the full range of these properties is not observable on the token level. In line with this strand of work on Levin-style verb classification, our classification approach will operate on the type level.

8.3 Corpus Annotation

As a starting point for distinguishing adjective classes relevant for ontology learning, we adhere to the three-way classification that has been proposed for Catalan adjectives by Boleda (2006). According to the class labels (**b**asic, **e**vent-related and **o**bject-related), we name this classification scheme *BEO classification*. In the following, we give a brief overview of the properties exhibited by the BEO classes, paying special attention to their relevance for ontology learning.

8.3.1 Classification Scheme

Basic Adjectives. Basic adjectives denote values of an attribute exhibited by an entity. In case of *scalar* attributes (Levinson 1983, Hatzivassiloglou and McKeown 1993), adjectives either denote points or intervals on the scale, as in (1a) and (1b), respectively. If the values of an attribute cannot be ordered on a scale (as for SHAPE, for instance), an adjective denotes an element in the set of possible values of the attribute, as in (1c).

[1]A strict comparison of the two approaches will not be possible due to the different languages considered and divergences regarding the selected target classes.

(1) a. blue car ↔ COLOR(car)=blue
b. young girl ↔ AGE(girl)=young
c. oval table ↔ SHAPE(table)=oval

Event-related Adjectives. These adjectives modify an associated event the referent of the noun takes part in, as illustrated by the following paraphrases (cf. Lapata 2001):

(2) a. eloquent person ↔ person that *speaks* eloquently
b. comfortable chair ↔ chair that is comfortable to *sit* on
c. interesting article ↔ article that is interesting to *read*

Object-related Adjectives. This class comprises adjectives that are morphologically derived from a noun, denoted as $A_{/N}$ and N_b, respectively, as in (3a). In these cases, N_b refers to an entity that acts as a semantic dependent of the head noun N.

(3) a. economic$_{[A_{/N}]}$ crisis$_{[N]}$ ↔ crisis of the *economy*$_{[N_b]}$
b. political$_{[A_{/N}]}$ debate$_{[N]}$ ↔ debate on *politics*$_{[N_b]}$
c. philosophical$_{[A_{/N}]}$ question$_{[N]}$ ↔ question about *philosophy*$_{[N_b]}$

BEO classes in Ontology Learning. As seen above, the BEO classes distinguish properties (basic and event-related adjectives) from relational meanings (object-related adjectives). This distinction can be utilized in ontology learning for the acquisition of property-based concept descriptions and semantic relations between concepts, respectively.

8.3.2 Annotation Process

Methodology. To validate the BEO classification scheme, we ran an annotation experiment with three human annotators. We compiled a list of 200 high-frequency English adjectives from the British National Corpus[2] and for each of them randomly extracted five example sentences from the written section of the BNC. The annotators labelled each item as `BASIC`, `EVENT`, `OBJECT` or `IMPOSSIBLE`. The latter was supposed to be used in case the annotators were unable to provide a label due to erroneous examples,[3] insufficient context, or instances belonging to alternative classes of adjectives not considered here.

Ambiguities between BEO Classes. The most notable ambiguity among BEO classes holds between basic and event-related adjectives. Consider the following competing analyses for *fast horse*:

(4) fast horse ↔ SPEED(horse)=fast
fast horse ↔ horse that *runs* fast

[2] We used version 3 of the BNC XML Edition, available from: http://www.natcorp.ox.ac.uk/

[3] Part of speech tagging was the primary source of errors here.

We argue that this ambiguity sheds light on the difference between *independent* and *founded* properties[4] of an object (cf. Guarino 1992). For disambiguation, we propose the inference patterns[5] in (5).

(5) a. ENT(ity) can be attested to be ADJ(ective) by EVENT.
 b. If ENT was not able to EVENT, it would not be an ADJ ENT.

Applied to (4), these patterns indicate that, in the case of a horse, being fast should be formalized as a property that is founded on the horse's inherent ability to run (or, at least, to move). If this ability was absent, it would no longer be possible to qualify the horse as being fast (cf. (5b)). Hence, we prefer an event reading for *fast horse*.

8.4 Corpus Analysis

8.4.1 Agreement Figures

Table 8.1 displays agreement figures for our annotation experiment in terms of Fleiss' Kappa[6] (Fleiss 1971). Total agreement between all three annotators amounts to $\kappa = 0.404$. Note that we observe substantial agreement of $\kappa = 0.762$ between two of the annotators, which suggests that the upper bound is higher than the observed overall agreement.

Table 8.1 Agreement figures in terms of Fleiss' κ

	Annotator 1	Annotator 2	Annotator 3
Annotator 1	–	0.762	0.235
Annotator 2	0.762	–	0.285
Annotator 3	0.235	0.285	–

[4]In its original statement, the notion of *foundation* is defined as follows: "For a concept α to be founded on another concept β, any instance χ of α has to be necessarily associated to an instance ϕ of β which is not related to χ by a part-of relation" (Guarino 1992). We extend this notion from concepts to properties, arguing that event-based adjectives denote founded properties that are necessarily associated with an implicit event.

[5]Note that these patterns are mutually exclusive: (5a) applies to examples such as *comfortable chair* and *interesting article* in (2b) and (2c), where ENT fills the PATIENT role of EVENT. In contrast, *eloquent person* in (2a) can be identified as event-based by (5b) only, as ENT acts as the AGENT of EVENT here (cf. Lapata 2001). We expect that disambiguating basic and event-related readings should work best if (5a) is constrained such that EVENT may **not** be instantiated by perception verbs such as *look*, *feel*, *taste* etc.

[6]κ measures the agreement among annotators on classification tasks. Its values range between 0 (no agreement at all) and 1 (perfect agreement), reflecting the degree of agreement *above chance* (Fleiss 1971).

Table 8.2 Category-wise κ-values for all annotators

	BASIC	EVENT	OBJECT	IMPOSS
κ	0.368	0.061	0.700	0.452

Table 8.3 Distribution of disagreement cases over classes

		1 voter			
		BASIC	EVENT	OBJECT	Total
2 voters	BASIC	–	172	16	283
	EVENT	18	–	1	21
	OBJECT	54	10	–	66

Table 8.2 displays the overall agreement figures broken down into the four class labels. These results underline our intuition that the distinction between the classes BASIC and EVENT is very difficult even for human subjects.

This is corroborated by a thorough analysis of the cases of annotator disagreements in Table 8.3. This table overviews all cases where one annotator disagrees with the other two. The rightmost column indicates the total number of 2:1-disagreements for each class. The missing mass is due to the IMPOSSIBLE class. As can be seen, the situation where two annotators vote for BASIC, while one prefers the EVENT class, accounts for most of the disagreements among the annotators (172 cases in total). The following instances, taken from the set of disagreement cases, exemplify the problems encountered by the annotators when being confronted with the BASIC vs. EVENT distinction:

(6) Any changes should only be introduced after PROPER research and costing, and after an initial experiment.

(7) Matthew thought his mother sounded very young, her voice BRIGHT with some emotion he could not quite define.

Resorting to (5), we argue for an event-based reading of *proper* in (6) (e.g., "research that has been properly conducted"), while *bright* in (7) should be given a basic interpretation.

As becomes evident from the quantitative analysis in Table 8.3 and these examples, the ambiguity between basic and event-related adjectives is the primary source of disagreement in our annotation experiment.

8.4.2 Re-analysis: Binary Classification Scheme

This observation led us to re-analyze our data using a binary classification that collapses basic and event-related adjectives into one class. This re-analysis is merely a shift in granularity: both basic and event-related adjectives denote properties, whereas object-related adjectives denote relations. Re-analyzing the data in this way improves overall agreement to $\kappa = 0.69$. See Table 8.4 for detailed agreement figures.

Table 8.4 Category-wise κ-values, binary classification scheme

	BASIC+EVENT	OBJECT	IMPOSS
κ	0.696	0.701	−0.003

The remaining disagreements between annotators have been manually adjudicated. After adjudication, the data set contains 689 adjective *tokens* that are unambiguously annotated, given the respective context, as denoting a property, while 138 tokens are labeled as relational. In total, 190 (out of 200) lexical adjective *types* are covered. Again, the missing mass is due to items marked as `IMPOSSIBLE` by at least one annotator.

8.4.3 Class Volatility

In order to judge the possibility of a *type-based* automatic adjective classification, we need to quantify the degree of class volatility we observe in the annotated corpus, i.e. the proportion of lexical types that are assigned alternating class labels at the token level.

We identified 12 adjectives that are volatile in the sense that they can undergo a type shift between basic and event-related vs. object-related adjectives[7] on the token level. Thus, the proportion of volatile types in the data set amounts to 6.3 %.[8]

In a further adjudication step, the number of volatile types could be reduced to 5 by evaluating fine-grained interpretation differences. Table 8.5 displays the full list of adjectives considered before and after adjudication, including their frequency distribution over the two classes. The subset of adjectives established as "true volatiles" after adjudication is given in boldface.

In the following, we discuss some typical cases of shifts between property-denoting and relational interpretations of adjectives.

8.4.3.1 Shifts from ATTR to REL

(8) a. Certain stations in BLACK rural areas or town locations were expected to be used exclusively by Africans.
  b. The suburban commuter station was emphatically a MALE preserve at certain times of day.

Both *black* in (8a) and *male* in (8b) have to be assigned a relational interpretation even though the basic meaning of these adjectives is property-denoting. This shift

[7]Henceforth, we will refer to these binary classes as ATTR(ibutive) and REL(ational).

[8]In a selective investigation on more representative data, class volatility turns out to be only slightly higher (cf. Sect. 8.6.1).

Table 8.5 Overview of volatile adjectives in the data set

	After adjudication			Before adjudcation	
Type	#ATTR	#REL	#ambig.	#ATTR	#REL
black	2	2	0	2	2
male	4	1	0	4	1
personal	2	2	1	2	3
political	2	2	1	1	4
white	3	1	0	3	1
detailed	5	0	0	4	1
mental	0	5	0	2	3
military	0	5	0	1	4
nuclear	0	5	0	1	4
professional	0	5	0	3	2
regional	0	5	0	1	4
technical	0	4	0	1	3

can be analyzed as a metonymic process where the adjective is re-interpreted as referring to an entity to which the respective property applies (concretely: *black people*). This entity, in turn, acts as an argument in a relation with the head noun. Thus, *black rural areas* in (8a) and *male preserve* in (8b) can be paraphrased as *rural areas* *inhabited by* *black people* and *a preserve* *occupied by* *male people*, respectively.

8.4.3.2 Shifts from REL to ATTR

Clear Contextual Shifts. In the following example, we observe a shift from a relational to a property-based adjective reading:

(9) But then aren't you taking a POLITICAL stance, rather than an aesthetic one?

(10) Their reasons for study are various and include simple PERSONAL interest and skill acquisition in connection with present or possible future employment.

We argue that a *political stance*, as in (9), does not denote a particular *stance on politics* (which would be the obvious relational interpretation), but a property: a stance that is *politically motivated* or *held for political reasons*. The given context crucially elicits the class-delineating function of the adjective, in that different subtypes of stances are contrasted.

The same holds for (10): Again, *personal* denotes a property that delineates a particular subtype of *interest*. This yields a semantic interpretation that is closer to a reflexive (*someone's own interest*) than to a relational reading (*someone's interest as a person/related to a person*).

Ambiguities. The following examples are considered ambiguous between a reading that has been shifted from relational to attributive and their original relational reading:

(11) By offering a range of study modes and routes, including part-time associate status, individuals are encouraged to use the course for a variety of PERSONAL purposes.

(12) Owing to unexplained POLITICAL pressures, General Choi then left the country.

Both a reflexive and a subjective interpretation (see discussion above) are possible for *personal purposes* in (11). Analogously, there are two possible readings for *political pressures* in (12): Either, the adjective is metonymically coerced to a noun reading (*people involved in politics*; see discussion of (8a) above) in order to fill the AGENT role of the noun, or the pressures are conceived of as being exerted for *political reasons*.

Comparing the examples in (9) and (10) to those in (11) and (12) sheds light on the possible influence of the head noun on the interpretation of the adjective. We presume that prototypical shifts as in (9) and (10) are licensed by a particular class of nouns we may call *psychological nouns*. Besides *interest* and *stance*, also *attitude*, *assessment* and *confidence*, among others, might be representatives of this class, thus licensing the same shift in the context of adjectives such as *personal* or *political*. A more thorough investigation of this hypothesis, however, is beyond the scope of this paper.

8.5 Automatic Type-Based Classification of Adjectives

In this section, we report the results of a machine learning experiment addressing the feasibility of an automatic corpus-based classification of adjectives on the type level. We restrict the task to the distinction between property-denoting and relational adjectives in the first place as we are not aware of any overt features that are (i) sufficiently discriminative to capture the fine-grained distinction between basic and event-based adjectives in borderline cases such as (4) and (ii) frequently observable in corpora. One particular focus of this experiment is on determining a feature set that yields robust performance on the binary classification task.

8.5.1 Features for Classification

Our classification approach is based on the observation that property-denoting and relational adjectives systematically differ with regard to their behaviour in certain grammatical constructions. These differences can be captured in terms of lexico-

Table 8.6 Set of features used for classification

Group	Feature	Pattern	Example
I	as	as **JJ** as	*as cheap as possible*
	comparative-1	**JJR** NN	*halogen produces a brighter light*
	comparative-2	RBR **JJ** than	*more famous than your enemies*
	superlative-1	**JJS** NN	*this is the broadest question*
	superlative-2	the RBS **JJ** NN	*the most beautiful buildings in Europe*
II	extremely	an extremely **JJ** NN	*an extremely nice marriage*
	incredibly	an incredibly **JJ** NN	*an incredibly low downturn*
	really	a really **JJ** NN	*a really simple solution*
	reasonably	a reasonably **JJ** NN	*a reasonably clear impression*
	remarkably	a remarkably **JJ** NN	*a remarkably short amount of time*
	very	DT very **JJ**	*gets onto a very dangerous territory*
III	predicative-use	NN (WP|WDT)? is|was|are|were RB? **JJ**	*my digital camera is nice*
	static-dynamic-1	NN is|was|are|were being **JJ**	*the current unit was being successful*
	static-dynamic-2	be RB? **JJ** .	*Be absolutely certain:*
IV	one-proform	a/an RB? **JJ** one	*a hard one*
V	see-catch-find	see|catch|find DT NN **JJ**	*90 % found the events relevant*
VI	morph	adjective is morphologically derived from noun	*culture* → *cultural*

syntactic patterns (Amoia and Gardent 2008, Beesley 1982, Raskin and Nirenburg 1998, Boleda 2006). We can cluster these patterns into groups (see Table 8.6[9]): I (features encoding comparability), II (gradability), III (predicative use), IV and V (particular constructions). All these feature groups encode grammatical properties that can be found with property-denoting adjectives only, while relational adjectives do not license them. As a positive feature for relational adjectives, we consider morphological derivation from nouns (group VI), e.g. *criminal* – *crime*, *economic* – *economy*. This information was extracted from the CELEX2 database (Baayen et al. 1996).

8.5.2 *Heuristic Generation of Training Instances from Seeds*

A major problem we encounter with the features presented above is their severe sparsity. Applied to our annotated corpus of 1,000 sentences, the complete feature set yields only 10 hits.

[9] The abbreviations used in the table denote part-of-speech tags according to the Penn Treebank nomenclature (Marcus et al. 1993).

Given the results of our corpus analysis in Sect. 8.4, however, we can raise the classification task to the type level, under the proviso that class volatility is limited to only a small number of adjective types and particular contextual occurrences. Under this assumption, we use our annotated data set as seed material for heuristically labelling adjective tokens in a large unannotated corpus. In this process, the unanimous class labels gathered from the manually annotated corpus are projected to the unannotated data. This means that potential class changes on the token level are completely disregarded.

8.5.3 Data Set Construction

Using the heuristic annotation projection technique described above, we created two data sets for our classification experiments. These provide the training data for two classifiers: a decision tree (ADTree) and a meta classifier that makes use of boosting. In the experiments reported here, we used the classifier implementations of Weka (Witten and Frank 2005).

Data Set 1. The first data set we created is based on the manually annotated corpus described above. We identified all adjective types in the corpus that exhibit perfect agreement across all annotators and are not found to be volatile. This yields 164 property-denoting and 18 relational types, which we use as seeds for heuristic token-level annotation. For each lexical adjective type, we acquired a corpus of 5,000 sentences from a subsection of the ukWaC corpus (Baroni et al. 2009) to which the labels from the annotated corpus were projected as described in Sect. 8.5.2. We refer to this data set as DS1.

Data Set 2. In order to assess the soundness of our features on a larger and possibly more representative sample and to evaluate whether our method of heuristic annotation projection can be generalized to different data sets, we also compiled a gold standard of property-denoting and relational adjectives from WordNet 3.0.

Like any other PoS category, adjectives in WordNet are organized in *synsets*, i.e. sets of (nearly) synonymous types. Every synset reflects fine-grained meaning differences in terms of *word senses*. All lexical knowledge in WordNet is encoded by semantic relations between word senses. The information of interest for our task is captured by the relations *attribute* and *pertainymy* (Miller 1998): Presence of an *attribute* relation between an adjective and a noun sense indicates that the noun denotes a property and the adjective specifies a possible value of this property. A *pertainymy* relation[10] linking an adjective and a noun sense indicates a relational

[10]Note that the pertainymy relation in WordNet is uni-directional as it contains only links from adjectives to their morphological base nouns, but not from derived nouns to base adjectives. For instance, *cultural* and *culture* or *dental* and *tooth* are linked by pertainymy, while no such link exists between *short* and *shortness*.

adjective meaning. If neither an *attribute* nor a *pertainymy* relation is specified for a given adjective, nothing can be inferred regarding the binary classification considered here.

For the construction of our gold standard, we collected all adjectives from WordNet that are unambiguously property-denoting or relational, meaning that *all* of their senses are marked with either the *attribute* or the *pertainymy* relation. This yields 3,727 property-denoting and 3,655 relational types (i.e., roughly one third of the overall 21,486 adjective types in WordNet). We only considered adjectives with more than 2,000 occurrences in the same subsection of the ukWaC corpus used for the construction of DS1. The final data set comprises 246 property-denoting and 140 relational adjective types. Again, we extracted up to 5,000 sentences from ukWaC for each of these adjectives, and assigned them the class labels ATTR and REL, respectively. The resulting data set is referred to as DS2.

8.6 Evaluation

As our classification is intended to be used in ontology learning tasks, we evaluate the performance of the classifiers in separating property-denoting vs. relational adjectives in terms of precision and recall. Depending on whether attribute or relation learning is in focus, it is primarily important to achieve high performance for the respective target category of adjectives rather than good overall accuracy for both classes. However, in case this classification might be of interest for tasks different from ontology learning as well, we also report accuracy scores.

In the following, we report on the classification performance on both data sets, based on different feature combinations: `all-feat` comprises all features individually, while in `all-grp` we collapsed them into groups (see Table 8.6). As a morphological lexicon might not be available in all domains and languages, we also experimented with a feature combination `no-morph` that incorporates all the collapsed features from `all-grp` except for the morphological derivation feature from group `VI`.

We compare all these feature combinations against (i) a *majority* baseline that assumes that all adjective types are classified as belonging to the class that accounts for the majority of types in the data and (ii) a rule-based *morph-only* baseline that relies on the *morph* feature only: If an adjective is derived from a noun, it is classified as relational, otherwise as property-denoting. The performance of this decision rule allows to assess the added value that results from a classification approach capitalizing on multiple corpus-derived features in comparison to a simple rule-based approach that merely relies on an existing lexical resource. All results reported in the following are statistically significant ($p < 0.05$) in comparison to the baselines, according to McNemar's test (McNemar 1947).

Table 8.7 Class-based precision and recall scores for the ADTree (DS1, cross-validation)

	ATTR			REL			
	P	R	F	P	R	F	Acc
all-feat	0.95	**0.98**	0.96	**0.71**	0.56	0.63	0.93
all-grp	0.95	**0.98**	0.96	**0.71**	0.56	0.63	0.93
no-morph	**0.96**	0.96	0.96	0.67	**0.67**	**0.67**	0.93
morph-only	**0.96**	0.78	0.86	0.25	**0.67**	0.36	0.77
majority	0.90	1.00	0.95	0.00	0.00	0.00	0.90

Table 8.8 Class-based precision and recall scores for the boosted learner (DS1, cross-validation)

	ATTR			REL			
	P	R	F	P	R	F	Acc
all-feat	**0.96**	**0.99**	**0.97**	0.79	0.61	0.69	**0.95**
all-grp	**0.96**	**0.99**	**0.97**	**0.85**	0.61	**0.71**	**0.95**
no-morph	0.95	0.96	0.95	0.56	0.50	0.53	0.91
morph-only	**0.96**	0.78	0.86	0.25	**0.67**	0.36	0.77
majority	0.90	1.00	0.95	0.00	0.00	0.00	0.90

8.6.1 Results on Data Set 1

We ran a first experiment on the heuristically annotated data set, using 10-fold cross validation.

Precision and Recall. Precision and recall figures achieved by the decision tree for both classes of adjectives are summarized in Table 8.7. We observe very high precision values for the ATTR class, while precision for REL adjectives is lower. In Hartung and Frank (2010a), we showed that even higher precision values, well above the baseline, can be obtained for both classes when an equal number of training instances is provided by random oversampling (Batista et al. 2004). This indicates that a corpus-based classification approach can be applied equally well for attribute and relation learning. Moreover, as revealed by the performance of the *morph-only* baseline, corpus-based learning is clearly superior to a simple lexical lookup procedure that relies on morphological derivation as the only source of information.

Comparing the decision tree and the boosted learner (see Table 8.8), we observe slight improvements for the ATTR class, but – more importantly – a considerable increase on the REL class when the `all-grp` combination is used with boosting. Apparently, this classifier benefits from collapsing individual features

Table 8.9 Volatility of prototypical class members

	ATTR	REL	IMPOSS
Type	Tokens	Tokens	Tokens
beautiful (ATTR)	50	0	0
black (ATTR)	35	7	8
bright (ATTR)	45	1	4
heavy (ATTR)	42	0	8
new (ATTR)	50	0	0
civil (REL)	0	49	1
commercial (REL)	5	44	1
cultural (REL)	2	48	0
environmental (REL)	0	48	2
financial (REL)	0	46	4

into groups, thus merging the values of sparse features. For this classifier, at least, the morphological feature provides valuable information, while the decision tree performs surprisingly well on the unbalanced set when this feature is omitted. Interestingly, this affects both classes, even though morphological derivation is the only positive feature we provided for the REL class. However, for the small set of relational adjectives in DS1, the morphological information is not sufficiently precise, as can be seen from the performance of the *morph-only* baseline.

In sum, our results indicate that automatically distinguishing property-denoting and relational adjectives at the type level is possible with high accuracy, even on the basis of small training sets.

Class Volatility. Yet, as discussed in Sect. 8.4.3, a type-based classification approach runs the risk of being affected by class shifts on the token level. This is not reflected by the evaluation carried out on the heuristically acquired corpus. In order to investigate the strength of this effect, we selected five adjective types of each class and inspected a random sample of 50 tokens for each type. As example cases, we chose types that were automatically classified with high confidence scores, since, at this point, we were particularly interested in the class change potential of prototypical class members.

The results of this investigation are shown in Table 8.9. The columns labelled with ATTR and REL display counts of tokens that matched one of our target categories, whereas the rightmost column subsumes all tokens that could not be assigned to the ATTR or REL class. The majority of these cases is due to contexts where the adjective is part of a multi-word expression that does not elicit either a property or a relation, e.g. *black hole* or *heavy metal band*.

The average class volatility on the token level amounts to 8.6 %. These figures can be considered as rough estimates for the average error that is introduced by raising our classification task to the type level. Still, our findings suggest that class volatility is not an issue that affects entire classes on a large scale, but seems to be limited to individual contexts.

Table 8.10 Class-based precision and recall scores for the Boosted Learner (DS2, test set)

	ATTR			REL			
	P	R	F	P	R	F	Acc
all-feat	0.85	0.82	0.83	0.70	0.75	0.72	0.79
all-grp	**0.91**	0.80	**0.85**	**0.71**	**0.86**	**0.77**	0.82
no-morph	0.87	0.80	0.83	0.69	0.79	0.73	0.79
morph-only	0.80	**0.84**	0.82	0.69	0.64	0.66	0.77
majority	0.64	1.00	0.53	0.00	0.00	0.00	0.64

8.6.2 Results on Data Set 2

With 246 property-denoting vs. 140 relational adjective types, the class distribution on DS2 is less skewed in comparison to DS1. Furthermore, DS2 offers sufficient training data for both classes. DS2 was therefore separated into training (80 %) and test data (20 %). The test set contains 49 property-denoting and 28 relational adjectives.

On DS2, the boosted classifier yields the best results. Detailed figures are displayed in Table 8.10. While all feature combinations outperform both baselines, the `all-grp` combination achieves the best results for both classes in terms of F-score and accuracy. Considering all features without collapsing them into groups yields lower performance in general, except for recall on the ATTR class. Again, *morph-only* constitutes a very strong baseline. Completely omitting the derivation feature leads to a slight decrease in performance, while the best results are obtained by combining derivation information with the corpus-based features.

Comparing the performance on DS1 and DS2, we find, above all, that the REL class benefits from the less skewed class distribution in terms of recall. This is in line with the results we observe in further experiments, using random oversampling on the training section of DS2 (Hartung and Frank 2010a). The results on DS2 underline that property-denoting adjectives can be identified with high precision and decent recall. With regard to relational adjectives, we also observe highly satisfactory recall scores, while precision is lower, but still acceptable.

8.6.3 Discussion

Our experiments show good and consistent results on both DS1 and DS2. The pattern-based features we use for classification on the type level achieve high performance on the identification of property-denoting adjectives. Due to heuristic instance generation, the approach involves a moderate annotation effort. It should also be applicable to attribute learning in specialized domains and other languages, where no linguistic resources are available.

For the identification of relational adjectives, both classifiers perform robustly. The best classification performance for this class is obtained if both an external morphological database and a sufficient amount of training data can be provided. On the other hand, relying on morphological information alone is certainly a good reference point, but not fully sufficient for separating the two classes at a high performance level.

Inspection of the decision trees learned from DS1 and DS2 sheds light on the features that are particular valuable for classifying adjectives denoting properties and relations. Being selected in both experiments, the following features (cf. Table 8.6) turn out to be most effective as they generalize well across both data sets: *comparative-1*, *very*, *superlative-2*, *one-proform* and *morph*. Interestingly, the informative features are dispersed over all feature classes, except for the classes `III` and `V`. This suggests that, contrary to proposals in the theoretical linguistic literature, predicative use of adjectives is not sufficiently discriminative for this task from an empirical perspective, while the *see-catch-find* test seems to be too sparse to be informative for automatic classification.

Our type-based classification, while being effective, runs the risk of being affected by type shifts on the token level. However, our findings on DS1, as well as empirical investigation of the annotated corpus suggest that class volatility is not an issue that affects entire classes on a large scale, but seems to be limited to individual contexts. This result is corroborated by examining WordNet: Analyzing the distribution of property-denoting and relational readings over the different word senses of adjectives in WordNet we found that 13.9 % of all types exhibit volatile word senses that cannot be uniformly assigned a property-denoting or a relational reading. Even though this proportion is higher than the one we observed in our corpus, it is still tractable. This holds all the more as a preliminary investigation on the token level suggests that, for *prototypical members* of the ATTR and REL class, the proportion of volatile tokens might be even lower (8.6 % on average, see Table 8.9). By further investigation of classified data on the token level, we hope to obtain useful contextual features that are indicative for class shifts. This is left for future work.

8.7 Conclusions and Outlook

In this paper, we investigated the task of distinguishing adjectives with regard to their ontological type in an empirical, corpus-based classification approach. Such a classification is a prerequisite for the task of learning attributes together with their values from text corpora.

In a corpus study based on human annotations and an automatic classification approach we find that only a coarse-grained classification into adjectives denoting properties and relations yields stable results in terms of annotator agreement. Similar to Boleda (2006), we do not find clear supporting evidence for a third class that highlights the difference between independent and founded properties. Moreover, we show that by abstracting from this subtle difference, automatic classification of property-denoting and relational adjectives is feasible at high performance levels. To compensate for sparse training data on the token level, we generate additional training instances in a semi-supervised manner, relying on observed low class volatility at the token level. Further performance improvements can be expected from contextual features that detect class changes on the token level. This issue needs to be addressed in future research.

Another open issue concerns the feasibility of separating adjectives that are neither property-denoting nor relational. As adjectives of this kind are too sparse in our annotated data and since they do not constitute a homogeneous class in WordNet, we could not investigate the problem in this paper. In future work, we will explore whether the approach presented here can be extended towards a multi-class classification, using linguistic class descriptions offered by Amoia and Gardent (2008).

In summary, we consider our type-based adjective classification an attractive method for supporting ontology learning in different languages or specialized domains, where appropriate lexical resources are not yet available.

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Chapter 9
Why Chocolate Eggs Can Taste Old but Not Oval: A Frame-Theoretic Analysis of Inferential Evidentials

Wiebke Petersen and Thomas Gamerschlag

Abstract So-called *phenomenon-based perception verbs* such as 'sound, taste (of)', and 'look (like)' allow for a use in inferential evidential constructions of the type 'The chocolate egg tastes old'. In this paper, we propose a frame-theoretic analysis of this use in which we pursue the question how well-formed inferential uses can be discriminated from awkward uses such as #'The chocolate egg tastes oval'. We argue that object knowledge plays a central role in this respect and that this knowledge is ideally captured in frame representations in which object properties are easily translated into attributes such as TASTE, SMELL, AGE, and FORM. We represent the more general knowledge of the range and domain of the attributes in a type signature. In principle, an inference is recognized as admissible if the values of one attribute can be inferred from the values of another attribute. In the analysis, this kind of inferability is modeled as an inference structure defined on the type signature. The definitions of type signatures and inference structures enable us to establish two constraints which are sufficient to discriminate the admissible and inadmissible uses of phenomenon-based perception verbs in simple subject-verb-adjective constructions.

Keywords Inferential evidential • Phenomenon-based perception verbs • Frame-theoretic analysis • Type signature

9.1 Introduction

As recently pointed out by Gisborne (2010) and Whitt (2009, 2010), perception verbs play an important role as a lexical means to express evidentiality. In languages like English and German especially, the evidential use of verbs of this

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type compensates for the lack of the elaborate grammatical system of evidential markers which is attested for other languages in the typological literature (among others Chafe and Nichols 1986, Willett 1988, de Haan 1999, Aikhenvald 2004). For example, the perception verb ‘taste (of)’ can be used to express inferential evidentiality as in (1). Here, the inference that the chocolate egg is old is based on the way it tastes. More precisely, the proposition made up of the predicative complement and the subject referent is inferred from the sensory evidence which is explicated by the perception verb.

(1) The chocolate egg tastes old.

The evidential use of ‘taste’ in (1) can be differentiated from the nonevidential use of the verb in (2), which is called the “attributary use” by Gisborne (2010). In this use, the quality expressed by the secondary predicate is not inferred but rather perceived directly in the way indicated by the perception verb. With respect to the example in (2), this means that the fact that the chocolate egg is bitter is perceived directly through its taste.

(2) The chocolate egg tastes bitter.

The attributary use can be considered more basic since the predicative complement simply highlights a quality specific to the sense modality indicated by the verb. By contrast, the evidential use in (1) is characterized by some kind of mismatch between the predicative complement and the verb, since ‘old’ does not refer to a gustatory quality of the chocolate. As a consequence, awkward combinations such as the one in (3) cannot be ruled out as inferential evidentials by a mismatch between the sense modality referred to by the verb and the quality expressed by the predicative complement. Rather, (3) is excluded because the form of the chocolate egg cannot be inferred from its taste.

(3) # The chocolate egg tastes oval.

The knowledge of admissible and nonadmissible inferentials such as (2) and (3) is part of the speaker’s object knowledge.[1] For instance, we know that chocolate has a taste and that there is some correlation between the taste of chocolate and its age. By contrast, we know that there is no such relation between the taste of a chocolate egg and its form. One might think of a situation in which a blindfolded person has to guess at the form of food put into his/her mouth, but then s/he would rather say that something *feels* oval.

[1]The admissibility and awkwardness of the examples (1)–(3) can neither be explained by pure linguistic nor by pure world knowledge. In our view, the strict separation between world and lexical knowledge has to be abandoned in order to account for evidential uses of perception verbs.

In Gamerschlag and Petersen (2012), we argue that this kind of object knowledge is best captured in frame representations understood as recursive attribute-value structures in the sense of Barsalou (1992). Properties such as taste, age, and form can be translated directly into the corresponding attributes TASTE, AGE, and FORM in the frame of an object such as a chocolate egg. Furthermore, we have argued that different object types such as different types of chocolate eggs can be represented in a type hierarchy whose elements differ with respect to the values of the attributes. We have proposed a general constraint which conceptually well-formed evidential constructions need to satisfy. It requires the attribute encoded by the perception verb to exhibit covariation with the attribute for which the predicative complement specifies a value. For instance, the attribute encoded by the verb 'taste' in the evidential construction 'The chocolate egg tastes old' is TASTE while the predicative complement 'old' refers to the value of the attribute AGE. The example is well-formed since the values of TASTE and AGE covary for different instances of chocolate eggs, i.e., the taste of an old chocolate egg is different from the taste of a new one. By contrast, the construction 'The chocolate egg tastes oval' is awkward because the attributes TASTE and FORM do not show covariation in the frame of a chocolate egg. Since chocolate eggs are conceptualized by their specific egg-form, they do not vary in their form. However, even the more general concept 'chocolate piece' does not exhibit covariation between the values of the attributes TASTE and FORM: an oval and a square piece of chocolate may have an identical taste.

Although our former approach in Gamerschlag and Petersen (2012) can be considered adequate to capture the cognitive process of experiential learning and deducing which underlies conceptually well-formed inferential evidentials of the type in focus, it is problematic with respect to untypical instances of objects. The approach depends on the key assumption that the type hierarchy can be learned from the experience of individual instances and thus that for every instance there exists an adequate type in the type hierarchy. Hence, in a realistic type hierarchy of chocolate eggs there will also be untypical instances such as a new chocolate egg with the taste of an old one and vice versa. As a consequence, covariation of TASTE and AGE only holds if one disregards the untypical instances and narrows the view to the typical instances. However, it is a nontrivial problem to capture the notion of typical and untypical instances in a formal approach. One option would be to introduce weighted type hierarchies in which the types are weighted by their typicality. But this would raise new problems like how to compute the weights and how to interpret them. In the present paper we will propose a different approach, in which admissible inferences are directly built into the type hierarchy. Thus, we extend the type hierarchies by explicit knowledge about admissible inferences. From a cognitive point of view, this knowledge can be induced from experience. Before coming to the details of our new analysis in Sect. 9.4, we will first introduce the frame model in the next section and then present some more data on inferential evidentials in Sect. 9.3.

9.2 Frame Model

In our frame model we follow Barsalou's claim that frames understood as recursive attribute-value structures "provide the fundamental representation of knowledge in human cognition" (Barsalou 1992, p. 21). A *concept frame* consists of a set of attribute-value pairs with each attribute specifying a property by which the described concept is characterized. For the attributes, we demand that they assign unique values to concepts and are thus functional relations. Frames are recursive in the sense that the value of an attribute is not necessarily atomic, but may be a frame itself. Formally, frames can be represented as connected directed graphs with labeled nodes (vertices) and arcs (edges): the arcs are labeled with attributes and the nodes with types. The latter restrict both the domain and the range of the attributes which are connected to the labeled nodes. Furthermore, one of the nodes in a frame is identified as the *central node* of the frame. The central node is the node which determines what the frame is about.

A graph drawing of an example frame is given in Fig. 9.1 (adapted from an example in Petersen et al. 2008). The central node, which is marked by a double border, represents the concept of a car with a 4-cylinder diesel engine.[2] As the central node is typed with *car*, this concept is modeled by a frame of type *car*. Furthermore, three attributes apply to the central node, namely COLOR, ENGINE and MILEAGE. These attributes specify the dimensions according to which the concept is further characterized. Values assigned to attributes are frames themselves and determine the concrete realization of the property given by the attribute. The values may differ with respect to specificity and structural complexity. For instance, in Fig. 9.1 the value of the attribute ENGINE is a complex frame with three additional attributes, whereas atomic values, which are not further specified by additional attributes, are assigned to the two attributes COLOR and MILEAGE. While the value

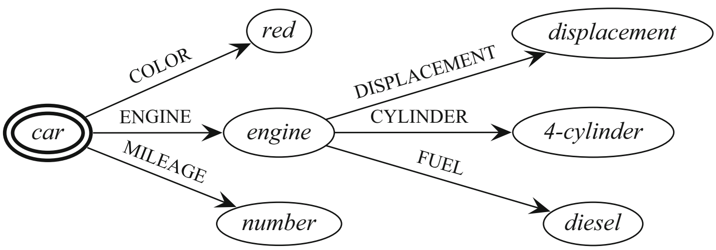


Fig. 9.1 An exemplary *car* frame in graph representation

[2]Note that in our framework the central node does not necessarily need to be the root of the graph (as it is in the example). Hence, it needs to be explicitly marked. For instance, in frames of functional concepts like 'mother of' or 'taste of' the central node is usually not a root node of the frame graph. For a discussion of frames with central nodes which are not roots see Petersen and Osswald (this volume).

of COLOR is rather specific, namely *red*, the value *number* of MILEAGE is not, since it comprises the whole range of the function MILEAGE. It is the recursive structure of frames and the possibility of choosing more or less specific types as labels for their nodes that makes them flexible enough to represent concepts of any desired grade of detail.

Note that our frames are closely related to feature structures as defined by Carpenter (1992). However, they differ from this kind of structure in that the central node need not be the root node of the graph (cf. Footnote 2). Frames, therefore, can be regarded as generalized feature structures. Hereby our definition gains the necessary flexibility to model the relationality of concepts like 'spouse' or 'sister' that bear an inherent relation (cf. Petersen and Osswald this volume). However, for the present paper, relational concepts and their properties are not relevant.

Formally, a concept frame is defined as follows (cf. Petersen 2007, p. 5):

Definition 9.1. Given a set TYPE of types and a finite set ATTR of attributes. A *frame* is a tuple $F = (Q, \bar{q}, \delta, \theta)$
where:

- Q is a finite set of nodes,
- $\bar{q} \in Q$ is the central node,
- $\delta : \text{ATTR} \times Q \to Q$ is the partial *transition function*,
- $\theta : Q \to \text{TYPE}$ is the total *node typing function*;

such that the underlying graph (Q, E) with edge set $E = \{\{q_1, q_2\} \mid \exists a \in \text{ATTR} : \delta(a, q_1) = q_2\}$ is connected.

The underlying directed graph of a frame is the graph $(Q, \mathbf{E})$ with edge set $\mathbf{E} = \{(q_1, q_2) \mid \exists a \in \text{ATTR} : \delta(a, q_1) = q_2\}$.

If $\theta(\bar{q}) = t$, we say that the frame is of type t. If $\theta(q) = t$ is true for a frame, we call this node a t-*node*. And if $\delta(a, q_1) = q_2$ is true for a frame, we say that the frame has an a-*arc* from q_1 to q_2.

So far, the frame representation as described above does not impose formal restrictions on either the type of the node an attribute may be attached to or on the type of its value. This can lead to undesirable frames in which attributes connect nodes with inappropriate type labels not fitting the domain and the range of the attribute (e.g., an attribute FUEL connecting a node of type *book* to a node of type *number*). In order to restrict the set of admissible frames, we assume a *type signature* which conveys two kinds of information: first, it defines the set of types and imposes an order on it. Second, it states appropriateness conditions for the types which specify the domain and range of attributes (cf. Carpenter 1992).

An example type signature is given in Fig. 9.2 (taken from Petersen et al. 2008). Here, subtypes, i.e., more specific types, are written below their supertypes (e.g., *apple* is a subtype of *fruit*, which is itself a subtype of *physical object*). The hierarchy of types is enriched with appropriateness conditions (ACs). For instance, 'SHAPE:*shape*' is an AC for the type *physical object*. ACs fulfill two tasks: first, they restrict the attribute domains by declaring the set of adequate attributes for frames of

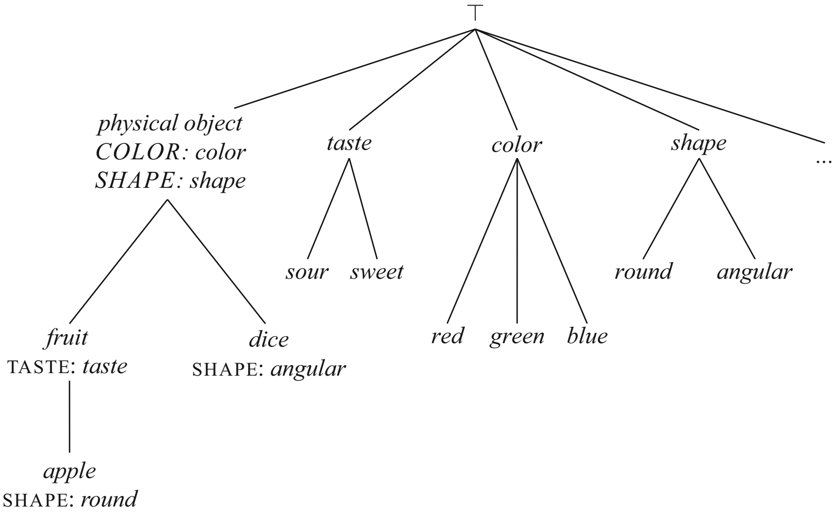


Fig. 9.2 Example type signature

a certain type (e.g., the attributes SHAPE and COLOR but not TASTE may be attached to nodes of the type *physical object*). Second, they restrict the attribute ranges by requiring all values of an attribute to be at least of a certain type (e.g., the values of TASTE may be of type *taste*, *sour* or *sweet*, but not of type *red*). Subtypes inherit all ACs of their supertypes and may tighten them up. For example, in the type signature in Fig. 9.2 the type *fruit* inherits the ACs 'COLOR:*color*' and 'SHAPE:*shape*' from *physical object*, adds the AC 'TASTE:*taste*' and passes all three ACs on to its subtype *apple*. The latter tightens the inherited AC 'SHAPE:*shape*' up to 'SHAPE:*round*'.

Both the example type signature in Fig. 9.2 as well as the example frame in Fig. 9.1 exhibit some kind of redundancy: strings which occur as attribute labels occur as type labels as well (e.g., the AC 'TASTE:*taste*' at the type *fruit* in Fig. 9.2 or the labels 'engine' and 'displacement' in Fig. 9.1). Such redundancies are typical in typed attribute-value representations like feature structures and frames. In contrast to grammar formalisms like *Head-driven Phrase Structure Grammar*, HPSG, (Pollard and Sag 1987, 1994) which use frames as a technical device, we assume that frames are cognitive structures (Löbner this volume). In order to capture the ontological status of attributes we follow the arguments given by Guarino (1992), who points out that attribute concepts like COLOR which bear an inherent relationality always carry two interpretations: they can be interpreted *denotationally* as the set of all colors and *relationally* as the function assigning to each object its color. Thus in terms of frames, there is a systematic relationship between the attribute COLOR and the type *color*; the former corresponds to the relational and the latter to the denotational interpretation of 'color'. The attribute COLOR denotes the color-assigning function and the type *color* the value range of this function.

In our type system, there exists for each attribute a unique type corresponding to the value range of the attribute. As the correspondence between these types and the attributes is one-to-one, we can identify the attributes by their range types and postulate that the attribute set is a subset of the type set (for details, see Petersen 2007). If we refer to such a label in its role of an attribute resp. function, we will simply call it *attribute* and use small capitals for its label and when we refer to it in its role of a type we will call it an *attribute type*. In our example type signature in Fig. 9.2 we can find three attribute types, namely *shape*, *color* and *taste*. Note that the subtypes of an attribute type need not be attribute types themselves. Furthermore, we assume that for each attribute ATTR the type signature contains an introductory type with the AC 'ATTR:*attr*', which states the relation between the label 'attr' used as an attribute and as a type, namely that the type denoting the value range of ATTR is *attr*.[3]

Formally, we define a type signature based on the definition of a type hierarchy (Petersen 2007, p. 13f.):

Definition 9.2. A *type hierarchy* (TYPE, $\sqsupseteq$) is a finite partially ordered set which forms a join semilattice, i.e., for any two types there exists a least upper bound. A type t_1 is a *subtype* of a type t_2 if $t_1 \sqsupseteq t_2$.

Given a type hierarchy (TYPE, $\sqsupseteq$) and a set of attributes ATTR $\subseteq$ TYPE, an *appropriateness specification* on (TYPE, $\sqsupseteq$) is a partial function Approp : ATTR $\times$ TYPE $\rightarrow$ TYPE such that for each $a \in$ ATTR the following holds:

(i) *Attribute introduction:* There is a type Intro(a) $\in$ TYPE with:

- Approp(a, Intro(a)) $= a$ and
- For every $t \in$ TYPE : if Approp(a, t) is defined, then Intro(a) $\sqsubseteq t$.

(ii) *Specification closure:* If Approp(a, s) is defined and $s \sqsubseteq t$, then Approp(a, t) is defined and Approp(a, s) $\sqsubseteq$ Approp(a, t).

(iii) *Attribute consistency:* If Approp(a, s) $= t$, then $a \sqsubseteq t$.

A *type signature* is a tuple (TYPE, $\sqsupseteq$, ATTR, Approp), where (TYPE, $\sqsupseteq$) is a type hierarchy, ATTR $\subseteq$ TYPE is a set of attributes, and Approp : ATTR $\times$ TYPE $\rightarrow$ TYPE is an appropriateness specification.

The first two conditions on an appropriateness specification are standard in the theory of type signatures (Carpenter 1992), except that we tighten up the attribute introduction condition. We claim that the introductory type of an attribute 'a' carries the appropriateness condition 'a:a'. By the attribute-consistency condition, we ensure that Guarino's consistency postulate holds (Guarino 1992).

Type signatures may be considered an ontology covering the background or world knowledge. According to Definition 9.3 below, a frame is considered to be

[3]Note that in the AC 'ATTR:*attr*' the expressions ATTR and *attr* do not refer to two distinct objects carrying identical labels, rather the two expressions are identical and denote the same object (attr $\in$ ATTR $\subseteq$ TYPE). Only to improve readability we use typography as a marker to distinguish between the attribute role and the type role of an attribute.

well-typed with respect to a type signature if all attributes of the frame are licensed by the type signature and if additionally the attribute values are consistent with the appropriateness specification.

Definition 9.3. Given a type signature (TYPE, $\sqsupseteq$, ATTR, Approp), a frame $F = (Q, \bar{q}, \delta, \theta)$ is *well-typed* with respect to the type signature, if and only if for each $q \in Q$ the following holds: if $\delta(a, q)$ is defined, then Approp$(a, \theta(q))$ is also defined and Approp$(a, \theta(q)) \sqsubseteq \theta(\delta(a, q))$.

The definition of the appropriateness specification guarantees that every arc in a well-typed frame points to a node that is typed by a subtype of the type corresponding to the attribute labeling the arc. In the remaining, we claim that all frames are well-typed.

For our frame-based analysis of inferential uses of PBVs in expressions like 'The chocolate egg tastes old' we need to solve the problem of deducing the implicit attribute AGE from its value *old* specified by the adjective 'old'. To this end, we introduce the notion of a *minimal upper attribute* of a type (cf. Petersen 2007). Since Definition 9.2 claims that the attribute set is a subset of the set of types, technically, types may be subtypes of attributes:

Definition 9.4. An attribute a is called a *minimal upper attribute (mua)* of a type t, if it is a supertype of t ($a \sqsubseteq t$) and if there is no other attribute a' with $a \sqsubseteq a' \sqsubseteq t$. A minimal upper attribute of a type t is denoted by mua(t).

The example type signature in Fig. 9.2 shows several instances of minimal upper attributes. For example, TASTE equals mua(*sour*) and COLOR equals mua(*red*). Note that, although no such instance occurs in the example type signature, a type may have more than one minimal upper attribute (cf. Petersen et al. 2008).

9.3 Inferential Evidentials and Phenomenon-Based Perception Verbs

Before presenting our analysis, we will first have a closer look at the type of perception verbs that show up in inferential evidentials. Characteristically, these verbs belong to a subclass of perception verbs which realize the stimulus as subject, whereas the experiencer usually remains unrealized. Since perception verbs of this type demote the experiencer and focus on the perceived phenomenon, they are called *phenomenon-based perception verbs* in the typological study by Viberg (1984). Alternative terms of reference for this subclass are *stimulus subject perception verbs* (Levin 1993), *object-oriented perception verbs* (Whitt 2009, 2010), and SOUND-*class verbs* (Gisborne 2010). In the following, we will use Viberg's term *phenomenon-based perception verbs* (henceforth: PBVs). As illustrated in (4) there is a PBV for each of the five sense modalities in English which isolates a specific sensory attribute of the subject referent 'chocolate egg' and allows for the specification of a value by means of an adjective. For instance, 'soft' in (4c) specifies a value of the attribute TOUCH while 'bitter' in (4d) denotes the value of the attribute TASTE. The attributes encoded by the PBVs in (4) can be translated directly into attributes in frame representations, as will be shown in the next chapter.

(4) The chocolate egg ...
 a. looks oblong. (SIGHT)
 b. sounds hollow. (SOUND)
 c. feels soft. (TOUCH)
 d. tastes bitter. (TASTE)
 e. smells sweet. (SMELL)

The examples given in (4) are instances of the attributary use of PBVs. In addition, all of the PBVs can show up in inferential evidentials. Since they select a predicative argument, they involve an embedded proposition which consists of the subject referent and the embedded predicate. This property makes verbs of this subtype particularly suitable for the use in inferential evidentials and sets them apart from other types of perception verbs such as 'hear' and 'listen (to)' which realize the experiencer as subject.

The sentences in (5) illustrate the evidential use of PBVs, in which a mismatch between the attribute encoded by the verb and the value explicated by the adjective leads to the inference of a suitable attribute. In (5a) 'happy' cannot be interpreted as the value of SIGHT. Instead, it is a specific state of a person's MOOD which is inferred from the way s/he looks. Likewise, 'solid' in (5b) does not specify a SOUND-quality but rather the SOLIDITY of the wall. In (5c) 'expensive' characterizes the PRICE of the seats, which is deduced from their TOUCH. The adjective 'French' in (5d) refers to the ORIGIN of the wine, something one can guess from its TASTE. Finally, in (5e) the smell emitted by the carpet serves as an indicator to judge its AGE.

(5) a. Peter looks happy. (SIGHT → MOOD: *happy*)
 b. The wall sounds solid. (SOUND → SOLIDITY: *solid*)
 c. The car seats feel expensive. (TOUCH → PRICE: *expensive*)
 d. This wine tastes French. (TASTE → ORIGIN: *French*)
 e. The carpet smells new. (SMELL → AGE: *new*)

The inferences in the above examples are implicatures since they can be negated without yielding a contradiction. As can be seen in (6), the sentence in (5d) can be combined with the negation of the inference.

(6) The wine tastes French, but actually it's not French, but Italian.

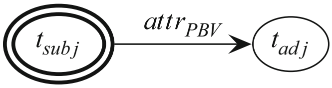
Before we come to our analysis, it is important to note that languages differ significantly with respect to the repertory of PBVs and the flexibility of inferential evidentials based on these verbs. As shown in Gamerschlag and Petersen (2012), French only has the PBVs *sonner* 'sound' and *sentir* 'smell (of)', which are highly limited with respect to the predicative complements they can take. Moreover, the inferential use of these verbs is virtually absent. By contrast, German has a repertory of PBVs which is similar to English and is at least as flexible in the inferential use. The following analysis is designed to capture the conceptual base of inferential evidentials in languages like English and German, whereas we will not address language-specific restrictions.

9.4 A Frame-Based Analysis of the Attributary and Evidential Use of PBVs

The aim of this section is to give a frame-based analysis of the different uses of PBVs that is rigid enough to model the conditions which determine the acceptability of these uses. We will examine the attributary use and the inferential use separately and formulate constraints that rule out awkward sentences such as 'The chocolate egg smells oval' or 'The sound tastes sweet'. As a premise of this analysis, we assume a fixed type signature (TYPE, $\sqsupseteq$, ATTR, Approp).

9.4.1 Attributary Use: Judging Well-Typed Instances by Object Knowledge (Direct Perception)

If a PBV is used noninferentially, as in 'The chocolate egg tastes bitter', its predicative complement expresses a quality of the subject referent that is perceived directly via the sense modality specified by the verb. From a frame-theoretic perspective, PBVs specify attributes. Hence, a noninferential use of a PBV is given if, first, the attribute specified by the verb is admissible in the frame of the subject referent and, second, if the adjective corresponds to a type that fits into the range of the attribute. To be more precise, we claim that the lexicon provides a lexical frame F_{subj} of type t_{subj} for the subject referent, a type t_{adj} for the adjective and an attribute $attr_{pbv}$ for the PBV. Moreover, the frame



consisting of these components is required to be well-typed:

(C1) WELL-TYPEDNESS CONSTRAINT: The frame $((q_1, q_2), q_1, \delta, \theta)$ with

- $\theta(q_1) = t_{subj}$,
- $\theta(q_2) = t_{adj}$,
- $\delta(attr_{\text{PBV}}, q_1) = q_2$

is well-typed with respect to the type signature (TYPE, $\sqsupseteq$, ATTR, Approp).

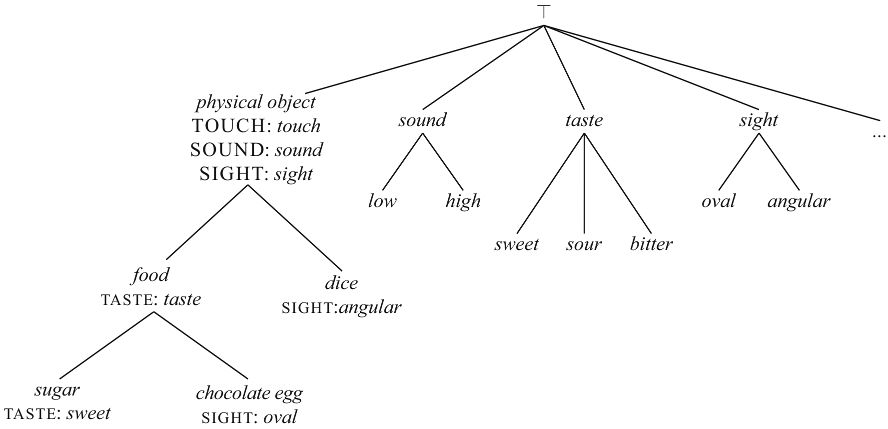


Fig. 9.3 Section of the type signature covering the background world knowledge

Fig. 9.4 Frame of a bitter-tasting chocolate egg

This constraint can be seen as a specific variant of a more general principle which captures the selectional restrictions of a verb (or of heads in general) by means of a constraint that requires the arguments to mirror (some of) the attributes encoded by the verb. Even more generally, a universal well-typedness constraint demands all concept frames to be well-typed. Constraint C1 is merely a specific instance of this universal constraint.

Three simple examples shall help to illustrate the constraint. Figure 9.3 shows a simplified section of the underlying type signature. It covers some world knowledge, like the fact that food usually has a taste, while for example sounds do not. Note that the actual type signature covering the full world knowledge of a speaker would be much more complex. An example that does not violate constraint C1 is (2), repeated as (7) below:

(7) The chocolate egg tastes bitter.

Since a chocolate egg is a kind of food and TASTE is an appropriate attribute for objects of type *food* and *bitter* is an admissible value for the attribute TASTE, it follows that the frame for example (7) in Fig. 9.4 is well-typed and that (7) does not violate constraint C1.

There are two possible ways to violate constraint C1: first, the attribute expressed by the verb may not be appropriate for the frame of the subject referent. Second, the adjective may not specify a possible value or a possible value set of the attribute expressed by the verb. An example of the first type of violation is:

(8) #The sound tastes bitter.

Fig. 9.5 Non-well-typed frame of a bitter-tasting sound violating constraint C1

Fig. 9.6 Non-well-typed frame of an oval-tasting chocolate egg violating constraint C1

Here, TASTE is not an appropriate attribute in a *sound* frame since in the type signature in Fig. 9.3 *sound* is not specified as a subtype of the type *physical object*, which is the introductory type of TASTE and thus the least specific type for which TASTE is an appropriate attribute. Hence, the frame for (8) in Fig. 9.5 is not well-typed and (8) is ruled out by constraint C1.[4]

The example in (3), repeated as (9), illustrates the second type of constraint violation:

(9) # The chocolate egg tastes oval.

The attribute TASTE is appropriate for a frame of type *chocolate egg*, since *chocolate egg* is a subtype of the type *physical object*. But, according to the type signature in Fig. 9.3, the values of TASTE must be of type *taste* or of one of the subtypes of *taste*. Since *oval* is not a subtype of *taste*, the frame for (9) in Fig. 9.6 is not well-typed and constraint C1 is violated by (9).

However, not all PBV-based constructions violating constraint C1 are unacceptable. In the next subsection, we will give a frame-based analysis of constructions with inferential uses of PBVs that exhibit the same type of mismatch as the example in (9), but are acceptable.

9.4.2 Inferential Use: Deducing Attributes and Types Through Knowledge of Admissible Inferences

A mismatch between the attribute encoded by the verb and the value type encoded by the adjective as in (9) does not necessarily result in an awkward construction.

[4]Note that it is not principally impossible to declare properties of abstract entities like sounds. Clearly, expressions like 'a loud sound', in which the adjective specifies the value range of the attribute VOLUME encoded in 'sound', are unproblematic. Even synesthetic metaphors like 'a loud color' are acceptable. For a frame-based analysis of these expressions see the discussion in Petersen et al. (2008).

Instances of inferential uses like the introductory example repeated in (10) are acceptable although, in principle, they exhibit the same kind of mismatch.

(10) The chocolate egg tastes old.

Although *old* is not a subtype of *taste*, a chocolate egg may taste old. This is because old chocolate usually has a special taste which results from chemical processes which take place over time. However, language users do not need to have any chemical knowledge to accept or produce (10), it is sufficient if they have experienced enough chocolate-tasting events with old and new (resp. fresh) chocolate in order to learn that the age of chocolate influences its taste and that thus usually the approximate age of a piece of chocolate is deducible from its taste. We will refer to this type of knowledge as *knowledge of admissible inferences*.

In our analysis, we will capture the knowledge of admissible inferences by defining an inference structure on the type signature. Such an inference structure states for each type which attributes can be inferred from others. It can thus be seen as a relation which assigns pairs of attributes to types. Two conditions must hold for an attribute pair which is related to a type by an inference structure: first, both the inferred attribute and the one from which it is inferred must be appropriate for frames of the type in focus. Second, we claim that subtypes inherit the inference properties of their supertypes. The first condition excludes undesirable inferences as for example TASTE → AGE for objects of type *movie* (a movie has an age, but no taste) or TASTE → COCOA CONTENT for objects of type *apple* (an apple has a taste, but no cocoa content). The second condition ensures that the knowledge of admissible inferences is not lost when specifying a concept in greater detail: in the type signature all information is monotonically transferred downwards from types to their subtypes. Hence, if an inference relation TASTE → AGE is true for chocolate in general, it is true for chocolate eggs as well. Formally, inference structures are defined as follows.

Definition 9.5 (preliminary version). INF $\subseteq$ TYPE $\times$ ATTR $\times$ ATTR is an *inference structure* on a type signature (TYPE, $\sqsupseteq$, ATTR, Approp) if the following holds:

(i) Compatibility: if $(t, a_1, a_2) \in$ INF then both Approp(a_1, t) and Approp(a_2, t) are defined.

(ii) Specificity closure: if $(t_1, a_1, a_2) \in$ INF and $t_1 \sqsubseteq t_2$ then $(t_2, a_1, a_2) \in$ INF.

Elements of INF are called *inference relations*. If $(t, a_1, a_2) \in$ INF we say that attribute a_2 is inferable from attribute a_1 in frames of type t.

So far, the definition of inference structures only captures the knowledge of which implicit attribute is, in principle, inferable from an explicitly mentioned one. For example, the information (*chocolate egg*, TASTE, AGE) $\in$ INF expresses that for chocolate eggs the attribute AGE, which is implicit in expression (10), is inferable

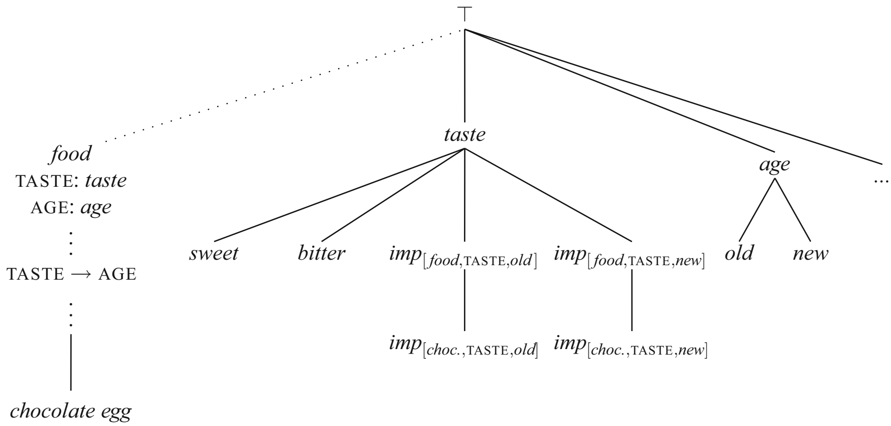


Fig. 9.7 Example type signature with inference structure and implicit value types

from the attribute TASTE, which is explicitly expressed by the verb in (10). However, the common knowledge of admissible inferences is more complex and quite fine-grained. It involves some knowledge of the implicit value of the attribute expressed by the PBV: the taste of an old-tasting chocolate egg is totally different from the taste of old-tasting whisky or old-tasting cheese. Hence, the type of the subject referent heavily influences the implicit value of the attribute expressed by the PBV. Furthermore, the implicit value also depends on the PBV used: for instance, old-tasting and old-looking are two different properties of an object. Finally, the implicit value depends on the adjective used: e.g., old-tasting and fresh or new-tasting is not the same. In consequence, the *implicit value type* of the attribute expressed by the PBV depends on three pieces of information: the type of the subject referent, the attribute expressed by the PBV and the type specified by the adjective. The following extension of Definition 9.5 captures the knowledge of implicit value types:

Definition 9.5 (continued). If INF $\subseteq$ TYPE $\times$ ATTR $\times$ ATTR is an inference structure on a type signature (TYPE, $\sqsupseteq$, ATTR, Approp) then the following holds:

(iii) Existence of implicit value type: if $(t, a_1, a_2) \in$ INF then there exists for each Approp$(a_2, t) \sqsubset t_i$ an implicit value type $imp_{[t,a_1,t_i]} \in$ TYPE with Approp$(a_1, t) \sqsubseteq imp_{[t,a_2,t_i]}$.

Figure 9.7 shows a section of an example type signature with inference structure and implicit value types. Note that due to space limitations, most types and ACs stated in the type signature in Fig. 9.7 are left out. However, in what follows we will assume that our type signature is complete and includes all the inference relations and ACs mentioned so far. In Fig. 9.7 the inference relation (*food*, TASTE, AGE) $\in$

INF is specified as TASTE $\rightarrow$ AGE for the type *food*.[5] The inference relation (*chocolate egg*, TASTE, AGE) $\in$ INF is inherited from type *food* and thus not explicitly stated in the type signature. Due to the third condition of Definition 9.5, the fact that (*chocolate egg*, TASTE, AGE) $\in$ INF and that *taste* $\sqsubset$ *old* implies the existence of the implicit value type $imp_{[chocolate\ egg,\text{TASTE},old]}$. Altogether, the single inference relation (*food*, TASTE, AGE) $\in$ INF implies the existence of four implicit value types: $imp_{[food,\text{TASTE},old]}$, $imp_{[food,\text{TASTE},new]}$, $imp_{[chocolate\ egg,\text{TASTE},old]}$, and $imp_{[chocolate\ egg,\text{TASTE},new]}$.

Furthermore, since the unification of two frames fails whenever the types are not unifiable, we have to assume additional types, for the conjunction of implicit value types with other types (e.g., a chocolate egg can at the same time taste old and bitter). It turns out that inference relations may increase the number of types in realistic type signatures dramatically and type signatures with inference structures can become quite complex. The question arises whether all types are needed and whether the assumption of such an extensive type signature is cognitively realistic. However, from a cognitive perspective, the huge amount of additional types is not problematic, as these types result from a productive process. Thus they do not need to be learned or memorized, they can be produced whenever necessary from the inference relations.

The problem as to whether all productively generated types are needed or whether they lead to overgeneralization needs more attention. First, we would like to point out that although expressions like ‘The chocolate tastes semi-aged’ sound awkward to the average chocolate consumer, this is not necessarily the case for chocolate experts. Additionally, for other types of food like ‘cheese’ it is common to assign them the property ‘tastes semi-aged’. Furthermore, the argument that our definition of inference structures produces for non-chocolate experts the superfluous type $imp_{[chocolate,\text{TASTE},semi\text{-}aged]}$ would only hold, if for objects of type *chocolate* the value type *semi-aged* would lie in the range of the attribute AGE (cf. Definition 9.5, condition (iii)). Thus, the expression ‘The chocolate tastes semi-aged’ can only be accepted by somebody who also accepts the expression ‘The chocolate is semi-aged’. Second, even if some superfluous types are likely to be produced, one could modify our analysis by assuming weighted types and a continuous adaption of the type signature in the process of language learning. Many awkward expressions produced by young children can be explained by overgeneralizations, resulting from a not yet finally fine-tuned type signature. To sum up, our assumption is that the types are first productively generated and then in a later stage speakers learn by experience which types give raise to less used expressions and consequently weaken their weights or remove them.

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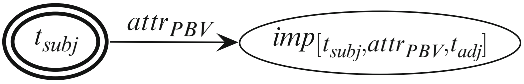
[5]It is not clear whether (*food*, TASTE, AGE) is a realistic inference relation as the value range of TASTE for objects of type *food* is so diverse that there is probably no general correspondence between the age of food and its taste. However, some of our informants accepted the sentence ‘The food tastes old’ and in order to exemplify the inheritance of inference relations we included this relation into our example type signature.

Given a type signature with an inference structure, an inferential construction such as ‘The chocolate egg tastes old’ is admissible if the frame



built from the type of the subject referent, the attribute specified by the PBV and the implicit value type, is well-typed with respect to the type signature. These conditions are formalized as follows.

(C2) INFERENCE CONSTRAINT: There exists a minimal upper attribute mua(t_{adj}) of t_{adj} such that $(t_{subj}, attr_{\text{PBV}}, \text{mua}(t_{adj})) \in$ INF and the inferred frame $(\{q_1, q_2\}, q_1, \delta, \theta)$ with

- $\theta(q_1) = t_{subj}$
- $\theta(q_2) = imp_{[t_{subj}, attr_{\text{PBV}}, t_{adj}]}$
- $\delta(attr_{\text{PBV}}, q_1) = q_2$

is well-typed with respect to the type signature (TYPE, $\sqsupseteq$, ATTR, Approp).

The frame inferred from ‘The chocolate egg tastes old’ is depicted in Fig. 9.8a. Since it is well-typed with respect to the type signature with the inference structure in Fig. 9.7, the example ‘The chocolate egg tastes old’ is admissible. Instead of using the technical type labels of implicit value types from Definition 9.5, one could alternatively use more descriptive type labels like *old chocolate taste* in Fig. 9.8b.

Example (9) which violates constraint C2 is repeated in (11):

(11) # The chocolate egg tastes oval.

In (11), the minimal upper attribute of type *oval* is SIGHT. Although SIGHT is an appropriate attribute for a frame of type *chocolate egg* and *oval* an appropriate value for SIGHT, (11) violates constraint C2 because TASTE $\rightarrow$ SIGHT is not an inference relation of type *chocolate egg* ((*chocolate egg*, TASTE, SIGHT) $\notin$ INF). That is, for chocolate eggs it is usually not possible to detect their optical appearance from their taste. By consequence, (11) is ruled out as an inferential evidential.

The fact that the inferences in the inferential uses of PBVs are implicatures, which can be negated, is compatible with the frame analysis. Consider the example in (12):

(12) The chocolate egg tastes old, but actually it is not old, but pretty new.

Logically, (12) states a conjunction of the propositions ‘The chocolate egg tastes old’ and ‘The chocolate egg is not old’. The conjunction is admissible although the adjective ‘old’ and *its negation* cannot hold of an object at the same time. The reason for this is that in (12) ‘old’ does not determine the value of the attribute AGE, but of the attribute TASTE. Hence, the value of AGE can be specified by the

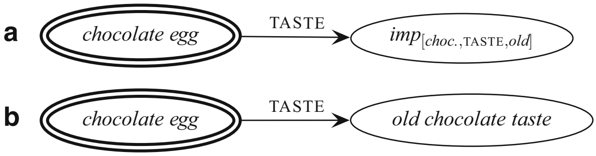


Fig. 9.8 Two variants of a frame of an old-tasting chocolate egg (above with technical type label, below with informal type label)

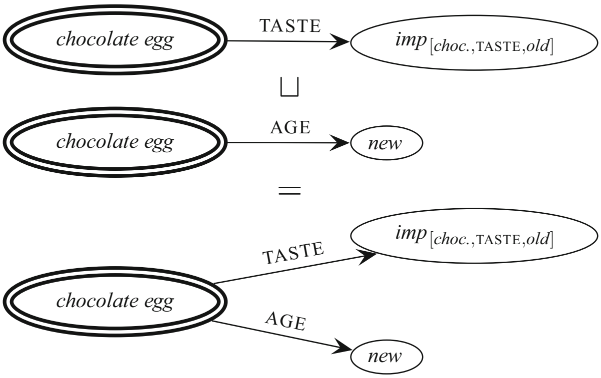


Fig. 9.9 Frame of an old-tasting chocolate egg which is not old but new

Fig. 9.10 Contradictory frames for old and new chocolate eggs

adjective 'new'. In terms of frames, both conjuncts in (12) can be translated into a frame, one for the old-tasting chocolate egg and one for the new chocolate egg. Figure 9.9 demonstrates that these two frames can be unified, resulting in a frame of an old-tasting chocolate egg that is not old but new.

An example of a nonadmissible conjunction is given in (13):

(13) # The chocolate egg is old, but it is new.

Conjunctions lead to contradictions if the frames of the conjuncts cannot be unified. For example, (13) is not admissible, since the two frames in Fig. 9.10 cannot be unified. The unification fails because both frames specify a value for the attribute AGE and both values are incompatible with each other with respect to the type signature and therefore cannot be unified. This follows from Definition 9.1, which states that attributes are partial functions and thus cannot simultaneously assign two distinct values to the same node.

9.5 Results

We have shown that the analysis of both the attributary use and the inferential use of phenomenon-based perception verbs requires explicit reference to object dimensions.[6] Consequently, a frame-theoretic approach which captures object dimensions as frame attributes is ideally suited for the analysis of both uses. For both uses, we have formulated a separate constraint that has to hold. By relating both constraints to each other, the following hypothesis on PBV uses sums up the results of the preceding sections:

HYPOTHESIS ON PBV USES: An expression:

(E) subject ∘ PBV ∘ adjective

is admissible if and only if (E) satisfies one of the constraints C1 and C2:

– If (E) satisfies C1 then (E) is an instance of an attributary use of a PBV.
– If (E) satisfies C2 then (E) is an instance of an inferential use of a PBV.

Both constraints C1 and C2 are based on well-typedness conditions of frames that are specific to PBV constructions. Thus, both constraints can be seen as special instances of a universal well-typedness constraint that claims that constructions are admissible if and only if they result in well-typed frames.

Moreover, we have shown that our approach can model the fact that the knowledge of admissible inferences exhibits varying degrees of abstraction. For example, the generalization that there is a relation between the taste and the age of food is captured by the inference relation $(\textit{food}, \text{TASTE}, \text{AGE}) \in \text{INF}$. The applicability of this generalization to more specific instances of food results from the principle that subtypes inherit all the properties of their supertypes. Furthermore, specific value co-occurrences of the attributes in an inference relation can be built directly into the type signature as implicit value types.

In our frame-theoretic analysis of inferential evidentials, we have focused on the identification of admissible PBV-uses and demonstrated that it is well-suited to account for the fact that the inferences are implicatures which can be negated. However, we have not discussed the process of inferencing as a result of which admissible inferences are established. We consider the integration of this process into the frame account as a future task which has to be tackled in order to arrive at a full-fledged frame model of inferencing. On the formal side, this also involves a truth-conditional interpretation of frames.

[6]From a cognitive perspective, abstract object properties such as taste and age can be conceived as object ‘dimensions’. A dimension can be defined as a set of mutually exclusive properties of which an individual has exactly one at each point of time (cf. Löbner 1979). Thus, stative verbs encoding specific object dimensions can also be referred to as ‘stative dimensional verbs’ (cf. Gamerschlag et al. 2013 for a frame analysis of posture verbs such as ‘stand’ and ‘sit’, which constitute another type of dimensional verbs.

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Part V
Frames in Concept Composition

Chapter 10
A Frame Approach to Metonymical Processes in Some Common Types of German Word Formation

Daniel Schulzek

Abstract Langacker (1987, 2008) defines metonymies as conceptual shifts within a domain or domain matrix. However, there are several cases in which metonymical shifts between conceptual entities that belong to the same domain are not possible. Thus, in this paper a more restrictive definition of metonymy is developed on the basis of frames, understood as recursive attribute-value structures. It is claimed that metonymies can be explained by a simple frame transformation requiring a necessary condition that I refer to as bidirectional functionality. This assumption is confirmed by an analysis of metonymical processes in various common types of word formation in German, including possessive compounds, *-er* nominalizations, and synthetic compounds. Furthermore, bidirectional functionality seems to underlie a sub-class of nominal compounds I suggest calling "frame compounds".

Keywords Frames • Concept types • Metonymy • Word formation

10.1 Introduction

In word formation, metonymies are mainly associated with the so-called possessive compounds (*bahuvrīhi*) that do not refer to the possible referents of their head nouns, but rather to something that is metonymically linked to what can be described as their "literal" reference (cf. Knobloch (1997)). The meaning of the German compound *Schlaukopf* (lit. 'clever head'), for instance, can be paraphrased as "someone with a clever head", where *head* is metonymically linked to the person referred to. Accordingly, the compound *Schlaukopf* does not refer to an entity

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characterized as being a head, but to the possessor of such an entity. Nevertheless, metonymies are not confined to this type of word formation. Hence, it will be argued that several phenomena in nominalization and compounding are also based on metonymical processes. These metonymical processes will be captured by frames in the sense of Barsalou (1992). In his view, frames are recursive attribute-value structures that constitute the general format of concept representation. In order to represent frames I will use the notation developed in Petersen (2007).[1]

Starting from Langacker's (1987, 2008) definition of metonymy, it will be shown that his approach is deficient in so far that it lacks the potential to exclude several cases in which metonymical shifts are not possible. Frames, on the other hand, provide an opportunity to formulate an explicit constraint for this kind of meaning shift to which I refer to as bidirectional functionality that is defined in terms of frames. Thus, this paper has two aims: firstly, to develop a restrictive and therefore more adequate definition of metonymy in general; and secondly, to demonstrate that metonymical processes are general patterns of word formation.

The paper is structured as follows: first, the definition of domains given by Langacker will be discussed, focusing particularly on the inability of explaining the capacity of metonymical shifts (Sect. 10.2). Subsequently, I will comment on some general aspects of meaning representation by frames. On this foundation, a frame-based explanation of metonymy will be given (Sect. 10.3). And finally, a frame-based analysis of metonymical processes in word formation will be developed by exemplifying it on some compounds and deverbal nouns (Sect. 10.4). Note that this paper merely deals with word formation in German. However, most of the examples are transferable into English.

10.2 Metonymies and Domains

10.2.1 State of the Art

Metonymy is a specific kind of meaning shift whose effect can be described as follows: the reference of a lexeme is shifted from the potential referents of the lexeme to something that is in the broadest sense part of, or thematically linked to, these potential referents. Metonymical shifts can be context-triggered (examples (1a) to (1d)) or lexicalized (example (1e)).

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[1]The works represented in Petersen (2007) as well as the works represented in this paper were developed in the research program "Functional Concepts and Frames" (FOR 600) at the Heinrich Heine University Düsseldorf. The research program is supported by the German Research Foundation (DFG).

(1) a. The locality refers to the institution.
Washington passes a new law.
b. The institution refers to the people working there.
The department of linguistics in Düsseldorf organises the conference.
c. The producer refers to the produced.
This painting is a real Picasso.
d. The container refers to the contained.
Jimmy drank a glass in one gulp.
e. The event refers to its participants.
to vote "event of voting" vs. vote "someone who votes"[2]

Lakoff and Johnson (1980) state that metonymy is a cognitive process based on a relationship between two conceptual entities, namely between the conceptual entity whose reference is metonymically shifted and the conceptual entity the reference is shifted to. As seen in (1), the relationships between the involved conceptual entities are grounded on general knowledge, including political, cultural, and historical awareness as well as knowledge about the common usage of an object. The diversity of these relationships is what causes the difficulty of formulating a rigid definition to cover all different cases of metonymies.

The most common solution is to define metonymy in respect of what is called a domain, understood as a network of contiguously related conceptual entities. The term *contiguity*, in this regard, is based on the idea that the conceptual representation of an element A is always associated with the conceptual representation of an element B if A is frequently perceived with B. First, Lakoff and Johnson (1980) point out the way in which contiguously related concepts constitute a *domain*. This approach is more precisely worked out by Langacker (1987, 2008), who explicates some assumptions that are merely implicit in the works of Lakoff and Johnson (cf. Croft (2002, p. 165)).

According to Langacker (1987, p. 147), "Most concepts presuppose other concepts and cannot be adequately defined except by reference to them, be it implicit or explicit."He illustrates his remarks by the example of a knuckle that cannot be understood without having knowledge about a finger, and hence, the concept 'knuckle' presupposes the concept 'finger'. Langacker calls the presupposed concept a *base*, whereas the concept requiring the presupposed base is called a *profile*. Bases and profiles are interdependent because, on the one hand, a profile cannot be understood without background knowledge provided by a base, and, on the other hand, a profile refers only to an obligatory part of a base so that a profile is always a constitutive entity for the base itself. Furthermore, a concept can simultaneously be both, a profile for a certain concept and a base for another concept; e.g., 'finger' is a base for the concept 'knuckle', and 'knuckle' is a profile for the base 'hand' which

[2]Here, an example is not given deliberately, due to the fact that the metonymical shift is not a matter of context-dependency, but rather a metonymically based polysemy.

is, in turn, a profile for the base ‘arm’. In addition, a base can be a base for more than one concept; e.g., the concept ‘circle’ is a base for the concept ‘arc’ as well as for the concept ‘radius’ and ‘diameter’. Moreover, a concept often presupposes more than one base; e.g., the concept ‘wind’ and the concept ‘water’ are both bases of the concept ‘surfing’.

Langacker (1987, pp. 147–148) defines a domain as a concept that functions as a base for at least one profile. This profile is part of the domain established by the base. As mentioned above, in many cases a concept presupposes more than one base and therefore more than one domain. Such a union of domains is called a *domain matrix*. In addition, Langacker (1987, p. 148) distinguishes between domains that are basic and those that are nonbasic. The underlying idea is that: “Although it is typical for one concept (or conceptual complex) to serve as domain for the characterization of another, there must be a point beyond which no further reduction is possible.” Domains which do not presuppose further concepts, and are therefore cognitively irreducible, are *basic* in terms of Langacker (1987, p. 148; 2008, p. 44). Examples are abstract concepts like conceptualizations of ‘shape’ or ‘time’. Domains that presuppose further concepts, on the contrary, are *nonbasic*.

Moreover, he sees metonymies as referential shifts within merely one domain or a domain matrix, not across domains. However, Langacker (2008, p. 44) points out that it depends on our particular purpose and it is also to some extent arbitrary, how many and which domains we recognize. Therefore, the term *domain* is rather general, and the question arises how it can be ascertained if reference is shifted within a domain or across domains. Neither Langacker nor Lakoff and Johnson make an explicit remark on this aspect. However, Croft (2002, p. 162) argues that the domain is determined by the context. He states that “all of the elements in a syntactic unit must be interpreted in a single domain.” Assuming Croft’s statement, Langacker’s definition of metonymy offers a criterion to verify whether the reference of a lexeme is shifted within a domain or not: metonymical shifts from a conceptual entity A to a conceptual entity B should be possible if A and B presuppose the same concept, functioning as a domain, within which a given sentence is interpreted.

In (1a), for instance, the domain is ‘political activity’. Washington, in its function as capital of the United States, presupposes the existence of political activity, as well as the concept ‘congress’. Thus, the concepts ‘capital’ and ‘congress’ are profiles of the base ‘political activity’ and hence part of the same domain. Therefore, the meaning shift in (1a) is a metonymical, and not a metaphorical one.

10.2.2 Missing Restrictions

The crux of defining metonymies on the basis of domains is that there are some cases in which two conceptual entities A and B are entities of the same domain; yet a metonymical shift from A to B is impossible. Sentence (2a), for instance, can be considered as “the campus of the university is situated in the centre of the city,” while (2b) cannot be considered in the sense "a student gave a miserable term paper to me." Hence, the reference of the lexeme *university* can be metonymically shifted in (2a), but it cannot be shifted in (2b).

(2) a. The university is situated in the centre of the city.
b. #The university gave a bad term paper to me.

The concepts 'student' and 'campus' as well as the concept 'university' presuppose the domain 'academic activity'. Thus, the concepts are profiles of the base 'academic activity' in the sense of Langacker and therefore entities of the same domain. Nevertheless, a metonymical shift is only possible from the concept 'university' to the concept 'campus', while a metonymical shift from the concept 'university' to the concept 'student' is impossible. The examples show that there are not only restrictions for metonymical shifts across domains but also within domains. However, Langacker's definition of metonymy is unable to exclude such shifts as it is not possible to create a plausible domain that includes 'university' and 'campus' but not 'student'.

The frame model as developed in the following chapter is not in contradiction to Langacker's domain approach: both are able to capture the same conceptual information. Yet, the frame model highlights the relationships between concepts that will be used to formulate explicit constraints to exclude shifts like those in (2b).

10.3 Metonymies and Frames

10.3.1 The Representation of Concepts as Frames

The frame model, as it is developed in Petersen (2007), is based on Barsalou (1992). The central assumption of Barsalou's approach is that all concepts are structured as recursive attribute-value structures[3] called frames. This conception applies to verbalized concepts as well as to concepts that cannot be expressed by words. Regarding the architecture of frames, attributes describe general properties or dimensions of the object or category represented in a frame, while values are concrete specifications of the attributes. According to Petersen (2007), frames are represented as directed graphs; e.g., Fig. 10.1 shows the frame of the concept 'car'.[4] Although the graph itself is not a frame (understood as a cognitive structure), but a representation of it, I shall refer to these directed graphs as "frames," too, in order to

[3] Apart from attribute-value sets, Barsalou (1992) states that structural invariants and constraints are further ingredients of frames. However, I will not comment on constraints and structural invariants as they are not relevant for the analysis proposed in this paper.

[4] The representation of frames that is proposed in this paper differs from the notation used by Barsalou (1992). Regarding these differences, see Petersen (2007).

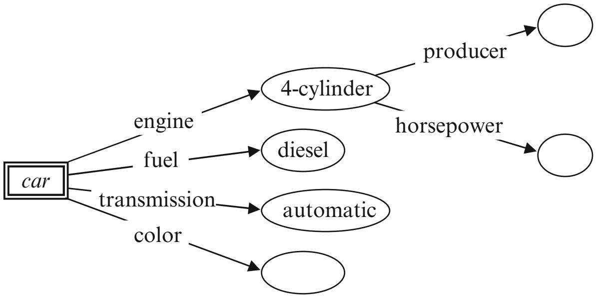


Fig. 10.1 *Car* frame

make the explications more straightforward. Additionally, names of attributes will be written in capital letters and names of values in small bound letters.

In directed graphs, the central node of a frame stands for the concept represented by the frame. It is highlighted by a double border. Values are depicted as nodes, while attributes are represented as arcs; e.g., in Fig. 10.1 the attribute ENGINE is specified by the value **4-cylinder**. The attributes are functions in the mathematical sense. That is, an attribute is specified by exactly one value and there cannot be more than one arc labelled with the same attribute. In this regard, the direction of the arcs is constitutive since the node that is source of the arc is the preimage of a function, and the node the arc goes to is its image. Furthermore, frames are recursive since values can be represented by additional frames. For instance, the value **4-cylinder** is represented by a frame containing the attributes PRODUCER or HORSEPOWER. If a value is nonspecific, it is represented by an empty node; e.g., the attribute COLOR in Fig. 10.1. An empty node has to be understood in the way of existential quantification, i.e., with respect to the example that a color of the car exists, but it is not known which color the car is. Also, two kinds of nodes have to be distinguished: angular nodes are used to mark open arguments concerning the syntax-semantics interface and hence have to be satisfied in a given context, whereas round nodes are used to represent satisfied argument nodes or values specifying conceptually relevant properties.

A central question concerns the attributes that frames contain. Barsalou's explications are not clear regarding this point; yet our analysis of frames constructed in the research program "Functional Nouns and Frames" has indicated that four different types occur frequently: potential attributes describe parts (EYES, HEAD, HANDLE), dimensions (COLOR, SIZE, AGE), correlates (MOTHER, ADDRESS), and specific functions (USAGE) of objects.

There is another point that has to be mentioned: assuming that frames are recursive and contain the entire knowledge about the object or category that is represented, it is almost impossible to reconstruct a "complete" frame. Therefore, I will consistently apply to partial frames in the following, i.e., only those attributes will be pointed out that are currently relevant.

Table 10.1 Löbner's (1985) classification of concepts

	Nonunique reference	Unique reference
Nonrelational	Sortal concepts	Individual concepts
	Dog, *table*, *car*, *house*	*Pope*, *semantics*, *sun*
Relational	Proper relational concepts	Functional concepts
	Brother, *sister*, *entrance*	*Mother*, *nose*, *name*

10.3.2 Frames of Different Concept Types and Verbs

Barsalou develops a theory for sortal concepts, i.e., concepts that classify their potential referents. Sortal concepts, e.g., *table*, *desk*, *dog* or *car*, are often understood as prototypical nouns. What these nouns have in common is that they are one-place predicates in the logical sense, i.e., their semantic effect can be described as classifying the denoted object to be a member of a certain class of objects, for instance the class of dogs. Löbner (1985), however, points out that there are nouns that are of the sortal type. He distinguishes four classes of nouns on the basis of two binary features, referential uniqueness and relationality. Sortal and individual nouns are nonrelational, and thus, they are typically used without a possessor argument. Sortal nouns denote categories. Since they are able to denote different representatives of a category, their reference is (usually) not unique. Individual nouns, on the other hand, refer uniquely. They denote entities like *pope* that are always determined definitely. Sortal and individual nouns differ from proper relational and functional nouns insofar as the latter are relational and are therefore typically used with a possessor argument. Examples for proper relational nouns are *brother* or *entrance* because a brother is always a brother of someone and an entrance is always an entrance of a location. Functional nouns are a specific subgroup of proper relational nouns: compared to other proper relational nouns, they refer uniquely as they establish a right-unique[5] mapping from their possessors to their referents. Examples are nouns like *mother* because everybody has exactly one mother. Table 10.1 outlines the four noun classes and their distinctive features.

The four classes of nouns correspond to four logical types on the one hand and to four different types of concepts on the other. A concept type can be shifted as seen in (3):

(3) a. Tom's mother is 42 years old.
    b. A mother has to be patient.

In (3a) *mother* is used as a functional concept, while in (3b) it is used as a sortal one. Such type shifts are always context-triggered (cf. Petersen 2007, p. 153).

[5]The term is used in the mathematical sense as (pontial) n-to-one mapping.

Fig. 10.2 *Mother* frame

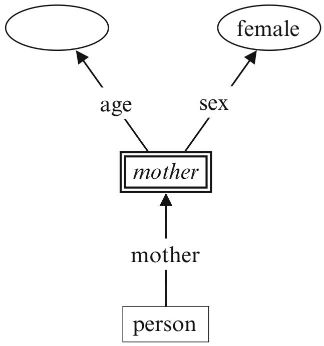
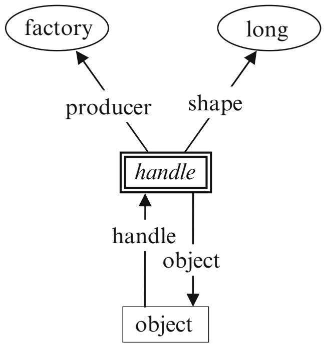


Fig. 10.3 *Handle* frame

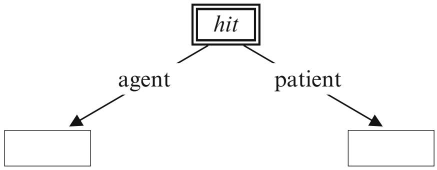


With respect to the analysis that is proposed in this paper, only functional concepts are of relevance. Therefore, I will comment merely on the frame-based representation of this special concept type. Frame-based representations of proper relational and individual concepts are submitted in Petersen (2007).

Figure 10.2 shows the frame of the functional concept *mother*. Since a mother is always a mother of someone, the frame contains a node which represents this person. Thus, in contrast to the frames of sortal concepts, the frames of functional concepts contain a possessor node that is linked to the central node by a so-called *determining arc*: the value of the possessor node determines the value of the central node. The determining arc is an outgoing arc for the possessor node and an ingoing arc for the central node. Since attributes are always functions in the mathematical sense, the direction of the arc guarantees that the mapping of the possessor node to the central node is right-unique. The possessor is a further argument of the concept, and hence, it is represented by an angular node.

It is also possible that the possessor node and the central node are linked by a second arc that heads for the opposite direction, as Fig. 10.3 shows. Here,

Fig. 10.4 *Hit* frame



the possessor node and the central node are linked by inverse arcs. Such links between the central node and the possessor node can be observed in some frames of functional concepts, but this is not obligatory for this concept type. In fact, the characteristic feature of frames of functional concepts is simply that the possessor node and the central node are linked by a determining arc.

Verbs can also be captured by frames. Figure 10.4 shows the frame of the verb *to hit*. Since the participants of the event of hitting are arguments of this event, the participants are represented by angular nodes.

The meaning of verbs, however, is surely not completely captured by representing their argument structure. Nevertheless, for the analysis proposed here, only the arguments of verbs are relevant, and therefore only those nodes will be illustrated.

10.3.3 Attributes, Functional Concepts, and Type Hierarchies

In the directed graphs depicted above, attributes are always titled with functional nouns.[6] Hence, the question arises, as to which manner functional concepts are connected to attributes in frames. This connection can be explained by the fact that functional concepts behave like mathematical functions. Given, for instance, a set P of persons, the referential properties of the nominal phrases (NP) in (4) can be translated into a function

$$f_{mot} : P \rightarrow P,\ f_{mot} = \left\{ (p_i, p_j) \,\middle|\, p_j \text{ is mother of } p_i \right\}.$$

The function f_{mot} is well-defined since it fulfils the existential condition and the condition of right-uniqueness: the first one is fulfilled since every person has a mother, and the latter is fulfilled as every person has exactly one mother. (These conditions are not fulfilled for proper relational nouns; e.g., someone can have no brother (violation of the existential condition), and on the other hand, someone can have more than one brother (violation of the condition of right-uniqueness).)

[6] I speak of nouns here because I am referring to a lexical-morphological level and not to a conceptual level.

(4) a. *Bart Simpson's mother*
f_{mot} *(bart simpson) = marge simpson*
b. *Kate Hudson's mother*
f_{mot} *(kate hudson) = goldie hawn*

The referents of the NPs in (4) correspond to the value of the function f_{mot} that is configured by the input for the independent variable, specified in form of a possessive construction. Hence, the referent of the NP in (4a) differs from the referent of the NP in (4b). Attributes in frames behave in a similar way as they define a right-unique relationship between two concepts. Indeed, frame attributes differ from functional concepts in the way that they are nonreferential.

The difference between functional concepts and attributes is fundamental for the frame model developed in Petersen (2007) and it can be rendered more precisely: Guarino (1992) distinguishes between the denotational and the relational interpretation of relational concepts. The first applies to the reference of such concepts, while the latter refers to the relation expressed by them. With respect to the NPs in (4), the denotational interpretation of the functional concept *mother* corresponds to the value of the function f_{mot}, whereas the relational interpretation corresponds exclusively to the relation between the independent variable and the value of the function; e.g., for (4) this relation can be paraphrased as "being-mother-of." Therefore, conceptual concepts have a denotational interpretation on the one hand, and a relational interpretation on the other. According to Petersen (2007, p. 163), "These considerations allow us to clarify the ontological status of attributes in frames: Attributes in frames are relationally interpreted functional concepts." In other words: assuming that concepts are organized in attribute-value structures, functional nouns are verbalizations of structuralizing components of mental concepts, and frames can be decomposed as relationally interpreted functional nouns (cf. Löbner 2005, p. 468).

So far, the question as to which values attributes can be specified has not been raised. According to Barsalou (1992, p. 43), values are subconcepts of attributes. However, he does not consider the differentiation between the denotational and the referential interpretation of relational concepts. Regarding Guarino's distinction, it is now possible to render Barsalou's statement more precisely and to explain by which values a given attribute can be specified: the possible values of an attribute are sub-concepts of the denotational interpretation of the functional concept the attribute is based on (cf. Petersen 2007, p. 164). For instance, *blue*, *yellow* and *red* are subconcepts of the concept *color*, and therefore **blue**, **yellow** and **red** are possible values of the attribute COLOR. In addition, possible values of an attribute are often structured with respect to their degree of specification; e.g., the value **red** is less specific than the value **rosso corsa**. From that point of view, possible values form a taxonomy composed of subconcepts of a given functional concept. In Petersen's frame model, this taxonomy is captured by a type hierarchy capturing possible values of attributes and the degree of specification of these values.

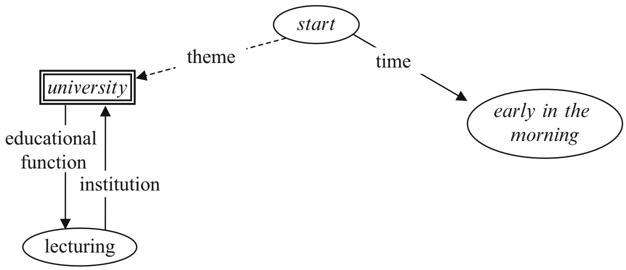


Fig. 10.5 *University* frame

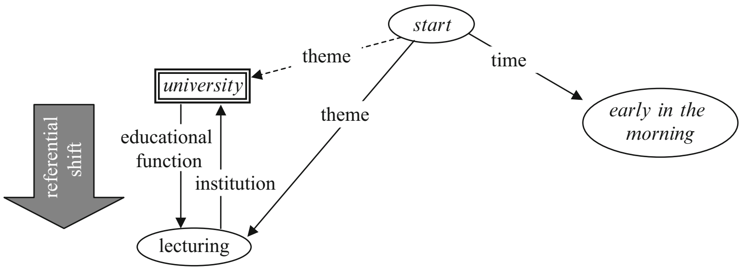


Fig. 10.6 Metonymical shift in the *university* frame

10.3.4 A Frame-Based Explanation for Metonymies

The effect of metonymical shifts can be explained by a simple frame transformation resulting in the fact that the central node is shifted.

(5) The university starts early in the morning.

In (5) the noun *university* is considered as "the lecturing at university." Figure 10.5 shows the frame-based representation of the sentence. Note that the representation of the phrase *early in the morning* is a simplification since it has to be represented as a complex frame. However, with regard to the example, the phrase is less important, and therefore, it is just represented by a single node to make the illustration more transparent.

The frame transformation mentioned at the outset is reflected in a conceptual shift from the central node to another node it is linked to. Since the lecturing starts early in the morning but not the other "parts" of the university, the central node is shifted to the *lecturing* node (Fig. 10.6). Furthermore, the metonymical shift results in a change of the conceptual properties of the involved nodes so that the *lecturing*

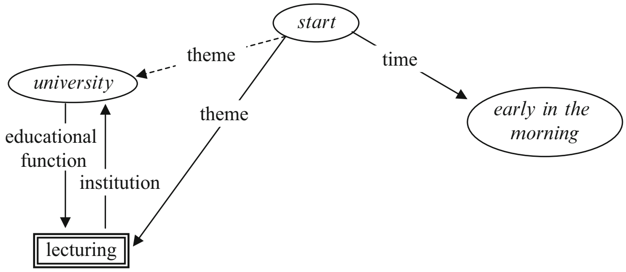


Fig. 10.7 Conceptually shifted *university* frame

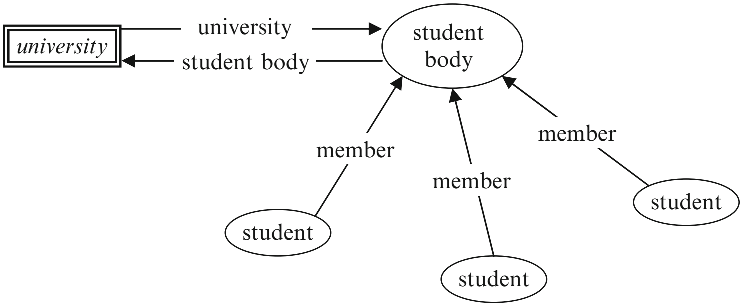


Fig. 10.8 *University* frame

node is transformed into an angular node, and the university node is transformed into a round node because *university* is not an argument of *lecturing* (Fig. 10.7).

As can be seen in Figs. 10.5, 10.6, and 10.7, the *lecturing* node is linked to the *university* node by a second arc. Due to the fact that attributes are always functional in the mathematical sense, the mapping between the *university* and the *lecturing* node is one-to-one. In the following, I refer to those arcs as *bidirectionally linked* and to this relation as *bidirectional functionality*. With regard to metonymies, bidirectional functionality is important, given that it guarantees the unique reference of metonymical shifts. This aspect can be illustrated by the example of the *university* frame in Fig. 10.8: the *university* and the *lecturing* node are linked by bidirectional arcs but there is no such link between the *university* node and the several *student* nodes. In fact, the mapping between the *university* node and the several *student* nodes is one-to-many. Hence, in case of a metonymical shift it would not be clear onto which of the student nodes the reference would be shifted to. On the other hand, the set of students is mapped one-to-one to the university node (see Fig. 10.8). For this reason, in (6a) a metonymical shift is possible, while in (6b) it is not. The *university* and the *lecturing* node, on the other hand, are bidirectionally linked, and therefore, in the case of a metonymy, the reference can be shifted uniquely.

(6) a. The university demonstrates against tuition fees.
b. #The university gave a bad term paper to me.[7]

Bidirectional functionality can be established by the context. So it may be possible that the expression *university* can be used to refer to a certain student, if specific conditions allow the unique identification of that student. For instance, if the student is a sprinter in the sporting team of a certain university, (7) can be used to refer to that student – other students of the same university are context-dependently excluded.

(7) The university won the race.

The assumption of the one-to-one mapping between the involved conceptual entities is confirmed by the examples mentioned in Sect. 10.2.1, in the following repeated as (8).[8]

(8) a. Washington passes a new law.
b. The department of linguistics in Düsseldorf organises the conference.
c. This painting is a real Picasso.
d. Jimmy drank a glass in one gulp.

The one-to-one mapping between the involved conceptual entities can easily be explained in (8a), (8b), and (8d): there is exactly one Congress in Washington passing laws, in Düsseldorf there is exactly one specific group of people working at the department of linguistics, and a glass contains exactly one content. With respect to (8c), it could be argued that Picasso painted more than one picture, and hence, the relationship between Picasso and his paintings is one-to-many. However, the statement made in (8c) does not refer to identifying a specific one of Picasso's paintings. Instead, (8c) predicates that the painting referred to is a painting produced by Picasso, i.e., the statement made in (8c) involves classifying the painting referred to as belonging to Picasso's oeuvre, and the relationship between Picasso and his oeuvre is one-to-one. The one-to-one mapping also explains why it is possible to refer metonymically to Picasso's oeuvre (*The exhibition does not show the whole Picasso*).

It can be concluded that, with respect to frames, metonymical shifts are possible, if the underlying nodes are bidirectionally linked. This necessary precondition restricts the capacity of metonymical shifts and has to be understood as an addendum to the domain-based definition of this type of meaning shift in the sense of Langacker (1987, 2008).

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[7]The example was discussed in our talk Kimm et al. (2010).

[8]The example (1e) is not repeated here but the one-to-one mapping between the agent of an action and the action itself can easily be motivated; see Sect. 10.4.2.

10.4 Metonymical Processes in Some Common Types of German Word Formation

10.4.1 Possessive Compounds

Several compounds, typically categorized as possessive compounds, can be used in a nonmetonymical manner as well as in a metonymical one. In sentence (9a) the compound *Lockenkopf* lit. ‘curly head’ is used in a nonmetonymical way, whereas in sentence (9b) it is used metonymically.

(9) a. *Peter hat einen Lockenkopf.*
‘Peter has curly hair.’
b. *Der Lockenkopf ist laut und nervig.*
‘The curly-haired person is loud and obnoxious.’

The nonmetonymical reading of the compound is the result of a unification of frames, while “unification” has to be understood as the fusion of two frames containing compatible information. In a technical sense, a unification is defined as follows: let the graphs A (seen in Fig. 10.9) an B (seen in Fig. 10.10) be frames, and let **f** be a concept that is more specific than the concept **c**. The unification of the two frames designates the process of integrating frame B into frame A. Figure 10.11 shows the result of the unification.

The interpretation of the compound *Lockenkopf* ‘curly head’ is the result of a similar process. First, the compound’s head *Kopf* ‘head’ as well as the modifier *Locken* ‘curls’ activate separate frames. The frame *Kopf* ‘head’ contains an attribute

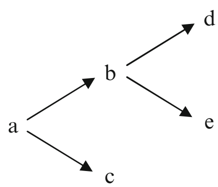

Fig. 10.9 Frame A

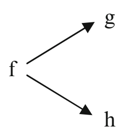

Fig. 10.10 Frame B

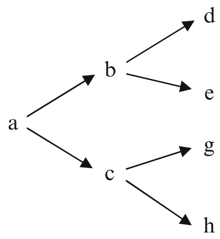

Fig. 10.11 Unification of A and B

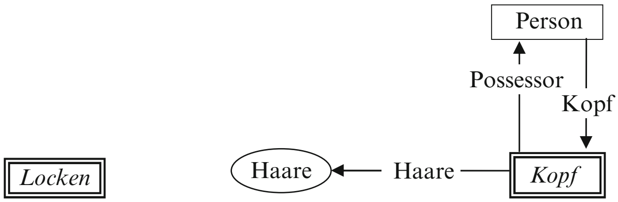

Fig. 10.12 *Locken* 'curls' and *Kopf* 'head' frame

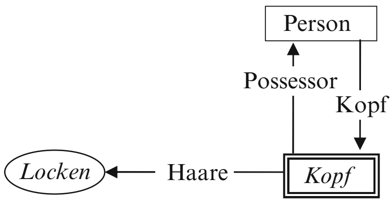

Fig. 10.13 Frame unification

HAARE 'hair'. Since *Kopf* 'head' is a functional concept as every human being has just one head, the frame contains a possessor node (Fig. 10.12). The value of the attribute HAARE 'hair' is specified by an empty node because the value is nonspecific. On the contrary, the concept *Locken* 'curls' is a hyponym of the concept *Haare* 'hair', and hence, **locken** 'curls' is a potential value of the attribute HAARE 'hair'. Since the value **locken** 'curls' is a subconcept of the concept *Haare* 'hair' in that curls refer to hair having a certain physical structure, the value **locken** 'curls' is a more specific value than the one expressed by the empty node. Thus, the two frames contain compatible information so that the *Locken* 'curls' frame can be integrated into the *Kopf* 'head' frame (Fig. 10.13). Since curls are not an argument of the concept *head*, the angular node transforms into a round node, i.e., the conceptual properties of the node activated by *Locken* 'curls' change as a result of the unification of the frames.

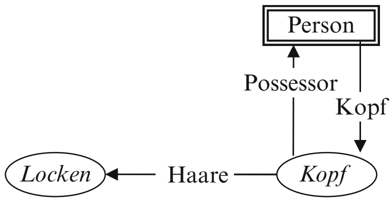

Fig. 10.14 Metonymical shift (Translations: Locken 'curls', Kopf 'head', Haare 'hair', Possessor 'possessor', Person 'person')

The metonymical reading of the compound *Lockenkopf* is the result of a metonymical shift. In the course of this process, the central node shifts to the possessor node (Fig. 10.14). Since the mapping between the two nodes involved in the metonymical shift is one-to-one, the same principle as mentioned in Sect. 10.3.4 can be noticed here. Additionally, the conceptual properties of the central node change, in that the central node of the frame *Kopf* 'head' transforms into a round node, because *head* is not an argument of the concept *person*. As can be seen in Fig. 10.14, every node in the frame can be reached from the central node, and the frame contains exactly one angular node. Both features are characteristic for sortal concepts, and thus, the metonymical interpretation of the compound *Lockenkopf* 'curly head' results not only in a referential shift but also in a conceptual shift: the metonymical interpretation of the compound evokes a sortal concept, while the nonmetonymical interpretation of the compound is a functional one.

10.4.2 Deverbal Nouns and Synthetic Compounds

The nominalization of verbs by the suffix *-er* also triggers a metonymical shift that can be captured by frames. Explaining nominalization on the basis of metonymies was also carried out by Panther and Thornburg (2002). In this Section, I will demonstrate that nominalization by the suffix *-er* confirms the assumption that a one-to-one mapping between the involved nodes is an obligatory precondition for metonymical shifts.

The frame of the verb *spielen* 'to play' contains the argument structure of the verb. The nominalization by the suffix *-er* results in a conceptual shift from the central node of the verbal frame to the node specifying the agent of the event of playing (Figs. 10.15 and 10.16). Löbner (1985, p. 316) points out that, given sufficient temporal (and contextual) restriction of the situation, the mapping between the agent of an action verb and the event, the action that the verb refers to, is one-to-one. Therefore, the nodes involved in the metonymical shift are, again, bidirectionally linked. From this point of view, the suffix *-er* is a morphological reflex, revealing a metonymical shift.

In contrast to bare metonymies, the metonymical shift is not triggered by the context but rather by a grammatical marker. In this regard, the *-er* suffix seems

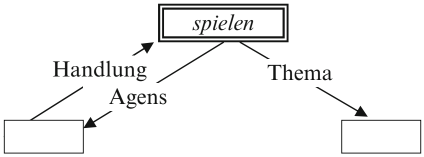

Fig. 10.15 *Play* frame

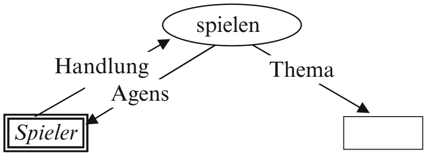

Fig. 10.16 *er* nominalization (Translations: Agens 'agent', Handlung 'action', Thema 'theme', spielen 'to play', Spieler 'player')

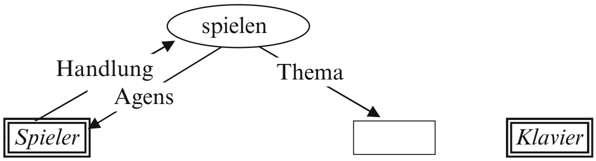

Fig. 10.17 *Klavierspieler* 'piano player' frame

to have two effects: it triggers the metonymical shift and "freezes" the new frame so that the frame cannot be shifted metonymically anymore. The last aspect is illustrated in (10) where the nominalization *Spieler* cannot be used to refer to an event of playing.

(10) a. *Der Spieler begann um 20 Uhr.*
'The player started at 8 p.m.'
b. *#Der Spieler dauerte zwei Stunden.*[9]
#'The player lasted two hours.'

However, the *Spieler* frame maintains the original frame of *spielen*. This is reflected in the fact that the theme argument of the *spielen* frame can be saturated within the so-called synthetic compounds whose interpretation is, therefore, based on metonymical relations. The German compound *Klavierspieler* 'piano player' can be explained as follows: the constituents of the compound activate separate frames, and subsequently, the frame activated by *Spieler* 'player' is linked to a node of playing that activates a frame containing attributes for the argument structure of such an event (Fig. 10.17). Finally, the interpretation of the compound *Klavierspieler* 'piano player' in the sense of "someone who plays the piano" is the result of a unification of frames (Fig. 10.18).

[9]One of the anonymous reviewers of this paper pointed me to the example.

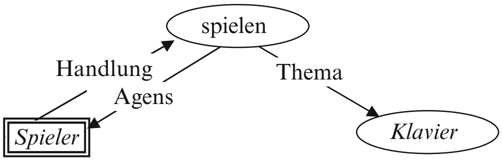

Fig. 10.18 *Klavierspieler* 'piano player' frame (Translations: Agens 'agent', Handlung 'action', Thema 'theme', spielen 'to play', Spieler 'player', Klavier 'piano', Zweck 'purpose')

To sum up, the meaning of deverbal nouns is the result of a metonymical shift. The interpretation of synthetic compounds is based on this metonymical process in that the verb frame derived from the compound's head is reconstructed on the basis of bidirectionally linked nodes.

10.4.3 Excursus: "Frame Compounds"

Bidirectionality is not only a constraint of metonymies but also occurs as a general interpretational pattern of ordinary compounds like *Suppenlöffel* 'soup spoon'. I speak of interpretational patterns since the interpretation of German compounds is a question of patterns rather than rules due to their ambiguity, (cf. Kanngießer (1987)). The interpretational pattern, that is subject of this section, corresponds to the Onomasiological Type III in the sense of Stekauer (2005). Such compounds underlie the semantic structure THEME–action–INSTRUMENT, where the theme and the instrument are represented on the linguistic surface, while the linking action has to be reconstructed. The meaning of the compound *Suppenlöffel* can be explained in the following steps: the constituents, *Suppe* 'soup' and *Löffel* 'spoon', activate separate frames. Then, the *Suppe* 'soup'frame as well as the *Löffel* 'spoon' frame is linked to a disposition of an eating action by a purpose attribute that is similar to the telic roles in Pustejovsky's qualia theory. According to Pustejovsky (1991), concepts of artifacts contain knowledge about the potential actions the referent of the concept can be used for. With regard to the nouns *Suppe* 'soup' and *Löffel* 'spoon', their concepts contain knowledge that a soup is something that can be eaten and a spoon is an instrument for this action. In terms of cognitive psychology, the purpose attributes correspond to some sort of conventionalized affordances, i.e., the referents of the concepts are artifacts made for a uniquely determined purpose. In the example, the purpose attributes link the frames of the compound constituents to a frame of eating. Both nodes of eating, in turn, activate frames in which the *soup* frame on the one hand and the *spoon* frame on the other hand are integrated (Fig. 10.19).

The *soup* node and the *eating* node as well as the *spoon* node and the *eating* node are bidirectionally linked. The one-to-one mapping can be accounted for similarly to the argumentation given in Sect. 10.4.2 regarding the uniqueness of the relation

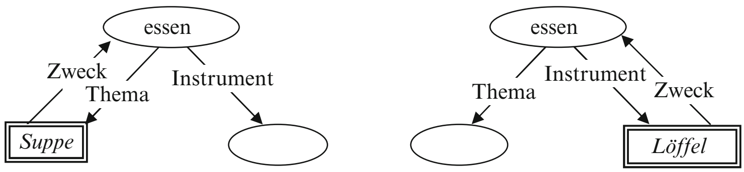

Fig. 10.19 *Suppenlöffel* 'soup spoon' frame

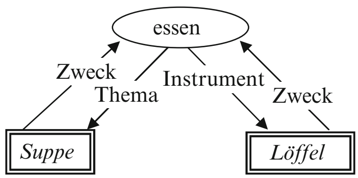

Fig. 10.20 *Suppenlöffel* 'soup spoon' frame (Translations: Agens 'agent', Handlung 'action', Thema 'theme', essen 'to eat', Suppe 'soup', Löffel 'spoon', Zweck 'purpose')

between an event expressed by an action verb and its participants. Therefore, the principle of activating the frames of eating is exactly the same principle that underlies the metonymies mentioned before. The meaning of the compound in the sense of "a spoon for eating soup" results from the unification of frames (Fig. 10.20). The bidirectional link between the frames of the compound constituents and the action frame is a precondition for the unification in that it is necessary that (a) the purpose attributes link the frame of the compound constituents to an action frame of an identical type, and (b) the frames of the compound constituents are integrated in the action frame by different attributes. Otherwise the unification would fail.

I suggest calling such compounds *frame compounds*. Frame compounds combine the meanings of their constituents by integrating them into an action frame which is re-constructed from the frames activated by the compound constituents. The reconstruction itself is based on a purpose attribute that is similar to the telic roles in Pustejovsky's qualia theory. The relation between the frames of the constituents and the mentioned action frame is bidirectional, although no metonymical shift is involved.

10.5 Conclusion

On the basis of frames as recursive attribute-value structures, metonymical shifts can be explained by a simple frame transformation in that the central node is shifted to another node it is linked to. This process is compatible with the current definitions of metonymy. Beyond that, I have postulated that the involved nodes in frames have to be bidirectionally linked, and hence, the mapping between the involved conceptual entities has to be one-to-one. This one-to-one mapping is a constraint which excludes metonymical shifts that are impossible within a given domain. Such a constraint is still missing in Langacker's (1987, 2008), Langacker's 1993 definition of metonymy in which metonymical shifts are only excluded across domains.

Furthermore, it was shown that metonymical processes can be observed in several kinds of word formation, in this paper illustrated for the German language. Above all, metonymies are not confined to the so-called possessive compounds, where the literal reference of the compound is metonymically shifted. Nominalizations by the suffix *-er* and synthetic compounds are also based on metonymies as in case of *-er* nominalization where the reference is shifted to an argument of the base verb. This metonymical relation between the base verb and the argument of the verb the reference is shifted to establishes a foundation for the interpretation of the synthetic compounds. Beyond that, bidirectional functionality explains the interpretational pattern of what I call frame compounds whose interpretation is based on an action frame that is reconstructed from the frames evoked by the compound constituents. This process underlies bidirectional functionality, although no metonymical shift is involved.

All examples discussed in this paper confirm the assumption that a one-to-one mapping between the involved nodes is an obligatory precondition for metonymical shifts. Furthermore, there are several examples whose meaning can be explained analogously to the examples discussed in Sect. 10.4 (see Appendix). Thus, we have rich evidence that metonymical processes are general patterns of word formation.

There are at least two questions that are not fully answered. First, the range of metonymies is still unknown. In this paper only metonymical shifts from the central node to another node it is linked to, were accounted. Therefore, the question arises as to whether a metonymical shift is possible across more than one node. Second, it has been argued that bidirectional functionality is a necessary condition for metonymical shifts. However, it may not be a sufficient condition; e.g., (11), where the concept of the expression *university* cannot be metonymically shifted to the concept 'students of the university', although there is a one-to-one correspondence between the mentioned concepts.

(11) #In the 1970s, the university had long hair and used to smoke and knit during the lectures.[10]

Thus, there must be further conditions beyond bidirectional functionality that have to be evaluated in later works.

Acknowledgements I would like to thank Sebastian Löbner, Anselm Terhalle, Nicolas Kimm, and Tanja Osswald for discussion and helpful comments. Furthermore, I would like to thank Mattis List and Carina Fueller for proofreading this paper. I am also grateful to the two anonymous reviewers for their helpful comments.

[10] We were advised of the example by Anja Latrouite. It was discussed in our talk Kimm et al. (2010).

Appendix

The following examples can be explained correspondingly to the examples in Sect. 10.4.

Possessive compounds:	
Hängebauch	hänge(n) 'to hang' Bauch 'belly'
Großmaul	mouth 'big' Maul 'mouth'
Dickwanst	dick 'fat' Wanst (colloq.) 'paunch'
Milchgesicht	Milch 'milk' Gesicht 'face'
Blauhelm	blau 'blue' Helm 'helmet'
Hinkebein	hinke(n) 'to limp' Bein 'leg'
Dickschädel	fathead (lit. dick 'here: massive' Schädel 'bonce')
Kahlkopf	kahl 'bald' Kopf 'head'
Trotzkopf	Trotz 'defiance' Kopf 'head'
Schreihals	schrei(en) 'to scream' Hals 'neck'
Kleinhirn	klein 'small' Hirn 'brain'
Synthetic compounds:	
Zeitungsleser	Zeitung 'newspaper' Leser 'reader'
Autofahrer	Auto 'car' Fahrer 'driver'
Geschichtenerzähler	Geschichte 'story' Erzähler 'teller'
Deutschlerner	Deutsch 'German' Lerner 'learner'
Turnschuhwerfer	Turnschuh 'sneaker' Werfer 'thrower'
Frame compounds:	
Betonmaschine	Beton 'concrete' Maschine 'machine' "machine producing concrete"
Zeitungsbote	Zeitung 'newspaper' Bote 'envoy' "newspaper delivery boy"
Märchenonkel	Märchen 'fairy story' Onkel 'uncle' "'uncle'who tells tall stories"
Billardtisch	Billard 'billiard' Tisch 'table' "table on which billiards can be played"
Zeitungsbericht	Zeitung 'newspaper' Bericht 'report' "report published in a newspaper"
Fassbier	Fass 'barrel' Bier 'beer' "beer that has been drawn from a barrel"
Getränkemarkt	Getränke 'drinks' Markt 'market' "market where drinks can be bought"
Prosaschriftsteller	Prosa 'prose' Schriftsteller 'writer' "writer of prose"
Bienenhonig	Biene(n) 'bee(s)'Honig 'honey' "honey that has been made by bees"
Regenschirm	Regen 'rain' Schirm 'screen' "screen [i.e., umbrella] that protects you from the rain"
Stahlwerk	Stahl 'steel' Werk 'factory' "factory where steel is made"

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Chapter 11
Concept Composition in Frames: Focusing on Genitive Constructions

Wiebke Petersen and Tanja Osswald

Abstract In this paper, we show how frames can be employed in the analysis of genitive constructions. We model the main approaches in the discussion about genitive constructions, i.e. the argument-only approach, the modifier-only approach and the split approach. Of these three, the split approach is modeled most naturally in frames. Thus, if frames are considered a cognitively adequate representation of concepts, our analysis supports the split approach to the interpretation of genitive constructions.

Keywords Genitive constructions • Frames • Concept composition

11.1 Introduction

In this paper, we give an analysis of genitive constructions in frame theory. Frames give a decompositional account of concepts. Thus, they are useful for representing single concepts. In the following, we give an example of how to apply the frame approach to operations on concepts. Our example is to model genitive constructions. In a nutshell, genitive constructions can be interpreted as arguments or as modifiers. We show that both interpretations can be modeled with frames. Still, for some genitives, it is easier to model them as arguments; for others it is easier to model them as modifiers. Thus, given that frames are cognitively adequate, frame theory favors a split approach to the interpretation of genitive constructions.

Following Partee and Borschev (2003), we refer to the constructions in focus as *genitive constructions*, although we consider a broader range of constructions

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which do not always involve syntactic genitives. In addition to the clear genitives in phrases like 'John's father' or 'John's car' our analysis also covers phrases like 'the father of John' or 'a brother of John's'.[1] Alternatively, we could have used the term *possessive phrases* instead. This term is syntactically more adequate but it is semantically inadequate since not all relations involved in such phrases are relations of possession: John's father is not possessed by John and Miro's picture may be in the possession of Miro, but it may also be painted by him or depict him. Since our aim is to contribute to the semantics and not the syntax of the phrases under consideration we have chosen to use the semantically neutral term *genitive construction*.

For a better understanding of the subject, we will briefly sketch the main lines in the discussion on the interpretation of genitive constructions. For a more detailed overview refer to Partee and Borschev (2003). The discussion concentrates on how to explain the difference in acceptability of the following constructions (cited from Partee and Borschev 2003, p. 69):

(1) a. John's team
b. a team of John's
c. That team is John's.

(2) a. John's brother
b. a brother of John's
c. (#) That brother is John's.[2]

The data suggests that not all nouns allow for a genitive in predicate position, e.g. (2c); at least not without a strong context (cf. Partee and Borschev 2003). A related phenomenon can be found in genitive *of* phrases (cited from Søgaard 2006, p. 88):

(3) a. (#) the knife of Shakespeare
b. the sister of Shakespeare

As there is no difference in the construction of the genitive phrases, it appears that the difference in acceptability of (1c) versus (2c) and of (3a) versus (3b) can only be explained by the different relational status of the main nouns. Relational nouns like 'brother' and 'sister' carry an open argument position which needs to be filled, while

[1]The former construction 'brother of John' is often referred to as a 'postnominal genitive *of* phrase' (Barker 2011). Whether the latter construction 'a brother of John's' is a genitive construction is controversial. While some, including Partee and Borschev (2003), classify 'of John's' as a postnominal Saxon genitive, Barker (2004) and others argue that it is not a true genitive but a partitive construction.

[2]Throughout this paper, we will concentrate on examples in which the main NP consists of a single noun. More complex NPs which involve relational adjectives, e.g., 'John's favorite movie', will not be considered in detail here.

nonrelational nouns like ‘team’ and ‘knife’ do not.[3] The data shows that predicative genitives (like (1c) and (2c)) require a nonrelational noun while genitive *of* phrases demand the main noun to be relational. Typological evidence for the phenomenon that the relational status influences the acceptability of genitive phrases has been reported for many languages: For example, Partee and Borschev (2003) focus on Russian, English and Polish, Hartmann and Zimmermann (2003) on adnominal genitives in German, and Søgaard (2006) presents a comparative typological study for the two concepts ‘book’ and ‘food’ for eight languages.

Concerning the acceptable examples (1a) and (2a), (1b) and (2b) respectively, the question arises as to why these parallel constructions are possible with relational as well as with nonrelational nouns. Two answers are possible: either the genitive constructions in the (1)-examples differ implicitly from the ones in the (2)-examples, or the nouns are shifted to one uniform relational type and are all subject to the same construction. In the first case, we have one genitive construction with nouns acting as modifiers ((1a) and (1b)) and another genitive construction with nouns acting as arguments ((2a) and (2b)). This analysis is known as the *split approach* (cf. Partee 1983/1997, Partee and Borschev 2003). In the second case, we would either assume a modifier-only construction or an argument-only construction and the nouns would be shifted accordingly before they enter the genitive construction. That is, in a uniform argument-only approach all nouns are shifted such that they become relational (cf. Jensen and Vikner 1994, Vikner and Jensen 2002, Partee and Borschev 1998) while in a uniform modifier-only approach the genitive in a genitive construction always acts as a modifier of the head noun independently of its relational status (for a discussion of the consequences of such an approach see Partee and Borschev 2003).

The relational status of the head noun in a genitive construction not only influences its acceptability but also influences the ambiguity of genitive phrases:

(4) a. John’s brother
b. John’s team
c. John’s stone

In some cases, there is a strongly preferred relation, e.g., in (4a), the relational noun ‘brother’ strongly forces the interpretation in which John is an argument in the brotherhood relation. Other readings, for example, those involving a possession relation, are suppressed and need a very strong context: take, for example, the setting of the production team of a documentary about brothers of famous women. This setting enables the following statement: “The brother I am interviewing is jealous of his sister, but John’s brother isn’t.”

Example (4b) does not have a strongly preferred default reading and thus is highly ambiguous: John may be the coach of the team, a member or a supporter

[3] A deeper discussion of the relational status of nouns follows in Sect. 11.2.2. A comprehensive discussion is given in Löbner (2011).

of the team, or he may manage the team. A standard account to explain this kind of variability in interpreting genitive constructions with nonrelational nouns is to make use of the *qualia structure* (Pustejovsky 1995) of these nouns. This qualia structure contains the relations leading to the different interpretations (e.g., Vikner and Jensen 2002, Søgaard 2006). Which relation is picked out for the genitive construction is down to context.

Although example (4c) also involves a nonrelational noun, its qualia structure does not provide any relations fit for a genitive construction. Thus, the only available reading without context is the possessive reading, where John actually possesses the stone. Again, context can make almost arbitrary readings possible: it could be that John sat on the stone, that he likes to look at it at the beach, that he had painted it or that it had dropped on his foot. All these relations between John and the stone come from context and are not part of the 'stone' concept. Thus, example (4b) is the only intrinsically ambiguous genitive phrase of the three.

To generalize from the examples, the question of the argument-modifier distinction and the interpretation of genitive constructions depends on the sort of relation involved. The two participants (often: possessor and possessum) in a genitive construction are related and this relation can either be introduced by the possessum or come from a separate source. A noun in possessum position can be relational, like 'brother', or nonrelational, like 'stone'. In the first case, the relation between possessum and possessor in a genitive construction is referred to by Partee and Borschev as *inherent*, in the second case, it is referred to as *free*.

For nonrelational possessums, we propose a further distinction: some nonrelational nouns are *weakly relational* in the sense that they can have a relation established that is not obligatory (as in example (4b)). That is a relation that does not demand an argument but which, under certain circumstances, can open an argument position which can be filled by the genitive. In these cases, we speak of a *shift* of the nonrelational noun to a relational one. So, overall, we assume three types of nouns: relational nouns (as in (4a)), weakly relational sortal nouns (as in (4b)) and pure sortal nouns (as in (4c)).

Similar proposals have been made in Vikner and Jensen (2002) on the basis of qualia structures. Jensen and Vikner (2004, p. 6f.) propose a fourfold semantic distinction of relations in genitive constructions, exemplified by the phrase 'the farmer's picture' (p. 7). An *inherent relation* (in Jensen and Vikner's terminology) leads to an interpretation where the possessor is an intrinsic aspect of the possessum (the picture depicts the farmer). The *producer relation* states that the possessor has produced the possessum (the farmer has painted the picture). The *part-whole relation* is in place if the possessum is a part of the possessor (e.g., 'the farmer's hand'). The forth relation is called *control relation*. This relation does not stem from the possessor or the possessum but comes from the genitive itself (the picture is owned by the farmer). In our terminology, the control relation is the default for genitive constructions with pure sortal nouns as the possessum. The other three relations are used with relational and weakly relational sortal nouns.

The decompositional concept analysis via frames models the relations expressed by the nouns in the lexicon explicitly, whether they stem from a relational noun or from a weakly relational sortal noun. Thus our frame-based approach can be seen as an extension of the qualia approach. While qualia structures enrich the lexical noun entries by adding a restricted set of qualia which are borrowed from the thematic roles of verbs, like agentive qualia or telic qualia, frames can exhibit a much more complex structure (cf. Sect. 11.2). In our paper, we show how the two main approaches to analyzing genitive constructions are modeled in frames. It turns out that a split approach between argument and modifier analyses is the most favored from the frame point of view.

The rest of the paper proceeds as follows: in the next section, we introduce our theory of frames, Löbner's conceptual classes and his analysis of their composition. In the third section, we model the different interpretations of genitive constructions in frames. In the last section we discuss our results.

11.2 Frames

In this section, we give an introduction to frames, conceptual classes and frame composition. Frames are a general format for describing concepts. They are decompositional, that is, they model the inner structure of concepts. One of the main motivations to employ frames in concept analysis is that they are supposed to be a cognitively adequate representation of concepts (Barsalou 1992). Linguistic evidence for this is presented in Löbner (this volume); a neurological model for frames is developed in Petersen and Werning (2007). As Barsalou's cognitive approach is not formal, the formal basis of frame theory lies in the theory of feature structures as presented in Carpenter (1992).

Feature structures encode concepts by decomposing them into attributes and values. They are usually written in a bracket notation but for our purposes we represent them as a connected directed graph with one central node. All nodes are labeled with types and all arcs are labeled with attributes. The attributes denote properties of the object described by the concept. Their values can be given explicitly or be left unspecified. In the latter case, just a type is given. A feature structure has two structural constraints: (a) no node can have two outgoing arcs with the same label, that is, each attribute is functional; in a fully specified feature structure it takes a unique value. (b) The central node is a root of the graph, that is, each node is reachable from the central node by a path following the direction of the arcs.

For example, in Fig. 11.1, we have the concept 'basketball' analyzed as being of type ball and having a round shape (in contrast to the oval shape of a football) and

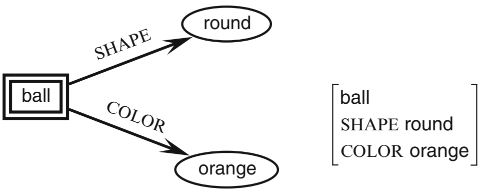


Fig. 11.1 The sortal concept 'basketball' in frame notation and in feature structure notation

an orange color. In the graph notation, the type of a node is written into the node. The type of the central node gives the sort of the objects denoted by the concept: A basketball is a ball. The central node is marked by a double border. The labeled arcs represent the dimensions along which the concept is decomposed. Here, we regard the shape and color of the ball. As extra notational markers, round nodes stand for satisfied arguments and rectangular nodes stand for open arguments in the frame. In particular, the central node is usually rectangular.[4] Please note that all example feature structures and frames throughout this paper are highly simplified, as we are concerned with structural properties and not with concrete representations of lexical concepts. The small example in Fig. 11.1 is not recursive, but obviously the values of an attribute can be complex feature structures themselves, having their own attributes.

The possible types of nodes are given in a *type signature* which may be considered as being an ontology covering the background or world knowledge. The type signature conveys two kinds of information: first, it gives a hierarchy of all admissible types. Second, it states appropriateness conditions for the types which specify domain and range of attributes. That is, the type signature tells which sort of entities can have a certain attribute and of which type the value of each attribute is. In the example in Fig. 11.1, an underlying type signature may be assumed which specifies that the shape-relation holds between a physical object and a shape as well as that the type ball is subsumed by the type physical object and thus that the shape-attribute is appropriate for objects of type ball, too. In the following, if a type is not mentioned explicitly, it is assumed to be the appropriate type from the type hierarchy. In particular, the type of a node can be omitted if it is uniquely determined by the appropriateness conditions in the type signature.

We propose a generalization of features structures because they can just model a limited (albeit huge) range of concepts; i.e. those that can be modeled by a graph whose central node is the root of the graph. For example, we can model a concept like ‘basketball’ as a feature structure (see Fig. 11.1) but not a concept like ‘flatmate’. A flatmate is someone who shares an accomodation with (at least) one other person. The natural way to model this is to introduce nodes for both flatmates and link them to the same accomodation. The resulting graph is shown in Fig. 11.2. Here, the central node is not the root of the graph. In fact, the graph does not have a root at all.

Taking this into account, we can formally define a frame as a directed, connected graph with nodes labeled by types and arcs labeled by attributes. The attributes are functional; i.e., each attribute can label at most one outgoing arc of a node. One of the nodes of a frame is marked as a central node and the set of nodes has a subset of argument nodes. Graphically, the central node is marked by a double border and the argument nodes are marked by a rectangular border. In Löbner’s terminology, the

[4] Exceptions occur when the node’s referent is uniquely determined, as will be discussed in Sect. 11.2.2.

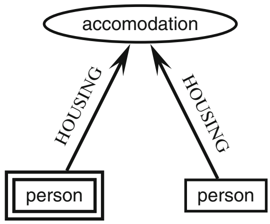


Fig. 11.2 A frame for the proper relational concept 'flatmate'

central node stands for the *referential argument* (cf. Löbner this volume). It refers to the extension of the concept.

In the following, we give a description of a frame in the λ-calculus (Sect. 11.2.1). We then introduce Löbner's *conceptual classes* (Sect. 11.2.2) and show how these classes are shifted if context enforces it (Sect. 11.2.4). We conclude the section by giving Löbner's account of concept composition with respect to the conceptual classes involved (Sect. 11.2.5). This will give us the background for analyzing genitive constructions in terms of frames (Sect. 11.3).

11.2.1 The Associated λ-Expression

Traditionally, the lexical semantics of a concept is expressed by predicate logic. As frames model the semantics of concepts, they can be described in predicate logic. As the λ-calculus can express terms, each frame has an *associated λ-expression*.[5]

The associated λ-expression is constructed as follows. For each open argument, a λ-variable is introduced, the λ-variable for the central argument being the innermost one in the λ-term. For each type p, a predicate P is introduced. For each attribute $\textsc{r}$ a relation R is introduced. The λ-expression is a conjunction of all information in the frame, going through all nodes starting with the central node. For example, the associated λ-expression for the 'basketball' frame in Fig. 11.1 is

$$\lambda x.\, \mathsf{ball}(x) \wedge \mathsf{round}(\textsc{shape}(x)) \wedge \mathsf{orange}(\textsc{color}(x)).$$

As not all nodes of a frame need to be reachable by a path from the central node, we have to provide for the case of a closed node that is a source in the frame graph. In this case, an ε-term is introduced to be able to address the node.

For example, the frame in Fig. 11.3 has the following associated λ-expression:

$$\lambda x.\, \mathsf{trunk}(x) \wedge \mathsf{bark}(\textsc{bark}(x)) \wedge \mathsf{girth}(\textsc{girth}(x)) \wedge \mathsf{tree}(\varepsilon u.\, \textsc{trunk}(u) = x).$$

[5]Note that this expression is not unique. We do not regard the dual question of which fragment of the λ-calculus is expressable by frames.

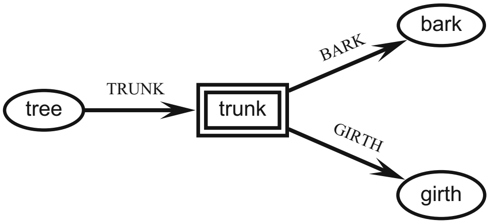


Fig. 11.3 A frame with a non-open source node: 'trunk' as a sortal concept

Table 11.1 Concept classification according to Löbner

	nonunique reference [−U]	unique reference [+U]
nonrelational [−R]	**sortal concept** $\langle e, t\rangle$	**individual concept** $\langle e\rangle$
relational [+R]	**proper relational concept** $\langle e, \langle e, t\rangle\rangle$	**functional concept** $\langle e, e\rangle$

11.2.2 Conceptual Classes

There are several classes of concepts that do not fit well into the feature structure format. Löbner (2011) proposes four *conceptual classes*.[6] These classes sort concepts with respect to inherent relationality and inherent referential uniqueness.

Löbner (1985, 2011) argues for a fourfold classification of concepts. In this, he relates two twofold distinctions: the distinction between inherently unique, [+U], concepts and not inherently unique, [−U], concepts and the distinction between relational, [+R], concepts and nonrelational, [−R], concepts. For example, 'pope' is inherently unique as there is only one pope (at a given time) while 'house' is not inherently unique. We follow Löbner (this volume) in that inherently unique concepts need not be seen as predicates. The second distinction is about relationality. Relationality means that a concept bears an inherent relation – to satisfy it, at least two entities have to be specified: one that falls under the concept and one that stands in a certain relation to the first entity.

These two dimensions are independent of each other (cf. Table 11.1), so there is a fourfold classification: *sortal concepts* (short: SC) are not inherently unique and nonrelational, in short [−U] and [−R]. They are of type $\langle e, t\rangle$ and of the logical form $\lambda x.\ P(x)$. For example, the concepts 'house', 'birch' and 'ball' are sortal concepts; they are neither inherently unique nor do they define an inherent relation. *Individual concepts* (IC) are inherently unique and nonrelational, in short [+U] and [−R], as proper names and definite descriptions. They are of type $\langle e\rangle$ and of the logical form $\iota u.\ P(u)$. For example, the concepts 'Mary', 'pope' and 'sun' are individual concepts. They do not have an inherent relation and their referents are uniquely determined. *Proper relational concepts* (RC) are not inherently unique but

[6]He calls them *conceptual types* but to avoid confusion with the type hierarchy and with logical types, we stick to 'classes' in this paper.

Fig. 11.4 A frame for the sortal concept ‘woman’

Fig. 11.5 A frame for the functional concept ‘mother’

relational, in short [−U] and [+R]. They are of type $\langle e, \langle e, t\rangle\rangle$ and of the logical form $\lambda y \lambda x.\ R(x, y)$. For example, the concepts ‘brother’ and ‘friend’ are proper relational. They are not inherently unique; there can be more than one brother and more than one friend for a given ‘possessor’. They are inherently relational, as a brother is always the brother of someone and a friend has to be the friend of someone. *Functional concepts* (FC) are both inherently unique (relative to a given possessor) and relational, in short [+U] and [+R]. They are of type $\langle e, e\rangle$ and of the logical form $\lambda y.\ f(y)$. For example, the concepts ‘mother’ and ‘shape’ are functional. As soon as the child or the object are given, the mother and the shape are determined, so they are inherently unique. They are relational because they depend on the particular child and the particular shape.

11.2.3 Concept Classes in Frames

The conceptual classes are reflected in the structure of frame graphs as we will see in this section. Figure 11.4 shows a frame of the sortal concept ‘woman’ which can be paraphrased as: something that is a person and that has a female sex, in short: a person that is female. The corresponding λ-expression is

$$\lambda x.\ \mathsf{person}(x) \wedge \mathsf{female}(\textsc{sex}(x)).$$

‘Woman’ is neither a unique nor a relational concept. Thus, in the corresponding frame, there is no open argument besides the central node. And there is no path from a determined node to the central node. λ-expressions of sortal concepts are of the form $\lambda x.\ P(x)$ where P is a one-place predicate which may be arbitrarily complex.

The frame in Fig. 11.5 for the functional concept ‘mother’ can be read as follows: something that is a person that is female and has something else that is a person and that it is mother of; in short: a female person who is mother of another person. The corresponding λ-expression is

$$\lambda y.\ \iota u.\ (\mathsf{person}(u) \wedge \mathsf{female}(\textsc{sex}(u)) \wedge \mathsf{person}(y) \wedge u = \textsc{mother}(y)).$$

Fig. 11.6 A frame for the proper relational concept ‘daughter’

This frame differs from the ‘woman’-frame in Fig. 11.4 in that the central node is not the root of the frame graph. Rather it has an incoming arc labeled MOTHER indicating that the referents of the central node are functionally dependent on referents of the open argument node. If this argument is filled with something of type person, the actual referent of the concept is determined (each person has a unique mother). Thus, the central node is closed because it is determined by the open argument node. In the following, we will refer to $\lambda y.\ f(y)$ as the default λ-expression for functional concepts although, as our example indicates, the actual expressions may be extended by further sortal restrictions on the variables.

Figure 11.6 shows a frame for the proper relational concept ‘daughter’. It is similar to the frame for ‘mother’ with just the direction of one arc changed. Thus, it can be read as: something that is a person that is female and has something else that is a person and is its mother,[7] in short: a female person that has a mother. The corresponding λ-expression is

$$\lambda y \lambda x.\ \mathsf{person}(x) \wedge \mathsf{female}(\textsc{sex}(x)) \wedge \mathsf{person}(y) \wedge y = \textsc{mother}(x).$$

Again, we have a relation requiring another entity, marked by an open argument, to satisfy the concept. Yet the referent of the central node is not functionally determined by the referent of the open argument, since there is no arc pointing from the latter to the former, so the concept is not unique (a mother can have more than one daughter). Thus, the central node is open. Though seen strictly, there are no nonfunctional relations in a frame (since all attributes are functional), for simplicity of notation we allow for arbitrary relations in our λ-expressions. The default λ-expression for proper relational concepts is thus $\lambda y \lambda x.\ R(x, y)$. R might correspond to different frames but all statements we make with the arbitrary relation will hold for all kinds of attribute constructions such a relation could stand for.

Figure 11.7 gives a frame for the individual concept ‘pope’. The pope is modeled as something which is the head of the Roman Catholic Church:

$$\iota u.\ u = \textsc{head}(\iota v.\ \mathsf{RCC}(v))$$

The unique reference of ‘Roman Catholic Church’ is modeled in the frame graph by the big arrow pointing at the node labeled RCC. Its uniqueness in turn determines the

[7] Again, please note that our examples are highly simplified.

Fig. 11.7 A frame for the individual concept 'pope' (*RCC* stands for Roman Catholic Church)

referent of 'head of RCC', i.e., of 'pope', uniquely. Because there is a directed path from a definite node to the central node, the central node is closed. λ-expressions for individual concepts are of the form $\iota u.P(u)$.

As the examples discussed above indicate, the concept classification is well-reflected in the corresponding frame graphs. If there is no open argument besides the central node, the concept is nonrelational, if there is such an open arugment, it is relational. Unique reference is encoded by a directed path from a determined node to the central node. Such a node can either be the noncentral open argument node, as for functional concepts, or it can be a node that is explicitly marked as being uniquely referring (big arrow), as for individual concepts. In the latter case, the path can be of zero length, i.e., the central node itself can be marked.

11.2.4 Class Shifts

Although it is assumed that each concept has a conceptual class it is lexicalized in (cf. Löbner 2011), context can force a concept into another conceptual class. We will call this a *class shift*. This shift is also called *type shift* in Löbner (2011)[8] or *coercion* (e.g., Pustejovsky 1995). Shift operations exist on all pairs of concept classes, as is discussed in more detail in Petersen and Osswald (2012). In (Barker 2011, p. 10ff.), several *class shifters* are discussed, in particular relativizers that shift concepts from nonrelational to relational such that they can be used in possessive constructions.

For example, regard the concept 'flat' and its frame graph in Fig. 11.8. A flat is seen here as something that has a landlord and a tenant. In turn, assuming that one person only rents one place, the flat is the tenant's housing, which is modeled by the housing-attribute pointing from the left person-node to the central accommodation-node. In its lexicalized use, 'flat' is sortal, as in

(5) It is more romantic to live in a houseboat than in a flat.

The information expressed in the frame is in logical notation

$$\lambda x.\mathsf{flat}(x) \wedge \mathsf{person}(\textsc{landlord}(x)) \wedge x = \textsc{housing}(\textsc{tenant}(x)) \\ \wedge \mathsf{person}(\textsc{tenant}(x)).$$

[8]Remember that Löbner calls 'type' what we call 'class'.

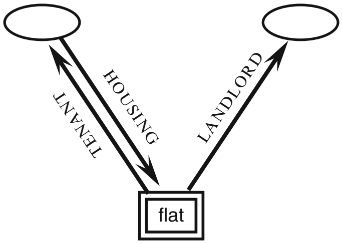


Fig. 11.8 'Flat' as a sortal concept

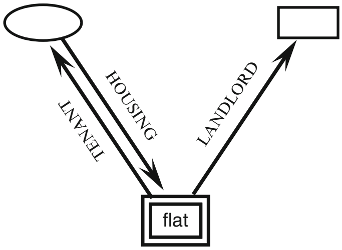


Fig. 11.9 'Flat' as a proper relational concept

Although 'flat' is lexicalized as a sortal concept it can be easily used in a relational context. In other words, depending on the context, 'flat' can be shifted to a different concept class. For a proper relational use, regard the following:

(6) This is a flat of John's; he rents it out to a family of five.

Here, the landlord is explicitly given as an argument. Hence, in the frame for the shifted concept, the value node of the landlord-attribute becomes an argument node (Fig. 11.9). Note that 'flat' is not an attribute value of 'landlord' since one person can own more than one flat. Thus, the frame of the shifted concept fulfills the criteria for a frame of a proper relational concept. In λ-notation, the frame expresses

$$\lambda y \lambda x.\, \mathsf{flat}(x) \wedge \mathsf{person}(\textsc{landlord}(x)) \wedge y = \textsc{landlord}(x) \\ \wedge\, x = \textsc{housing}(\textsc{tenant}(x)) \wedge \mathsf{person}(\textsc{tenant}(x)).$$

Additionally, the concept 'flat' can undergo an alternative shift in which not the landlord but the tenant becomes an argument as in

(7) Mary's flat is huge and her rent is reasonable.

The frame corresponding to the shifted concept is given in Fig. 11.10. This frame is the frame of a functional concept as the flat is functionally dependent on the tenant,

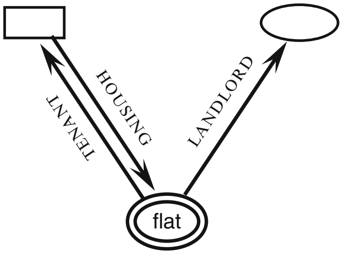


Fig. 11.10 'Flat' as a functional concept

if we assume that each person rents only a single flat. The information expressed by the frame in logical notation is

$$\lambda y.\ \iota u.\ (u = \textsc{housing}(y) \wedge \mathsf{person}(y) \wedge$$
$$\mathsf{flat}(u) \wedge \mathsf{person}(\textsc{landlord}(u)) \wedge y = \textsc{tenant}(\textsc{housing}(y)))$$

The example shows that a shift need not be unambiguous. Concepts can have several attributes in the lexicon allowing for shifts and each might be the one the shift goes to. Disambiguation has to be provided by context.

Although shifts occur frequently, not all attributes can yield a relation for a shift. For example, qualities such as weight or color are not fit for shifting a sortal concept to a relational one. More generally, only *reference-shifting attributes* (cf. Petersen and Werning 2007) can be used for a shift of the conceptual class, i.e., those attributes whose values can belong to a different entity than their domain.

The context can prohibit a shift, too. Jensen and Vikner (2004, p. 23) discuss the example of the concept 'teacher' in the phrase 'the car's teacher'. 'Teacher' is analyzed as having one agentive role, i.e., the teacher teaches someone. This someone has to be animate. Since a car is not animate, it cannot be taught by the teacher. This rules out both a relational interpretation and a weakly relational interpretation of 'teacher' in the phrase. In fact, Vikner and Jensen come to the conclusion that 'the car's teacher' cannot be interpreted semantically at all. The interpretation has to be provided by context which will have to yield a framework to counteract the exclusion of one of the candidates for a relation, e.g., by making the car animate.

Linguistic evidence for the existence of the concept classes and of class shifts is discussed in Löbner (this volume) and especially in Ortmann (this volume). Concerning uniqueness, languages like Ripuarian, Dutch and Fering feature a weak and a strong definite article. The weak definite article is used with a [+U] noun, the strong definite article is used when the noun is lexicalized as a [−U] noun but used as a [+U] noun. Thus, the strong article indicates a class shift. Swedish makes the same distinction but uses a suffix instead of the weak definite article. Concerning relationality, some languages use relativizing or derelativizing morphemes in order to shift nouns from [−R] to [+R] or vice versa. For example, languages like Lakhota or Yucatec shift [−R] nouns to [+R] nouns before they use them in genitive constructions. In contrast, in Mam relational nouns have to be derelativized before they can be used in a construction for a nonrelational noun. Koyukon uses the same morpheme, $k'e$, for both purposes.

11.2.5 Concept Composition

Löbner (2011) argues for composition rules for the combination of relational nouns with a possessor of each of the four concept classes. In genitive constructions, the concept class of the resulting concept is determined by the concept classes of the possessor and possessum. He calls such a construction a 'possessive chain' and defines it as follows: 'A "possessive chain" consists of a head (denoting the possessum), a possessor specification, and possibly recursively embedded further possessor specifications' (Löbner 2011, p. 16). A possessive chain is *maximal* if it is not a proper part of another possessive chain. Maximal possessive chains, Löbner argues, are always [−R], as 'referential maximal NPs carry absolute determination' (Löbner 2011, p. 15). For example, 'father of a friend' is not a maximal chain, '*a* father of a friend' is a maximal chain. *Initial* possessive chains are those that are a proper part of a possessive chain.

Löbner (2011, p. 17) summarizes the composition rules as follows:

For any possessive chain, initial or maximal,

(i) the total [R] value is the minimum of the [R] values of the members of the chain, where initial chains are [+R] and maximal chains are [−R];
(ii) the total [U] value is the minimum of the [U] values of the members of the chain.

In other words, if the possessum is proper relational, i.e., a [−U] and [+R] concept, we get a resulting [−U] concept and the resulting concept inherits the relational status of the possessor. For example, 'cake of a friend' is sortal, as 'friend' is proper relational and 'cake' is sortal, i.e. in particular a [−R] concept. For a possessum that is inherently unique, like 'father', the concept class of the genitive construction loses its uniqueness, i.e., 'friend's father' is a [−U] concept (but still relational).

If the possessum is functional, the concept that results from the genitive construction is of the same concept class as the possessor. For example, 'mother's cake' is sortal while 'mother's father' is functional. Table 11.2 gives an overview over all possible combinations (compare Table A1 in Löbner (2011)). We use the symbol $\overset{\text{POSS}}{\sqcup}$ as an abstract symbol for the formation of possessive chains.

Table 11.3 summarizes the logical analyses of all eight cases from Table 11.2.

Table 11.2 Löbner's composition hypothesis

RC	$\overset{\text{POSS}}{\sqcup}$	SC	$\mapsto$	SC	sibling OF judge (sibling of a judge)
RC	$\overset{\text{POSS}}{\sqcup}$	IC	$\mapsto$	SC	sibling OF Mary (sibling of Mary)
RC	$\overset{\text{POSS}}{\sqcup}$	RC	$\mapsto$	RC	sibling OF friend (sibling of a friend [of somebody])
RC	$\overset{\text{POSS}}{\sqcup}$	FC	$\mapsto$	RC	sibling OF spouse (sibling of the spouse [of somebody])
FC	$\overset{\text{POSS}}{\sqcup}$	SC	$\mapsto$	SC	mother OF judge (mother of a judge)
FC	$\overset{\text{POSS}}{\sqcup}$	IC	$\mapsto$	IC	mother OF Mary (mother of Mary)
FC	$\overset{\text{POSS}}{\sqcup}$	RC	$\mapsto$	RC	mother OF friend (mother of a friend [of somebody])
FC	$\overset{\text{POSS}}{\sqcup}$	FC	$\mapsto$	FC	mother OF spouse (mother of the spouse [of somebody])

Table 11.3 Logical analysis of composition in possessive constructions (ε is short for $\lambda Q.\ \varepsilon u.\ Q(u)$)

RC(ε(SC))$\mapsto$ SC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \lambda r.\ P(r) \mapsto \lambda x.\ R(x, \varepsilon u.\ P(u))$
RC(IC)$\mapsto$ SC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \iota u.\ P(u) \mapsto \lambda x.\ R(x, \iota u.\ P(u))$
RC $\circ$($\varepsilon \circ$ RC)$\mapsto$ RC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \lambda y' \lambda x'.\ S(x',y') \mapsto \lambda y' \lambda x.\ R(x, \varepsilon u.\ S(u,y'))$
RC $\circ$ FC$\mapsto$ RC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \lambda y'.\ g(y') \mapsto \lambda y' \lambda x.\ R(x, g(y'))$
Pred(FC)(ε(SC))$\mapsto$ SC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \lambda r.\ P(r) \mapsto \lambda x.\ x = f(\varepsilon u.\ P(u))$
FC(IC)$\mapsto$ IC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \iota u.\ P(u) \mapsto \iota v.\ v = f(\iota u.\ P(u))$
Pred(FC) $\circ$($\varepsilon \circ$ RC)$\mapsto$ RC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \lambda y' \lambda x'.\ S(x',y') \mapsto \lambda y' \lambda x.\ x = f(\varepsilon u.\ S(u,y'))$
FC $\circ$ FC$\mapsto$ FC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \lambda y'.\ g(y') \mapsto \lambda y'.\ f(g(y'))$

11.3 Genitive Constructions

In this section, we model two analyses of genitive constructions: the argument-only analysis and the modifier-only analysis. Although both can be modeled in frames, it turns out that relational nouns can be best analyzed as part of an argument construction while pure sortal nouns are amenable to a modifier construction. Thus, frames favor the split approach.

11.3.1 Genitives as Arguments

Seeing genitive constructions as argument constructions means, in terms of frames, that the genitive fills an attribute value of the head noun's frame. Thus, the argument construction is modeled straightforwardly in case there already is an attribute of the right type in the frame. This is the case for relational nouns and – to some extent – for weakly relational sortal nouns.

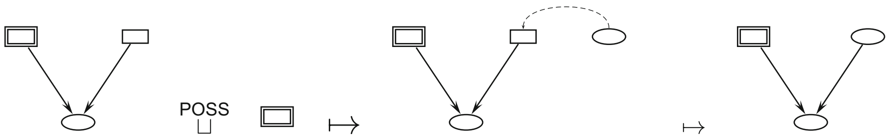


Fig. 11.11 Composition of an RC and an SC yields an SC

11.3.1.1 The Case of Relational Nouns

In the case of a relational noun, constructions with genitives in the argument position can be modeled straightforwardly. For example, the phrase 'sibling of a judge' involves a relational noun plus a sortal noun. Here, 'judge' specifies the argument of the relational noun.

In terms of frames, saturating the possessor argument of a relational concept is analyzed as unifying the argument node of the relational frame with the central node of the possessor frame. To unify the nodes, the central node's reference has to be uniquely determined. In the cases where the concept is [−U], an (otherwise unspecific) object falling under the concept is chosen. This step of losing the argument property is overtly realized in of-constructions in English: the possessor noun has to be accompanied by a determiner in constructions of this type; hence we get 'sibling of *a* judge' instead of 'sibling of judge'. As none of the other frame nodes is affected by this form of composition, it follows from the considerations about frame graphs of different concept classes in Sect. 11.2 that the composed frames correspond to the concept classes Löbner predicts. Table 11.4 summarizes all eight cases of frame composition in argument constructions.

We discuss two examples in detail. In Fig. 11.11, a default frame for an RC is composed with a default frame for an SC. In logical notation, this is of the form $\lambda y \lambda x.\ \mathrm{R}(x, y)$ applied to a representative of the SC $\lambda r.\ \mathsf{P}(r)$.[9] The choice of an arbitrary representative of the SC is done by the ε-operator, which is similar to Partee's iota operator (Partee 1986) with the difference that is does not require uniqueness of the chosen object. Hence the resulting expression is of the form $\varepsilon u.\ \mathsf{P}(u)$ instead of $\iota u.\ \mathsf{P}(u)$. In short, we want to calculate ε(SC), where ε stands for $\lambda \mathsf{Q}.\ \varepsilon u.\ \mathsf{Q}(u)$:

$$\lambda \mathsf{Q}.\ \varepsilon u.\ \mathsf{Q}(u)(\lambda r.\ \mathsf{P}(r)).$$

By β-reduction, we get

$$\varepsilon u.\ \lambda r.\ \mathsf{P}(r)(u).$$

[9]We write predicates in the same fonts as in frames, i.e. A for an attribute and T for a type.

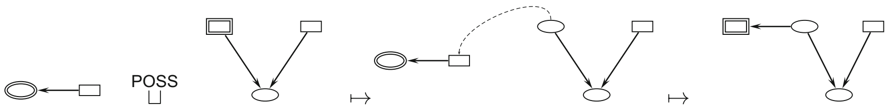


Fig. 11.12 Composition of an FC and an RC yields an RC

Another β-reduction yields

$$\varepsilon u.\ \mathsf{P}(u).$$

By functional application of the RC to the choice for the SC, short RC(ε(SC)), we get

$$\lambda y \lambda x.\ \mathrm{R}(x, y)(\varepsilon u.\ \mathsf{P}(u)).$$

By β-reduction, we get

$$\lambda x.\ \mathrm{R}(x, \varepsilon u.\ \mathsf{P}(u)),$$

which denotes an SC, as Löbner predicts. The resulting expression corresponds to the logical interpretation of the resulting frame in Fig. 11.11. Functional application of the RC to the representative for the SC (chosen by the choice function) corresponds to unification of nodes in frames.

The second example is the composition of an FC with an RC. The procedure is similar (Fig. 11.12): a representative for the RC is chosen, so the central node of the RC is uniquely determined. This node is unified with the open argument node of the FC. The resulting frame has the central node of the FC and the open argument of the RC. Since there was no path from the open argument node in the RC to its central node, and this is the only connection between the two parts of the frame, there is no path from the open argument node to the central node in the new frame. Thereby, the central node is open. Thus, the resulting frame represents an RC.

In λ-notation, we have that an FC of the form $\lambda y \lambda x.\ x = f(y)$ is composed with an RC of the form $\lambda y' \lambda x'.\ \mathrm{S}(x', y')$. Note that the FC is seen as predicative here.[10] In order to unify the possessor argument of the FC with the possessum argument of the RC, we again choose one arbitrary representative of the RC; i.e. $\varepsilon \circ$ RC:

$$\lambda y' (\lambda \mathsf{Q}.\ \varepsilon u.\ \mathsf{Q}(u)(\lambda x'.\ \mathrm{S}(x', y'))).$$

[10]This is an artefact of the λ-notation. In the graph notation, the central node is closed iff it is determined by an incoming arc from another open node or from context. If a construction fills that node or destroys the connection to the open node, the central node is open. In λ-notation, there is no such straightforward constraint.

By β-reduction we get

$$\lambda y'(\varepsilon u.\ \lambda x'.\ \mathrm{S}(x', y')(u)).$$

Another β-reduction yields

$$\lambda y'.\ \varepsilon u.\ \mathrm{S}(u, y').$$

Now we can compose the predicative FC with the result[11] Pred (FC)$\circ$($\varepsilon\circ$ RC):

$$(\lambda y \lambda x.\ x = f(y)) \circ (\lambda y'.\varepsilon u.\ \mathrm{S}(u, y'))$$

which yields

$$\lambda y'(\lambda y \lambda x.\ x = f(y)(\varepsilon u.\ \mathrm{S}(u, y'))).$$

By β-reduction, we get

$$\lambda y' \lambda x.\ x = f(\varepsilon u.\ \mathrm{S}(u, y')).$$

Since the variable x in the formula is not uniquely determined by the variable y', we have a proper relational concept, as the composition rules predict.

The examples show that constructions with relational nouns and genitives in argument positions can be straightforwardly modeled in frames. In Table 11.4, a summary of all possible combinations with relational nouns in genitive constructions plus their associated λ-expressions are given.

11.3.1.2 The Case of Weakly Relational Sortal Nouns

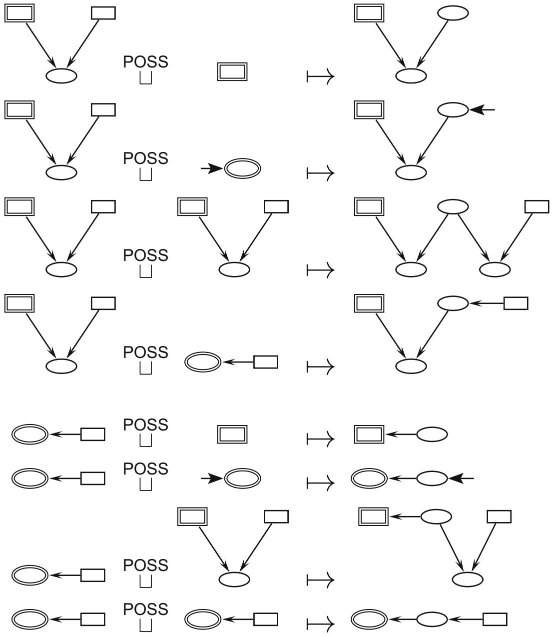
For relational nouns, the argument construction is straightforward. For sortal nouns, it is less so, but there is a subclass of sortal nouns that facilitate an argument construction, i.e., the weakly relational sortal nouns. As introduced in Sect. 11.1, weakly relational sortal nouns are those that have a relation established in the lexicon that can be used in an argument construction although it is not obligatory.

What happens in the argument construction is that a weakly relational sortal noun is *shifted* to a relational noun, using the relation given in the lexicon. Then, the argument construction proceeds as for relational nouns.

[11] We write Pred (FC) to denote the predicative reading of the FC.

Table 11.4 Frame composition in possessive constructions

$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{SC} \mapsto \mathrm{SC}$	
$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{IC} \mapsto \mathrm{SC}$	
$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{RC} \mapsto \mathrm{RC}$	
$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{FC} \mapsto \mathrm{RC}$	
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{SC} \mapsto \mathrm{SC}$	
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{IC} \mapsto \mathrm{IC}$	
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{RC} \mapsto \mathrm{RC}$	
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{FC} \mapsto \mathrm{FC}$	



11.3.1.3 The Case of Pure Sortal Nouns

So far, we have discussed argument constructions with relational concepts and with weakly relational sortal concepts, i.e., with those kinds of concepts that come with a relation that can be used in the genitive construction. Let us now regard the third kind of nouns in argument constructions: pure sortal nouns are those that cannot be shifted for semantic reasons, thus in the notation of Löbner (2011) they can just be shifted by level-2 shifts, i.e., shifts that are fully dependent on the given context of utterance.

To establish a relation for the argument construction, a new attribute has to be added to the possessum frame. By default, this is a possessor relation; any more specific relation that context provides can overrule the default. With the new relation added, the possessum frame is shifted from an SC to an RC, using the new attribute (see Fig. 11.13 for an example of such a shifted concept). Even stronger shifts can be necessary to stick with the argument-only analysis, i.e., shifts that do not introduce just one more attribute into the frame but a more complex structure. Accepting such strong shifts which involve the addition of a new attribute is necessary in order to support the argument-only thesis of genitive constructions in a frame-based analysis.

Fig. 11.13 'stone' as a relational concept

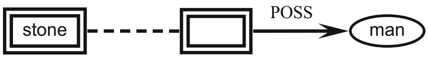


Fig. 11.14 The genitive-as-modifier construction for 'stone of a man'

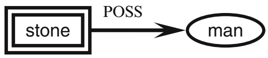


Fig. 11.15 The frame for 'stone of a man'

11.3.2 Genitives as Modifiers

If genitive constructions are seen as modifier constructions, the genitive structure is brought along by the genitive marker itself. Under this analysis, 'stone of a man' is interpreted by first constructing the frame for 'of a man' which we call a *genitive frame*, and then connecting that frame to the 'stone' frame. Which relation gets chosen for the connection depends on the concepts involved. The default is an attribute for possession or control which we will call POSS in the following. The constraint on this is that the relation has to match the types of the nodes to be connected.

Löbner (p.c.) proposes a *minimality maxim* that demands that as much information as possible should be integrated, i.e., the genitive frame should be merged with a suitable substructure of the frame whenever possible.

As for the argument interpretation of genitive constructions, we distinguish three cases: genitives with pure sortal concepts, with weakly relational sortal concepts and with relational concepts. In the following, we will discuss each of these cases separately.

11.3.2.1 The Case of Pure Sortal Nouns

In the case of pure sortal concepts, the genitive construction adds the genitive frame to the possessum frame. By default, the relation is specified as possession, but it can be overruled by any relation that the context may provide.

For example, take the phrase 'stone of a man'. The genitive construction is shown in Fig. 11.14. 'Stone' does not have any inherent relation that is fit for a genitive construction, thus, the attribute is specified by default as possession. The resulting frame is shown in Fig. 11.15. In case there is another relation suggested by context, that relation overrides the default. For example, if it is the stone the man has painted, the relation is specified by an attribute like PAINTER.

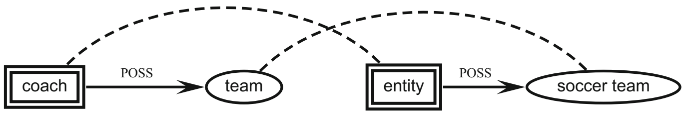
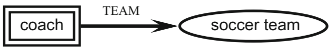


Fig. 11.16 The genitive-as-modifier construction for 'coach of a soccer team'

Fig. 11.17 The frame for 'coach of a soccer team'



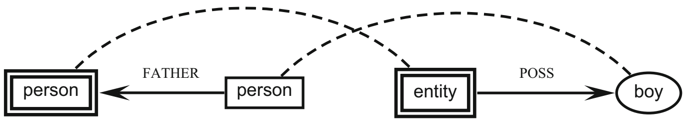


Fig. 11.18 The genitive-as-modifier construction for 'father of a boy'

11.3.2.2 The Case of Weakly Relational Sortal Nouns

For weakly relational sortal concepts, the genitive construction starts in the same way as for pure sortal concepts: the genitive frame is introduced and connected with the possessum frame. The difference lies in the specification of the relation. Here, we have a suitable relation available, i.e., one that can connect possessum and possessor without a clash of types. Thus, following the minimality maxim, the genitive frame is merged with the given relation and its value.

For example, take the phrase 'coach of a soccer team'. The genitive construction is shown in Fig. 11.16. As we see, the types of the respective nodes match, i.e., 'coach' is a subtype of 'entity' and 'soccer team' is a subtype of 'team'. Thus, the frames can be merged along the TEAM attribute. The POSS attribute is overruled. The resulting frame is depicted in Fig. 11.17.

11.3.2.3 The Case of Relational Nouns

The case of a relational concept is similar to that of weakly relational sortal concepts. First the genitive frame is connected to the possessum frame and then, to avoid unnecessary information, the genitive frame is merged with a suitable relation that is already in the possessum frame. The only difference lies in the status of the possessum node. In the frame for a relational concept, this is an open argument. Thus, an extra step has to be taken, i.e., closing the argument.

For example, take the phrase 'father of a boy'. The genitive frame is shown in Fig. 11.18. As 'father' is a subtype of 'entity' and 'boy' is a subtype of 'person', the respective nodes can be unified. The POSS relation gets overruled by the FATHER relation. The open argument of the 'father' frame is closed. Figure 11.19 shows the resulting frame.

Fig. 11.19 The frame for 'father of a boy'

Fig. 11.20 Another frame for 'father'

Fig. 11.21 The genitive-as-modifier construction for 'father of a boy', merging with the node for the offspring

Fig. 11.22 The genitive-as-modifier construction for 'father of a boy', merging with the node for the ancestor

This example can be taken to point out a difficulty with the modifier construction. As a father is a person, he has a father himself. Thus, the frame in Fig. 11.20 is a frame of 'father', too. Now, when the genitive frame is added, there are two possible results, as in Figs. 11.21 and 11.22. Prima facie, there is no reason why the interpretation in Fig. 11.21 should be favored – on the contrary, in the frame in Fig. 11.22, both of the following constraints are fulfilled. The direction of the POSS relation is preserved by the relation that overrides it, and it does not have to change the argument status of the merged node.

We do not claim that this difficulty cannot be overcome[12]; it just shows that the modifier approach is not straightforward to model in the case of relational nouns, and, as similar phenomena can occur there, in the case of weakly relational sortal nouns.

Another approach to the modifier construction lies in using frames less restrictively. So far, we have regarded frames for concepts, not frames for grammatical constructions. Using these, the modifier account can be made more uniformly. For example, Löbner (p.c.) proposes an analysis in which the genitive construction is facilitated by an extra frame for the relation between possessor and possessum. E.g., a frame for 'control' has one attribute for the controller and one for the entity controlled. Unifying the values with the central nodes of the respective frames yields

[12]For example, it can be argued that the genitive construction should be made with a minimal frame for the concept, like the one in Fig. 11.18. This, in turn, opens the question about definition and existence of minimal frames.

a frame for the genitive construction that explicitly models the control relation. A frame for the concept 'man's stone' would thus start with a control frame and have the frame for 'man' and 'stone' inserted such that the central node of the new frame is the node of type stone.

11.4 Discussion

In our paper, we have shown how concept composition is modeled in terms of frames, regarding the special case of genitive constructions. As frames are proposed to be cognitively adequate, our frame results speak in favor of the split approach. Genitive constructions with relational and weakly relational sortal nouns are best interpreted as argument constructions while genitive constructions with pure sortal nouns are most naturally interpreted as modifier constructions.

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Part VI
Nominal Concept Types and Determination

Chapter 12
Definitely Not Possessed? Possessive Suffixes with Definiteness Marking Function

Doris Gerland

Abstract In this paper I argue that the definiteness marking function of the possessive suffix of some Uralic languages is not the outcome of a grammaticalization pathway but has always been inherent to them. The possessive suffix has thus two main functions: establishing a relation between entities or a relation between an entity and the discourse and indicating the definiteness of the referent of the marked noun. The interpretation of the suffix as a marker of definiteness or a marker of possession depends on the conceptual noun type of the marked noun and on the context.

Keywords Concept types • Grammaticalization • Uralic languages • Definiteness • Possession

Abbreviations

ABL	Ablative
ACC	Accusative
ALL	Allative
DAT	Dative
DEM	Demonstrative
DEMIN	Deminutivum/Diminutive
EMPH	Emphasis
EP	Epenthetic vowel
EXL	Exclamative
GEN	Genitive

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IMP	Imperative
INE	Inessive
INF	Infinitive
INS	Instrumental
LAT	Lative
LOC	Locative
NARR	Narrative
NEG	Negation
OBJ	Objective conjugation
PART	Participle
PF	Perfect
PTPASS	Participium passivum
PROSEC	Prosecutive
PRS/PST	Present
PRT	Preterite
SUB	Subjective conjugation

12.1 Introduction: Possessive Suffixes with Definiteness Marking Function

The basic function of a possessive construction is to encode the relationship between two entities (Barker 1995; Heine 1997). This relationship can be indicated in several ways, by pure juxtaposition, by case, possessive pronouns, predicative constructions, or possessive suffixes (Seiler 1983). In Uralic languages, a possessive relationship is typically marked with a suffix on the possessed entity, agreeing in person and number with the possessor and also indicating the number of the possessee.

(1) Udmurt[1]:	(2) Komi:	(3) Hungarian:
tir-e	*nyl-ys*	*lány-aink*
axe-POSS1SG	daughter-POSS3SG	girl-POSS.PL.1PL
'my axe'	'his/her daughter'	'our daughters'

Possessive suffixes are not restricted to a certain kind of possessive relation, they mark inalienable and alienable possession, i.e. kinship relations, part-whole relations, ownership relations, control relations, etc. Uralic languages which distinguish morphologically between alienable and inalienable possession (e.g., Udmurt, Edygarova 2009; Winkler 2001) or between animate and inanimate possession (e.g., Mari, Kangasmaa-Minn 1998) use different sets of suffixes to mark the respective kind of possession. The possessive suffixes may co-occur with other possessive markers, e.g., with case or predicative possession.

[1]Komi and Udmurt examples are taken from Edygarova (2009).

Apart from their function as possessive markers, the possessive suffixes of some Uralic languages have another main function: they mark definiteness in the same way as definite articles in Indo-European languages (Collinder 1955; Bechert 1993; Fraurud 2001; Künnap 2004; Nikolaeva 2003; Rédei 1978; Schlachter 1960; Schroeder 2006). Consider the following examples:

(4) Nganasan (Wagner-Nagy 2002, p. 156):

Məu- δu	*śürü*	*ŋil'ənu*	*čiiməə*
earth-3SG	snow.GEN	under	hidden.PTPASS.3SG

'The earth is covered with snow'

(5) Komi (Fraurud 2001, p. 248):

Vęr-as	*lịmj-ịs*	*sịlema n'in.*
forest-INE.3SG	snow-3SG	melted already

'In the forest the snow has melted already.'

In (4) the possessive suffix is attached to a noun which refers to a unique entity. The earth is (without a special context) not possessed and according to Wagner-Nagy (2002) the possessive suffix is clearly interpreted as a marker of definiteness. In (5) *forest* and *snow* are realized with the possessive suffix of the 3rd person and again no possessor for either of them is mentioned in the context (and again only a special context would allow an interpretation where at least snow is possessed; nonetheless imagining a possessor for forest might be easier). Thus, the interpretation of the suffix is that of a definiteness marker.

This phenomenon of the definiteness-marking function of possessive suffixes occurs unequally distributed in the Uralic languages family[2]: in the Ob-Ugric languages Mansi (Keresztes 1998) and Khanty (Abondolo 1998), in the Permic languages Udmurt (Csúcs 1998) and Komi (Hausenberg 1998), in Mari (Kangasmaa-Minn 1998), and in the Samoyedic languages Nenets (Nikolaeva 2003), Enets (Siegl 2008), Nganasan (Helimski 1998a), and Selkup (Helimski 1998b). These languages not only use the 3rd person singular possessive suffix as a definiteness marker but also the 2nd person singular, and even the use of the 1st person singular is attested (Nikolaeva 2003). Künnap (2004) summarizes that in Permic, Volgaic and Ob-Ugric the use of the 3rd person suffix as definiteness marker is more frequent than the use of the 2nd person suffix. In the Northern Samoyedic languages (Nganasan, Enets and Nenets) the 2nd person suffix is said to be more common for definiteness marking, whereas in the Southern Samoyedic languages (Selkup) the 3rd person suffix is preferred in this function. In general there seems to be a tendency to use the 2nd person suffix for referents which are in some way closer to speaker and/or hearer (see Sect. 12.2.2 for details).

The frequency of the use of the possessive suffix as a definiteness marker is not equally distributed in all Uralic languages, however. Whereas it is considered to be

[2]The only Uralic language with a free definite article is Hungarian (*a ház*, DEF house, 'the house'), whereas Mordvin exhibits a morphological bound definite article. In both languages the definite article is derived from a demonstrative (Bechert 1993).

quite common in Komi (Künnap 2009, p. 239 cites a Komi grammar in which the possessive suffix is called the demonstrative-possessive suffix) it seems to be not that frequent, for example, in the Samoyedic languages or in Udmurt and Mari (Wagner-Nagy 2002; Winkler 2001; Schroeder 2006; see also a short corpus analysis at the end of Sect. 12.2.2). Furthermore, all languages exhibit different additional strategies to indicate that a noun is to be interpreted as definite. Tereščenko (1979) and Havas (2008, p. 5) illustrate for the Samoyedic languages Nenets, Enets and Selkup that direct objects in the nominative can only be (interpreted as) definite objects. All languages have demonstrative pronouns and use them for the indication of definiteness, too. Another strategy of definiteness marking might be the use of verbal suffixes: In Hungarian and the Ob-Ugric languages Mansi and Khanty, the objective (or definite) verbal conjugation indicates the definiteness of the direct object, whereas the subjective (or indefinite) conjugation indicates the indefiniteness or absence of the direct object. However, there are several exceptions to this rule: In Hungarian, for example, 1st and 2nd person pronouns do not trigger the objective conjugation, whereas the reflexive pronouns of the 1st and 2nd do (cf. Coppock and Wechsler 2012; Gerland and Ortmann 2013). Wagner-Nagy (2002, p. 163) states that in Nganasan no correlation between the definiteness of the direct object and the use of the respective conjugation is found. Körtvély (2005) shows that for (Tundra) Nenets both the transitivity of the verb and the definiteness of the direct object influence the choice of the suffix. On the other hand, Dalrymple and Nikolaeva (2011) state that, with the exception of Hungarian, the distribution of the subjective and objective conjugation in the Uralic languages is triggered by information structure and not by the definiteness of the direct object. Künnap (2006, p. 37) summarizes "there is no common set of rules valid for the whole Uralic language group". As a matter of fact, the distribution of objective and subjective conjugation is not exhaustively clarified for most of the languages.

In this paper, I will concentrate on the possessive suffixes as definiteness markers and show that this function has not developed in terms of grammaticalization but has always been inherent to them. I will show that instead of a possessive suffix we deal with a relational suffix whose main function is twofold: to indicate a link between two entities, on the one hand, and to mark the entity that bears the suffix as definite, on the other. The paper is structured as follows: First, I will briefly address the question whether the so-called "non-possessive use" (Fraurud 2001; Pakendorf 2007) of the possessive suffixes can really be classified as a definiteness marker since it seems not always to be the first choice for indicating definiteness of a noun. Section 12.3 will show why assuming a grammaticalization pathway comparable to the Indo-European development of definite articles is not plausible for the Uralic languages. This raises the question as to how the definiteness marking function may have evolved and if it is the result of a grammaticalization pathway at all. In Sect. 12.4 it will be shown that two factors trigger the interpretation of the relational suffix as a marker of definiteness or a marker of possession, namely the semantics of the respective noun and the context.

For this purpose, examples from the literature will be applied as well as data from small text collections, primarily for Nganasan, Nenets, Enets, Mansi and Khanty.

The grammatically annotated and translated corpora are allocated by the Project "Typology of Negation in the Ob-Ugric and Samoyed languages", University of Vienna[3]; and the Project "Obbabel/Eurobabel", Ludwig Maximilians University of Munich.[4] The respective transliteration and gloss from the literature and the corpora is adopted in this paper, only the glossing of the possessive suffixes is adjusted to the theme of this paper and henceforth the suffixes are glossed with the respective person marker only.

12.2 Definiteness Markers

12.2.1 Function and Use of the Definite Article

The debate about function and use of the definite article is old and still continuing (see Abbott 2006 for an overview). According to Abbott (2006) most of the theories concerning the definite article can be grouped into the familiarity or the identifiability/uniqueness approach. To put it in a nutshell, theories following the familiarity approach (e.g. Christophersen 1939; Heim 1982) state that the referent of the definiteness-marked noun has to be familiar in the discourse. Theories consolidated in the identifiability/uniqueness approach (e.g. Russell 1905; Strawson 1950; Hawkins 1978; Abbott 2006) claim that the respective referent must be the only entity which satisfies the content of the so-called definite description. In this paper, the uniqueness approach will be followed but in the more fine-grained sense as proposed by Löbner (1985, 2011). Löbner distinguishes pragmatic and semantic definiteness: If the definiteness of a noun depends on special situations and contexts for the non-ambiguity of a referent, the referent is pragmatically definite, as in *the flower you have bought is ugly*. For semantic definiteness, on the other hand, the referent is established independently of the immediate situation or context of utterance; the referent of the marked noun is thus inherently unique as in *the sun is shining*.[5] Hence, uniqueness is relativized to the discourse situation and to the context of utterance.

Himmelmann (2001), leaving apart theoretical discussions about the function and use of definite articles, lists formal and semantic criteria for distinguishing articles from other elements (such as demonstratives). Two formal criteria are essential: articles occur only in nominal expressions, and their position within nominal expressions is fixed. In addition to formal criteria, semantic criteria are

[3] Available at http://www.univie.ac.at/negation/

[4] Available at http://babel.gwi.uni-muenchen.de/index.php?abfrage=textcorpus_en

[5] As proposed in Gerland and Horn (2010) the term definiteness is used to refer to the grammatical marking of uniqueness, whereas the term uniqueness represents the unique status of the referent. Thus, I will follow this distinction between the grammatical side and the semantic function. See also Ortmann (this volume).

relevant for identifying articles. Hawkins (1978) classifies four typical uses for the English definite article:

(A) The direct anaphoric use: *a car ... the car*
(B) The immediate situation use: *press the clutch* [uttered in a car]
(C) The associative anaphoric use: *a book ... the author*
(D) The larger situation use: *the queen* [uttered in Great Britain]; *the sun*

Whereas in (A) and (B) the use of demonstratives is also possible, associative anaphoric uses and larger situation uses are only considered grammatical with definite articles. This classification is in accordance with the distinction made by Löbner (1985, 2011): in direct anaphoric and immediate situation uses the referent is pragmatically definite, in larger situation uses it is semantically definite. Associative anaphoric uses may be pragmatically or semantically definite (see Ortmann this volume, for a detailed discussion).

12.2.2 Function and Use of the Non-Possessive Suffix as a Definiteness Marker

Applying Hawkins's classification shows that the possessive suffixes with definiteness marking function appear in all uses which are assumed typical for definite articles.
(A) Direct anaphoric use:

(6) Selkup (Nikolaeva 2003: 4/5):
Qolty-t qanyq-qyn anty totta anty-ty lapykə:l e:ŋa.
big.river-GEN bank-LOC boat stands boat-3SG oar.without is
'A boat stands on the riverbank; the boat doesn't have an oar.'

(7) Komi (Klumpp 2009, pp. 326/7)
Men jen s'et-is mös da ösh.
I-DAT god give-PRT3SG cow and ox
'God gave me a cow and an ox.
Vaj let't's-am da ösh-sö nat's'k-am a mös-sö vid'z'-am.
Bring.IMP2SG go.down-PL and OX-ACC3SG butcher-PL but cow-ACC3SG keep-PL
Come on, let's go down and butcher the ox, but let's keep the cow.'

(8) Mansi (Data from the project "Typology of Negation in Ob-Ugric und Samoyed languages"(henceforth NoS), text03.123)
nājəŋxāp-n tāl-i nājəŋxāp-e Samarowa-n juwle joxt-i
steamboat-LATsit.down-3SG steamboat-3SG Samarowa-LAT back come/arrive-3SG
'He gets on the steamboat;it [lit: the steamboat] takes him back to Samarowa.'

In all three sentences (6)–(8) a referent is introduced, the respective noun is realized without any marker of definiteness or indefiniteness. When picked up anaphorically, the nouns bear a possessive suffix. Note that Komi distinguishes between non-possessive accusative suffixes and possessive accusative suffixes. Definite direct objects normally bear the possessive accusative suffix; however, if the marked referent is human (or at least animated) there seems to be a tendency to mark it with the non-possessive accusative (cf. Klumpp 2009 for a detailed analysis on differential object marking in Komi).

(B) Immediate situation use:

(9) Komi (Nikolaeva 2003, p. 7)
wanta tăm mašinaj-en jowra mănəs.
look DEM car-2SG awry went.3SG
'Look, the car went awry.'

(9) is an example for the use of possessive suffixes as definiteness markers in immediate situation uses, i.e. in cases where the referent is present and visually accessible, which is emphasized by *wanta* 'look'. The co-occurrence of the demonstrative in (9) is not counterevidence for the status of the suffix as a definiteness marker. In Hungarian, such co-occurrence is grammatical: *ez a ház*, DEM DEF.ART house, lit.: 'this the house'. According to Zaicz (1998) Mordvin allows this co-occurrence as well, Winkler (2001) attests it for Udmurt (10) but translates the demonstrative and the possessive suffixes as one unit with the English demonstrative.

(10) Udmurt (Winkler 2001, p. 32)
Mon (ta) kńiga-jez lĭdž-i.
I DEM book-3SG read-PRT1SG
'I have read this book.'

(C) Associative anaphoric use:

Associative anaphors can be perceived as being on the borderline between possession and definiteness: The referent is associatively anchored to another referent which is introduced earlier (often this referent is the possessor of the referent of the associative anaphor: this is reflected by languages which allow both a definite article or a possessive construction for associative anaphors). If the anchor is identifiable and the relation between the referent of the associative anaphor and the referent of the anchor is a 1-to-1-relation, the referent of the anaphor is identifiable, too. Hence, the interpretation of the suffix as a definite article is appropriate. (11) is a good example of a typical associative anaphor. It shows a kinship-relationship between a baby and its mother, therefore the suffix might be interpreted as expressing this kind of relation. But since every child has only one mother and hence the mother is unique in relation to the baby, the definite interpretation is also available (Löbner 1998):

(11) Mari (Bechert 1993, p. 33)
aza šoceš awa-şe mõlam pua aza-m.
baby be.born mother-3SG I-ALL give baby-ACC
'When a baby is born, the mother gives the baby to me.'

(12) Komi (Klumpp 2009, p. 332)
Pop lokt-is [. . .] vos't-is öd'z'ös-sö.
priest come-PRT3SG [at the woman's house] open-PRT3SG door-ACC3SG
'The priest arrived [at the woman's house]. He opened the door.'

In example (12) the woman's house the priest visits has been mentioned before (Klumpp 2009, p. 332). Hence, the door is linked unambiguously to this anchor and a possessive interpretation is possible. The definite interpretation is appropriate as well: The sentence describes an arriving event and a house which will be entered from outside. Since houses usually have only one entrance door, *öd'z'ös-sö* refers uniquely and the interpretation of the suffix would be therefore definite (analogous to the English definite associative anaphora in 'He arrived at the house. He opened the door'). Consider the following example, the third sentence of a Nganasan story. The tale starts with "This is a tale my father told me when I was a child, it doesn't have a name, I'll write it down. Just a fairy tale about wild animals."

(13) Nganasan (NoS, meu djamezi.003)
tahariaa büübtar-tu tərəd'i kərutətu mou-ntənu s'iti maʔ nən'd'i-t3
now start-3SG such ordinary earth-LOC two tent stand-PRS
'Well, in the beginning there are two tents simply standing on the ground.'

The noun *start* refers to the beginning of the tale (which is aforementioned in the previous sentence). Since every story has one and only one beginning, the *start* is unique in its relation to the respective tale. The suffix can be interpreted both as possessive and as definite.

(D) Larger situation use:

(14) Nganasan (Wagner-Nagy 2002, p. 156):
Məu- δu śürü ŋil'ənu čiiməə
earth-3SG snow.GEN under hidden.PTPASS.3SG
'The earth is covered with snow'

(15) Nganasan (NoS,NK-94_kehy_luu.044)
Ŋuə-mtu rugaet.
deity-ACC.3SG curse.3SG[6]
'He curses god.'

(16) Nenets (NoS, shicha_ne_ngashki 056)
tajʔn'a xiła-ta kaʔmaj
then snow-3SG fall.NARR
'Then, the snow fell.'

[6]In this case, the Russian word for "to curse" is used. I would like to thank an anonymous reviewer who pointed out this case of code-switching to me.

(17) Udmurt (Csúcs 1998, p. 285)
šundi-jed
sun-2SG
'the sun'

In (14) to (17) the possessive suffixes occur with nouns whose referents are inherently unique. It is not appropriate to assume possessors for earth, sun or snow without a certain context. For example (15), however, it might be more appropriate to interpret *Ŋuə-mtu* as 'his god', as this use often occurs in bible texts. Example (17) might pose a counterexample for the assumption of Künnap (2004) that all unique nouns bear the 3rd person possessive suffix. However, Csúcs states that the use of the 2nd person singular suffix seems to have an "affective overtone" (Csúcs 1998, p. 285) and the whole NP might be translated as 'the dear sun'.

This affective interpretation (or "subjectivization", Schlachter 1960) is often seen as the main function of the 2nd person possessive suffix. Schroeder (2006) postulates that, for Nganasan at least, the distribution of the 2nd and 3rd person suffix resembles the distinction between anaphoric and non-anaphoric article, but there is counterevidence for this statement (e.g. in the corpus of the Project "Typology of Negation in the Ob-Ugric and Samoyed languages", University of Vienna; where anaphoric resumption of referents is realized with the 3rd and the 2nd person singular suffix likewise). Wagner-Nagy (2002, p. 156) states that for Nganasan, the 3rd person is used for natural phenomena whereas the 2nd has a general determining function. However, data from corpora give counterevidence for this statement, too. Therefore, it seems to be the most plausible solution to assume that the application of the 2nd person establishes a closer link between hearer and the marked referent. Similar uses of the 2nd person possessive suffix can be found in many languages. In German the sentence *Da steht dein Auto* ('There is your car') might be interpreted as 'There's the car you've been dreaming of/speaking of'.[7] In the sentence *Dein Paul hat angerufen* ('Your Paul has called') the 2nd person possessive pronoun indicates a somehow close relationship between the hearer and Paul. In this sense, the 2nd person possessive suffix can be used intentionally to establish a close link between referent and hearer or to express an assumed close relation between them. Actually, the 2nd person suffix is found often in Uralic stories and fairy tales and marks the hero or the main character. In (18) the landowner "Mantu" plays a crucial role in the course of the story, therefore he bears the 2nd person suffix. In (19) the crow is the main character of an animal fable and also marked with the 2nd person suffix.

(18) Nenets (NoS, tesjada_nisjami 010)

Mantu	*teta-r*	*xo-t-wa!*
Mantu	land.owner-2SG	bring-IMP.2SG-EXL

'Bring the rich Mantu here!'

[7]See Vikner and Jensen (2002) for possible interpretations of possessive constructions. They distinguish between lexical and contextual interpretations of the English genitive of which the emotional interpretation is one.

(19) Nenets (Mus 2009, p. 44)

wərŋe-r°	*ma:*	*“məny°*	*nyd-d°m*	*xan°tə-q”*
crow-2SG	say.3SG	1SG	NEG-1SG	go-CONNEGATIVE

‘The crow says: “I will not go.’

However, there are cases in which the use of the 2nd person possessive suffix seems not to indicate this kind of affective interpretation. In the following sentence from a Mansi story, a person walks to a herd of reindeers.

(20) Mansi (NoS, text02.069/02.070)

Mātra S’il’ka	*pāγl’e*	*ti jūw3.*	*Lōŋxan’s’ap-a-ne*	*sujt-ē-γət*
Matra Silka	to.the.herd	so come.3SG	bell-EP-PL.2SG	sound-EP-3PL

‘Matra Silka goes to the herd. The bells are ringing.’

The bells are neither previously mentioned nor do they play a role in the continuing story. Rather the noun *bells* can be regarded as an associative anaphor with the aforementioned herd as anchor. Thus, the 2nd person singular suffix indicates simple definiteness here.

So far we can sum up that the possessive suffix occurs in all the uses which count as typical for a definite article and hence we can state that they are used in analogy to definite articles. Their uses cover both pragmatic uniqueness and semantic uniqueness. Further evidence for the definiteness function of the 3rd person marker comes from the fact, that in Mari (Alhoniemi 1993) and Nganasan (Wagner-Nagy 2002), for example, the suffix has a contrastive function, comparable to the contrastive function of Indo-European demonstratives and definite articles.

Another formal criterion for definite articles is not fulfilled, though: according to Himmelmann (2001, p. 832), obligatoriness (in grammatically definable contexts) is a useful heuristic for identifying definite articles. The use of a possessive suffix as a definiteness marker is not obligatory in any of the languages investigated, neither with pragmatic nor with semantic unique referents. This is reflected by an examination of a number of corpora: In two Nganasan stories comprising a total of 583 sentences, 68 uses of the 3rd person singular possessive suffix[8] were counted. 29 can be assumed as indicating definiteness. In these cases, no possible possessor is available: the referent of the noun is already introduced in the story and hence identifiable or the referent of the noun can be considered as inherently unique (see examples below). Among the remaining 39 uses, some might be considered as definite but the possessive interpretation is also appropriate, as explained for cases of associative anaphora above. For (Forest) Nenets in a corpus with 61 sentences the 3rd person singular possessive suffix occurs 42 times of which 19 can be considered as definite. In a corpus of (Tundra) Nenets with 260 sentences, of 47 occurrences of the suffix 15 can be considered as cases of definiteness marking. For Northern Khanty a corpus of 186 sentences was investigated. 68 of the occurrences of the

[8]Only occurrences of nouns were counted, occurrences e.g. of demonstrative pronouns were left out.

3rd person singular possessive suffix can be interpreted as indicating possession, 14 as indicating definiteness. Again, among the possessive uses several can also be interpreted as definite. For Mansi, in 224 sentences 52 occurrences of the 3rd person singular suffix were counted. Eight of them could be clearly interpreted as definite since the context provides no possessor for the respective noun. However, in all stories many more nouns can be interpreted as definite since the referents are, for example, pragmatically unique (and occur anaphorically picked up) and semantically unique. In most cases, these nouns occur unmarked in the nominative.

This distribution of the possessive suffix as definite article gives rise to certain questions: Why is it sometimes used for definiteness marking but not obligatory? Does this tell us anything about the grammaticalization of the suffix as definite article? If not, how can the distribution be explained and which role do other definiteness strategies play? Fraurud (2001) and Schroeder (2006) assume that the non-obligatoriness of possessive suffixes as a definiteness marker is due to the fact that they are not fully grammaticalized as definite articles. In the next section, this statement will be investigated.

12.3 Is There Any Grammaticalization Pathway?

Grammaticalization in general is characterized by different processes which have an impact on a linguistic unit. *Morphological reduction* specifies the loss of the ability for conjugation or the like, *phonetic erosion* the phonetic simplification. The term *obligatoriness* reflects that the "freedom of the language user with regard to the paradigm is reduced" (Lehmann 1995), i.e. the new form is obligatory in its new function. Grammaticalization pathways do not only affect the form but also the meaning of elements: *Semantic bleaching* describes the loss of semantic content. On the other hand, new semantic content might be added, a process called (*semantic*) *extension*. Both semantic changes come along with new applications for the element in question. Typical for grammaticalization is also the move from a concrete to a more abstract meaning and function (as shown, for example, by Bybee et al. (1994) for the English future marker *going to*). Thus, grammaticalization in general can be perceived as a coevolution of form and meaning.

12.3.1 Grammaticalization of the Definite Article in Indo-European

According to Greenberg (1978) the development of definite articles follows certain stages, summarized as:

Demonstrative →	definite article →	specific article →	noun (class) marker
stage 0	stage 1	stage 2	stage 3

In stage 0 the demonstrative is used to signal that the intended referent is available from the (linguistic or non-linguistic) context, the deictic content of the demonstrative points toward the referent. In stage 1 the deictic content is bleached out. The definite article indicates that the marked referent is unique, either semantically or pragmatically. The definite articles of Indo-European languages are perceived as being in stage 1 or between stage 1and 2. In stage 2 the definite article expands its range of use to all specific nouns independent of definiteness. At this stage Greenberg assumes the article to become an affix on the marked noun. In stage 3 the use of the former article spreads to all nouns, the morpheme functions as a noun class marker independently of uniqueness and specificity. A process happening in certain stages like the ones proposed by Greenberg is typical for grammaticalization in general. Hopper and Traugott (1993) call this kind of course the "cline of grammaticality" where each item to the right is more grammatical and less lexical than its neighbour to the left (in short: content item > grammatical item > clitic > inflectional affix).

The emergence of the definite article in Indo-European languages perfectly displays the general and article-specific grammaticalization parameters as will be shown for German, starting with the distal demonstrative pronoun of the 3rd person masculine singular *theser*:

(i) Morphological reduction: the demonstrative pronoun occurs in prenominal position (i.e. as a determiner) only in the nominative (*theser*, this.MASC.NOM, 'this')
(ii) Phonetic erosion: *theser* changed to the reduced form *ther*, the.MASC.NOM 'the' (nowadays: *der*)
(iii) Semantic bleaching: the demonstrative *theser* loses its deictic content
(iv) Obligatoriness: *der* marks all nouns which are unique, either pragmatically or semantically

According to Greenberg (1991), the grammaticalization of the Indo-European definite articles starts by an extensional use of demonstratives within direct anaphora. Thus the concrete deictic function of the pronoun becomes more abstract and refers not only to visually available referents but to aforementioned referents. In a next step, the use of the demonstrative spreads to associative anaphoric uses. In this stage, the element marks referents which are anchored only associatively in the linguistic context. In the last step, even this associative anchor is no longer necessary. As shown by Oubouzar (1992), Demkse (2004), Carlier and de Mulder (2010) and Ortmann (this volume), the spread of the definite article, for example in German, can be described in terms of semantic pragmatic and semantic uniqueness. Nouns whose referents are not inherently unique and not unambiguous without further context were marked much earlier with definite articles than nouns whose referents are inherently unique. The use of the definite article spreads from pragmatically unique nouns to semantically unique nouns.

12.3.2 Grammaticalization of the Definite Article in Uralic

The possessive suffixes with definiteness marking function in Uralic languages show neither the typical features of grammaticalization nor do they follow the typical process or cline, as will be shown in this section. The possessive suffix did not (and does not) lose its possessive content: its use as a marker for possessive relationships is continued. Thus, semantic bleaching does not take place. Neither is there any significant morphological reduction or phonetic erosion; the forms of the possessive suffixes with non-possessive function have not changed. Fraurud (2001) yields further arguments which provide evidence against a classical grammaticalization pathway: the use of the suffixes as possessive markers is continued. The possessive meaning is not lost but even stable. Although this co-existence (*persistence*) of two functions is not unusual at a certain stage of grammaticalization, one would expect either a new form for definiteness or a different form for possession. Such changes cannot be observed for the possessive suffixes in possessive and non-possessive function. Moreover, the definite use of the relational suffix has even been suggested for Proto-Uralic (Décsy 1990). Künnap (2004) states that "a general-definite function has always been inherent to the Uralic 3PX [3rd person possessive suffix". Further evidence against the hypothesis of a grammaticalization pathway comes from the lack of obligatoriness. Obligatoriness is often assumed as an indicator for a high degree of grammaticalization (Lehmann 1995; Himmelmann 2001). Compare (21) a and b for Komi (a language in which the definiteness marking function of the possessive suffix is regarded as the main function, i.e. one might assume a high grammaticalization). In both examples, the referent of pop ('priest') has already been introduced, the anaphoric resumption is possible with and without the definiteness marker.

(27) Komi (Klumpp 2009: 332; 330)

(a)	*Pop*	*lokt-i.s*			
	Priest	come-PRT3SG			
	'The priest arrived.'				
(b)	*Pop-yd*	*ord-yn*	*tulysja*	*vyy-nad*	*vaj-öma.*
	Priest-2SG	at-INE	springtime	on-INS2SG	bring-PF3SG
	[The cow was pregnant.] 'When it was nearly spring she calved at the priest's.'				

So far there seems to be no evidence for a grammaticalization path comparable to that of the Indo-European definite articles can be found. Even assuming a wider definition of grammaticalization (cf. Bybee et al. 1994 stating that none of the typical grammaticalization features has to be really met during the grammaticalization pathway) or starting the analysis under terms of 'grammaticization' (Himmelmann 2005) brings no solution to the question as to if and how the definiteness marking function arose from the possessive marking function.

Hence, I would like to follow Bisangs (forthcoming) notion concerning grammaticalization. He states that in a large number of languages in East Asia, grammaticalization is characterized by a lack of obligatoriness and a very limited (or even non-existent) coevolution of form and meaning. He observes the lack of obligatoriness especially in cases "where the concept inferred is an abstract grammatical concept that is expressed by obligatory categories in Indo-European languages" (Bisang forthcoming, p. 3). He remarks also that in a number of cases, the same marker can be used for different grammatical constructions with different interpretations. He concludes that in such cases "an initial source concept (...) simultaneously radiates into different directions." Bisang (forthcoming, p. 3) This insight might offer an explanation for the Uralic suffixes which can mark possession and likewise definiteness: There is no grammaticalization pathway with a unit changing its form and function. The suffix in question is rather an element containing both the possessive and the definite component in its core meaning. It is the context and the semantics of the respective noun which trigger the interpretation as a definiteness marker or a possession marker. The main function of the suffix is thus (roughly speaking) to establish either a more or less concrete possessive relation or an associative relation which is much more abstract than in unambiguous possessive constructions. In non-possessive constructions, the suffix links the referent of the marked noun to the situation of discourse, the location in which the discourse takes place and/or the discourse participants live. In other words: the suffix links the referent to a cognitive frame evoked in the discourse or already established between the participants. Note that the definite interpretation applies for both possessive and non-possessive relations, the marked referent is always definite, but its uniqueness is caused in different ways. Assuming this, it would be appropriate to call the suffix a RELATIONAL SUFFIX (instead of possessive suffix or 'relational possessive' as proposed by Schroeder 2006).

12.4 Relational Suffixes

12.4.1 Establishing Relations with Definite Participants

Winkler (2001) treats the 3rd person possessive suffix of Udmurt as a portmanteau that fulfills more than one function at the same time. The main functions he ascribes are: possession marking, definiteness marking, and markers of nominalization. The latter function seems to be limited to Udmurt, at least it is not attested in the literature for the other Uralic languages. Schlachter (1960, p. 93), in his study of the Komi (more precisely Komi-Zyrian, the largest dialect group of Komi), claims that the possessive suffix at least of the 3rd person singular has a personal and a demonstrative element from the first. It depends on the context as to whether the referent of the marked noun can be interpreted as possessed or as definite or as both possessed and definite, since in some cases (e.g. associative anaphora) there is no sharp distinction between the two. This explains why the respective suffix can be used as a possessive marker or as a definiteness marker without splitting up into two different forms (one for possession, one for definiteness). Klumpp (2009, p. 329) reports that in Komi grammars (Önija komi kyv morfologija 2000) the possessive suffixes are referred to as *indan-asalan suffiksjas*, 'demonstrative-possessive suffixes'. Actually the grammars even state that the expression of possession with possessive suffixes is limited to kinship terms, bodypart terms and abstract nouns expressing ideas and feelings, i.e. to terms which are commonly interpreted as inalienable. All other kinds of possession are expressed by case markers (genitive, ablative) realized on the possessor. Nikolaeva (2003) argues similarly: according to her, possessive constructions with possessive suffixes (at least of Nenets/Ostyak) render a two-place relation with a very vague meaning *X related to/associated with Y* (Nikolaeva 2003). Nikolaeva takes the predestinative construction of Nenets, which contains the relational suffix, as a two-place relation, too.

Ewing (1995), analysing Cirebon Javanese which likewise uses the 3rd person possessive suffix as a definiteness marker, comes to a similar conclusion: "-e [the erstwhile possessive suffix] is also used more generally to indicate indirect, frame-evoked identifiability in contexts where possession is no longer a relevant interpretation" (Ewing 1995, p. 75). Ewing states that the use of the possessive suffix invites the hearer to infer the possessor without referring to anything or anyone. In the non-possessive use of the suffix –é the marked referent is identifiable through a cognitive frame to which the referent is linked via the suffix.

(22) Cirebon Javanese (Ewing 1995, p. 79)

Poto	*semono*	*jelasé,*	*bisa,*	*[. . .]*	*endhas-é*	*buntung*	*kabéh.*
Picture	that.much	clear	can		head-3SG	cut.off	all

'Pictures that are that easy [to take] can [end up with], the heads all cut off.'

Ewing explains that the possessive suffix on the noun *endhas* 'head' does not indicate a possessive relationship to someone since the possessing people are only hypothetical. Thus, they do not serve as an anchor. The possessive suffix rather indicates a link to the general discourse, i.e. the knowledge of photographs in general and the knowledge of possible problems in taking pictures in particular. (23) could be interpreted in analogy. The possessive suffix links the noun *kou-δu* ('sun') to our knowledge and experience that there can be only one sun disappearing behind the clouds.

(23) Nganasan (Wagner-Nagy 2002, p. 79)

Kou-δu	*kantü"ə*	*čiirü"*	*tagə*
Sun-3SG	disappeared	cloud.PL.GEN	behind

'The sun disappeared behind the clouds.'

In general, one can state that the main discourse function (in the sense of Ariel 2008) of the relational suffix is to establish some kind of relation between two entities. This kind of relation may differ in the constructions. The two main distinctions are:

Relational suffixes in possessive NPs (i.e. with a given possessor):

- The marked referent is anchored by another, already unique referent. The link is more or less concrete (and includes inalienable possessive constructions such as kinship, part-whole, and alienable possessive constructions such as ownership or control possession).
- The marked referent is semantically or pragmatically unique. Its uniqueness comes from the uniqueness of the possessor.

Relational suffixes in non-possessive NPs (without any possessor):

- The marked referent is anchored by association through cultural knowledge or through the discourse situation. The link is of an associative kind and maybe very broad.
- The marked referent is semantically or pragmatically unique.

The definite interpretation of the marked noun in both the possessive and non-possessive NPs comes from the semantics of the possessive pronoun. Possessive NPs in general are often considered definite (Abbott 2006; Lyons 1999). While this statement is not completely valid for possessive constructions with lexical possessors (Barker 2004), it seems to be true for possessive pronouns. They refer like "bare" pronouns which are always definite (Lyons 1999; Barker 2000, 2004), the referent indicated by the suffix is semantically or pragmatically unique, otherwise the use of a possessive pronoun would not be appropriate (one would not utter a sentence like *I don't like his house* if the hearer is not assumed to know who the man referred to by *his* is). The effect of a definite possessor is that the possessum is definite as well. As a diagnostic criterion for determining the definiteness of a noun phrase, Barker (2000, p. 218) formulates it thus: "A noun phrase containing a possessor phrase is definite just in case the possessor phrase is definite." Hence, a noun marked with a possessive pronoun can always be interpreted as definite. Note that this does not entail that the marked noun is also unique since the sentence "*My brother moves to New York*" would not exclude that the speaker has another brother. The interpretation would be nevertheless that the speaker has only one brother (otherwise a repairing mechanism such as *"Which of your brothers?"* would be necessary for disambiguation).

12.4.2 The Role of Conceptual Noun Types in the Interpretation of the Relational Suffix

The interpretation of the relational suffix as a marker of possession or definiteness depends on the semantics of the marked noun and the context is secondary. It seems that in possessive NPs with a possessor the relational suffix is interpreted as a possession marker, the definiteness component of the suffix is suspended (see Horn (2010) for a detailed analysis of focus of attention and suspension). In definite interpretations, the process works the other way round: the possessive component is suspended, the definite interpretation is focused. This is in accordance with Ewing (1995). He states that the interpretation, whether the suffix represents a possessive relation or an associative relation, is up to the hearer. However, assuming the context as the main trigger for the interpretation of the relational suffix does not complete the picture. The semantics of the respective marked noun play a role in the interpretation as well. Löbners (1985, 2011) theory of conceptual noun types helps to shed light how the nouns are interpreted with and without further context.

Starting with a classical distinction of sortal and relational nouns (as made by Partee 1983/1997, Asudeh 2005; Barker 1995) where one-place predicates are separated from two-place predicates, Löbner (1985, 2011) subdivides the nouns additionally according to their (non-)unique reference. The outcome is a cross-classification into four logical types that differ with respect to their referential properties, i.e. uniqueness (inherently unique vs. non-unique) and relationality (inherently relational vs. non-relational). Löbner distinguishes between sortal nouns (such as *flower, table*), relational nouns (*sister, friend*), functional nouns (*mother, president*), and individual nouns (*sun, pope*). Within this classification, individual and functional nouns are inherently unique in the sense that the number of possible referents is restricted to one in a given context. In contrast, for sortal and relational nouns the number of possible referents is unrestricted. Relational and functional nouns are inherently relational and require the specification of an additional argument for reference. Löbner thus assumes underlying semantic (or: lexical) properties for each noun. He further assumes that these lexical referential properties influence the way nouns are used grammatically (Horn and Kim, this volume). In accordance with their referential properties, functional and relational nouns can be seen as predisposed for possessive use. Due to their inherent uniqueness, individual and functional nouns exhibit a predisposition for definite use.

The lexical properties of the respective noun account for the interpretation of the relational suffix. Uniques such as 'sun' and 'earth' are individual concepts and refer to inherently unique concepts. Since we know that our world has only one sun and only one sky we interpret the relational suffix as a marker of definiteness indicating the uniqueness of the referent and not indicating the possessor. Hence, in these cases the possessive element of the suffix is suspended to a large extent, and the definite interpretation comes to the fore.

(23′) Nganasan (Wagner-Nagy 2002, p. 79)
Kou-δu kantü"ə čiirü" tagə
Sun-3SG disappeared cloud.PL.GEN behind
'The sun disappeared behind the clouds.'

(24) Nenets (NoS,t'et wel'i teta 084)
Xajer-ta pakal-c' ŋisi-n tæwi-dʔ
sun-3SG set-INF nomad.camp-DAT arrive-3PL
'They arrived at the camp at sunset.'

(25) Nenets (NoS, t'et wel'i teta 010)
Numʔ-da taʔ-wna pæb'i-n'uʔ
sky-3SG there-PROSEC dark-3SG.EMPH
'The sky is still dark.'

The relational component can be assumed to be still existent. 'Sun' and 'sky' are associated to our world even we know that there are many suns in our galaxy.

Inherently relational nouns, on the other hand, might rather lead to a possessive interpretation of the relational suffix. The suffix in (26) and (27) would be interpreted as indicating a possession because of the inherent relationality of the kinship term *brother* and the noun *friend*. The pure definite interpretation without any possessive connection would be favoured only with an appropriate context (and seems to be hard to coerce).

(26) Komi (Hausenberg 1998, p. 313)
vok-ïs
brother-3SG
'his brother'

(27) Udmurt (Winkler 2001, p. 28)
eš-tı̯
friend-2SG
'your friend'

Note that the referents of the marked nouns are nonetheless definite because their possessor is definite. Barker (2004) calls this kind of definiteness *possessive weak definiteness*. The marked nouns are not semantically unique because we can imagine several brothers and friends of a person. But they can be interpreted as pragmatically unique since no further information is given – which is only reasonable when the referent is unambiguous.

Functional nouns such as *father* or *boss* are both inherently unique and inherently relational. Consider the noun *father*: everybody has only one father (at least one biological father) and stands in a kinship relationship to him. Hence a functional noun such as *father* requires a definite and a possessive construction for disambiguation, which in these cases is combined in the relational suffix. Consequently both readings, the possessive and the definite, lead to the same referent. The same holds for the functional noun *door* (in the sense of entrance door):

(13′) *Komi* (Klumpp 2009, p. 332)
Pop lokt-is [...] vos't-is öd'z'ös-sö.
priest come-PRT3SG [at woman's house] open-PRT3SG door-ACC3SG
'The priest arrived [at the woman's house]. He opened the door.'

Houses – as already argued above – usually have only one entrance door so they are unique within this relationship and therefore identifiable. Other uniquely occurring items in a home are functional nouns to. Consider the following example:

(28) Nganasan (NoS, Kehy Luu, NK-94_kehy_luu.024)
Tə ənti tuj –t'üənti s'iə -ntiʔ huan-ʔə-tu
that sort.of fire-3SG sort.of hole-LAT.PL put-PF-3SG
'He put it in the pit under the fire, [...].'

As in the Samoyed culture every tent has one fireplace and therefore one fire, the relational suffix indicates its relation to the respective tent on the one hand and the uniqueness of the noun within in this relation on the other. Moreover, the context of the story reveals that the acting person referred to with the personal pronoun (realized on the verb) cannot be the possessor of the fire since he is in a foreign tent. Further typical examples for functional nouns are uniquely occurring body parts, as in examples (29) and (30):

(29) Mansi (NoS, text02.020)
Māɣl-e taj s'ar t'ēr-ə-l nas wol'ɣ-i
chest-3SG then totally iron-EP-INSTR simply sparkle-3SG
'His chest simply sparkled with all the decorations.'

(30) Khanty (NoS, text09 012)
Ij ne-t-na ux-t kănš-ta pĭt-s-a
one woman-3SG-LOC head-3SG search-INF begin-PST-PASS.3SG[9]
'The girl started looking at his head.'

Sortal nouns are neither unique nor relational and do not require markers of definiteness and possession. However, they occur with the relational suffix as well, which can be explained in terms of *type shifts*. The theory of concept types and determination contains also the notion of *shifts*, i.e. every noun can be shifted to a different type of noun (Gerland and Horn 2010; Löbner 2011). These shifts are marked with the use of the grammatical markers of the respective class in which the noun is shifted. Thus a sortal noun occurring in a definite and possessive construction is shifted to a functional concept, a sortal noun occurring in a definite construction is shifted to an individual concept, and a sortal noun occurring in a possessive construction is shifted to a relational concept. The interpretation of sortal nouns occurring with a relational suffix indicating definiteness and/or possession depends thus on the context.

(31) Udmurt (Winkler 2001, p. 77)
Mon so-leš lĭdž-ono kńiga-z-e adž-i
I he-ABL read-PART book-3SG-ACC see-PRT1SG
'I saw the book which must be read by him.'

Both the definite and the possessive reading are possible, but the definite interpretation seems to be more appropriate due to the non-relationality of the sortal noun. The noun is shifted to an individual concept which refers pragmatically unique, because its referent is only available with additional information (which is given here cataphorically). It is this additional information to which the book is linked, hence the relational component of the possessive suffix is still existent. It would be appropriate to assume this linking component to a discourse for all nouns which refer in a pragmatically unique manner. Consider the following examples:

[9]Note that this example also provides a use of the suffix which is not yet explained, namely the co-occurrence with a numeral (or indefinite article).

(32) Northern Mansi (Data from the Project Obbabel/Eurobabel at the Ludwig-Maximilians University Munich, Lu:ima se:ripos, sentence 21)
Su:j pil lu:pta pa:ŋxwit josa-ŋ xumi-te s:aj aj-s jol ta xuj-as.
lingonberry leaf wide ski-with man-3SG tea drink-PRT3SG down ACT lay
'The man with skis, small like lingonberry leaves, drank tea, afterwards he lay down.'

(33) Northern Khanty (NoS, text09 020)
Jĭɣpŏx-t măn-əm jŭwpə-na ĭs'ə xu-t jŏxət-ə-s-3
brother-3SG go-PT.PRF back.part-LOC same man-3SG come-EP-PST-3SG
'After he [the brother] had gone away, the same man came again.'

In both cases, the referent of the suffix-marked sortal noun *man* has been introduced before and is picked up anaphorically. Again, the possessive component links the pragmatically unique noun to the discourse.

Consequently, the relational suffix cannot grammaticalize into a pure definiteness or a pure possession marker, since its respective interpretation depends ultimately on the semantics of the marked noun and on the context.

At first glance, Komi might pose a counterexample for the assumption of a relationality suffix: the preferred use of the relational suffix is that for definiteness marking. For possession marking it is only used with inalienable (i.e. inherently relational) nouns. All other kinds of possession are expressed by case marking and predicative constructions. However, this fits perfectly to the assumption: the relational suffix is used as a possession marker in undoubtedly relational contexts, the definiteness component is thus suspended and there is no question as to whether the possessive or the definiteness interpretation is appropriate. For all other non-relational nouns in possessive constructions (which might lead to confusion if the possessive or the definite interpretation is meant) other constructions are preferred which lead unambiguously to a possessive or definite interpretation. The definiteness interpretation on the other hand is twofold: for inherently unique, i.e. semantically unique nouns the possessive component is suspended to a large extent. For pragmatically unique nouns the possessive component of the relational suffix links the marked referent to the discourse. However, since with non-relational nouns a possessive construction would be realized with case or predicative constructions, the noun would undoubtedly be interpreted as definite.

12.5 Conclusion

The analysis of this paper shows that the possessive suffix of the Uralic languages also has the function of definiteness marking. Contrary to definite articles in the Indo-European languages, this definiteness marking function seems not to be the result of a grammaticalization pathway but was always inherent to the suffix. Thus, it might be appropriate to speak of a relational suffix instead of a possessive suffix. The main function of the relational suffix is to link two entities and to mark the uniqueness of the non-anchoring entity. The link can be more or less concrete as in possessive relations or associative as in non-possessive relations. The marked referent is always perceived as definite due to the weak possessive definiteness (Barker 2004) of the possessive pronoun. The interpretation of the suffix as a marker of possession or a definiteness marker depends mainly on two factors: The context and the conceptual noun type of the marked referent. Concept types which are inherently unique (individual and functional concept types) always evoke a definite interpretation of the relational suffix. Relational nouns evoke a possessive interpretation, sortal nouns again a definite interpretation as long as no possessor is mentioned or inferred. However, all nouns can be shifted to a different noun type. Hence, the relational suffix on an individual noun such as *sun* would be interpreted as a marker of possession when a possessor would be available in the context (*his sun* in a science fiction context where a person owns a sun).

However, some questions are left open, e.g. whether further uses of the suffix as the occurrence on demonstrative pronouns or the co-occurrence with numerals can be numbered among the functions of the relational suffix. One essential question concerns the non-obligatoriness of the relational suffix as a definiteness marker: is its use really purely optional or are there some factors which can account for its distribution? Finally, the suggestions made in this paper need further investigation. This includes not only a more detailed analysis of different corpora (here only tales were used. However, data from other genres as newspapers and spoken language should also be investigated) but mainly a semantic investigation of the respective nouns occurring with the possessive suffix.

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Chapter 13
Definite Article Asymmetries and Concept Types: Semantic and Pragmatic Uniqueness

Albert Ortmann

Abstract The goal of this paper is to explain the various asymmetries with regard to the (non-)use of definite articles in diverse languages by exploiting the distinction of semantic and pragmatic uniqueness as originally introduced by Löbner (*Journal of Semantics* 4: 279–326, 1985). I put forward the claim that typologically speaking, there are two kinds of such definite article splits. Both of them follow the scale of uniqueness Löbner (*Journal of Semantics* 28: 279–333, 2011), a concept hierarchy that is defined by the (in)variance of reference of nominal expressions. The first kind is a split such that the bottom segment of the scale is marked by the definite article, whereas the rest remains unmarked. The second kind of split is characterised by pragmatic and semantic uniqueness being morphosyntactically distinguished by different forms of the definite article, commonly a strong and a reduced form. I propose a few amendments to the scale of uniqueness so that the variation both between and within individual languages is captured in terms of spreading along the scale.

Keywords Definite article • Uniqueness • Semantic definiteness • Pragmatic definiteness • Concept types • Type shifts • Germanic languages • West Slavic • Old Georgian

13.1 Introduction: Two Kinds of Article Split Systems

According to the theory of definiteness put forward by Löbner (1985) all definite descriptions are construed as functional concepts. In other words, any definite noun phrase can be assigned exactly one referent. A crucial distinction in this theory is

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that between semantic and pragmatic uniqueness. By the former it is meant that the reference of an NP is unambiguous because of the noun's lexical semantics, while pragmatic uniqueness refers to those uses of NPs whose unambiguous reference only comes about by the given context of utterance, as is the case with deictic and anaphoric use. In exploiting the distinction, I argue that the conceptually driven definite article splits one encounters across languages all belong to one of the following kinds:

Split I: Pragmatic uniqueness is marked by the definite article, whereas semantic uniqueness is unmarked. The use of demonstrative pronouns as definite articles in some West Slavic languages essentially covers the contexts of pragmatic uniqueness. As a diachronic counterpart, the distribution tends to spread from pragmatic to semantic definiteness, eventually also covering such concepts as uniques or names, where it is of little functional load.

Split II: Pragmatic and semantic uniqueness are distinguished by different forms, either lexically or phonologically. The contrast of strong and weak definite articles in dialects of German is shown to reflect this distinction, thus providing the background for analyses of the article systems of Dutch and Mainland Scandinavian.

I will propose that all individual language-specific splits follow a conceptual scale that is conceived according to the narrowness of possible referents. When the top segment of the scale is marked by the definite article and the rest remains unmarked, I speak of Split I. Split II is characterised by different forms for two different segments.

The paper is organised as follows. Section 13.2 recapitulates Löbner's classification of nouns into four concept types. Section 13.3 illustrates the distinction of semantic and pragmatic uniqueness and the scale of uniqueness. The remainder is devoted to case studies of article asymmetries: Sects. 13.4 and 13.5 address the Split II systems of Germanic, especially Dutch and Scandinavian. As representatives of Split I, two West-Slavic languages are analysed in Sect. 13.6 in the cross-linguistic context of the border of semantic and pragmatic uniqueness. Later, in Sect. 13.7 the complex development of article use in Georgian is analysed against the background of the concept type distinction. Section 13.8 sums up the major results.

13.2 Nominal Concept Types

Löbner (2011) extends his (1985) division into sortal, relational and functional nouns towards a cross-classification of nominal concepts. The classification is based on the dimension of reference and on that of relationality. That is, the oppositions that underlie the concept types distinction are the contrast of monadic and polyadic predication on the one hand, and the contrast of inherently identifiable and not inherently identifiable on the other hand.

(1)

	Non-unique reference	Unique reference
Monadic	Sortal nouns (SN)	Individual nouns (IN)
	Dog, stone, water	*Sun, weather, Mary, prime minister*
Polyadic	Relational nouns (RN)	Functional nouns (FN)
	Sister, finger, blood	*Father, head, age, difference*

The four conceptual types, then, fall out from a cross-classification of the dimensions 'relational' und 'unique reference'. Sortal nouns (henceforth SNs) classify the universe, while RNs do so in relation to an argument, normally a possessor argument. The logical type of the former is thus $<e,t>$, while that of the latter is $<e,<e,t>>$. INs unambiguously pick out individuals (often depending on a given time/world coordinate, which is, however, not considered any further in what follows), and FNs do so in relation to a possessor argument. Their logical types are therefore e and $<e,e>$, respectively.

The concept type approach draws heavily on the flexibility in the usage of nouns. Virtually any noun can be used as any one of the four concept types. This means that type shifts in all directions are possible. For example, a shift from sortal noun to relational concept results in what is commonly referred to as an 'alienably possessed' noun. As a consequence, a noun can be used either in congruence with or deviating from its underlying concept type. Whenever an underlyingly sortal noun occurs as a definite description, this implies its use as an individual or functional concept (IC/FC). Thus, the terminology differentiates the noun's underlying type, such as FN, and its actual use, such as FC. For example, *the dog* involves unique reference that comes about by anaphoric or deictic use (hence pragmatic uniqueness). We are thus dealing with a type shift from SN to FC, which in many though by far not all languages is overtly encoded by a definite article. In languages such as German and English the definite article also occurs with INs (*the sun*) but since no shift is involved here it applies vacuously, and is therefore semantically redundant. The indefinite uses of INs and FNs (*a sun*, *a mother*) imply a shift in the opposite direction, that is, to a sortal concept (SC).

13.3 Semantic Versus Pragmatic Uniqueness

As stated above, I assume with Löbner that all definite NPs – that is, noun phrases marked by definite articles, demonstrative pronouns or prenominal possessors, as well as proper names and personal pronouns – are to be analysed as functional concepts (ICs/FCs). In other words, any definite NP displays non-ambiguous reference. Obviously, unambiguousness of reference (or 'uniqueness' for short) may come about in different ways. Above all, in order for a concept to be unique, it is not a necessary condition that the referent of the NP be known by the hearer. The key criterion is that reference is determined by an inherently (rather than accidentally) unambiguous concept. This has two important consequences. First, it is precisely in this sense that the distinction between semantic and pragmatic uniqueness seems to be more apt for capturing the data than an approach to definiteness based on the notion of familiarity, hence in essential regards on anaphoricity (in particular, Heim 1988). Second, the property of specificity is logically independent of that of uniqueness, since the referent of a definite NP does not even have to be known to the speaker, as is verified by, for example, *the next winner of the championship, the partner you will marry one day.* All that matters is that the concept as such warrants unambiguousness.

The crucial overall distinction of Löbner's approach is the distinction between semantic and pragmatic uniqueness. Semantic uniqueness means that reference is unambiguous for reasons that are context-independent and inherent to the meaning of the noun. This is the case with individual and functional nouns (INs, FNs), as in *the sun, the temperature in Vienna at noon (on a particular day), John's mother*. Put differently, the unambiguity of these expressions follows from the lexical semantics of their head nouns. Pragmatic uniqueness, by contrast, results from the (linguistic or extra-linguistic) context. This is the case with uses of NPs that refer unambiguously only within a given utterance context, especially with deictic or anaphoric use, which involves a type shift from SN/RN to IC/FC: the referent of *the man* (with an underlyingly sortal noun) varies according to the utterance context. One central thesis advocated in Löbner (2011), and to be elaborated in this paper, is that the distinction between semantic and pragmatic uniqueness is the basis of all conceptually governed article splits, in that a shift towards an IC or FC is overtly signalled.[1] The exact threshold of the occurrence of articles at the borderline between semantic and pragmatic is subject to variation and change in a way that will be made more precise in the subsequent sections.

To begin with, the distinction explains otherwise unexpected non-occurrences of definite articles. Even in a language with generalised article use, genuine functional count nouns often appear as bare nouns even in the singular, especially as complements of prepositions; cf. English *the items differ in shape*. Furthermore, configurational uses of SNs and RNs as ICs and FCs give rise to the lack of the article (cf. *finish school, shake hands*), especially in prepositional contexts as in *at court, be in hospital/prison*. In Dutch, too, configurational uses of nouns are articleless: *op tafel* 'at the table', *naar bed* 'to bed', *op slot* 'in the castle'; in German, they involve fusion with prepositions as in ***zur** Schule gehen* 'go to school', ***im** Krankenhaus/Gefängnis sein* 'be in hospital/prison'; ***am** Tisch* 'at the table', ***ins** Bett* 'to bed', which is not usually found in cases of pragmatic uniqueness (Löbner 1985). Starting out from this distinction I follow Löbner (2011, p. 320) in assuming

[1]An example of a split which is not primarily conditioned by conceptual factors is what is known as Definite Article Reduction (DAR) in the dialects of Northern England. Instead, phonological and extra-linguistic factors seem to be more crucial here; see Tagliamonte and Roeder (2009) and the references contained therein.

a scale that is defined according to the degree of invariance of reference of nominal expressions:[2]

(2) **Scale of uniqueness** (to be completed):
deictic SN < anaphoric SN < SN with establishing relative clause < definite associate anaphors < IN/FN < proper names < 3rd person personal pronouns < 2nd and 1st person personal pronouns

The scale, then, reflects the restriction in the choice of possible referents of the head noun. On the right (or 'bottom') end, the potentiality of referents is necessarily limited, whereas towards the left (or 'top') end the choice of referents gets increasingly broader because we are dealing with SNs, which characterise a potentially infinite set of referents. Accordingly, the necessity of relying on world knowledge grows from right to left.

The expectations that are entailed by the scale are the following:

Prediction 1: A decrease of obligatoriness in the use of articles as one moves from the left end to the right. This decrease correlates with a decrease of functional load.

Prediction 2: Diachronically, the use of the article spreads from left to right along the scale, thus eventually covering also those areas where it is functionally redundant.

Prediction 1 is an implicational statement which will be examined in the remainder of this paper. Prediction 2 is in accordance with the concept of grammaticalisation, both in general and with respect to definiteness (see Himmelmann 1997 and Lyons 1999, p. 275ff).

Let me first comment on the two margins of the scale. As regards the lower end, for articles to occur with personal pronouns is typologically very rare. In Tzutujil Maya, according to Dayley (1985, p. 254f) "[t]he definite article is often used with non-third person pronouns when they are topics or subjects"; cf. *jar oojoj oq* DEF PRON1SG 1PL.ABS, lit. 'the we' (l.c.: 255). Crucially, *jar* also occurs with expressions of all other steps of the scale, including proper names. Similarly, in Maori the article variant *a* (which contrasts with *te*/*ngaa* and *taua*/*aua*; cf. Sect. 13.6) is used with proper names and personal pronouns. This holds true of all persons: *ki a au* PREP DEF PRON1SG 'to me', *a koutou* DEF PRON2.PL 'you', *i a raatou* DOBJ DEF PRON3PL 'them' (Bauer 1993, p. 4, 371, 368). Having found

[2]The scale of uniqueness is not to be confused with a hierarchy that is often referred to as the 'Definiteness Scale' (cf. Aissen 2003). The latter notion denotes a salience hierarchy that accounts for a variety of grammatical splits concerning (among other things) ergativity and differential object marking.

As for the labels of the steps on the scale, I stick to the conceptual types themselves, whereas Löbner (2011, p. 320) uses 'sortal (or functional, rsp.) CNP' (for 'common noun phrase'). Löbner furthermore separates "functional CNP with explicit definite possessor" from INs and sets them on a par with SNs with establishing relative clause. In the absence of clear evidence of the significance of possessor phrases for the present study, I conflate individual and functional nouns.

no empirical support for Löbner's (2011) original suggestion of separating 3rd from local persons on the scale (semantic uniqueness being most obvious with speech-act participants) I dispense with this division in what follows.[3] One step higher, proper names (n.b. in their genuine use, rather than as sortal concepts) are accompanied by articles in quite a few languages such as Albanian, Modern Greek, colloquial German, and Pima (Uto-Aztecan). Crucially, in all these languages articles are illicit with pronouns, but obligatory with nominals further to the left on the scale.

As for the other extreme, many languages do not have definite articles at all. This means that their demonstratives are always deictic, involving either a proximal or distal specification, and are not obligatory with anaphoric nouns; neither are they used with associative anaphora (see Himmelmann 1997 for these and other criteria).[4] If a language employs definiteness markers in only some contexts but not in others, these contexts will always comprise those of pragmatic uniqueness, in which the functional load of the article is obvious for it denotes a shift from SN/RN to IC/FC. The diachronical expectations expressed by the scale should be thought of in just the same sense (see also Schroeder 2006, p. 600f). In Old High German, for example, definite articles are obligatory with anaphoric NPs but often missing with FCs; cf. the following two passages of Luke 2, 4–6, taken from a translation of the New Testament dating from the eight century: … *her uuas fon huse inti fon hiuuiske Dauides*, lit. 'he was from house and from line David's', … *vvurðun taga gifulte thaz siu bari* 'were days fulfilled that she gave birth'.

The same contrast can be illustrated from the diachrony of Scandinavian. Faarlund (2009) analyses the development from Old Norse to the modern Scandinavian languages. With respect to the reanalysis of the postnominal definite article from clitic to suffix, Faarlund speaks of semantic bleaching, since the definite article originally occurs in only those contexts where it is not redundant, but not in those contexts where unique reference is already expected owing to the meaning of the word (that is, in Löbner's terms, semantic uniqueness). Faarlund (2009, p. 632) provides the following contrastive pair from Old Norse, which involves article-less FNs in (3a), in contrast to an underlying SN whose shift towards pragmatic uniqueness is signalled by the suffixed article in (3b)[5]:

[3] As regards the article distribution over grammatical person in Tzutujil Maya, it appears to be the opposite of what would be predicted by the original suggestion. Note however that the form *ja(r)* is derived from the 3rd person singular of the personal pronoun, *jaa'*. This may account for its absence with third person pronouns.

[4] The view of a deictic opposition as the defining property of demonstratives is, however, explicitly argued against by Lyons (1999: 19f, 55ff), who provides examples both of demonstrative systems without and of article systems with a deictic distinction.

[5] Throughout the paper I use the following abbreviations for grammatical categories: ACC 'accusative', ADV 'adverbial case', AOR 'aorist', COMP 'complementizer', COP 'copula', DAT 'dative', DET 'determiner', DEF 'definite article', DOBJ 'direct object', ERG 'ergative', F 'feminine', GEN 'genitive', INDEF 'indefinite article', INFL 'inflectional affix', LOC 'locative case', M 'masculine', NEG 'negation', NOM 'nominative', OBL 'oblique case', PART 'participle', PAST 'past tense', PL 'plural', PRON 'personal pronoun', REFL 'reflexive pronoun', REL 'relative

(3) a. *sat konnugr ok dróttning i hásæti*
sat king.NOM and queen.NOM in high_seat
'The king and the queen were sitting in the high seat.'

b. *Þeir sjá nú skip-**in** fyrir sér*
they see now ship-DEF.ACC.PL before themselves
'They now see the ships in front of them.'

One may wonder why the variation that one observes exists, and why not all languages restrict the use of articles to just those cases where they are 'meaningful'. In other words, why do languages tend to extend the article use to environments where it is redundant? Such variation speaks in favour of a tension of competing factors. The factors that are at issue here are economy on the one hand (to be stated as: "Overt operators occur only where they apply, and are avoided where they are vacuous"), and the uniform treatment of nouns on the other hand. The latter may be stated as: "Treat all noun phrases with unique reference alike", which, in inflectional languages, is motivated by other purposes served by articles such as case-marking and NP-internal concord, on which I do not comment here any further. Any language that has articles available at all will have to balance these two factors, and it is therefore only natural that, at a closer look, most languages that have articles turn out to exhibit some split.

The overall claim I would like to put forward is this. Typologically, all conceptually driven definite article splits belong to one of two kinds which can be interpreted as follows:

Split I: A top (or leftmost) segment of the scale of uniqueness is marked by the definite article, whereas the rest remains unmarked.

Split II: Two segments of the scale (normally pragmatic and semantic uniqueness) are morphosyntactically distinguished in terms of different article forms, each of which will be subject to the above Predictions 1 and 2.

The variation among and within languages as to the exact location of a split will turn out to centre on the intermediate part of the scale, so I will later argue for a few amendments.

Examples of Split I are Old High German and Old Norse (as well as Upper Sorbian, Upper Silesian and Old Georgian, on which see Sects. 13.6 and 13.7). As an exemplification of Split II, consider the Siouan language Lakota with its two postnominal definite articles *kį* and *k'ų* (Buechel 1939; Pustet 1992; cf. also the NLD 2008, p. 755). Roughly put, the former indicates that the speaker assumes a discourse referent to be identifiable, and it can also be used to refer to entities that have not been explicitly mentioned before. The form *k'ų*, by contrast, is often glossed as 'the aforementioned', and the referent of the noun that it determines must have been explicitly mentioned previously in the discourse context and must

clause marker', SG 'singular', SUPERL 'marker of superlative'; 1, 2 and 3 represent first, second and third person.

furthermore be a salient entity with respect to the content of the discourse. More concretely, the form *kį/cį*, also spelled *kiŋ*, on the one hand, occurs with subcases of situational or deictic reference, hence pragmatic uniqueness. Above all, however, it is found with semantic uniqueness, cf. the FNs *wa kiŋ* 'the snow', *wiwáŋyaŋg wacípi kiŋ* 'the sundance' (Karol 1974, p. 97f), *wį'yą wą b.lu'ze cį* woman REL 1.SG.take DEF 'the woman I married' (Pustet 1992, p. 8). The form *k'ų/c'ų*, on the other hand, occurs exclusively in contexts of pragmatic uniqueness; namely such anaphoricity where the antecedent is remote rather than close in the discourse.[6] We are thus dealing with a split whose threshold is located higher than in Old High German, for example, since it is "somewhere within" pragmatic uniqueness: In a narration reported by Deloria (1932, p. 70, quoted after Pustet 1992, p. 3f) the noun *mat'o´* 'bear' is introduced by the indefinite article *wą*, and picked up anaphorically two times with *kį*, and eventually with *k'ų*.[7]

The goal of the next two sections is to show that the distinction between semantic and pragmatic uniqueness is clearly grammaticalised in modern Germanic languages in terms of Split II systems, and that the splits are governed by the concept type of the determined nouns.

13.4 Split II Systems: Strong and Weak Definite Markers in West Germanic

In this section, I review some instances of article splits that are reported in the literature and for which the distinction of semantic and pragmatic uniqueness is relevant. In light of this, I present a fresh analysis of definiteness marking in Dutch.

13.4.1 Strong and Weak Articles in Frisian and Dialects of German

To begin with, consider **Fering**, the Northern Frisian dialect spoken on the island of Föhr. According to Ebert (1971a, p. 159f) there are two paradigms of definite articles:

[6]Note that neither of the two Lakota article forms is akin to any of the demonstratives *le'* (proximal) and *he'* (medial) and *ka'* (distal) (Buechel 1939, p. 108). Besides, demonstratives require the presence of an article.

[7]See Wespel (2008) for a related, though slightly different generalisation of the split in Lakota, as well as for analyses of definite article splits in two Creole languages.

(4)

	Masc	Fem	Neuter	Plural
'D-form'	*di*	*det (jü)*	*det*	*don (dö)*
'A-form'	*a*	*at*	*at*	*a*

Leaving aside two contexts of variation which will be discussed in Sects. 13.6.3 and 13.6.4, and building on Ebert's (1971a, b) analysis, one can safely assume with Löbner (1985) that the forms referred to as 'D-articles' are confined to pragmatic uniqueness, hence indicate the shift SN → IC as in (5).

(5) *Oki hee an hingst keeft.* ***Di****/*A hingst haaltet.*
'Oki bought a horse. The horse founders.'

A-forms', by contrast, are in charge of semantic uniqueness and hence are found with INs such as *a/*di san* 'the sun', *a/*di meesel* 'the measles' (Ebert 1971a, p. 160).

In Fering the article for pragmatic uniqueness does not constitute the phonological base from which the 'weak' article, as it were, is derived. This is in contrast to dialects of German that show the split: typically the forms are at least arguably related in terms of phonological complexity. The strong article is in turn an unstressed variant of the distal demonstrative pronoun (which in turn may be reinforced by a deictic particle derived from *da* 'there'). For all variants at issue here, therefore, both definite articles are at least prosodically distinct from the distal demonstrative. Consider the definite articles of the Central Franconian and Low Franconian dialects of the **Rhineland**:

(6)

		Masc	Fem	Neuter	Plural
Strong	NOM/ACC:	*dä*	*die*	*dat*	*die*
	DAT:	*däm*	*dä*	*däm*	*dänne*
Weak	NOM/ACC:	*dr*	*de*	*et*	*de*
	DAT:	*däm, 'em*	*dr*	*däm, 'em*	*de*

The weak article occurs with semantically unique concepts (INs or FNs) as ***et*** *Läve* '(the) life', ***dr*** *Zoch kütt* 'the train (here: the Carnival parade) comes', including kinship terms such as ***de*** *Omma* 'granny', and proper names (*dr Jupp*). The strong article, by contrast, occurs in contexts of anaphoricity or deictic reference uniqueness, hence pragmatic uniqueness (see Hartmann 1982 for details as well as Schroeder 2006, p. 560f and references there).

The same dichotomy holds of the **Alemannic** dialects, spoken in the south west of Germany, in Switzerland ('Swiss German'), and in the westernmost part of Austria. The paradigm in (7) draws on Studler (2004, 2007), who speaks of 'reduced' and 'full articles:

(7)

		Masc	Fem	Neuter	Plural
Strong (= 'full')	NOM/ACC:	*dä*	*di*	*das*	*di*
	DAT:	*däm*	*dere*	*däm*	*dene*
Weak (= 'reduced')	NOM/ACC:	*de*	*d*	*s*	*d*
	DAT:	*em*	*de*	*em*	*de*

(Note that the function of the distal demonstrative pronoun was taken over by the form *säll* in Alemannic.) As Studler (2004, p. 626) points out, the reduced form is only found with expressions of inherent uniqueness: The examples in (8) involve INs and FNs. The full forms in (9) (taken from Studler 2007) signal anaphoric and 'endophoric' use, thus pragmatic uniqueness.[8]

(8) a. ***de** Sepp* 'Sepp' b. ***de** Bräutigam* 'the groom' c. ***de** sterchscht Maa vo de Wäut* 'the strongest man in the world'

(9) a. *De Paul het es Ross gchouft. ... **Das** Ross laamt.*
'Paul bought a horse. ... The horse founders.'

b. ***di** Frou, wo früener näbe üüs gwoont het*
'the woman who used to live next to us'

Like in Föhr Frisian and Rhinelandic, then, the contrast of forms clearly reflects the conceptual difference between semantic and pragmatic uniqueness, the latter involving a shift of the sort SN/RN → IC/FC, indicated by the choice of the strong article. Essentially the same holds for **Bavarian**, where the forms at issue are *dea* (strong) and *da* (weak) for masculine as well as *des* and *s'* for neuter; see Schwager (2007) for data and analysis. In Bavarian, the split does not seem to pertain to the feminine, where the form *d'* occurs throughout (cf. however Breu 2004, p. 45), while in the plural the distinction is observed in terms of the forms *d'* and *de*.

13.4.2 Strong and Weak in Dutch

Dutch has the article forms *de* (utrum gender into which masculine and feminine are merged) and *het* (neuter) and in addition the strong 'demonstrative' forms *die* and *dat*, respectively. The analysis I would like to suggest, namely to treat the distribution in Dutch as an article split equivalent to those in the other West Germanic languages, seems, somewhat surprisingly, to have never been proposed so far. This may be due to the fact that the strong forms are traditionally referred to as (distal) demonstrative pronouns. This characterisation may be adequate for the stressed variants, which always involve deictic force just like the proximal demonstratives *deze/dit*. The question is, therefore, whether unstressed *die/dat* can serve the sole function of marking anaphoricity or whether they necessarily involve deictic force. To extricate this question, an inspection of attested non-oral material is appropriate. In the following, passages from three novels illustrate that the distinction of semantic and pragmatic uniqueness is a decisive factor of the distribution of the forms.

[8] By 'endophoric' uniqueness (or autophoric uniqueness, as I will call it) it is meant that the referential anchor is found in the NP itself, typically by means of an establishing relative clause, rather than in terms of an antecedent. On the significance of autophoricity for the split of Alemannic and beyond see Sect. 6.4.

Let me start by considering a passage from *De Aanslaag* (English: "The Assault") by Harry Mulisch[9]:

(10) In **dat** gedicht wilde ik **de** liefde vergelijken met **het** soort licht, dat je vlak na zonsondergang soms tegen **de** bomen ziet hangen.
'In the poem I wanted to compare love to the sort of light which you sometimes see against the trees right after sunset.'

Both *liefde* 'love'and *bomen* 'trees' are semantically unique by virtue of abstract and generic reference, respectively, and therefore take the weak article. By contrast, g*edicht* is an SN that was previously introduced by the indefinite article *een* and is used anaphorically, hence its shift to an IC is indicated by the strong form. The NP headed by *soort licht* is an instance of autophoric reference, with uniqueness being established by a relative clause, and gives rise to the weak article (but see Sect. 13.6.4 on the variation found with autophoricity in Dutch).

The opposition of semantic and pragmatic uniqueness is also evident in the following passage taken from Remco Campert's *Het leven is verrukkulluk*[10]:

(11) Langzaam stroomt **de** middag verder. Wat een rust, en ook wat een opwinding in **die** rust.
(lit.:) 'Slowly streams the noon further. What a quiet, and also what an excitement in the quiet.'

Being an FN, *middag* requires the weak article. The SN *rust* is introduced by the indefinite article, then taken up anaphorically, thus involving a shift to an IC, which is indicated by the strong form *die*. In the same vein, consider an excerpt from *Figuranten* by Arnon Grunberg.[11]

(12) Niet dat er iemand op mij lette, want er denderen van's ochtends zes tot's avonds acht vrachtwagens door mijn straat en die overstemmen elk geluid. Zelfs als je met een megafoon uit het raam zou gaan hangen kom je er nog niet bovenuit.
Door **die** vrachtwagens komt er een zwart poeder in mijn woning, ook al sluit je het raam.
'Not that anybody took notice of me, because there are lorries rumbling through my street from six in the morning to eight in the evening, and they drown out any noise. [. . .]
Due to the lorries a sort of dust comes into my flat, even if you close the window.'

What the example shows is that, despite its traditional label of demonstrative pronoun, the unstressed strong form *die* occurs in a context of plain anaphoricity

[9]Harry Mulisch, *De Aanslaag*. De Bezige Bij, Amsterdam 1982. Quoted passage on p. 53.

[10]Remco Campert, *Het leven is verrukkulluk*. De Bezige Bij, Amsterdam 1961. Quoted passage on p. 53 of De Bezige Bij Pocket edition, Amsterdam 1994.

[11]Arnon Grunberg, *Figuranten*. Nijgh and Van Ditmar, Amsterdam 1997. Quoted passage on p. 10.

in which no deictic force is involved. One might object that the weak article in the second occurrence of *het raam* is not expected under the present account. I suggest that this NP does not involve specific reference but is configurationally unique (possibly anchored via the frame of 'building' that is invoked by the subject matter), which also explains the definiteness in the first token.

To conclude, the generalisation for the various article splits dealt with so far is that weak forms indicate inherent uniqueness, and therefore the concept types IN/FN, whereas strong forms indicate that uniqueness comes about by reference to the context or discourse, thus involving a shift of the sort SN/RN → IC/FC. According to this analysis Dutch is in line with neighbouring as well as with more remote varieties of German as analysed in Sect. 13.4.1.

More formally, the generalisation for West Germanic can be represented in terms of type logic along the following lines: weak articles are semantically vacuous, thus denoting an identical mapping of the shape < e,e > (where e is the type of an IN as well as of an FN whose argument has been saturated). Strong articles instantiate the type shift semantics < <e,t>,e > (where < e,t > is the type of an SN as well as of an RN whose argument has been saturated).

13.5 Free Articles and Definite Suffixes in Mainland Scandinavian

Overall, the Scandinavian languages attach a definiteness suffix *–en* (utrum)/-*et* (neuter)/-*ne* (plural) to the noun in contexts of uniqueness. The free article *den/det/de* is used in addition to the suffixed article if the former is not adjacent to the noun, as is the case with modification by adjectives or numerals; thus Swedish *man* 'man' – *den gaml-e mann-en* 'the old man'. In this respect, the distribution of the free article is purely syntactically determined.[12] However, it also has the function of signalling pragmatic uniqueness, since in the case of deictically or contrastively established uniqueness it is obligatory, in addition to the suffixed article, even in the absence of a prenominal modifier: Norwegian *den (hvite) bil-en* DEF white car-DEF 'the (white) car'.[13] Note that this function differs from that of genuine demonstratives such as *denne/dette*, *den/det här* vs. *den/det där*, which involve a distinction of proximal and distal. Furthermore, in Norwegian free articles optionally occur in autophoric contexts where uniqueness is established

[12]What is also syntactically determined is the absence of both free and suffixed articles in case of determination by prenominal possessors, be they possessive pronouns or genitive-marked NPs, irrespective of the conceptual type of the head noun: Swedish (*Hän älskar*) *sin man/sitt barn/sina barn* '(She loves) her husband/child/children', *familjens bil* 'the family's car', *Evas bok* 'Eva's book', *Mammas gula klänning* 'mother's yellow dress' (examples taken from Bonner 1985 and Ritte 1986).

[13]Special thanks go to Eirik Welo, to whom I owe the Norwegian data used in this section and in 6.3.

by a relative clause, which will be discussed in Sect. 13.6.4. To this extent the distribution of free articles is conceptually governed. Elsewhere only the suffixed article is obligatory, and free articles occur in addition if the noun is preceded by an adjective:

(13)	a.	*mor-en*	*til*	*Peter*	b.	*den*	*syke*	*mor-en*	*til*	*Peter*
		mother-DEF	of	Peter		DEF	sick	mother-DEF	of	Peter
		'Peter's mother'				'Peter's sick mother'				

There is an alternation with non-lexical concepts of unique reference, that is, with SNs that combine with a modifier such as an ordinal number or a superlative adjective so as to yield an IC. One option is to treat these modifiers like other adjectives, thus to employ the free article: ***det*** *første kapitl-et (av boken)* 'the first chapter (of the book'), ***det*** *høyeste fjell-et i Norge* 'the highest mountain in Norway'. The alternative is entirely article-less: *første kapittel (av boken)*. The latter strategy is especially common in Norwegian, both with ordinal numbers and superlatives (*siste dag* sixth day', *øverste hylle* 'topmost board'), which is not predicted by the scale given that FNs such as *mor-en* in (13) do show the suffixed article, and must be admitted as an idiosyncratic exception. However, in Swedish the suffixed article occurs consistently in this context: *förra år-**et*** 'last year', *högra fot-**en*** 'the right foot', *övre/nedre del-**en*** 'the upper/lower part', *första/sista kapitl-**et*** 'the first/last chapter'. (The cross-linguistic variation with complex functional concepts will be addressed in Sect. 13.6.2.)

Swedish differs from Norwegian with respect to the distribution of the suffixed article in at least two more details. First, if a restrictive relative clause follows the noun the latter does not always take the suffixed article (cf. Stroh-Wollin 2003, p. 336, 341, and Strahan 2008, p. 207ff, who both point out the role of specificity), whereas in Norwegian it does (see Sect. 13.6.4). Second, fixed adjective-noun expressions that refer like proper nouns take only the suffixed and not the free article: *Stilla oceanen* 'the Pacific', *Franska revolutionen* 'the French revolution', *Vita huset* 'the White House' (Bonner 1985; Ritte 1986; Schroeder 2006, p. 564); in Norwegian the distribution is the reverse: *det hvite hus, de franske revolusjon*.[14]

The upshot for Mainland Scandinavian, then, is that both articles show a split that is in line with the scale of uniqueness:

1. **Suffixed articles** indicate uniqueness in general. Compared with Old Norse their range is extended along the scale down to FN, thus excluding proper names

[14] For completeness, let me briefly touch on two other Scandinavian languages. In **Danish**, the occurrence of the free article is solely governed by the syntactic condition that is also operative in Swedish and Norwegian, namely the presence of prenominal modifiers. However, the suffixed article is in complementary distribution to the free one rather than co-occuring with it: *mand-en* 'the man' – *den gamle mand* 'the old man'. As a consequence, there are no semantically driven contrasts of the sort discussed here. **Icelandic** differs from Mainland Scandinavian in that free articles are restricted to formal written style. Suffixed articles are obligatory, though; thus *gamli maður-inn* old man-DEF 'the old man'.

(even with prenominal adjectives: Swedish *trötta Lena* 'tired Lena'; note the contrast with German ***die*** *müde Lena*) and pronouns.[15] This corresponds to their longstanding grammaticalisation process. Recall from Sect. 13.3 that in Old Norse the threshold was higher: suffixes did not yet occur with IN/FN.

2. The additional occurrence of **free articles** is syntactically conditioned by a prenominal modifier. To the extent that their occurrence is conditioned by semantic factors (that is, irrespective of the presence of a prenominal modifier) they signal pragmatic uniqueness, thus, the shift SN/RN → IC/FC in case of deictic and autophoric reference. The forms still have some affinity to distal demonstratives and consequently do not occur with definite associative anaphora (to be illustrated in Sect. 13.6.3). Their usage reflects a more recent development in line with Prediction 2 of Sect. 13.3 and constitutes the first steps of the scale of uniqueness.

13.6 The Threshold of Semantic and Pragmatic Uniqueness as a Source of Variation

13.6.1 Split I Systems in West Slavic

The system and use of articles in Colloquial **Upper Sorbian** has been extensively studied by Breu (2004) und Scholze (2008). The demonstrative *tón, ta, to* was

[15]Crucially, a further kind of article Split II comes into play here which must not go unmentioned: the so-called preproprial articles, that is, articles that are used especially with proper names. For example, Northern Norwegian dialects employ 3rd person pronouns as preproprial articles (Matushansky 2008, p. 581):

(i) a. *Ho* *Marit* *så* *han* *Øystein.*
3SG.F Marit saw 3SG.M Øystein
'Marit saw Øystein.'

b. *Han* *Øystein* *så* *ho* *Marit.*
3SG.M Øystein saw 3SG.F Marit
'Øystein saw Marit.'

Typologically, preproprial articles are not unusual. They also occur, for example, in Catalan and in many Austronesian languages. Strahan (2008) points out that in Scandinavian adnominal third person pronouns not only serve as genuine preproprial articles but also occur in demonstrative function: *han mannen* 'that bloke'. The question arises as to the motivation of a special form for preproprial articles, and why this is the personal pronoun, instead of extending the domain of an already existing article. The rationale seems to lie in the fact that personal pronouns can exclusively be used as ICs with semantically unique reference, hence are located on the lower end of the scale, as are proper names too. Preproprial articles thus go beyond the typology in terms of Split I and Split II in that they give rise to a split originating from the lower end of the scale.

They can, moreover, give rise to overt three-way splits, as in, e.g., Maori and the Balearic Islands variety of Catalan. According to Hualde (1992) Balearic has the following system: (i) *es, sa, ses* (< Latin *ipse*), (ii) (*e*)*l, la, els, les* (< Latin *ille*), restricted to "nouns that have a unique referent" (l.c.: 281); thus: *l'Església* 'the (Catholic) Church' vs. *s'església* 'the church (building)', and (iii) e*n, na* used with proper names (*en Joan*).

grammaticalised to a definite article, while the original demonstrative function is now indicated by the morphologically reinforced forms *tóne, tane, tene* (Breu 2004, p. 13f). As for the precise distribution of the article, note first that it is absent with INs/FNs: *Tame jo dwórnišćo/cyrke* 'There's the station/the church', *słónco* 'the sun' (l.c. 2004, p. 30f).[16] By contrast, the article occurs on all positions 'further up' the scale: first and foremost in contexts of anaphoricity, furthermore in those of autophoricity; see (14a) and (14b) (l.c. 2004, p. 19, 22):

(14) a. *Měrko jo s ćaom šijoł.* ***Tón*** *ća jo dźewećich Kamencu bół.*
'Mirko came by train. The train arrived in Kamenz at twelve o'clock.'
b. *Kóždy dóstane* ***tón*** *žonu, kiž sej wón zasłuži.*
'Every man gets the wife he deserves.'

Autophoricity, that is, uniqueness established by a restrictive relative clause, constitutes an in-between case of semantic and pragmatic uniqueness and is dealt with in Sect. 13.6.4.

Consider next **Upper Silesian**, a south-western dialect of Polish. The results of an investigation carried out with Adrian Czardybon are documented in Czardybon (2010). The demonstrative *tyn, ta, te* has obtained the function of a definite article, as the obligatory occurrence with anaphoric and autophoric uses of nouns displays (l.c.: 23; 34):

(15) a.

Łon-a	*potwierdzio-ł-a,*	*że*	*tak-o*	*kronik-a*
PRON.3SG-F	confirm-PAST.SG-F	that	such-F	chronicle-F

był-a	*pisan-o.*	*Łon*	*boł*	*autor-ym*
COP.PAST.SG-F	written-F	PRON.3SG	COP.PAST.SG	author-INS

ty	*kronik-i.*
DEF.F.SG.GEN	chronicle-SG.GEN

'She confirmed that such a chronicle had been written. He was the author of the chronicle.'

b.

Jak	*sie*	*nazywo*	***tyn***	*ptok,*	*co*
how	REFL	be_named.3SG	DEF.ACC.M.SG	bird	REL.PRON

kradn-ie?
steal-3SG
'What is the name of the bird that steals?'

Conversely, articles do not occur with lexical ICs/FCs, as shown by *koniec tego film-u* end DEF.GEN film-GEN 'the end of the film' and *różnica miyndzy Anielk-i i Trudk-i* 'the difference between Anielka and Trudka' (Czardybon 2010, p. 37f). So where articles occur in Upper Silesian they indicate pragmatic uniqueness, hence a type shift from SN to IC.

[16] In the examples bold type highlights articles, while underscoring the noun signals the absence of an article.

Like in other article split languages, the cut-off point for the occurrence of the article in the two West Slavic languages under consideration is therefore at the edge of semantic and pragmatic uniqueness. In the various contexts in which these two factors of uniqueness overlap one often encounters variation both between languages and within individual languages. In order to approach the exact language-specific cut-off points I will analyse three fields at the borderline of semantic and pragmatic uniqueness.

13.6.2 Non-Lexical (or Complex) Functional Concepts

By non-lexical FCs I understand those 'complex' concepts where semantic uniqueness comes about by syntactic structure and semantic composition rather than by the lexical meaning of the head noun. In particular, these are nouns combined with ordinal numbers, and with superlative forms of attributive adjectives. In these cases uniqueness is achieved by the lexical meaning of the modifier (the adjective or the ordinal number, respectively) which comprises a function over the domain that is characterised by the noun predicate.

In Upper Sorbian ordinal numbers and superlatives necessitate the article, albeit depending on information structure. It is obligatory if the NP is the comment rather than the topic of the clause (*tón najwetši šuft* 'the biggest rascal'; *tón prejni wesnanosta* 'the first mayor'; Breu 2004, p. 24, 34; see also Scholze 2008, p. 164). By contrast, for Upper Silesian, Czardybon (2010, p. 35f) finds that articles (though not totally unacceptable for all speakers) are missing:

(16)	a.	*noj-lepsz-o*	*zoz-a*	b.	*w*	*drug-ij*	*szuflodzie*
		SUPERL-best-F	sauce-NOM		in	second-LOC.SG	drawer
		'the best sauce'			'the second drawer'		

Another instance of micro-variation between closely related languages that are otherwise analogous in relevant aspects was pointed to in Sect. 13.5. Suffixed articles occur on nouns combined with ordinal numbers or superlatives in Swedish, but usually not in Norwegian.

As an instance of the variation often found within one particular language one may consider Fering (Föhr Frisian). Recall from Sect. 13.4 that the 'A-article' contrasts with the 'D-article', the former signalling semantic and the latter pragmatic uniqueness. According to Ebert (1971b, p. 163) both forms are possible with ordinal numbers and superlatives: ***a/die*** *huuchst bereg van Feer* 'the highest mountain of Föhr'.

The varying degree of semantically redundant article usage between two closely related languages and also within individual languages underpins the point I want to make here, namely that non-lexical FCs are one major source of variation. The same will turn out for the two contexts that are analysed subsequently.

13.6.3 Definite Associative Anaphora (DAAs)

'Definite associative anaphora' (henceforth DAAs) describe nouns which like other anaphora are anchored by the referent of a previously mentioned NP, though not coreferent with the latter but rather with some link provided by it, typically a functional concept (see the frame analysis in Löbner 1998). The phenomenon is also called 'bridging'. DAAs combine properties of pragmatic uniqueness (by virtue of anaphoricity) and semantic uniqueness (by virtue of involving an FN). It is therefore natural for there to be considerable variation in the use of articles. The variation is nevertheless to some extent governed by an additional semantic factor.

To begin with, in Upper Sorbian DAAs usually take the article as in (17). However, for older speakers at least, this is not obligatory in cases such as (18) (Breu 2004, p. 20, 41).

(17) *Noš wučor jo nam jenu kniu pokazał. Tón* ***to*** *awtora wosobinsce znaje.*
'Our teacher showed us a book. He knows the author personally.'

(18) *Moje nowo awto jo dórbjało do reparatury, (tón) <u>motor</u> be kaput.*
'My new car needed repairing, the motor was broken.'

In this connection, an analogous asymmetry in German is instructive. It was mentioned in Sect. 13.3 that in the case of semantic uniqueness definite articles display fusion with prepositions. To that extent, Standard German also manifests a Split II (strong vs. weak article). In general, fusion also occurs with DAAs, but Schwarz (2009, p. 34) observes the following contrast:

(19) *Das Theaterstück missfiel dem Kritiker so sehr, dass er in seiner Besprechung kein gutes Haar* ***#am/an dem*** *Autor ließ.* (*am* < *an dem*: at_the.DAT)
'The play displeased the critic so much that he tore the author to pieces in his review.'

(20) *Der Kühlschrank war so groß, dass der Kürbis problemlos* ***im/#in dem*** *Gemüsefach untergebracht werden konnte.* (*im* < *in dem*: in_the.DAT)
'The fridge was so big that the pumpkin could easily be stowed in the crisper.'

Schwarz bases his account of the distribution of 'strong' and 'weak' articles on the generalisation that bridging of producer and product as in (19) involves an anaphoric relation, whereas (20) involves a relationship of containment, that is, a part-whole relation between antecedent and DAA. Schwarz (l.c.: 34) speaks of the part-whole type as involving 'situational uniqueness' since if a situation contains an individual it can be said to contain its parts. This close relation is reflected by fusion with the preposition. Schwarz's distinction of 'relational anaphora' and 'part-whole bridging', however vague it may seem at first sight, makes the right predictions for the asymmetry among DAAs in Silesian Polish and other varieties of Slavic:

As regards Upper Silesian, the intra- and inter-speaker variation with DAAs has proven particularly tough. However, in the following pair informants agree as to their translations and judgements: The ‘relational anaphora’ shows the article whilst the part-whole DAA does not (Czardybon 2010, p. 32, 30):

(21) *Wczoraj bołach w kin-ie. Ale* ***tyn*** *film boł nudny.*
yesterday was.F in cinema-LOC but DEF.M.SG.NOM film was boring
‘Yesterday I went to the cinema, but the movie was boring.’

(22) *Mo-m fajno szklonka. Ale ucho jest ułomane.*
have-1SG nice cup but handle COP.3SG broken_off
‘I’ve got a beautiful cup, but the handle broke off.’

Although there remain some counter-examples, the contrast Czardybon finds for Upper Silesian is analogous to that of German: no article and fusion, respectively, with part-whole DAAs, as opposed to (preferably non-fused) articles with ‘relational anaphora’.

For Upper Sorbian, the distinction between ‘relational’ and part-whole anaphora has independently been held responsible for variation among generations. According to Breu (2004, p. 40f), it is precisely these part-whole DAAs for which articles are often left out by older speakers whereas in the case of other relations the article is used throughout irrespective of age. This accounts for the above contrast between (17) and (18).

Similarly, even for Standard Polish, in which the spread of articles is not so far advanced, the part-whole distinction is significant. Mendoza (2004, p. 283) reports that while DAAs with part-whole relation remain unmarked, other instances of DAAs are optionally marked. Schwarz’s generalisation with respect to language-internal variation is therefore independently corroborated by the findings for Slavic languages (Standard Polish, Upper Silesian, and Upper Sorbian). Both the semantics and the variation within individual languages, then, provide reasons for supplementing the scale of uniqueness with another step regarding DAAs, which will be made more explicit at the end of the section.

Finally, turning to the variation across languages, I propose to reduce the differences to the type of article split. Abstracting away from language-internal variation, the generalisation emerges that Split I languages realise, rather than leave out, the article in DAA contexts, like in contexts of pragmatic uniqueness (West-Slavic; Old Georgian, cf. Boeder 1997, p. 210f). Split II languages, by contrast, tend to use the same article as with semantic uniqueness: German displays fusion with prepositions, Maori employs its ‘elsewhere’ article *te* (SG)/*ngaa* (PL) (Czardybon (2010, p. 65), Fering its ‘A-article’ (albeit not without variation: Ebert 1971b also mentions DAAs with ‘D-article’). This trend is corroborated by the Norwegian data in (23):

(23) a. *I går gikk jeg på kino. Film-en var kvedelig.*
yesterday go.PRET PRON1SG at cinema movie-DET COP boring
‘Last night I went to the cinema. The movie was boring.’

b. *Jeg har en fin kopp, men hank-en er brukket.*
PRON1SG have INDEF beautiful cup but handle-DEF COP broken
‘I’ve got a beautiful cup, but the handle broke off.’

Observe that unlike with the examples just discussed, the inherence vs. contextuality of the relation between anchor and anaphor is not decisive for Norwegian. In both (23a) and (23b) the DAA is (in the absence of an adjective) only accompanied by the definiteness suffix, and not by the equivalent of the strong article of other languages, namely the free article.

13.6.4 Autophoric Noun Uses

By ‘autophoric SN’ I understand those noun uses where unique reference is established by a relative clause, hence the alternative notion ‘establishing relative clauses’.[17] So far, we have seen two autophoric uses of SNs in Alemannic and Dutch, the first of which is accompanied by a strong article, hence on a par with pragmatic uniqueness, whereas the latter behaves exactly the other way round. From a semantic point of view one may indeed think of a distinction of autophorics into context-dependent and context-independent, the former inducing pragmatic and the latter semantic uniqueness. This way, DAAs would be sandwiched between context-dependent and context-independent autophorics (thus, ... *anaphoric SN < SN with context-dependent establishing relative clause < definite associative anaphora < SN with context-independent establishing relative clause < SN with ordinal number <* ...).

Autophoricity essentially gives rise to variation within individual languages. One example is **Dutch**; compare (24) and (10) above, which exhibit the weak article, to (25)[18]:

(24) ... ze leek hem **het** soort vrouw dat, als ze een vriend had, geen seconde langer dan nodig was bij haar man zou blijven.
‘to him she seemed to be the kind of women that if she had a boy-friend she would not stay with her husband a second more than needed.’

(25) Ben jij **die** Kees die als kind daar en daar (...) op school ging?
‘Are you the Kees who went there and there to school when he was a child?’

Crucially, while the NPs in (10) and (24) exhibit unique reference independently of the speech situation, (25) does not in that it involves at least some common knowledge between speaker and hearer about some individual(s) named ‘Kees’. This may motivate the contrast of article forms. Similarly, **Alemannic** usually

[17]Löbner (1985) speaks of ‘endophoric’ rather than autophoric uses. The latter notion seems more adequate since the referential anchor is found in the complex meaning of the NP itself rather than in terms of a following NP. Autophoricity can also be established by other syntactic means such as adnominal PPs (e.g., *the man at the door*), which I do not consider here.

[18]Remco Campert, *Het leven is verrukkulluk*. De Bezige Bij, Amsterdam 1961. Quoted passages on p102 and p148 of De Bezige Bij Pocket edition, Amsterdam 1994.

features the strong article in autophoric contexts (see Sect. 13.4.1), but as Studler (2007, p. 4) points out in certain cases the weak article occurs:

(26) a.

d	*Lüüt,*	*wo*	*für*	*äin*	*de*	*münd*	*schaffe*
DET.PL	people	REL	for	one	then	must	work

'the people who've got to work for (some) one then'

b.

vo	*de*	*Materie,*	*wo*	*mer*	*bearbäitet*
of	DET.DAT.F	material	REL	one	manipulate

'the material that one works'

c.

i	*de*	*Phönkt,*	*wos*	*drof*	*a*	*chont*
in	DET.DAT.PL	point.PL	REL-it	thereon	depend	

'in the points that are essential'

What these examples have in common is that they involve what Studler calls 'selective' relative clauses, which I reinterpret as referring entirely independent of the speech context. Note in particular that the reference of the NP is determined in purely qualitative terms, irrespective of speech-act participants or other context, hence we are dealing with generic concepts.

Fering (Föhr Frisian) also, by and large, employs the 'D-article' in autophoric contexts, that is, the one that is responsible of pragmatic uniqueness. The examples in (27) are taken from Ebert (1971a, p. 164) and (b, p. 160):

(27) a.

Di	*hingst,*	*wat*	*Oki*	*keeft*	*hee,*	*haaltet.*
DEF.STRONG	horse	REL	Oki	bought	has	lames

'The horse that Oki bought is lame.'

b.

Det	*as*	*det/*at*	*buk,*	*wat*	*hi*	*tuiast*
DEM	COP	DEF.STRONG/WEAK	book	REL	PRON3SG	first
skrewen	*hee.*					
write.PART	has					

'This is the book which he wrote first.'

c.

Dön/A	*foomnen,*	*wat*	*ei*	*mülki*	*kön,*
DEF.STRONG/WEAK	girls	REL	NEG	milk	can
fu	*neen*	*maan.*			
find	no	man			

'Those girls that can't milk a cow won't find a husband.'

In (27b) the 'D-article' also occurs with apparent context-independent uniqueness. Note, however, that the relative clause involves a pronoun, hence a deictic expression, in contrast to the generic, hence undoubtedly context-independent NP in (27c). This contrast is probably the reason why only the latter example optionally allows for the 'A-article'.

Fering displays a further autophoric context with the 'A-article', which is discussed in Keenan and Ebert (1973, p. 423) and is illustrated by the following example.

(28) *John wonnert ham, dat a maan wat woon*
John wonder REFL COMP DEF.WEAK man REL won
bisööpen wiar.
drunk was
'John wonders that the man who won was drunk.'

Significantly, this context is discussed by Keenan and Ebert just in order to make a point which clearly underpins the present account. (28) only allows for an opaque (or *de dicto*) reading, not for a transparent (or *de re*) interpretation. In other words, it is the concept of 'winner' as such rather than the extensional meaning of *winner* in (28) that determines the meaning of the sentence. Thus, what the 'A-article' indicates is that the uniqueness comes about independently of the situation. Keenan and Ebert furthermore show that the opposition in terms of opacity and transparency also holds for the distribution of the articles *ny* and *ilay* of Malagasy. This opposition, then, is on a par with the ones pointed out above for Dutch and Alemannic.

Norwegian exhibits uniform behaviour with respect to the context-(in) dependency of autophorics. The free article in addition to the definiteness suffix is in some cases obligatory and optional in others such as the ones in (29c):

(29) a. *den bil-en som ble vist på tv*
DEF car-DEF REL become.PRET show.PART on TV
'the car that was shown on TV'
b. *den bil-en som du ser der borte*
DEF car-DEF REL PRON2SG see over_there
'the car that you see over there'
c. *(det) hus-et som står der borte*
DEF house-DEF REL stand over_there
'the house which is standing over there'

Although there is variation with Norwegian (as well as Swedish) autophorics and the determining factors are not fully obvious, it is not decisive whether the establishing relative clause is context-dependent or not.

The pattern of Split I languages observed for West Slavic above is corroborated by **Old Georgian**, in which the article is also present rather than absent in contexts of autophoricity:

(30) *xolo me viʒmen adre da mivic'ie*
but PRON1SG.NOM go.AOR.1SG early and come.AOR.1SG
daba-sa ***mas,*** *romel-sa-ca iq'o*
settlement-DAT DEF.DAT REL.PRON-DAT-also COP-AOR.3SG
net'ari šušanik'.
holy-NOM Shushanik-NOM [Sus I] 5th c.
'I, however, left earlier and arrived at the settlement in which Holy Shushanik lived.'

All in all, the empirical evidence for a division of autophoric uses of SNs in terms of the occurrence of articles is somewhat equivocal. On the one hand, it could be shown that Alemannic and Fering feature an alternation which is driven by the relative clause's (in)dependency of context and speech participant. On the other hand, however, the articles of Upper Sorbian and Upper Silesian systematically occur not only with context-dependent autophorics: cf. (14b) and (15b) above with totally context-independent generic reference. In fact, this occurrence is even more systematic than that with DAAs, which rank one step higher on the scale than a supposed step 'context-independent autophorics'. Therefore, like with the case of local versus third person of pronouns addressed in Sect. 13.3, I dispense with subclassifying autophorics into conceptually defined subkinds. Instead, the overall picture is this: In Split I languages such as West-Slavic and Old Georgian articles generally occur with establishing relative clauses; given that they also occur with DAAs this is predicted by the scale of uniqueness. As regards Split II languages with variation, only Dutch shows a tendency to use weak articles. Other Split II languages prefer the article of pragmatic uniqueness: the strong article in Alemannic (and other German dialects); the 'D-article' in Fering; Maori *taua/aua*, otherwise restricted to anaphoric reference according to Czardybon (2010, p. 64); correspondingly, Norwegian uses the free article. This preference is predicted by the assumption that autophoric SNs in general, be they context-dependent or not, rank one step above DAAs on the scale of uniqueness, and are therefore more likely than DAAs to pattern with anaphoric reference. This corresponds to the fact that nouns serving as DAAs typically are FNs, hence predisposed to unique reference, whereas autophoric SNs necessarily undergo a type shift established by the relative clause, the comprehension of which is facilitated by a prenominal indicator.

To conclude I return to non-lexical FNs and DAAs and the general issue of the overlap of pragmatic and semantic uniqueness as sources of variation. Recall that non-lexical FNs, that is, nouns with ordinal numbers or superlative adjectives, usually do not take the article in Upper Silesian whereas in Upper Sorbian they do (as long as they are non-topic). I have also pointed out above the significance of the kind of relation between DAAs and their anchors. My proposal is therefore to endow the uniqueness scale with two further refinements necessitated by phenomena on the borderline between pragmatic and semantic uniqueness:

(31) **Scale of uniqueness** (refined version):
deictic SN < anaphoric SN < SN with establishing relative clause < relational DAAs < part-whole DAAs < non-lexical FNs < lexical IN/FN < proper names < personal pronouns

As for the language-specific thresholds on the scale, Upper Sorbian is two steps further advanced than Upper Silesian: The latter language marks only a subtype of DAAs (the variation being the highest here), but the former marks them systematically, including (except for older speakers) part-whole DAAs, as well as non-lexical FNs.

13.7 Old and Middle Georgian as a Split I System

Throughout a period of about one-thousand years, there is considerable variation, both inter- and intra-textually, as to the (non-)occurrence of articles. The major factors are (i) the variation in terms of text genres; (ii) the role of language contact, in particular the influence of Greek, from which the bulk of the religious literature was translated; (iii) the opposition of semantic and pragmatic uniqueness. My main focus will be the latter factor here.[19]

13.7.1 The Issue of Demonstrative Pronouns and Definite Articles in Old Georgian

As for the historical classification, Sarjveladze (1997) distinguishes Old Georgian, which denotes the period from the fourth to the eleventh century, from Middle Georgian (twelfth to eighteenth century). Modern Georgian dates from the nineteenth century. Like in many other languages, in Old Georgian the distal demonstrative (nominative *igi*, ergative *man*, dative *mas*, genitive *mis*) had adopted the function of a definite article in the earliest texts already (to be illustrated below). The distal demonstrative furthermore served as the 3rd person personal pronoun. The forms do not differ dramatically from their Modern Georgian correspondents (cf. Vogt 1971, p. 52f), but the latter are only used as demonstratives, whereas non-deictic uniqueness is no longer indicated.

Most statements in the literature regarding the article function of the Old Georgian demonstrative tend to be global and not in harmony with each other: Sardjveladze (1997, p. 63f) denies the function of the demonstrative as a definite article altogether. Fähnrich (1991, p. 150) takes the opposite position, assuming a one-to-one correspondence between (in) definiteness and presence or absence of the article. Somewhat more sophisticated, Harris (1991, p. 22) notes: "Presence of the article, postposed to the head noun, indicates that the nominal is definite; it is absent from indefinites." The most extensive survey to date on the matter is by Boeder (1997), who investigates the distribution according to how unique reference comes about. In a subsequent diligent case study, Boeder (2009, p. 149) argues that the demonstrative is absent from contexts of semantic uniqueness and hence does not qualify as an article in a stricter sense.

Articles usually follow rather than precede their nouns in Old Georgian, whereas the same items in their original use as demonstratives occur prenominally (as they still do in the modern language). Like Harris (1991), Boeder (1997, p. 208, 2009,

[19]This section essentially draws on joint work with Tinatin Kiguradze. For a more comprehensive treatment that also highlights the role of the text genre see Ortmann and Kiguradze (2008).

p. 142f) regards this state of affairs as a formal criterion for the status of the putative article as such, which he considers to be an enclitic version of the demonstrative with a different textual distribution and meaning.

13.7.2 Data and Analysis

13.7.2.1 Earlier Old Georgian

In the earliest texts one encounters a fairly systematic occurrence of articles in contexts of pragmatic uniqueness (especially anaphoric), but not in contexts of semantic uniqueness.[20] Consider the following example from the Shushanik hagiography, the earliest existing literary work in the language[21]:

(32) *čika-j* ***igi*** *p'ir-sa* *šealec'a* *da* *ġvino-j*
glass.NOM DEF.NOM mouth-DAT throw and wine-NOM
igi *daitxia.*
DEF.NOM spill
'She threw the glass into her face and the wine was spilled.' [Sus VI] 5th c.

Both *čika* 'glass' and *ġvino* 'wine' are underlying SNs that are used anaphorically, hence shifted into FCs. This shift is marked by the article, in contrast to the FN *p'ir* 'mouth' which occurs without article in accordance with its semantic uniqueness (the possessor being clear from the context).

In the preceding section it was illustrated that the article furthermore occurs in contexts of autophoricity (cf. also Boeder (1997, p. 210). Note however that not even anaphoric uniqueness is signalled throughout. This is obvious from a passage of the Shushanik hagiography ([Sus I, 18 to 20]) with two anaphoric tokens of *k'acman* 'man-ERG' of which only the first is followed by the article form *man*.

[20]The data used in this section are taken from the following sources, to which I refer in the examples by the short titles in square brackets:

[Bal] Balavariani. http://titus.uni-frankfurt.de/texte/etca/cauc/ageo/hagio/balavarb/balav.htm. Here quoted from Sardjveladze (1997).
[Leon] Leontius Ruensis, Vitae regum Iberorum. http://titus.uni-frankfurt.de /texte/etcs/cauc/ageo/kcx1 /kcx1.htm
[Luc] Bishop Pomphilos: Martyrium Luciani. http://titus.uni-frankfurt.de/texte/etca/cauc/ageo/ keimena/ keimena2/keime.htm
[Mcxet] Biblia Mcxetica. (Old Testament). http://titus.uni-frankfurt.de/texte/etcs/cauc/ageo/at/ mcat/mcat.htm
[NT Athon] Novum Testamentum georgice e redactione Georgii Athoniensi. http://titus.uni-frankfurt.de/texte/ etca/cauc/ageo/nt/giornt/giorn.htm
[Sus] Iacob Tzurtaveli: Martyrium Susanicae ("The Martyr Life of the Holy Queen Shushanik"). http://titus.uni-frankfurt.de/texte/etcs/cauc/ageo/gh/gh1/gh1.htm

[21]As in the previous, bold type highlights articles, while their absence is signalled by underscoring the noun.

13.7.2.2 Later Old and Middle Georgian

In the later Old Georgian period from ninth to eleventh century, the use of articles in religious translated texts is – contrary to what Boeder (2009, p. 149) concludes; cf. Sect. 13.7.1 – extended so as to cover contexts of semantic uniqueness as well. In (33) and (34) the notions 'true path of monotheism', '(point in) time' and 'appearance' are FCs and are marked by the definite article:

(33) *gza-sa* ***mas*** *č'ešmarit'-sa* *ertġmteeb-isa-sa*
way-DAT DEF.DAT true-DAT monotheism-GEN-DAT
'the true path of monotheism' [Luc 9] 9th c.

(34) *da* *gamoik'itxa* *mat-gan* *žam-i* ***igi***
and ask.AOR.3SG PRON.OBL.PL-from time-NOM DEF.NOM
gamočineb-ul-isa ***mis*** *varsk'ulav-isa-j*
appear-PART-GEN DEF.GEN star-GEN-NOM
'and he learned from them when the star had appeared.' [NT Athon, Mt. 2, 7] 11th c.

Observe that *mas* in (33) and *mis* in (34) are in the 'Wackernagel' position immediately following the head noun and thus preceding its modifiers. Recall that, according to Boeder (1997, 2009), this shows that they do not function as demonstrative pronouns. The spread of articles is strongly dependent on the text sort. In contrast to translations from Greek, semantic uniqueness is usually not marked in autochthonous texts. Note the contrast of the anaphoric *p'iloj* 'elephant' in (35) to the underlined FN and INs:

(35) *p'ilo-j* ***igi*** *saxe* *ars* *sik'udil-isa*
elephant-NOM DET.NOM face.NOM COP.3SG death-GEN
'The elephant is the face of death.' [Bal] before 11th c.

(36) *odes* *babilon-s* *godol-i* *aġašenes*
when Babylon-DAT tower-NOM build.AOR.3PL
'after they had built the tower in Babylon' [Leon I, 9–10] 11th c.

All in all, the development of extending article use was aborted long before it was firmly established across text sorts. As is expected, in translations the article is, albeit only optionally, maintained significantly longer. Importantly, the reduction of article usage also follows the distinction of concept types – that is, it is abandoned first in contexts of semantic uniqueness, and lasts longest with anaphoric uniqueness. The SN *dedak'ac* in the following passage of the Genesis refers anaphorically to Abraham's wife Sarah:

(37) *ixiles* *megvip't'-el-ta* *dedak'ac-i* ***igi***, *rametu* *šuenier*
see.AOR.3PL Egyptian-PL-OBL woman-NOM DEF that very
COP.AOR pretty
iq'o *priad*
'The Egyptians saw the woman and that she was beautiful.'[Mcxet, Gen 12, 14] 16th c.

Generalising from these observations the long-term development of the use of the definite article firstly shows a substantial increase, and later an equally substantial decrease, with respect to both its frequency and contexts of application. As far as the language-internal factors are concerned, the synchronic and diachronic predictions of the scale of uniqueness are borne out: For each individual historical stage of Georgian, and within the individual texts, the distribution of articles is explicable by the distinction of semantic and pragmatic uniqueness.

13.8 Conclusion

On the basis of data from various languages, it has been shown that two kinds of asymmetries regarding the distribution of definite articles are to be distinguished typologically:

Split I: A top (or leftmost) segment of the scale of uniqueness is marked by the definite article, whereas the rest remains unmarked (**West Slavic, Old Georgian**).

Split II: Two segments of the scale (normally pragmatic and semantic uniqueness) are morphosyntactically distinguished in terms of different article forms, each of which will be subject to the above Predictions 1 and 2 (**Germanic**).

I have argued that both kinds of splits reflect the conceptual difference of semantic and pragmatic uniqueness: The articles of Split I languages as well as ‘strong’ articles were analysed as denoting a type shift of the kind $< <e,t>,e >$ from a sortal or relational noun (SN/RN) to a functional concept (IC/FC). In other words, a noun devoid of unique reference by virtue of its lexical meaning is used so as to refer uniquely in a given context, and this is indicated by the article. ‘Weak’ articles, by contrast, are semantically vacuous. Denoting an identical mapping of the kind $< e,e>$, they merely redundantly display unambiguous reference. This redundancy is typically avoided by split I languages, which initially lack definite articles in contexts of semantic uniqueness. A later spread of articles into such contexts proceeds along the scale.

Those noun uses that combine properties of pragmatic uniqueness and semantic uniqueness give rise to considerable variation as to the usage of articles both between and within individual languages. These are:

– Autophorics, that is, sortal nouns shifted to an IC by a relative clause
– Definite associative anaphora (DAAs; ‘bridging’), which combine pragmatic uniqueness (by virtue of anaphoricity) and semantic uniqueness (by virtue of involving an FC)
– Non-lexical FCs for which semantic uniqueness is due to composition; in particular sortal nouns shifted to FCs by means of ordinal numbers or adjectives that establish uniqueness.

In the case of autophoric reference articles tend to be distributed analogously to pragmatic uniqueness. In the case of DAAs Split II languages prefer the weak article as they do with semantic uniqueness. These trends as well as the contexts of variation in general have been shown to follow from a refined version of the conceptually motivated scale of uniqueness.

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Chapter 14
The Indefiniteness of Definiteness

Barbara Abbott

Abstract This paper is about the difficulties involved in establishing criteria for definiteness. A number of possibilities are considered – traditional ones such as strength, uniqueness, and familiarity, as well as several which have been suggested in the wake of Montague's analysis of NPs as generalized quantifiers. My tentative conclusion is that Russell's uniqueness characteristic (suitably modified) holds up well against the others.

Keywords Definiteness • Existentials • Partitives • Uniqueness • Semantic scope

14.1 Introduction

This paper is about definiteness, and more specifically about the difficulties involved in getting clear on which NPs should be classified as definite, or more properly, which NPs have uses which can be so classified. (I use "NP" here the way many linguists now use "DP". I also use "CNP", following Montague 1973, to mean 'phrase of the category of common nouns' – i.e. for the head N plus any restrictive modifiers.) Intuitively, as a rough first approximation, an NP should be considered definite only if it can be used to talk about some particular entity, where an entity may be either concrete or abstract, and may be a group of entities, or a mass of stuff. Many people agree that there are at least four categories which have such uses: proper names, definite descriptions, demonstrative descriptions, and (personal and demonstrative) pronouns. However, the question arises whether these are the

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only kinds of NPs that deserve the label "definite", and if so why. As we will see, universally quantified NPs, partitives, possessive NPs, and specific indefinites all raise issues concerning definiteness.

In the following sections we will look at a number of different attempts to characterize the property of definiteness. We start in Sect. 14.2 with three "traditional" proposals: the notion of strength, which arose in connection with the so-called "definiteness effect" in existential sentences; uniqueness/exhaustiveness, a legacy of Bertrand Russell's 1905 analysis of definite descriptions; and familiarity, which has been a major competitor to uniqueness following Irene Heim's 1982 dissertation. In Sect. 14.3 we turn to three proposals which can be seen as descendents of Richard Montague's classic 1973 work analyzing NPs as generalized quantifiers: those of Jon Barwise and Robin Cooper (1981), Barbara Partee (1986), and Sebastian Löbner (2000). The final section contains a few brief concluding remarks. Throughout the paper I will be ignoring NP uses described as "generic" or "bound variable" unless otherwise mentioned. Even so, space prevents anything like a thorough examination of the topic at hand; the presentation will be necessarily condensed and we will be forced to skip over many important issues.

14.2 Classical Proposals

14.2.1 Strength

The possible role of definiteness within early Chomskyan approaches to English grammar arose in connection with NONCONTEXTUALIZED (cf. Abbott 1993) existential (*there-be*) sentences. Such existentials, which may occur discourse initially, do not allow all NP types, as illustrated in (1) and (2).

(1) a. There was a/some (student's) dog in the yard.
    b. There were some/several/many/too few/no dogs in the yard.

(2) a. *There was Bill/it in the yard.
    b. *There was the/that/every/each/neither/Mary's dog in the yard.
    c. *There were all/most/both (of the) dogs in the yard.

As indicated, the NPs following *be* in (1) are welcome in this type of existential while those in (2) are not.

Initially the distinction was thought to be one of definiteness and the term "definiteness effect" is often used to describe these differences in felicity. Gary Milsark's classic work on this topic (1974, 1977) revealed many of the complications surrounding this criterion of definiteness, and it is to his credit that he created the new terms "weak" and "strong" for those NPs which can, and cannot, occur felicitously in an existential. Based on examples like those above in (1) and (2), we may sort NPs (and determiners) into two categories asshown in (3).

(3) Weak: *a/some (student's) dog, some/several/many/too few/no dogs*
Strong: *Bill, it, the/that/every/each/neither/Mary's dog, all/most/both dogs*

As can be seen, our basic four kinds of definites (proper names, definite and demonstrative descriptions, and pronouns) – do not occur felicitously in noncontextualized existentials and are correspondingly classified as strong. In the case of possessive NPs (*a/some student's dog*, *Mary's dog*), it appears that the weakness or strength of the genitive NP determiner is transferred to the NP as a whole. (This has been noted by McNally 1998; Barker 2000, and Peters and Westerståhl 2006, among others. Cf. also the property of "transparency" noted by Löbner 2003.) Compare too the related example in (4) (from Woisetschlaeger 1983, p. 142).

4. There was the wedding photo of a young black couple among his papers.

The underlined focus NP in this example is intuitively in the same class with the possessives, but with a postposed "possessor" phrase (*a young black couple*).

There are at least a couple of potential difficulties here. One concerns the universally quantified NPs – those with *all*, *every*, or *each* (hereinafter "the universals"). They are intuitively definite in many of their uses, so their exclusion from existentials seems natural. However they are often considered not to be definite, especially if definiteness is associated with referentiality, which is traditionally **opposed** to quantification. But then, part of my purpose is to question these traditional oppositions.

On the other hand NPs with *most* as determiner are more problematic. They do seem intuitively to be indefinite; a sentence like the following:

5. When the power went off, most students headed for the dorm.

does not specify which actual students are involved – the speaker clearly does not intend to be talking about any particular students. It is true that morphologically, *most* is a superlative – thus requiring the definite article in its adjectival use. However the definiteness in this case seems to be associated with the quantity involved rather than the denotation of the NP as a whole. (That is, assuming *most students* amounts to more than half of them, the complement of this group does not allow another subset as big.) So the exclusion of NPs with *most* presents a genuine problem for viewing nonoccurrence in a noncontextualized existential as an adequate criterion for definiteness. (For more discussion of this issue *vis-à-vis* this construction, see Abbott 2010: Chap. 9.)

14.2.2 Uniqueness

We'll begin this subsection by reviewing Russell's classic analysis of definite descriptions, as well as some additions and modifications that have been proposed for it. Following that we turn to more recent variations on the uniqueness theme, and see how well it applies to other sorts of NPs which are usually considered to be definite.

14.2.2.1 Russell's Analysis of Definite Descriptions

As is well known, Russell (1905) analyzed denoting expressions quantificationally. (6) and (7) below show the difference between indefinite and definite descriptions, in his view.

(6) a. A representative arrived.
  b. $\exists x[\text{representative}(x)\ \&\ \text{arrived}(x)]$

(7) a. The representative arrived.
  b. $\exists x[\text{representative}(x)\ \&\ \underline{\forall y[\text{representative}(y) \rightarrow y = x]}\ \&\ \text{arrived}(x)]$

On this analysis, definite descriptions share with indefinites an implication of existence of an entity meeting the descriptive content of the CNP. (Following Frege (1892) and Strawson (1950), this element of content may be viewed as PRESUPPOSED in the case of definite descriptions. We return briefly to this issue below.) For Russell, the crucially differentiating element was the implication that this descriptive content apply uniquely – spelled out in the underlined portion of (7b). The formal analysis shown above in (7b) can be extended to definite descriptions with mass or plural heads, as shown by Sharvy (1980; see also Hawkins 1978). In such cases it is the totality of stuff or entities that is in question.

Definite descriptions like *the representative* in (7a) are called "incomplete" or "indefinite", since there are an abundance of representatives in the world. In order to maintain Russell's analysis we must assume that the uniqueness element in (7b) is relativized to context in some way. The issue of incomplete definite descriptions is a complex one which we will skip over for the most part here; see Abbott 2010, Horn and Abbott 2010 for discussion, as well as Löbner's (1985) "pragmatic" definites, which we will come to very shortly.

It is important to note that the uniqueness aspect of Russell's analysis is separable from the quantificational aspect. That is, definite descriptions could be seen as simple referring expressions (as in the views of both Frege and Strawson) which nevertheless require unique applicability of their descriptive content. This is true of the approach of Löbner (1985; 2000), according to which the definite article is a marker of "functionality", in the sense that the CNP with which it is combined is taken to denote a function from contexts to individuals. Some CNPs – e.g. *king of France*, *first person to swim the English Channel*, *claim that pigs can fly* – do this automatically; Löbner (1985) termed these "semantic definites". The others – e.g. *representative*, *red car*, *person who called last night* – he called "pragmatic definites". (Rothschild (2007), apparently unfamiliar with Löbner's work, introduced the terms "role type" and "particularized" for the two subcategories, respectively.) Incomplete definite descriptions, noted above, fall into Löbner's category of pragmatic definites. Löbner (2000) argued specifically against any interpretation of definite descriptions as quantificational. We return to that issue in Sect. 14.3 below.

14.2.2.2 Semantic Versus Referential Uniqueness

It will be useful to distinguish two distinct but closely related ways in which an NP could be described as "uniquely referring". If Russell's theory of definite descriptions, as amended by a suitable approach to incomplete descriptions, correctly captures their contribution to the truth conditions of utterances in which they appear, then the essence of definite descriptions is that there is at most one thing (which may be an atomic entity or a group or mass individual) in the relevant context or situation which matches that descriptive content. Let us call this SEMANTIC UNIQUENESS. (Cf. also Roberts 2003 for a slightly different concept.)

There is another way of viewing uniqueness, which takes into account the goals a speaker has with respect to their addressee. On this view, the essence of definiteness in a definite description is that the speaker intends to use it to refer to some particular entity, and (crucially) expects the addressee to be able to identify that very intended referent. (Compare the concepts of "unique identifiability" and "individuation" discussed by Birner and Ward 1998, p. 121f.) This is a pragmatic property which I have called (Abbott 2010) REFERENTIAL UNIQUENESS. (Compare Löbner's (1985) functional analysis, and also the remarks of Bach 2004, p. 203.)

14.2.2.3 Extending Uniqueness to Other NPs

We must now check to see how well the idea of uniqueness fits the other categories of NP which are commonly considered to be definite. We'll start with proper names and then move on to pronouns. For the purposes of this discussion, it will help to separate demonstrative pronouns from the personal pronouns, and group them instead with demonstrative descriptions.

Proper Names

It seems clear that proper names are similar to definite descriptions in possessing both semantic and referential uniqueness. First, proper names present themselves as being associated with a single referent; the term "proper" indicates this property, which is also reflected in the fact that proper names, used as such, constitute a complete NP and do not accept determiners or restrictive modifiers. On the pragmatic side, as with definite descriptions, speakers can expect their addressees to be able to determine, from the use of a proper name, who or what is being spoken about as long as those addressees are already familiar with the name and its referent (see Prince 1992, p. 301).

Pronouns

When we consider personal pronouns it quickly becomes clear that most of them are not semantically unique. Third person pronouns in English incorporate only minimal descriptive content. Although this minimal content may occasionally apply uniquely in a constrained or shrunken universe of discourse, it need not, as shown most clearly by examples like the following (from Winograd (1972, p. 33)).

(8) The city councilmen refused the demonstrators a permit . . .

a. . . . because they feared violence.
b. . . . because they advocated revolution.

The city councilmen and the demonstrators are both plural objects suitable for the pronoun *they*. However, importantly, in the pair of sentences in (8), the content of the predication makes it clear who is being referred to. Use of a pronoun in a context in which a typical addressee would **not** be able to determine a referent uniquely results in infelicity, as in (9).

(9) # I told Sue and Betty about the problem, and she said she would work on it.

So it seems that use of a personal pronoun shares with uses of definite descriptions and proper names an assumption that the addressee is expected to be able to determine a referent uniquely.

Demonstratives

Demonstratives are different from the kinds of definite NP we have been considering in requiring (in their demonstrative uses) some kind of "demonstration" (pointing, nod, etc.) from the speaker. Such indicators may of course be used with other definites, but the other kinds of definite NP do not incorporate this requirement as a part of their semantics. As a result, as pointed out by King (2001, p. 27), a single demonstrative may be used repeatedly in an utterance for different intended referents, unlike definite descriptions or personal pronouns:

(10) a. I want that cookie, and that cookie, and that cookie.
b. # I want the cookie, and the cookie, and the cookie.

(11) a. I want that, and that, and that.
b. # I want it, and it, and it.

The requirement of a demonstration helps demonstratives achieve referential uniqueness without semantic uniqueness.

14.2.2.4 Subsection Conclusion: The Universals

As we have seen, definite descriptions, proper names, pronouns, and demonstratives all seem to share referential uniqueness – an intention on the part of the speaker using them to speak about a particular entity which they assume that the addressee should be able to identify. Thus this property has a strong claim to be the essence of definiteness. Furthermore, if that claim holds up then it would seem that the universals (those NPs with *all*, *every*, or *each* as determiner) should also be included in the category of definite NPs, since in at least some of their non-generic uses their denotation should similarly be identifiable to an addressee.

14.2.3 Familiarity

We turn now to a competitor to Russell's uniqueness theory. On Heim's (1982, 1983) approach to semantics, definite and indefinite descriptions both introduce a variable with information concerning some entity (the information contained in the CNP). The difference, in Heim's view at that time (following Christophersen 1939), was that indefinite descriptions were required to introduce novel entities while definite descriptions were required to denote familiar ones. When we introduced Russell's uniqueness theory, we noted in passing that both Frege and Strawson had proposed that definite descriptions **presuppose** the existence of a referent, rather than asserting it as Russell's theory seems to imply. Furthermore, on the common ground view of presuppositions, they are propositions which the speaker assumes are shared beliefs between speaker and addressee (see, e.g., Stalnaker 1974, 2002; but also Abbott 2008b). Thus familiarity theory of definiteness comes close to being just a special case of this view of presuppositions.

The main problem with this approach to definiteness (and in general with the common ground theory of presuppositions) is that there are many counterexamples. As noted above Löbner (1985) (and Rothschild (2007)) have distinguished semantic or role-type definite descriptions, where the CNP content itself determines a unique referent, from pragmatic or particularized definite descriptions, where the uniqueness in context is signaled by the definite article itself. As Löbner pointed out, the familiarity theory of definiteness neglects the first kind, which can naturally be used to introduce new entities into the discourse (1985, p. 320). However pragmatic, particularized definite descriptions may also be used to introduce new entities into the discourse, as shown by (12) below.

(12) The case of a Nazi sympathizer who entered a famed Swedish medical school in 2007, seven years after being convicted of a hate murder, throws a rarely discussed question into sharp focus.... [The New York Times on line, 1/28/08; underlining added.]

In this example, the entity in question was being mentioned for the first time. Newspapers yield many such examples. In fact empirical research by Fraurud (1990) and Poesio and Vieira (1998) has shown that more than 50 % of definite descriptions in naturally occurring discourse may introduce new entities.

Supporters of the familiarity theory typically respond to such examples by citing ACCOMMODATION in the sense of David Lewis (1979). However, as has been observed by, e.g. Gazdar (1979, p. 107), Soames (1982, p. 461, n. 5), Abbott (2000, p. 1419), among others, appeals to accommodation in this case make the familiarity theory virtually vacuous – definites denote familiar entities unless they don't. More importantly, such appeals do not explain the fact that it is possible to explicitly or implicitly deny any assumption that the referent of a definite description is familiar to the addressee, as shown in (13).

(13) a. The new curling center at MSU, **which you probably haven't heard of**, is the first of its kind. [= Abbott 2008a, ex. 6]
b. I'd like to **introduce** you to the idea that Scientology is a gigantic money-laundering scheme.

If it were correct that familiarity were conventionally encoded in definite descriptions, then examples like those in (13) should be anomalous, but they are not.

By contrast, uniqueness apparently **is** conventionally encoded in definite descriptions. For one thing, when *the* and *a/an* are explicitly contrasted it is always uniqueness that is at issue, not familiarity. (See Horn and Abbott 2010 for many examples.) For another, denying uniqueness for the content of a definite description results in anomaly, as shown in (14).

(14) # Russell was the author of *Principia Mathematica*: in fact, there were two. [= Abbott 2008a, ex. 11]

The natural conclusion is that uniqueness is part of the meaning of the definite article while familiarity is not. Instead, familiarity may be derived as a conversational implicature – something which may be cancelled or otherwise neutralized in context. (See Abbott and Horn 2011 for further discussion of this interesting issue.)

14.2.4 Section Conclusion

Of the criteria considered here – strength, uniqueness, and familiarity – it is clear that uniqueness, especially viewed as referential uniqueness, comes closest to characterizing definite NPs. We turn now to some other proposals.

14.3 Principal Filters

In this section, we consider three proposals which arose in the wake of Montague's (1973) treatment of NPs as expressing generalized quantifiers, or sets of sets (ignoring intensionality, which we will continue to do for the duration of this paper). They have in common focusing on those generalized quantifiers with non-empty generator sets. There are some differences among the proposals, with possibly different conclusions about which NPs would be considered to be definite. We will also look at some syntactic evidence.

14.3.1 The Proposals

14.3.1.1 Barwise and Cooper 1981

We consider first the definition of definiteness in Barwise and Cooper (1981, p. 183f; italics in original).

(15) DEFINITION. A determiner D is *definite* if for every model $M = \langle E, \| \ \| \rangle$ and for every A for which $\|D\|(A)$ is defined, there is a non-empty set B, so that $\|D\|(A)$ is the sieve $\{X \subseteq E | B \subseteq X\}$. (Hence, $\|D\|(A)$ is what is usually called the principal filter generated by B.)

In more or less ordinary language, this definition requires definite determiners, when combined with a set term, to yield a set of sets with a nonempty intersection – the generator set for the filter. NPs with a definite determiner are then definite.

This definition raises a couple of issues. The first is that it does not include NPs without determiners, such as pronouns and proper names. However it should be relatively easy to revise this kind of definition of definiteness to include them, since the generalized quantifiers interpreting them would also be principal filters. The second issue is more complicated. Barwise and Cooper intended to include definite descriptions (of course) while excluding the universals. One reason for this is that they assumed (following Jackendoff 1977) that a crucial property of definite NPs is the ability to serve as the embedded NP in a partitive, and that the universals cannot appear there. However excluding the universals while including definite descriptions required a couple of stipulations. One was that definite descriptions for which the CNP set is empty (like *the present king of France*) are undefined. Thus Barwise and Cooper follow Frege (1892) and Strawson (1950) in their view that definite descriptions semantically presuppose the existence of a referent. The other stipulation is that the universals do not share this presupposition of existence. (This latter stipulation does not follow Strawson; cf. Strawson 1950, p. 344.) We will return to the issue of partitives below in Sect. 14.3.3.

14.3.1.2 Partee 1986

Our second characterization was not actually proposed as a definition of definiteness, but is nevertheless highly congruent with the Barwise & Cooper idea. Broadly within the Montagovian framework, there are three possible (extensional) types for NPs: e (the type of NPs which denote entities), $\langle e,t \rangle$ (the type of NPs which denote sets of entities), and $\langle \langle e,t \rangle ,t \rangle$ (the type denoting generalized quantifiers – sets of sets). Partee (1986) noted that many NPs can appear in more than one type, depending on the context, and she proposed a number of "type shifting principles", to provide appropriate interpretations. The principle of interest here is one called "*lower*", which applies to NPs of type $\langle \langle e,t \rangle ,t \rangle$ and yields NPs of type e. *Lower* only applies to generalized quantifiers which are generated by single entities, where plural sums and masses are also considered to be entities, and maps them on to those entities. Overtly quantificational NPs like *most chickens* and *no good ideas* are not subject to this principle (although it is not clear that the universals are excluded, given that totalities can be considered to be plural sums). Partee pointed out that the traditional division between referential and quantificational expressions seems to correlate well with the division between NPs which may be of type *e* and those which may not be. (Cf. Partee 1986, p. 132.)

Partee's type *e* NPs are the same as Barwise & Cooper's definites with one exception – indefinite descriptions. Partee's criterion for being of type *e* was the ability to serve as the antecedent of a singular discourse pronoun. As shown in (16) (from Partee 1986, exx. 7, 8), this criterion groups indefinite descriptions with definite NPs.

(16) a. John/the man/a man walked in. He looked tired.
b. Every man/no man/more than one man walked in. *He looked tired.

As noted above, Heim (1982) treated indefinite descriptions similarly to definites. Chastain 1975; Kamp 1981, and Fodor and Sag 1982 have also argued that indefinite descriptions can be referential. In order to achieve a type *e* interpretation for indefinite descriptions, Partee (following Zeevat 1989) suggested that they might receive a generalized quantifier interpretation based on a particular variable – roughly, the set of sets containing x, where *x* would be assigned a value in context. This would allow *lower* to apply, yielding *x*. If this proposal is right, then we would have to conclude at this point either that indefinite descriptions can be definite (this would be when they introduce a discourse referent), or, more plausibly, that being of type *e* does not correspond to being definite.

14.3.1.3 Löbner 2000

Löbner (2000) explored the interaction between negation and NP interpretation. He argued that definite descriptions are associated with a (semantic) PRESUPPOSITION OF INDIVISIBILITY, so that predicates apply to them as a whole. This is most easily illustrated with a plural definite description, as shown in (17):

(17) a. The cows are in the field.
b. The cows are not in the field.

Löbner argued that (17a) is true only if all of the cows are in the field, and (17b) is true only if all of the cows are not in the field. If some of the cows are in the field and some are not, then neither (17a) nor (17b) is defined. This property then plays an essential role in Löbner's characterization of definiteness, and also serves to distinguish plural definite descriptions from the universals (as well as other quantified NPs). Note that the negation of (18a) is not (18b), but rather (18c).

(18) a. All the cows are in the field.
b. All the cows are not in the field.
c. Not all the cows are in the field.

It is this difference in behavior which separates definite NPs from quantificational NPs definitively, in Löbner's view.

It is worth noting that this characterization of definiteness, like Partee's criterion for type *e* NPs, could be held to include specific indefinite descriptions. As the examples below in (19) suggest, the specific indefinite descriptions, like definites, take scope outside of negation. (*This* in the examples below should be read as the specific indefinite *this* (cf. Prince 1981), and not the demonstrative *this*.)

(19) a. This/A certain strange cow is in the field.
b. This/A certain strange cow is not in the field.
c. No (#certain) strange cow is in the field.

The natural negation of (19a) is (19b), not (19c).

Löbner supported this classification of NPs with some syntactic characteristics. One concerned general scope taking ability. He asserted that "definite NPs do not have scope at all", while quantificational NPs, of course, do take different scopes. Another property concerned behavior in partitives; like Barwise and Cooper, Löbner assumed that only definite NPs may appear embedded in a partitive. In the next two subsections we take up these assumptions.

14.3.2 Scope Taking

In this subsection we will take a look at the scope taking abilities of NPs. It will help to break these down into two possibilities – the ability to take narrow scope, and the ability to take wide scope – since these might differ. Of particular interest will be similarities and differences between definite descriptions and quantified NPs.

14.3.2.1 Narrow Scope

Proper names, and pronouns and demonstrative NPs when they are used demonstratively, generally speaking do not take narrow scope with respect to other operators. This is true whether the operator in question is a quantifier, a propositional attitude predicate, or a modal. This behavior is unlike that of quantificational NPs. Each of the examples in (20) is ambiguous, and has an interpretation in which the underlined NP is interpreted with narrow scope relative to the boldface operator.

(20) a. **Everybody** loves <u>somebody</u>.
b. Rush Limbaugh **hopes** that <u>many liberals</u> will fail.
c. <u>Several philosophers</u> **might** have gone into plumbing.

In contrast to the ambiguity of the examples in (20), the univocality of those in (21) illustrates the fact that proper names, pronouns, and demonstratives do not take narrow scope.

(21) a. **Everybody** loves Madonna/her/that singer over there.
b. Rush Limbaugh **hopes** that Obama/he/this person sitting here will fail.
c. Aristotle/he/those philosophers **might** have gone into plumbing.

Exceptions to these generalizations have been argued for, but by and large the pattern holds.

In these contexts, definite descriptions can pattern with the quantificational NPs rather than the referential ones, as shown in (22).

(22) a. **Each of those people** loves the color they look best in.
b. Rush Limbaugh **hopes** that the current president will fail.
c. The number of US states **might** have been odd.

So as far as classifying an NP type as definite or indefinite, the ability to take narrow scope does not seem to give us good results.

The kind of narrow scope Löbner was particularly concerned with was narrow scope with respect to negation. And it is true that (17b) above, repeated here as (23), seems strongly to suggest that the cows as a group fail to be in the field.

23. The cows are not in the field.

However *each* also refuses to take narrow scope with respect to negation; (24) is likewise unambiguous.

24. Each of the cows is not in the field.

But Löbner does not seem to allow that quantification involving *each* involves definite reference.

14.3.2.2 Wide Scope

As sentence operators, quantifiers can take wide scope with respect to other sentence operators – propositional attitude predicates, modals, or other quantifiers. Thus the examples in (20) above also have readings where the underlined NP has wide scope. Wide scope would seem also to be unexceptionable for definite NPs, if we take the examples above in (21) to be ones in which the underlined NPs have wide scope. An alternative, however, is to conclude that those NPs are simply scopeless. On the other hand it has been argued that we need to recognize actual scope taking on the part of proper names (and other definites) in order to account for cases of sloppy identity. Consider, e.g., (25)

25. Mary likes her boss but Jane doesn't.

The relevant reading here is the sloppy one where Jane doesn't like her own boss. On the standard analysis, the pronoun (*her*) in the first VP is construed as a variable bound by *Mary*. (This allows for the second, pronominal, VP to be interpreted as identical with the first.) In order to bind this pronoun, it is typically assumed that the NPs *Mary* and *Jane* must have sentential scope taking capabilities. (Cf. Heim and Kratzer 1998, following Keenan 1971; Partee 1972.)

Peters and Westerståhl (2006) gave example (26) as evidence that definite descriptions are not quantifiers.

26. The novices chose a mentor.

They remarked, concerning this example, that it "unambiguously entails that all novices have the same mentor" (17, n. 12). However that is not so clear. Example (27)

27. In their sophomore year the students chose a major.

does not seem to me necessarily to imply that each of the students chose the same major. And likewise (28) seems to have a nonanomalous reading.

28. For lunch, the children ate an apple.

On the other hand it is not so clear that these facts require a quantificational analysis of the definite descriptions in question. Why isn't it simply an issue of distributive vs. collective predication? In which case why did Peters and Westerståhl take this kind of fact to be significant concerning the quantificational status of definite descriptions? I must confess to being at a loss as to how to interpret these kinds of scopal facts.

14.3.2.3 Conclusion Concerning Scope

It seems to me we must conclude from this exploration that scope facts are quite complex and require further investigation. The statement that definite NPs do not have scope at all seems definitely too strong. If we want to include definite descriptions in the super category of definite NPs, then we cannot take inability to take scope as a characteristic of the category. On the other hand Löbner's claims about negation have held up well, with the exception that *each* does not behave like the other quantificational determiners in this regard.

We turn now to partitive NPs, which have been taken by Löbner as well as many others to provide a criterial context for definites.

14.3.3 Partitives

Superficially, partitive NPs seem to have the form *Det of NP*.[1] Some examples are given in (29) below.

29. Some of the apples, few of those options, all of Mary's dogs

[1]Much of the material in this section was first presented in Abbott 1996. That paper also presents an analysis of partitives, which is not attempted here.

If that is indeed their structure, they present a problem: ordinarily determiners combine with CNPs, which denote sets of entities. But with the exception of predicate nominals, NPs denote either generalized quantifiers (sets of sets), or entities, and so they do not provide a suitable interpretation for another determiner to combine with.

Jackendoff (1977) argued that the NP embedded in a partitive had to be definite; he termed this "the Partitive Constraint". As was mentioned above in Sect. 14.3.1.1, Barwise and Cooper (1981) assumed that Jackendoff was correct, and proposed an analysis of "definite NP" which was tailored to that assumption. As we saw, this definition requires a definite NP to always have a non-empty intersection (the generator set) – thus including definite descriptions (on the assumption that they semantically presuppose existence), but excluding the universals (on the assumption that they do **not** semantically presuppose existence) as well as all other overtly quantified NPs. The beauty of the Barwise and Cooper analysis was that it suggested an explanation for the Partitive Constraint: only a generalized quantifier with a nonempty intersection would yield a set for the initial determiner to combine with. Barwise & Cooper suggested that *of*, in this construction, acts as an instruction to take the generator set of the NP with which it combines (1981, p. 206f).

Given that the universals have a nonempty intersection (unless the CNP fails to denote, as in, e.g. the case of *every unicorn*), Barwise & Cooper's reasoning would lead us to expect them to be able to occur embedded in a partitive. Consider an example like (30).

30. Most of every apple was in the bowl.

It is true that (30) cannot mean most of the apples are in the bowl. However that is because *every* is a necessarily distributive quantifier – hence its denotation cannot be taken as a group. Below we will see that the universal quantifier *all* does allow a group interpretation, and does appear embedded in partitives.

We should note (30) does have an interpretation as a MASS partitive, where the initial determiner (*most* in this case) applies to the individual apples rather than the apples as a group. On this interpretation the individual apples have been cut up or mashed, and a majority portion of each put in the bowl. The necessary distributivity of *every* forces the initial determiner to apply to the individuals in the denotation of its NP. The failure of NPs with *each*, *most*, or *both* to occur embedded in a group partitive is a result of the same property. They may readily occur in mass partitives however, as shown in (31).

(31) a. The Smithsonian donated most of <u>both rare book exhibits</u>.
b. One third of <u>each book Chomsky writes</u> is footnotes.
c. At least some of <u>most fruits</u> consists of rind and seeds.

In mass partitives like these the initial quantifier is applying to individuals within the denotation of the embedded NP, and not that NP as a whole.

Returning to the main theme, a number of researchers (most of whom concentrate on group partitives) have concluded that partitives do not, in fact, have the structure *Det of NP*. Keenan and Stavi (1986, p. 287) and Peters and Westerståhl (2006,

p. 269) argue that partitives have the structure *[[Det of Det] CNP]*; while Barker (1998), Löbner (2000), and Ionin et al. (2006) (among others), support a two NP structure. If one of these different structures is correct, the rationale for the Barwise and Cooper analysis disappears. Despite this fact, there is still widespread confidence in Jackendoff's partitive constraint. Keenan and Stavi assumed that the second Det in their *Det of Det* partitive structure must be definite (1986, p. 297). Peters and Westerståhl conclude that it must be either definite or possessive (cf. Peters and Westerståhl 2006, p. 278). Similarly, as we have seen, Löbner holds that only definite NPs, and not quantificational NPs, occur embedded in a partitive (2000, p. 253).

Leaving aside the case of the necessarily distributive NPs, there remain many counterexamples to the Partitive Constraint, viewed as a requirement of definiteness. Thus consider the examples below in (32)–(36). (The original sources are given following the examples; (32)–(34) also appeared in Abbott 1996.)

32. He ate three of some apples he found on the ground.
(Stockwell et al. 1973, p. 144)
33. This is one of a number of counterexamples to the PC.
(Ladusaw 1982, p. 240)
34. They called the police because seven of some professor's manuscripts were missing.
(Keenan and Stavi 1986, p. 297)
35. I would hate for my boy-friend and me to be two of seventeen housemates – we would never be able to kiss in private.
(Ionin, et al. 2006, p. 364)

(36) a. Ants had gotten into most of some jars of jam Bill had stored in the basement.
b. Three quarters of half the population will be mothers at some point in their lives.
c. Any of several options are open to us at this point.
d. Each student only answered a few of many questions that they could have.
e. Half of all dentists who chew gum prefer Trident.
(Abbott 1996: passim)

With the exception of the last example ((36e)), each of the underlined NPs above is intuitively indefinite, and would not be classified as definite by any of the analyses of that concept which we have looked at so far. The last example has an embedded universal (*all dentists who chew gum*) with a group interpretation.

Data like those above (and more examples can be easily found) suggest that any NP that can have a group interpretation can appear embedded in a group partitive. The only exception is bare plural and mass NPs, which are not welcome there, as illustrated by (37).

(37) a. *Most of books by Chomsky are on politics.
b. *Some of green slime is created by bacteria.

As is also indicated by these two examples, it does not matter whether the bare NP is interpreted as indefinite (as in (37a)) or generically (as in (37b)). Neither is possible embedded in a partitive. (Interestingly, in this characteristic bare plural and mass NPs are different from proper names; viz., e.g., *Most of Australia is desert*.)

The upshot of this investigation into partitive NPs is that they do not provide a good diagnostic for definiteness.

14.3.4 Section Conclusions

In this section we have looked at three further attempts to characterize a distinction in NPs. In two cases the authors were explicitly attempting to get at the essence of definiteness (Barwise and Cooper, and Löbner), while Partee suggested that being of type *e* might turn out to coincide with the closely related concept of referentiality. However, as we have seen, there are substantial problems with each of these attempts – viewed as definitions of definiteness. In one (and possibly two) cases the universals seem to be excluded only arbitrarily. Furthermore in the case of the Barwise and Cooper analysis their exclusion was motivated by an assumption which we have seen ample reason to question. On the other hand specific indefinite descriptions would be regarded as definite according to two of the characterizations, which raises further questions about their adequacy – again, as definitions of definiteness. I would certainly not want to claim that the semantic properties brought to light in the three works considered here are not interesting, or that they do not correspond to significant linguistic properties of NPs. My only claim is that none of them appear to give a satisfactory definition of definiteness, or one that is superior to referential uniqueness.

14.4 Concluding Remarks

This paper has explored the concept of definiteness, and in particular whether existing characterizations of this notion seem to capture its essence. In the course of this exploration we have seen a number of issues and problem areas which make the selection of a single characterization as **the** correct one difficult. My own feeling is that referential uniqueness is the strongest contender. However, I want to reiterate a comment from the beginning of the paper – that space prevents anything like a full examination of the issues under investigation here. Interested readers are urged to consult both the references listed below and the works they cite.

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Chapter 15
Nominal Concept Types in German Fictional Texts

Christian Horn and Nicolas Kimm

Abstract This paper presents the preliminary annotation guidelines and the results of the first empirical investigation of Löbner's (Journal of Semantics 28(3): 279–333, 2011) semantic distinction of four basic conceptual noun types (sortal, relational, functional, and individual concepts). On the basis of two German fictional texts, we test the hypothesis that the concept types are more frequently used with semantically congruent determination than with incongruent determination with respect to definiteness marking, number and possession. The proposed annotation guidelines follow a two-level approach and comprise (i) the semantic analysis of the nouns in the texts followed by (ii) the annotation of their particular grammatical uses. The results provide first empirical evidence for the distinction of the four concept types.

Keywords Concept types • Semantics • Semantic annotation • Statistics

15.1 Conceptual Noun Types and Their Expected Determination Profiles

In his theory about concept types and determination (CTD), Löbner (2011) distinguishes four basic noun types which differ with respect to two binary properties, i.e. inherent (non-)relationality [±R][1] and inherent (non-)uniqueness [±U]. Whereas the distinction between relational and non-relational nouns as a

[1]Square brackets indicate referential properties.

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distinction between one-place and two (or more)-place predicates has long been observed and described in the literature (cf. Asudeh 2005; Behaghel 1923; Barker 1995; de Bruin and Scha 1988; Partee 1983/1997; Vikner and Jensen 2002), the introduction of a uniqueness opposition as an additional basic conceptual property of nouns is innovative in this approach which is based on the considerations in Löbner (1985). Löbner (2011, p. 284) points out the crucial difference between [+U] and [−U] nouns as follows: "unique nouns 'say': this is the description of the referent, in the given context of utterance there is exactly one that fits it. [−U] nouns 'say': this is the description of the referent (it need not be unique)." *Pope,* for instance, is argued to be a [+U] noun since there can only be one such person.[2] Löbner (2011) argues that the cross-classification of the values of the two referential properties leads to four basic types of nouns. For each noun, a corresponding concept type is assumed: functional nouns (or functional concepts FC), relational nouns (RC), sortal nouns (SC), and individual nouns (IC). With respect to uniqueness, RCs (*sister, branch*) and SCs (*tree, table*) fall into the [−U] class; FCs (*mother, head*) and ICs (*sun, pope*) fall into the [+U] class. SCs and ICs share [−R] whereas RCs and FCs are both [+R].

[+R] nouns require the specification of their inherent possessor argument in the respective context of utterance. For functional nouns, this has the effect, that once their possessor argument is saturated, this value specification allows for uniquely determined reference of the noun. Consider the functional noun *mother*. A mother is always 'mother of someone' ([+R]) and there is, in principle, only one mother per person; if the possessor argument is saturated, as in *mother of Barack Obama*, the number of potential referents is exactly one ([+U]). This even holds when the expression is used without the definite article. [+R] nouns furthermore provide an inherent kind of relation (cf. Barker 1995 and Vikner and Jensen 2002 for 'relational nouns' in the traditional sense, comprising RCs and FCs; Gerland and Horn 2010; Nissim 2004 for an analysis along the lines of CTD). Typical examples for such relations are body-part relations (*head, leg*) or kinship relations (*mother, uncle*). *Sister* in its relational kinship meaning variant, for example, conceptually denotes a relation s(x, y) where x is female and x and y are direct descendants of the same parents (or at least have the same father or mother). For [−R] nouns, the case is different; their interpretation in possessive constructions depends more on the linguistic specification or on the particular context of utterance, i.e. the relation between a [−R] noun and another entity has to be established and might be of various kinds. As Vikner and Jensen (2002, p. 195) point out, in the utterance *The girl's car* the relation between 'the girl' and 'car' could be interpreted not only as 'the car which the girl has at her disposal' (which Vikner and Jensen (2002, p. 195) call "lexical interpretation") but also, for instance, as 'the car which the girl has ordered', or 'the car she has smashed to pieces' ("pragmatic interpretation").

[2]Löbner adds that this applies even at times when there were two popes who each claimed to be "the" pope, which he interprets as an indicator for the inherent uniqueness of the noun.

Table 15.1 Types of nouns and modes of determination (Löbner 2011, p. 307)

	[−U]	Inherently unique [+U]
[−R]	**Sortal nouns** *stone book adjective water* ✓ Indefinite, plural, quantifier, demonstrative ↦ Singular definite ✓ Absolute ↦ Relational, possessive	**Individual nouns** *moon weather date Maria* ↦ Indefinite, plural, quantifier, demonstrative ✓ Singular definite ✓ Absolute ↦ Relational, possessive
Inherently relational [+R]	**Relational nouns** *sister leg part attribute* ✓ Indefinite, plural, quantifier, demonstrative ↦ Singular definite ↦ Absolute ✓ Relational, possessive	**Functional nouns** *father head age subject* (gramm.) ↦ Indefinite, plural, quantifier, demonstrative ✓ Singular definite ↦ Absolute ✓ Relational, possessive

✓ congruent determination, ↦ incongruent determination

In CTD, the noun types are considered to be stored in the mental lexicon. Each of the four types is considered to have certain semantic predispositions for different modes of determination and vice versa. This leads to three principal claims:

Claim 1: For nouns, CTD predicts that their lexical referential properties influence the way they are used grammatically. Löbner (2011, p. 306) distinguishes between congruent and incongruent determination for the four different noun types (cf. Table 15.1). The mode of determination a noun is used with is considered congruent if it does not change the type of the noun. Incongruent determination, on the other hand, is considered to trigger a type shift. However, semantic effects of incongruent determination are beyond the scope of this paper.

We adopt this understanding of (in)congruency; that is, the match or mismatch of the semantic properties of concept type and determination. We refer to this kind of congruency as linguistic (in)congruency and distinguish it from the level of pragmatic (in)congruency. Whereas the former only includes all kinds of explicit linguistic determination, the latter draws on contextual clues (e.g. associative anaphors) and mutual knowledge. Both kinds together make up "overall" (in)congruency. In this paper, only the level of linguistic (in)congruency is addressed; for an investigation that also takes pragmatic congruency into account see Kimm and Horn (2011).

The predicted determination profiles for the different noun types can be summarized as follows: **Sortal nouns** are seen as "natural" (Löbner 2011, p. 287) with indefinite articles, plurals, quantifiers, free choice determiners, negative indefinites, interrogatives, numerals, and contrastive demonstratives, due to the fact that these determiners presuppose more than one possible referent for the

NP they are used in. SCs are taken as congruent with definite plurals since the referent of the whole definite plural NP is composed of more than one single case and is hence not unique (cf. Löbner 2011, p. 288; for critical discussions of the definiteness of plural NPs cf. Hawkins 1978; Lasersohn 1995). Furthermore, SCs are considered natural in non-possessive, i.e. absolute, constructions. Sortal nouns and **relational nouns** are assumed to share their congruency with respect to (in)definite determination. RCs differ from SCs in that they are seen as predisposed for possessive constructions. **Individual nouns** are expected to have a predisposition for singular definite determination, for instance the singular definite article (for an analysis of the definite article cf. Abbott 2004; Hawkins 1978; Heim 1982; Himmelmann 2001; Löbner 1985). In analogy to SCs, ICs do not require an additional argument for reference; thus they are seen as natural in absolute constructions. **Functional nouns** are assumed to share their predispositions for the singular definite article with ICs. Like RCs, FCs are taken as congruent with possessive constructions.

Claim 2: For the different modes of determination, Löbner (2011, p. 290) analyses certain input requirements. These requirements lead to preferences for certain noun types. As a result, not only does each noun type have a predisposition for certain modes of determination, but each mode of determination also has a predisposition for a certain noun type. Löbner (2011, p. 290) classifies a selection of English modes of determination with respect to their predispositions. In Sect. 15.2.2, we introduce five operative determination classes for the different modes of determination that are used in the German texts. These classes are to reflect their predispositions and we classify the different modes of determination that were given in the texts into these classes. This is a prerequisite for our empirical study.

Claim 3: The combination of the noun (or the CNP[3]) with its respective determination leads to an output type on the NP-level, which is again a combination of [±R] and [±U]. This output type may be congruent or incongruent with the respective type of the noun's concept. Incongruent output types are considered to reflect type shifts.

For incongruent uses, marked with ↦ in Table 15.1, Löbner (2011, p. 307) postulates three general tendencies: (i) they are assumed to be less frequent in comparison to the congruent determination, (ii) they are said to receive more salient expressions, e.g. morphologically more marked constructions, and (iii) to require contextual support. Typological findings support the second and third assumption (cf. Gerland and Horn 2010; Löbner 2011). The first assumption is tested in the pilot study in this paper.

[3]Löbner follows Abbott (2010) in using the term CNP (common noun phrase) for operands of determination.

15.2 Empirical Analysis of Two German Fictional Texts

Before we turn to the results of our empirical investigation, we present our annotation guidelines for the assignment of the concept types (Sect. 15.2.1) and their grammatical uses (Sect. 15.2.2) to the meaning variants.[4] The guidelines are still preliminary but provide a first step for the assignment of concept types and capture up to ten annotations per item. In Sect. 15.2.3, exemplary results are combined and compared.

15.2.1 Annotation Guidelines

The annotation guidelines comprise several steps divided into two parts, which are applied to each noun in the texts one after the other. The first part comprises the identification of the given meaning variant and the determination of the respective concept type. In the second part, the respective grammatical use in the texts is captured.

15.2.1.1 Part 1: Identification of the Meaning Variant and Assignment of the Concept Type

Part 1 consists of five steps: (i) identifying the given meaning variant in the context of utterance, (ii) excluding mass nouns and idiomatic uses, (iii) paraphrasing the meaning variant, (iv) determining the referential properties and assignment of the concept type, (v) enriching the paraphrase with referential information. Every noun in the texts is analyzed along these steps.

Step 1: Identifying the Given Meaning Variant

When we investigate types of nouns, polysemy has to be taken into account. Each of the meaning variants of a noun may exhibit different referential properties. Hence the assignment of one ‘noun type’ to all meaning variants of a noun is misleading. Accordingly, the first step of the annotation process consists in the identification of the respective meaning variant that is given in the context of utterance. Consider the noun *Frau* ‘woman’ in the sentence in (1).[5]

[4]The considerations presented in this chapter are part of the investigation carried out in Horn (in prep.). For an advanced version and a flow chart of the annotation process, see Horn (2012).

[5]Since our language of investigation is German, the examples given in this paper are also from German.

1. *Peter hat seine Frau vor fünf Jahren kennengelernt.*
   'Peter met his wife five years ago.'

Lexically, the noun *Frau* is polysemous in that it may denote either 'wife' as in (1) or simply a female adult ('woman'). However, the disambiguation of polysemous nouns is far from trivial; hence, we drew on the well-established lexicon Duden (1997) which lists meaning variants and their paraphrases, if necessary. In some cases, the meaning variants of a noun show differences in their morphological realizations of plural which may help for disambiguation, e.g. *Bank* ('bank'/'bench') and its plural forms *Banken* ('banks') vs. *Bänke* ('benches').

Step 2: Excluding Mass Nouns and Idiomatic Uses

At this point of the annotation process, we exclude cases that are not supposed to enter our pilot study. First, this concerns mass nouns. Currently, we are not yet sure whether mass nouns can be assigned a concept type by the same considerations that underlie count nouns (Löbner (2011, p. 307) mentions *water* as sortal but does not go into further detail). Hence, we focus on count nouns in this study and leave mass nouns for a later stage. In step 2, the annotator determines whether a meaning variant given can be classified as a mass noun on the basis of respective semantic and syntactic criteria discussed in the literature (cf. Allan 1980; Bisle-Müller 1991; Chierchia 2010; Helbig and Buscha 2005; Pelletier (2012) for an overview). The annotator tests whether the noun can be used in plural, whether it can be combined with the indefinite article without meaning shifts, and she tests for divisibility. Examples for mass nouns from our text collection are *Schnee* ('snow'), *Saft* ('juice'), *Wein* ('wine'), *Spülmittel* ('dishwashing detergent'), and *Reis* ('rice'). Furthermore, the annotator determines whether the given meaning variant is part of an idiomatic expression; for this the dictionary is consulted, if necessary. In our empirical analysis, nouns in idiomatic phrases were excluded since they usually occur with fixed grammatical determination in German as, for instance, in *reinen Tisch machen* ('to make a clean sweep').

Step 3: Paraphrasing the Meaning Variant

In step 3, the annotator paraphrases the meaning of the identified meaning variant. If a noun is non-polysemous, it is simply used in its singular form in the paraphrase. For polysemous nouns, each meaning variant found in the texts is represented by an adequate unambiguous expression, e.g. for *Frau*, (i) *Ehefrau* ('wife') or (ii) *erwachsener weiblicher Mensch* ('adult female person').

Table 15.2 Sample annotation for four nouns

Noun	Paraphrase (Ger.)	Paraphrase (Eng.)	[±R]	[±U]	CT
Frau	1. eine erwachsene weibliche Person	1. 'woman': an adult female person	–	–	SC
	2. die Ehefrau von x	2. 'wife': the wife of x	+	+	FC
Papst	das Oberhaupt der katholischen Kirche	'pope': the head of the Catholic church	–	+	IC
Nachbar	ein Nachbar von x	'neighbor': a neighbor of x	+	–	RC
Baum	ein Baum	'tree': a tree	–	–	SC

Step 4: Determining the Referential Properties and Assignment of the Concept Type

For step 4 of the analysis, the identified meaning variant needs to be considered independently of its context of utterance. In this step, the annotator assigns the respective concept type (CT) to each meaning variant on the basis of the given paraphrase, i.e. she classifies the meaning variant with respect to its referential properties [±R] and [±U], if possible. The annotator also determines the number of possessor arguments the meaning variant provides (0; 1; >1). Meaning variants with more than one possessor argument (as e.g. *distance* (between A and B)) were not taken into further consideration since in this study we focus on the four basic concept types only.

From the combination of the values of the referential properties, the concept type is derived. For instance, *Frau* in the sense of 'wife' is assigned [+R] (a wife is always somebody's wife) and [+U] (there is normally only one wife for her husband in this cultural context). Therefore, *Frau* is classified as an FC.

Step 5: Enriching the Paraphrase with Referential Information

In this step, each paraphrase is enriched with information about the referential properties that are relevant to capture the respective meaning variant as one of the basic concept types as far as possible. In case of [+R] concepts (RCs/FCs), the paraphrase is to adequately reflect the inherent relationality. The (preliminary) paraphrase for *Frau* in (1) would be *Ehefrau von x* 'wife of x'. In case of [+U] concepts (FCs/ICs), the paraphrase is to adequately reflect the inherent uniqueness of the concept which is represented by the definite article in the paraphrase (as opposed to the indefinite article for [−U]). Thus the full paraphrase for *Frau* in (1) is *die Ehefrau von x* ('the wife of x'). At the end of this step, the bare nouns are listed in our database along with their meaning variants, concepts types, and enriched paraphrases. Table 15.2 illustrates the procedure for four different German nouns with selected meaning variants.

Part 1 is carried out on all nouns in the entire corpus before we proceed with Part 2. Only when the semantic analysis is completed, may we turn our attention to the grammatical uses of the nouns. This is to prevent priming effects from actual grammatical uses of the nouns on their semantic classification.

15.2.1.2 Part 2: Grammatical Use of the Noun in the Text

Part 2 of the annotation process focuses on the grammatical uses of the nouns in the texts. For that, the NPs are considered independently of their semantic annotations. For each NP we annotate its mode of determination, comprising the marking of definiteness, number, and possession. Afterwards, we classify the different modes of determination into determination classes which allows for the statistical evaluation.

The first category regards **definiteness marking.** In the study presented here, we are only concerned with definiteness as the realization of respective determiners (for an overview of definiteness markers in German cf. Eisenberg 2006; Helbig and Buscha 2005) and not with referential uniqueness. German provides a rich inventory of determiners which comprises, for instance, a definite and an indefinite article, contracted forms of the definite article and a preposition (e.g. *im* ‘in the’, *am* ‘at the’; for an extensive analyses see Schwarz (2009)), demonstratives (*diese* ‘these’, *jene* ‘those’), a variety of quantifiers (cf. Löbner 2005), and numerals. Hence, for our analysis we may primarily draw on such explicit marking with two exceptions: first, German does not provide an explicit plural form of the indefinite article; in respective cases the null article is used. Second, certain proper names such as toponyms (*Spanien* ‘Spain’) and company names (*Starbucks, Bayer*) generally take the null article; furthermore, personal names in written texts are used with the null article in accordance with the norms (or “rules”) of standard written German. Since we are investigating written texts, we expect that these concepts mainly occur in their “natural” mode of determination, i.e. the combination of null article and singular.

During the annotation process, the annotator assigns the kind of definiteness marking of the respective NP (e.g. *der/die/das* ‘the’ as the definite article; viele ‘many’ as quantifier). Referential aspects, such as specificity (*ich habe heute ein Auto gekauft* ‘I bought a car this morning’) or generic uses of nouns (*der Hund ist ein Säugetier* ‘the dog is a mammal’) are not considered since we do not analyse referential operations in this paper.

The second category that needs to be considered is **number.** The annotator decides whether a noun is used singular or plural. In German, number is often realized by means of alternation of the article (*der Computer* (sg.) vs. *die Computer* (pl.)), by suffixation (*Frau* (sg.) ‘woman’ vs. *Frauen* (pl.)) or in some cases by stem alternation (*Mutter* (sg.) ‘mother’ vs. *Mütter* (pl.)); combinations are possible and frequent (*der Mann* (sg. ‘the man’) vs. *die Männer* (pl.)) (cf. Eisenberg 2006; Helbig and Buscha 2005). In indefinite singular NPs, nouns take the indefinite article (*ein/eine*). Indefinite plural NPs exhibit the null article. Definite articles are available for both singular and plural uses. Contractions of definite article and preposition are always singular. In the case of coordinations (*im Frühjahr und Sommer* 'in spring and summer'), the scope of the determiner extends to all nouns within the coordinated noun phrase as long as the following noun is not preceded by a determiner on its own.

The third category concerns all types of **possessive constructions** within the NP. The annotator decides whether a noun is used in a possessive or non-possessive construction. The latter is often referred to as 'absolute' use. German exhibits different markers for possessive relations (cf. Plank 1992), including possessive pronouns, genitive markers (left-adjacent possessor constructions as in *Tims Katze* 'Tim's cat' and right-adjacent ones as in *Tür des Hauses* 'door of the house' (lit.)), prepositions, and verbs that express a possessive relation like *haben* 'have'. Possession is different in comparison to definiteness in that in German only possessive uses are explicitly marked; there is no morphological marker signalling absolute use. Some prepositions may express possessive relations in certain constructions (such as *mit* 'with'/'by' in *das Mädchen mit den langen Haaren* (lit.) 'the girl with the long hair') but indicate no possessive relation in others (*er kam mit dem Zug* 'He came by train'); hence, manual annotation is necessary for such cases and the annotators classify all NPs in the text as possessive or absolute. Referring back to our example in (1), the noun *Frau* is used as a definite singular in a possessive construction with a possessive pronoun (*seine Frau* 'his wife').

15.2.2 Classification of the Modes of Determination in the Texts

According to CTD, the modes of determination differ semantically with respect to their preferences for certain concept types. We now sort the collected modes of determination into five operative determination classes[6] which are to reflect their congruency with the different predispositions of the concept types.

[±U] concepts are considered congruent with the following DET_U classes:

- DET_{+U}: modes of determination congruent with [+U] concept types
- DET_0: mode of determination prescribed for certain proper names in standard written German
- DET_{-U}: modes of determination congruent with [−U] concept types

[6]The number of classes investigated here is preliminary (that is why we call them "operative"); further sub-classifications might be useful for classes of determiners that show semantic congruency with certain concept types. In fact, such classes would also help for the automatic detection of concept types, based on probabilistic methods. For our study, we aim at a rather global approach for a principle test of the predictions made by CTD and hence restrict ourselves to these five classes only.

Table 15.3 Determiners found in the texts classified with respect to $\mathrm{DET_U}$

$\mathrm{DET_{+U}}$	Singular definite article (*der, die, das* 'the');
	Contractions of definite article and preposition (*im* 'in the', ...);
	Singular possessive pronouns (*mein* 'my', ...);
	Singular left-adjacent possessives (*Maries Idee* 'Marie's idea')
$\mathrm{DET_0}$	Singular null article
$\mathrm{DET_{-U}}$	Indefinite articles (*ein, eine* 'a');
	Demonstratives (*diese* 'this');
	Quantifiers (*mehr* 'more', *kein* 'no', *alle möglichen* 'all kinds of', *irgendein* 'any', *beide* 'both', *jede* 'every', *ein paar* 'a couple of');
	Numerals (*drei Euro* 'three euros');
	Definite article + numeral (*die drei Euro* 'the three euros')

[±R] concepts are considered congruent with the following $\mathrm{DET_R}$ classes:

- $\mathrm{DET_{+R}}$: modes of determination congruent with [+R] concept types
- $\mathrm{DET_{-R}}$: modes of determination congruent with [−R] concept types

First, we turn to the distinction of [±U] concept type congruency and classify combinations of definiteness marking and number as found in the texts. The modes of determination congruent with [+U] concept types are subsumed in the class $\mathbf{DET_{+U}}$. Similar to Löbner's (2011) analysis for English, the only determiners in German that are semantically congruent with [+U] concept types are the singular definite article, contractions of the definite article and a preposition, and singular possessive pronouns. Furthermore, singular left-adjacent genitive constructions belong to this class since they also exhibit a semantic predisposition for [+U] concepts.

The class $\mathbf{DET_0}$ is motivated by certain subtypes of ICs which comprise various proper names such as certain toponyms, personal names and company names. As pointed out above, even when used singular they generally take the null article in written texts (this is not necessarily required in spoken language). Nouns of this kind are generally subsumed in the class of ICs in CTD and would hence be expected to occur with $\mathrm{DET_{+U}}$ determination, contrary to the rules of standard written German. Hence, we consider it useful to split up ICs to sharpen our results: (i) $\mathrm{IC_{+U}}$ which are congruent with $\mathrm{DET_{+U}}$, and (ii) $\mathrm{IC_0}$ which are congruent with $\mathrm{DET_0}$. In corpora based on spoken language, however, this separation might not be necessary for personal names.

For all other combinations of definiteness marker and number, at least one component contributes a [−U] property: the indefinite article, demonstratives, numerals, quantifiers and all plurals presuppose non-uniqueness of the potential referent and are hence incongruent with [+U] but congruent with [−U]. Accordingly, these combinations are subsumed in the determination class $\mathbf{DET_{-U}}$.

As a result, we can derive Table 15.3 for the determination classes and the modes of determination found in the texts. Note that in accordance with our annotation guidelines, we did not consider cases occurring with mass nouns.

Table 15.4 Possessive constructions found in the texts classified with respect to DET_{R}

$\text{DET}_{+\text{R}}$	Possessive pronouns (*sein Vater* 'his father'); Left-adjacent possessor constructions (*Maries Idee* 'Marie's idea'); Right-adjacent possessor constructions (*Tür des Hauses* 'door of the house'); Possessive constructions with prepositions (*mit* 'with' in *das Mädchen mit den langen Haaren* (lit.) 'the girl with the long hair'); Possessive constructions with *haben* 'have'; *in Richtung Fenster* 'towards the window'; *heute Abend* (lit.) 'today's evening'; (*Duft*) *nach Raps* 'scent of (rape)'.
$\text{DET}_{-\text{R}}$	Absolute uses

Table 15.5 Full annotations of four nouns

Noun	Paraphrase	CT	Example	DET_{R}	DET_{U}
Frau	2. the wife of x	FC	*Peter hat seine Frau vor fünf Jahren kennengelernt* 'Peter met his wife five years ago'	$\text{DET}_{+\text{R}}$	$\text{DET}_{+\text{U}}$
Papst	the head of the Catholic church	$\text{IC}_{+\text{U}}$	*Der Papst ist in Köln* 'The pope is in Cologne'	$\text{DET}_{-\text{R}}$	$\text{DET}_{+\text{U}}$
Nachbar	a neighbor of x	RC	*Der Nachbar hat angerufen* 'The neighbor called'	$\text{DET}_{-\text{R}}$	$\text{DET}_{+\text{U}}$
Baum	a tree	SC	*Mein Nachbar fällt seinen Baum* 'My neighbor is cutting down his tree.	$\text{DET}_{+\text{R}}$	$\text{DET}_{+\text{U}}$

Second, we turn to the distinction of [±R] concept type congruency. We classify all modes of possession marking as congruent with [+R] concepts in the determination class $\textbf{DET}_{+\textbf{R}}$. In contrast, the absence of possession marking exhibits a congruency with [−R] concepts and such constructions are hence grouped into $\textbf{DET}_{-\textbf{R}}$. The types of possessive constructions within the NP found in the texts are given in Table 15.4.

15.2.3 Combination of the Results

We can now combine the results of this grammatical analysis with the results of the semantic analysis (the respective concept type 'CT'). Table 15.5 lists complete annotation examples for the nouns presented in Table 15.1.

In the examples in Table 15.5, *Frau* ('wife') and *Papst* ('pope') are used in accordance with the predispositions of their respective concept types. In contrast, *Nachbar* ('neighbor'), as an RC, is used as an absolute and singular definite. In CTD, this use would reflect a type shift of the concept. The same holds for the SC

Baum ('tree'), which occurs in a singular definite possessive construction. These examples illustrate that the particular grammatical use does not necessarily reflect the lexical type of the noun. Accordingly, it is essential for the annotation process to keep the lexical level and the grammatical level apart. Only this two-level procedure allows us to test if a relation really exists between the concept types and their specific grammatical uses.

In the next section, we present the case study for which we employed the annotation procedure to nouns in a text.

15.3 Case Study

15.3.1 Setting of the Study and Distribution of the Concept Types in the Texts

The investigation was carried out on German texts since German provides (among others) definiteness markers (including a definite article), indefiniteness markers (including an indefinite article), demonstratives and explicit possession marking (cf. Sect. 15.2.1.2). The texts chosen consist of two fictional short stories by anonymous authors from the website www.kurzgeschichten.de. They comprise 2340 word tokens including 456 noun tokens. The text size facilitates full annotation which is sufficient to gain a robust though smaller amount of data. One goal was to set up guidelines. Although the annotation guidelines are preliminary, they provide a first systematic step for the investigation. The annotation process was then jointly conducted by a team of five native speakers of German (including the authors); hence, we did not measure annotator agreement (e.g. Fleiss' kappa, cf. Fleiss 1971). Nevertheless, we stored the individual annotations of each annotator in our database.

In accordance with our annotation guidelines, we only considered one- and two-place nouns for the statistical analysis and left out nouns of higher arities and mass nouns. From the remaining 389 tokens, we only took those nouns into account for which the annotators had 100 % agreement with respect to the concept type (369 tokens). The tokens that could not be classified during the annotation process only add up to 20 nouns and will be dealt with in further investigations. Finally, all idiomatic uses were excluded, resulting in 363 tokens in total. To ensure an equal distribution of the nouns in our statistical analysis, only the respective first occurrence of a meaning variant was counted.[7] Altogether, we identified 236 different meaning variants[8] which were then entered into the statistical evaluation.

[7]We would like to add two remarks here. First, we consider diminutives like *Löffelchen* [lit.] '*little spoon*' as one token of the noun *Löffel* '*spoon*' and hence as a subsequent mention, since the diminutive does not change the referential properties. Second, the analysis of coreferential chains would be helpful for this task and is currently being developed.

[8]The proportion of meaning variants per noun is rather low (1.073). We expect a higher proportion in collections comprising more and larger texts.

Table 15.6 Distribution of the concept types in the texts

	Meaning variants	%
IC	17	7.2 %
FC	67	28.4 %
RC	42	17.8 %
SC	110	46.6 %
Total	**236**	**100.0 %**

As Table 15.6 shows, SCs (46.6 %) form the majority of the meaning variants in the texts, followed by FCs (28.4 %) and RCs (17.8 %). The number of ICs is relatively low, and this has effects for the statistical evaluation, as we will see in Sect. 15.3.2.3. The proportions of the concept types lead to the following distribution of [±U] and [±R] concepts: [+U] concepts add up to 35.6 % and 64.4 % of the concepts are [−U]. [+R] concepts add up to 46.2 % and 53.8 % of the concepts are [−R].

15.3.2 Hypotheses and Results of the Study

On the basis of the prediction made by CTD, we hypothesize that the concept types occur more often with congruent determination than with incongruent determination. To test this hypothesis, we split it up into three hypotheses that reflect possible combinations of the conceptual properties [±R] and [±U]. In principle, one could test these hypotheses starting from the [±R] or the [±U] distinction but due to the fact that the [±R] concepts are more uniformly distributed in the texts than the [±U] concepts, we start with the distribution of [±R] concepts and their occurrence with DET_R. Subsequently, each of the groups of [+R] concepts and [−R] concepts is analyzed on their own regarding their use with DET_U. Methodologically, we use the Pearson chi-square test (applicable for expected counts > 5) or the Fisher's Exact test (applicable if there are expected counts < 5) (cf. Field 2009, p. 690ff) to evaluate our hypotheses. Furthermore, we also provide descriptive statistics for the data. These include (i) a description of the proportions of the concept types among each determination class, and (ii) a description of the proportions of the determination classes among each concept type. All tables present the absolute and relative number of the respective combination, and the expected counts.

15.3.2.1 Investigation of the Relation Between [±R] Concepts and DET_R

The hypothesis is that [+R] concepts occur more often with DET_{+R} than [−R] concepts, and [−R] concepts occur more often with DET_{-R} than [+R] concepts, respectively. Table 15.7 gives the results. The numbers for ICs comprise both IC_{+U} and IC_0 since they have the same predisposition for DET_{-R}.

Table 15.7 DET_R uses of [+R] and [−R] concepts

	DET_{+R}	DET_{-R}	Total
[+R] (FC/RC)	36	73	109
% of all [+R]	33.0 %	67.0 %	100.0 %
Expected count	18.9	90.1	109.0
[−R] (IC/SC)	5	122	127
% of all [+R]	3.9 %	96.1 %	100.0 %
Expected count	22.1	104.9	127.0
Total DET_R	41	195	236
% of all DET_R	17.4 %	82.6 %	100.0 %

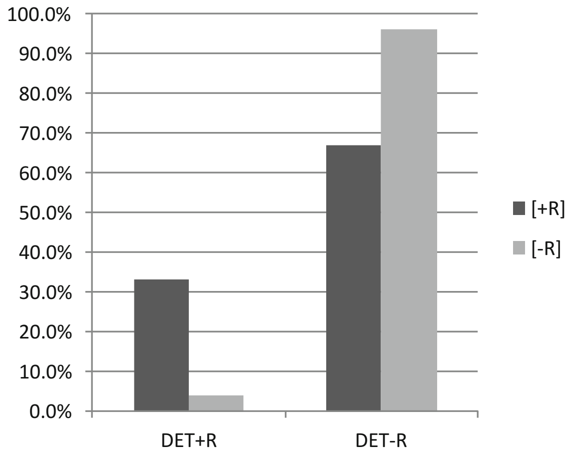

Fig. 15.1 DET_R uses of [+R] and [−R] concepts

We use the Pearson chi-square test since all expected counts are greater than 5. The analysis shows that the relation between the inherent (non-)relationality of a concept type and its use with DET_R is significant (Pearson $\chi^2 = 34.580$, $df = 1$, $p = .000$ [asymptotic significance, two-sided]).

Descriptively, the proportion of DET_{+R} occurrences among [+R] concepts is eight times higher than among [−R] concepts; on the other hand, the proportion of DET_{-R} occurrences is roughly 30 % higher among [−R] concepts than among [+R] concepts. As for the [+R] concepts, roughly one-third is used with DET_{+R}, whereas almost all [−R] concepts are used with DET_{-R}. Figure 15.1 illustrates the relative proportion of [±R] concepts used with DET_R.

The next hypothesis concerns the relation among [+R] concepts, i.e. FCs and RCs, and their use with DET_U.

15.3.2.2 Investigation of the Relation Between [+R] Concepts and DET_U

The hypothesis is that FCs occur more often with DET_{+U} than RCs. Likewise, we hypothesize that RCs occur more often DET_{-U} than FCs (Table 15.8).

We use Fisher's exact test since the expected count of those RCs used with DET_0 is 3.5. The analysis shows that the relation between the (non-)inherent

Table 15.8 DET_U uses of FCs and RCs

	DET_{+U}	DET_{-U}	DET_0	Total
FC	48	12	7	67
% of all FC	71.6 %	17.9 %	10.4 %	100.0 %
Expected count	36.3	25.2	5.5	67.0
RC	11	29	2	42
% of all RC	26.2 %	69.0 %	4.8 %	100.0 %
Expected count	22.7	15.8	3.5	42.0
Total DET_U	59	41	9	109
% of all DET_U	54.1 %	37.6 %	8.3 %	100.0 %

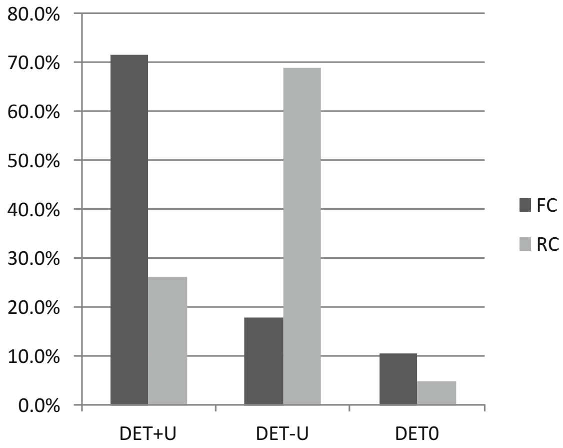

Fig. 15.2 DET_U uses of FCs and RCs

uniqueness of [+R] concepts and their occurrence with DET_U is significant (Fisher's exact = 28.673, $p = 0.000$ [exact significance, two-sided]).

Descriptively, the proportion of DET_{+U} uses is 2.7 times higher among FCs than among RCs. In contrast, the proportion of DET_{-U} uses is four times higher among RCs than among FCs. The proportion of DET_0 among FCs is twice the proportion of DET_0 among RCs. As for FCs, more than 70 % are used DET_{+U} in accordance with their predisposition. Less than 18 % occur with DET_{-U} and roughly 10 % with DET_0. Analogously, more than two-thirds of the RCs are used in congruence with their predisposition for DET_{-U}. One-fourth of them occur with DET_{+U} and roughly 5 % with DET_0. Figure 15.2 illustrates the results.

Our last hypothesis concerns the use of DET_U among [−R] concepts.

15.3.2.3 Investigation of the Relation Between [−R] Concepts and DET_U

We hypothesize that IC_{+U} are used more often DET_{+U} than SCs, whereas SCs are used more often DET_{-U} than IC_{+U}. Since IC_{+U} exhibit counts which were too low to be statistically evaluated, we only provide a description of the data. For IC_0, we hypothesize that they occur with DET_0 only.

Table 15.9 DET_U uses of IC_{+U}, IC_0, and SCs

	DET_{+U}	DET_{-U}	DET_0	Total
IC_0	0	0	8	8
% of all FC	0.0 %	0.0 %	100.0 %	100.0 %
Expected count	3.4	3.6	1.0	8.0
IC_{+U}	6	3	0	9
% of all FC	66.7 %	33.3 %	0.0 %	100.0 %
Expected count	3.8	4.0	1.1	9.0
SC	48	54	8	110
% of all RC	43.6 %	49.1 %	7.3 %	100.0 %
Expected count	46.8	49.4	13.9	110.0
Total DET_U	54	57	16	127
% of all DET_U	42.5 %	44.9 %	12.6 %	100.0 %

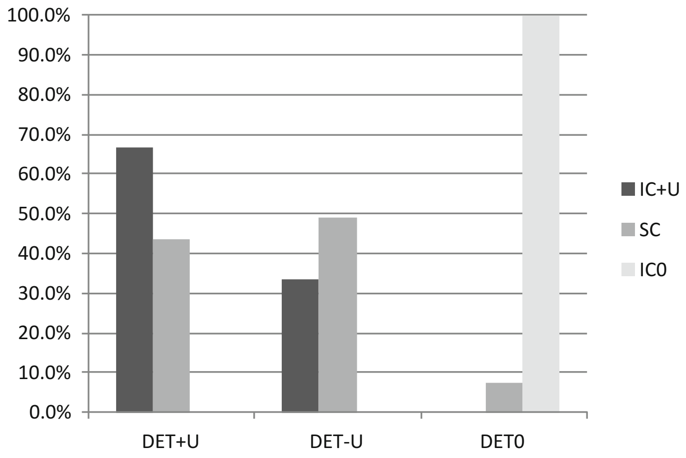

Fig. 15.3 DET_U uses of IC_{+U}, IC_0, and SCs

As Table 15.9 shows, the highest proportion of DET_{+U} is among IC_{+U} (66.7 %) compared to 43.6 % among SCs. On the other hand, the highest proportion of DET_{-U} is among SCs (49.1 %) which is almost 50 % higher than among IC_{+U} (33.3 %). The proportion of DET_0 is 100.0 % among IC_0, 7.3 % among SCs and zero among IC_{+U}.

As for the IC_{+U} concepts, two-thirds are used DET_{+U} in accordance with their predisposition, the remaining ones occur with DET_{-U}. Among the SCs, the proportion of DET_{-U} occurrences is almost 50 %, more than 43 % occur with DET_{+U} whereas 7 % are used DET_0. Figure 15.3 illustrates the data.

15.3.3 Summary and Discussion of the Statistical Results

The results of the statistical investigation can be summarized as follows:

(i) Proportion of concept types in the texts

The proportions of the concept types in the texts show interesting results. First, the [+R] concepts and the [−R] concepts are almost uniformly distributed in the texts. This supports the distinction between one-place and two-place predicates. Second, we observed a relatively high proportion of [+U] concepts (35.6 %) in the texts. If this finding is proved on the basis of larger text collections, [+U] concepts and the linguistic phenomena that go along with them (such as respective type shifts) should also deserve more attention.

(ii) Distribution of [±R] concepts with DET_R

The semantic distinction between inherently relational and non-relational concepts is reflected by their uses with DET_R. [+R] concepts are used more often in possessive constructions than [−R] concepts. For [−R] concepts, the proportion of congruent DET_{-R} occurrences is higher than the proportion of incongruent DET_{+R} uses. In contrast, the proportion of [+R] concepts incongruently used DET_{-R} is higher than the proportion of congruent DET_{+R} uses. How can we account for the high number of DET_{-R} uses among [+R] concepts? Here we draw back on the pragmatic congruency introduced in Sect. 15.1. Apart from shifts that may apply to all concept types, one explanation refers to pragmatic factors and language-specific well-formedness conditions and is grounded in Grice's Maxim of Quantity ("do not make your contribution more informative than is required", Grice 1975, p. 45), relevance theory (cf. Wilson and Sperber 1981), and the assumption of mutual knowledge (cf. Clark and Marshall 1981). Accordingly, the possessor argument does not necessarily need to be realized within the NP if the speaker assumes that the addressee can retrieve it from the context of utterance or previous knowledge. One example of such pragmatic uses is the phenomenon of associative anaphora (cf. Chafe 1976; Erkü and Gundel 1987; Löbner 1998; Prince 1981). An empirical analysis of associative anaphors with nominal anchors (NAA) hand in hand with the concept type distinction is subject to a related study (cf. Kimm and Horn 2011). The study shows that in the texts investigated roughly half of the absolute uses of [+R] concepts can be explained by NAAs. An example from the texts for the FC *Display* that is used as an NAA is given in (2).

(2) Anonymous (2010)

Hannes hasste das Lachen mittlerweile, [. . .] *mit dem sein Handy*$_{\text{anchor}}$ *ihn immer gleich weckte*. [. . .] *Er tastete nach* ***dem Display***$_{\text{NAA}}$ [. . .].

'Hannes began to hate the laughter [. . .] with which his mobile$_{\text{anchor}}$ always woke him up instantly. [. . .] He tried to find **the display**$_{\text{NAA}}$ [. . .].'

The FC *Display* is used in an absolute NP, i.e. with incongruent determination. However, the reader retrieves the referent of *sein Handy* ('his mobile') as the possessor from the previous discourse. Hence, the FC is used pragmatically congruent.

(iii) Distribution of [±U] concepts with DET_U

The semantic distinction between inherently unique and non-unique concepts is only partially reflected by their uses with DET_U. On the one hand, the distinction between FCs and RCs is reflected by the use of DET_U. FCs are used more often DET_{+U} and RCs are used more often DET_{-U}. For IC_{+U}, IC_0, FCs, and RCs, the proportion of congruent DET_U is higher than the proportion of incongruent DET_U. On the other hand, for SCs, the proportion of congruent DET_{-U} and incongruent DET_{+U} is roughly equal. An explanation for the high proportion of SCs used with DET_{+U} might be that in discourse uniquely referring singular expressions are also common for [−U] concepts, as for example for personal belongings like *Hemd* (‘shirt’) in (3).

(3) Anonymous (2010)

Er setzte sich auf [. . .]. *Den Bügel mit* ***dem Hemd*** *von der Stange nehmen* [. . .].
‘He sat up [. . .]. He removed the hanger with **the shirt** from the clothes rail [. . .].’

The SC *Hemd* is used with the definite article, i.e. with incongruent determination. However, the NP *dem Hemd* refers to the unique shirt the protagonist is going to put on in this scenario. Consequently, [−U] concepts may be frequently realized DET_{+U} in such cases, too.

Altogether the analysis provides evidence for the distinction of the four concept types. Nevertheless, we are aware of the fact that the text size limits the representativeness and the generalizability of our results. A larger collection of texts would allow more fine-grained distinctions. Other text sorts may also provide different proportions of concept types.

15.4 Conclusion

The goal of this paper was to empirically test whether the claimed semantic predispositions of the four basic concept types are reflected in their grammatical use. In order to answer this question, we first proposed a procedure for the annotation of nouns, their meaning variants, their respective concept types, and their grammatical uses. Second, we applied our procedure to two fictional German texts. The results show the following for the concepts that entered the statistic evaluation: (i) the distinction between [+R] concepts and [−R] concepts is reflected by the significantly higher proportions of possessive uses among [+R] concepts than among [−R] concepts. Nevertheless, a high proportion of [+R] concepts was used DET_{-R} and we explained such cases partly by pragmatic factors. (ii) The data also reflect the distinction between functional concepts and relational concepts. Here the picture is very clear in that the functional concepts show significantly higher proportions of DET_{+U} use. (iii) As for the distinction between individual $concepts_{+U}$ and sortal concepts, the former exhibit counts that are too low for a statistical evaluation. Descriptively, however, the individual $concepts_{+U}$ are used more often DET_{+U} than sortal concepts, in accordance with their referential properties. Despite the fact that the text size was limited, the study provides first empirical evidence for the distinction of the four basic concept types and encourages further investigation.

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