Chapter 1
The Study of Verbs in Cognitive Science

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Verbs are the key elements of syntactic and semantic (or conceptual) representations of events and states.[1] Rarely this assertion requires much more elaboration in linguistic circles. This is so because virtually every linguist assumes that verbs—more than any other grammatical category—carry core semantic properties of the events and states that sentences describe, and also license a myriad of information about the nature of the syntactic arguments that are constitutive of grammatical sentences. Besides its importance in linguistics, the nature of events and the very notion of predicate-argument structure, crucial to understanding verb meaning, have long been prominent topics in analytic philosophy (e.g., Davidson 1967). Thus, while linguistics and philosophy have generally taken verbs to play a central role in the representation of linguistic meaning and in the conceptualization of events, other

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[1] Just to be clear on what we mean by "semantic" and "conceptual": We take verb meanings and word meanings in general to be encoded in the mind/brain as *concepts,* i.e., mental particulars bearing content. Thus, the verb *drink* is a lexicalization of a particular event, which is encoded (or represented) as a concept. The concept, just like the lexical item itself, refers to any drinking event. We will use "semantic" and "conceptual" interchangeably although in some theoretical contexts—viz., linguistics—it might be more appropriate to use "semantic" to refer to the content and structure of token items. See Sect. 1.2, for further discussion.

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cognitive science branches have not given the same attention to verb representation. The psychological literature on word meanings (or concepts), for instance, has for a long time focused primarily on concepts that are lexicalized by nouns (e.g., Smith and Medin (1981) and Murphy (2002) for reviews) with relatively few studies investigating how concepts lexicalized by verbs are represented (e.g., Gentner 1975; Kintsch 1974; Fodor et al. 1980; Miller and Johnson-Laird 1976). Until recently, a similar state of affairs could be found in the cognitive neurosciences. The vast majority of studies bearing on the so-called category-specific semantic deficits in patients with brain damage or disease have focused on dissociations within semantic categories labeled by nouns (see, e.g., Tyler and Moss 2001; Humphreys and Forde 2001). Comparatively few studies focusing on patterns of dissociation within categories labeled by verbs have been reported (e.g., Breedin et al. 1998; Grossman et al. 1996; Kemmerer et al. 2001).

Recent years, however, have brought us numerous aphasia and neuroimaging studies focusing on verb meaning and structure (e.g., Bastiaanse and van Zonnevelt 2005; Faroqi-Shah and Thompson 2010; Kemmerer 2006; Kemmerer and Eggleston 2010; Meltzer-Asscher et al. 2013; Manouilidou et al. 2009; Thompson et al. 2007, 2010).[2]This relatively recent surge of studies on the nature of verb representations in cognitive neuroscience and related fields can be attributed in part to the increasing cross talk between theoretical linguistics (e.g., Jackendoff 1990, 2002; Levin and Rappaport Hovav 2005) and the experimental wings of cognitive science, propelled in particular by the refinement of empirical hypotheses and methods. Despite recent progress, there are still great divides both between disciplines and within linguistics. We aim to contribute to narrowing these gaps with the present chapter as well as with the present volume—with contributions on verb meaning stemming from diverse linguistic-theoretical camps, philosophy, psycholinguistics, neurolinguistics, and cognitive neuroscience more broadly.[3]

In this chapter, we provide a general introduction to the domain of inquiry of verb representation and processing. We briefly discuss theories and experimental studies within particular areas of investigation—most notably, argument structure, thematic roles, and semantic/conceptual structure—aiming to show how different types of evidence (theoretical, cross-linguistic, experimental) support or refute linguistic-theoretical constructs and advance our knowledge of how events and states are conceptualized. Although these areas of investigation have been prolific in linguistics

[2] This brief survey is certainly nonexhaustive and leaves out a long tradition of psycholinguistic work on verb *argument structure* and *thematic roles* (see, e.g., Fodor et al. 1968, for an early account, and Sects. 1.3 and 1.4). For reasons of space, the present chapter does not discuss a vast literature on how verbs are acquired—i.e., on the origins of the link between token verbs and events and states (see, e.g., Gleitman and Gleitman 1992; Gleitman et al. 2005; see also Chaps. 12, 13). Our concern here is that qua mental particulars bearing content far less attention has been given to verbs in areas such as the psychology of concepts and categorization.

[3] We do not mean to legislate on disciplinary boundaries. We use traditional labels for these disciplines simply for convenience (see Sect. 1.1). For us, as for many others, linguistics, psycholinguistics, and related fields, are part of cognitive science, for what really matters is the explanatory adequacy of any given theory and its empirical evidence.

and psycholinguistics, we imposed some constraints on our discussion: (i) First, we keep the discussion on different views on argument structure and lexical semantics to a minimum. Most current views stem from syntactic and semantic theories from earlier periods of generative grammar (e.g., Jackendoff 1983; Katz 1972; McCawley 1972). We believe that the distinctions between various more current verb representation theories (e.g., Croft 2012; Dowty 1991; Levin and Rappaport Hovav 2005; Goldberg 1995; Jackendoff 1990; Pietroski 2005; Pustejovsky 1995) boil down to the type of semantic information that are constituents of verb meaning in terms of more elementary predicates, and how the constituents of semantic representation are mapped onto the arguments of a verb and event structure. We acknowledge that there are several important distinctions between these approaches, but one issue stands out: whether one conceives verb meaning to be atomic (e.g., Fodor 1998) or whether it is molecular (or *decompositional*; e.g., Jackendoff 1990; Levin and Rappaport Hovav 2005). This distinction is key to understanding how verb meaning and argument realization are attained and how sentences and their constituents are processed. We focus on this issue in Sect. 1.5. (ii) Second, we also attempt to limit our discussion of experimental results to those studies which we believe aim at elucidating the nature of verb *representation,* beyond their contribution to our understanding of language *processing*. We will see that this particular constraint is important vis-à-vis our view of how evidence for linguistic constructs are gathered. To advance a bit our discussion: We deem all methods—from native-speakers' intuitions to neuroimaging—as equally relevant in uncovering the nature of mental representations, for we take all relevant data (and in particular intuitions) to be *psychological* data. (iii) And finally, the most obvious constraint: Since our discussion cannot possibly cover all relevant topics (see chapters in the present volume and their references for a rather comprehensive coverage), we are compelled to focus on only a few representative issues within the domains we chose—ranging from argument structure to semantic/conceptual templates. With regard to this last constraint, but for reasons of familiarity, we bring to fore sample research from our own labs, whenever appropriate. Our goal is to provide the reader—perhaps most importantly the uninitiated on verb matters—enough background to venture into the readings collected here and beyond.

This chapter is organized as follows. We first establish the domain of investigation—verbs—as the object of different disciplines and methodologies, beyond traditional linguistic theorizing. Thus, we start off by laying out a few methodological points with regard to how we see the study of verbs and linguistic objects more generally from an interdisciplinary perspective characteristic of cognitive science. Then, we situate the study of verb representation and processing within cognitive science by providing a few criteria on what might be relevant for understanding verb content and structure. Following these two sections, we present brief discussions of three content areas that constitute basic types of representation bearing on verb meaning. We move "up the ladder" from purely structural aspects of verb representation to questions of semantic composition (and predicate *decomposition*). We conclude by providing a short overview of the accompanying chapters.

1.1 Verb Representation and Psychological Evidence

It has long been the tradition in linguistic theorizing to rely on a sort of purity of method, with native-speaker intuitions driving much of the analytic endeavor together with cross-linguistic and distributional sources of evidence (i.e., based on the "behavior" of certain constructions or the validity of certain postulates within a language and between languages). In principle, this grants a certain degree of autonomy for linguistics in the investigation of the principles underlying verb structure and meaning. Although we must recognize that to a large extent linguistic theory is predicated on native-speaker intuitions, cross-linguistic data, and distributional arguments, investigating how linguistic principles are represented in the mind/brain, how they emerge during language acquisition, how they have evolved in the species, and how they are used in utterance contexts are within the scope of many constituent cognitive sciences. As Chomsky (1986, p. 37) once put it, "there is no way of delimiting the kinds of evidence that might, in principle, prove relevant."

While in principle the empirical evaluation of linguistic postulates is subject to contributions from many different methods and data-gathering procedures, it is not clear the extent to which psycholinguistic and other experimental data are taken to be the basis of theoretical advances on linguistic *representations*.[4] This is so in part because psycholinguistics (as well as related experimental disciplines) has been mainly concerned with *processing* mechanisms, appropriately motivated by the idea that a theory of grammar characterizes the knowledge employed in language processing. But, the relatively low impact that experimental data has had on linguistic theory is also due to the long-held practice of distinguishing roles for linguistics and psycholinguistics, possibly on the assumption that core principles of the language faculty in the "narrow sense" (Hauser et al. 2002) might be beyond the reach of processing data. But it is not possible to know in advance which principles constitute the core computational domain of the language faculty or how much of the linguistic characterization of the grammar constitutes the knowledge used in processing mechanisms. Besides, native-speakers' intuitions—to mention one key method of gathering data on grammaticality—are psychological data, as Fodor et al. (1975) observed, and purity of method entails that *all* psychological data be taken into account in evaluating linguistic representations, including data brought about by psycholinguistic and cognitive–neuroscience methods (see de Almeida 2006). Moreover, if understanding (or producing) a sentence relies on recovering its representations, the

[4] We can think of a few linguistic theories whose goals are to be somehow compliant with language-processing constraints. Lexical-functional grammar (LFG; see Kaplan and Bresnan 1982), for instance, came out committed to "psychologically plausible processing mechanisms" (pp. 173–174). A similar commitment was made by head-driven phrase structure grammar (HPSG; see Pollard and Sag 1994) and, more recently, by Culicover and Jackendoff (2005). This of course is not equivalent to taking experimental evidence into account in postulating linguistic principles. In fact, as Pollard and Sag say, "[w]hereas it is reasonable to expect that further research into human language processing will produce specific results that inform the minute details of future linguistic theories, we do not yet know how to bring these considerations to bear." (p. 13).

processes involved in comprehension and production ought to be taken as informative on the very nature of the representations involved.[5] It should be clear by now that psychology—or nonbehavioristic psychology—is about the characterization of the internal mechanisms underlying observable behavior, on a par with linguistic competence.

Although this methodological discussion concerns mainly issues on the nature of empirical evidence for hypothetical core linguistic principles, it is also related to how we ought to investigate the faculty of language and its interfaces more broadly. Much of the present chapter—and volume—is concerned with issues taken to be at the interface between these hypothetical core principles of linguistic structure (e.g., argument structure) and systems of *interpretation*. It is perhaps at this interface where contributions from diverse cognitive science disciplines show greater promise. Experimental studies employing response-time measures (e.g., lexical decision, eye tracking), the recording of electrical currents (e.g., ERPs, MEG), patterns of blood flow (e.g., functional magnetic resonance imaging, fMRI), as well as on- and off-line studies with impaired populations (e.g., Alzheimer's patients, people with aphasia) have brought forth great insights not only on the nature of the mechanisms involved in processing but also on the nature of *representations*—even when these insights are not explicitly incorporated in linguistic theory. It is our view, however, that bridging the gap between experimental data and linguistic theorizing is also the mission of those conducting experimental work.[6]

It is with the aim of bridging this gap that we think that guiding assumptions common to the practice of theoretical linguistics and the experimental wings of cognitive science are required. Linguistic—and more broadly, cognitive—theorizing requires generalizations at different but often interacting levels. Let us assume (with Pylyshyn 1984) that these levels are the *biological,* the *semantic,* and the *symbolic*.[7] The *biological* level aims at explaining regularities in behavior—including here covert behavior such as linguistic processes—by appealing to the vocabulary of biology (or the neurosciences). Anatomical or neurophysiological descriptions of particular processes

[5] We are not implying that empirical data should necessarily determine theory change: data cannot be the sole basis of such change. Without being exegetic in our philosophy of science, we expect this to be a common guiding assumption (see, e.g., Laudan et al. 1986). What we are saying is that experimental data should be taken seriously in advancing theories on representations, if we are to rely on psychological evidence.

[6] As important as it is to provide support for linguistic claims, experimental data play an important role in refuting those claims, thus motivating theory change. There is by now a handful of such cases in psycholinguistics. See, for instance, experimental studies on the reality of empty categories—which has been a point of contention between different syntactic theories (e.g., Bever and McElree 1988). For a more recent case, see experimental studies and theoretical debates on the nature of so-called semantic coercion (e.g., de Almeida 2004; de Almeida and Dwivedi 2008; de Almeida and Riven 2012; Pylkkänen and McElree 2006). And as we show in Sect. 1.5, psycholinguistic evidence for and against verb-semantic decomposition lingers within reach of lexical-semantic theories.

[7] These are hardly new because perhaps most nonlinguists in cognitive science are keen on describing processes and representations at all these different levels. The case of vision—a hypothetical faculty akin to language—is paradigmatic (see, e.g., Pylyshyn 2004).

answer to a specific set of questions about particular manifestation of a cognitive system—the patterns of physical implementation, including here the neurological correlates of particular processes or knowledge. The *semantic* level of explanation accounts for certain regularities in behavior by appealing to what one knows about the world or to the content of representations. We can include here overt judgments of grammaticality or intuitions about the semantic content of linguistic expressions. And finally, the *symbolic* level is where explanations appeal to the symbols and rules that underlie certain types of behaviors, primarily the rule-governed behaviors such as parsing and rule-driven aspects of semantic interpretation. The reason why this level is important—perhaps the most important for the purposes of understanding the fixed linguistic and cognitive capacities—is that it provides a common ground for establishing the regularities in linguistic representations (the nature of the symbols, their combinatorial or syntactic properties) and how these symbols are put to use.

While these levels of description often involve their own vocabularies, theoretical postulates, and empirical predictions, in actual practice understanding a given domain of knowledge—say, the nature of verb representations—requires descriptions at all levels (see also Marr (1982) on this point). Also, in actual practice it is difficult to determine whether or not explanations at one level are independent of or immune to explanations at other levels. For instance, explaining the neuronal correlates of different verb classes also requires appealing to the symbolic level—which is the characterization of the rules and representations underlying the classes and their linguistic behavior. We expect that much of the theoretical and empirical investigations on verb representations and processes aim at characterizing the fixed properties of verb representations and at providing what Pylyshyn (1984) called "strong equivalence" of cognitive processes: That the rules we postulate are instantiated as rules in the system, perhaps realized as physical patterns corresponding to actual rule-following computations. Finding out the strong equivalence of particular cognitive/linguistic processes and the representations that these processes involve requires a concerted effort within cognitive science.

1.2 Verb Content and Structure

We now turn to more specific issues characterizing our cognitive science perspective on verb representation and processing. This section sets the stage for a review of some specific controversies on the nature of verb representation and processing, presented below. Our goal here is to briefly discuss criteria for sorting out linguistic and nonlinguistic aspects of verb meaning.

We take as the standard view—perhaps common to all theoretical approaches to verb representation—that verbs qua linguistic entities are lexicalizations of "happenings" (Levin and Rappaport Hovav 2005). This means that verbs are morphologically simplex or complex lexical items whose referents are events or

states in the world.[8] We also assume that it is standard to take verb meanings to be encodings—i.e., *representations* in the mind/brain—of such happenings. This is much of what we take to be uncontroversial, for what exactly verbs pick out of these events or states, how they interact with other linguistic constituents, and how they are mentally represented and neurologically implemented are matters of great divide in the literature.[9]

Beyond their linguistic life, verb meanings—the representations of happenings—are *concepts* and thus might be represented "outside" the linguistic system proper, on the assumption that a line can be drawn between linguistic and nonlinguistic representations and processes. That is to say, whatever properties of the world (events/states) a verb picks out, these properties are available to other cognitive systems, perhaps at a central system common to different perceptual and cognitive domains. To wit, the verb *drink* picks out (or refers to) drinking events, whether this event is perceived linguistically (e.g., during sentence comprehension), visually (e.g., perceiving someone drinking), or is part of one's action (e.g., drinking). Moreover, because the very idea of *drinking* is a concept, it is available to thoughts and other higher-cognitive processes (reasoning, planning actions, making decisions, etc.). Concepts that are labeled by verbs, thus, are not necessarily linguistic entities, as they share with other concepts (the likes of DOG, LOVE, and BACHELOR) the property of being mental particulars that are constituents of thoughts and other cognitive processes. This in fact goes for any word meaning: Entertaining a thought entails entertaining a complex expression in the language of thought whose constituents are concepts (call it "the language of thought" hypothesis).[10]

As it is the case with any token lexical item, however, besides being a label for a particular concept, a verb also encodes *linguistic* information proper. This bears on the combinatorial properties of the verb (e.g., arguments and their hierarchy) as well as perhaps thematic-role information. We think that this assumption is somewhat controversial because not all theories acknowledge that verbs encode arguments, or that arguments bear thematic roles. These issues are discussed in Sects. 1.3–1.5. Leaving aside these controversies for now, following Grimshaw (1993), we can say

[8] We use "reference" in a broad sense to include events and states whether they are observable or not—i.e., within and beyond the "perceptual circle" to use Fodor and Pylyshyn's (2014) term. Thus, while *to drink* refers to an observable event, *to think* does not. In both cases, verbs are lexicalizations of the meanings of such happenings.

[9] In reality, not even the idea that verb meanings are mental representations (or neurologically encodings) of "happenings" is absolutely uncontroversial—for one might assume that there are no mental/linguistic representations but only behaviors to talk about (e.g., Quine 1960), or that word meanings are not encoded in the mind/brain (e.g., Putnam 1970, 1975a)—not at least as definitions but as a form of "use" or "disposition" (see also Wittgenstein (1953) for an anti-mentalistic approach). We take the idea of verb meanings as mental representations to be common to theories within the classic (symbolic) tradition in linguistics and cognitive science.

[10] Although this hypothesis might be more readily identified with Fodor (1975), it is also current in other theories (e.g., Jackendoff 1983, 2002) albeit there are some important distinctions. Of general concern here are the productivity and systematicity of linguistic and conceptual representations, which hinge on the characterization of the very nature of their elementary constituents.

that there are linguistically *active* aspects of verb meaning as well as linguistically *inactive* ones. The linguistically *inactive* part of verb meaning is what we called *concept*, above, and bears on the content—possibly the referential content of a verb, i.e., what sort of event/state it picks out. As Grimshaw puts it, the differences between *melt* and *freeze* are probably irrelevant from the perspective of linguistics: These verbs mean what they mean (namely, MELT and FREEZE) although linguistically they behave in similar ways—i.e., they enter into similar constructions, they have the same number of arguments, and probably assign the same thematic roles. Linguistically active aspects of verb meaning, then, are those that have an effect on the linguistic behavior of a predicate, that is, the aspects of meaning which determine the nature of argument structure and the thematic-role properties of these arguments.

The active/inactive divide raises a great number of empirical questions. For instance, if content (the linguistically inactive aspect of a verb's meaning) is opaque to the linguistic behavior of a predicate, how do they compose to form expressions in the language of thought? This issue is important vis-à-vis the hypothesis that concepts are the elements of thoughts and that, just like sentences, thoughts are compositional. One possibility is that conceptual representations inherit structural properties of linguistic predicates such that conceptual composition mirrors the linguistic structure of events. Yet, it is also possible that concepts are atomic while their labeling verbs are structurally complex, reflecting their linguistic properties such as predicate–argument relations (see, e.g., Chaps. 2, 4 for contrasting views). Sorting out which aspects of a verb's meaning are *active* and which ones are *inactive* is ultimately an empirical question requiring multiple methods—the classical methods employed in linguistic theory and the theoretical and experimental tools of other cognitive science disciplines. The characterization of what in fact constitutes the "behavior" of a given verb or verb class and how they are implemented in psychological and neurological processes might prove fruitful in further determining the active/inactive divide. While the linguistically active aspects of verb meaning have been of greater concern in linguistics and psycholinguistics, what is supposedly linguistically *inactive* is also key to understanding the nature of the conceptual system and what we encode of events and states.

We will briefly examine, next, theoretical and empirical work bearing on three types of information implicated in the representation of the meaning of a verb (or the meaning of a sentence that a verb partakes): (1) the bare specification of structural relations between the predicate and its arguments (see Argument Structure), (2) the interpretation of these arguments in terms of the roles they play in the event or state denoted by the predicate (see Thematic Roles), and (3) a discussion of the conceptual representation of a verb's meaning, traditionally studied in linguistics and psycholinguistics in terms of conceptual primitives within a conceptual or semantic template representing a verb or verb class (see Conceptual Structure).[11] Although

[11] We have to leave aside many other types of information contributing to the meaning of a predicate and its carrier sentence, such as tense and aspect. But see part III of the present volume for studies involving processing, representation, and impairment of tense and aspect.

these different types of representation of information regarding the meaning of a verb are rather complementary or even redundant (e.g., Jackendoff 1990; Levin and Rappaport Hovav 2005), they have constituted major areas of research in linguistics and cognitive science. We will consider arguments for and against each type of information, as well as their empirical (mostly psycholinguistic and neurolinguistic) evidence.

1.3 Argument Structure

In its standard conception, argument structure—a linguistic version of predicate logic predicate–argument relations—specifies the number and type of grammatical constituents (usually noun phrases, pronouns, and prepositional phrases) licensed by a verb. The arguments of a verb stand, in principle, for the obligatory participants in the event or state referred to by the verb and, thus, encode the hypothetically *necessary* linguistic (syntactic/semantic) properties of the event/state. A simple way of conceiving argument structure is by specifying the constituents as variables devoid of content, as in (1).

(1) drink (*x*, *y*)

Under this view, argument structure is said to be encoded with the verb. The assumption is that lexical entries—or at least verbs—are structurally complex with regards to the kinds of syntactic constituents with which they partake in grammatical sentences.

Beyond projecting the set of constituents of an event/state, argument structure can also be taken as a specification of the prominence relations of the arguments (Grimshaw 1990). The idea of prominence relations gives structural arguments a semantic life. This is so because, in order to conceive such prominence relations, arguments ought to bear information about the nature of events and states that their root verbs refer to. Thus, in (1), which represents the argument structure of the transitive variant of *drink,* the variable *x* stands for the external argument, the syntactic subject, while *y* stands for the internal argument, the syntactic object position. And moreover, given what *drink* means, *x* stands for the one who drinks while *y* stands for the thing drank. One way of further specifying the semantic life of arguments is to assign them *roles* such as *Agent* and *Theme*. In Grimshaw's (1990) theory, prominence relations are determined by thematic and aspectual properties of the predicate and thus are intertwined with the nature of thematic roles and the hypothesis of thematic hierarchy. We return to semantic or *thematic roles* in the next section. Suffice it to say that there is no agreement on how such prominence relations are established—whether by thematic properties of the arguments or whether by other purely syntactic principles blind to semantic properties of the predicate. In a theory such as Levin and Rappaport Hovav (2005), for instance, thematic role labels are not used to represent the semantic nature of the participants and thus arguments correspond to syntactic variables represented within the verb's semantic template (see Sect. 1.5).

While we have presented rather simply the view of argument structure as lexically specified information, i.e., verb-encoded structure, this is far from being a universally

accepted notion. Many researchers have espoused the idea that argument structure is determined by more general syntactic principles. There are several perspectives on this camp (e.g., Åfarli 2007; Borer 2003; Goldberg 1995; Marantz 2013), but its main tenet is the idea that verbs are simplex, containing no necessary structure to be projected. Some (Åfarli 2007; Borer 2003) assume that there are syntactic–semantic *frames* which are generated independently of the verb meaning itself—i.e., not as an encoded property but as an independent frame appropriated by the verb for different uses. The idea is that the verb is *inserted* into different frames to convey different events/states, and it is then that the verb *gets* an argument structure, i.e., by being associated with a particular frame. Åfarli (2007), for instance, assumes that there are only five frames (in Norwegian) for a verb to pick from. In other approaches (see, e.g., Marantz 2013), verbs are, roughly, roots which are merged with different features to yield a variety of canonical syntactic configurations. Importantly, the syntactic structures are independent of verb meaning. Thus, for instance, the transitive and intransitive variants of *drink* as in (2) are given by independently generated syntactic structures which merge with the verbal root *drink* producing complex verb phrases.

(2) a. The man drinks
b. The man drinks beer in the morning
c. The man drinks his way out of trouble

The meaning of *drink* in these contexts remains invariant, only determined by its ontological *activity* denoting a particular concept (namely, DRINK), with semantic composition relying on the resulting syntactic structure to determine other properties of the event/state the sentence describes. Thus, meaning differences between (2a), (2b), and (2c) are given not by the root, which is constant, but by the semantic composition emerging from the different syntactic structures.

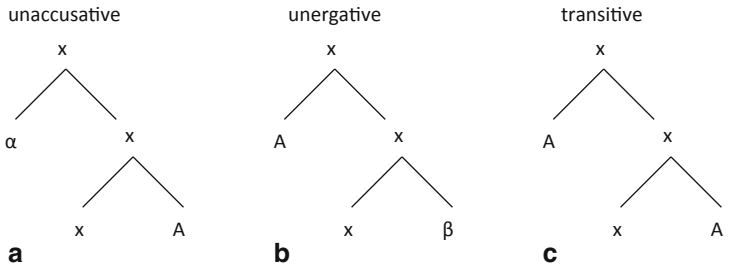
The idea that verbs can be *flexible* in their syntactic contexts (i.e., with varying internal arguments) or in the types of syntactic configurations it allows for is perhaps one of the main reasons for doubting a strict lexicalist view represented in (1). Another source of evidence against strict lexicalism comes from verbs coined anew (e.g., *to tweet*) or *verbbed* proper names such as *Justin Bieber* (as in *He Justin Biebered into the party*—whatever this means), which have no established argument structure to project. It is possible that these verbs pick up their meanings by appropriating a frame from a similar class (e.g., *to Google* for *to search*) analogically, although, as pointed out by Åfarli (2007), this just begs the question on how analogical processes work. What is relevant for the present purposes is that it seems to be the case that argument structure might not be encoded with the verb but may arise from their host frame or syntactic configuration. One advantage of separating the verb root from its structure is that it accounts for crosslinguistic variability for verb roots, which often appear in different syntactic configurations in different languages (see Marantz 2013).

There is yet another advantage of keeping roots apart from their syntactic projections and it has to do with how we might ultimately encode concepts. Although verb-encoded argument structure is said to be strongly tied to the meaning of a predicate—i.e., how the predicate encodes properties of events and states—it is not

entirely clear if the idea of *necessary* constituents carries all the way to the predicate's concept. If *drink* is represented as in (1), does the very concept of drinking somehow encode these *necessary* arguments as event participants (e.g., DRINK(X, Y))? If, however, concepts are atomic or *monadic* (see, e.g., Fodor 1998; Chap. 2), they do not carry constituents by necessity and their modes of combination in the language of thought do not come from their valence but from independent syntactic (/compositional) principles akin to natural language syntax.

However, it is possible to conceive of *flexibility* as part of lexically specified argument structures as in (1) without necessarily committing to conceptual complexity, assuming flexible argument structures for the purpose of syntactic composition but atomic roots that map into concepts. Di Sciullo (2007), for instance, proposes that argument structures can shift similarly to semantic type-shifting operations (Partee 1986), with arguments occupying noncanonical positions within the default argument structures of a verb. So, for instance, assuming a canonical set of argument structures, as in (3), structures can *shift* to adjust for missing arguments or to account for different syntactic configurations (roughly, *A* stands for argument positions).

(3)



Consider, for instance, the case of *middle* constructions such as in (4).

(4) This book sells well

The verb *sell,* in its transitive sense, with a structure as in (3c) (see Keyser and Roeper 1984; Bowers 2002), specifies one internal and one external argument, similarly to (1). But, by hypothesis, *this book* is the internal argument of *sell,* while occupying the subject, external argument position. Contrast (4) with (5), which are unergative structures (i.e., they project only an external argument).

(5) a. This clerk sells well
b. This store sells well

If argument structures are lexically specified, it is not clear how the projection of arguments, as in the case of middles, would be obtained. Di Sciullo's (2007) proposal would entail shifting the structure such that the internal argument in (3c) appears in the external argument position, yielding a structure that behaves like (3b) on the surface. This solution allows for flexibility while also preserving lexically specified binary projections.

This brief introduction is certainly far from offering any verdict on which alternative carries greater validity. As it is often the case in linguistics, with its numerous competing schools, different perspectives might in fact be guided by different sets of assumptions, which in turn make different empirical predictions. It is also possible that progress might come from converging ideas towards some form of consensus. We think that for any sort of consensus to be obtained, it would also be necessary to look at what experimental approaches have informed us about the nature of argument structure.

Most evidence coming from psycholinguistics and cognitive neuroscience (aphasia and neuroimaging) are presented in support of the very idea that verb structural complexity correlates with different neuronal signals or that verbs with more arguments are more difficult to process in cases of aphasia. For instance, many psycholinguistic studies have suggested that argument structure information is automatically accessed when verbs are encountered during sentence comprehension (e.g., Boland 2005; Boland et al. 1990; Friedmann et al. 2008; MacDonald et al. 1994; Trueswell and Kim 1998; Trueswell et al. 1993). Some of these studies have also been taken as evidence for the use of thematic information brought about by the verb (see next section). Although there are numerous methodological and theoretical differences between these studies, the general findings have been interpreted as supporting the idea that argument structure is part of a verb's representation (lexicalist view). An interesting dimension of argument structure processing comes from the literature on implicit arguments. For instance, Mauner et al. (1995) showed that speakers appear to activate (and, by assumption, encode) implicit arguments during sentence processing (e.g., an *agent* in a passive sentence) and that this activation does not require additional processing time compared to explicit argument processing. Subsequent experiments on implicit agents (Mauner and Koenig 2000) extended those findings, suggesting that argument structure information is accessed immediately at the verb, yielding semantic information about arguments even when these are not overtly expressed. These studies raise several questions with regard to the nature of arguments—whether they are only structural elements or whether they are "filled" with content by default. Either way, at a minimum they show that the system is *fast* in making semantic (content) decisions driven by the structure of the predicates (see also Chaps. 3, 4, 10 for related discussions).

Studies with agrammatic patients, in several languages, have also contributed important evidence to our knowledge about argument structure. Employing a variety of techniques, most studies have showed that more complex argument structures engender greater production difficulties, suggesting that number and perhaps semantic type of arguments play a role in the representation and processing of sentences (see, e.g., Thompson 2003; Kim and Thompson 2000, 2004; Lee and Thompson 2004; Thompson and Choy 2009, for English; Luzzatti et al. 2002, for Italian; Jonkers and Bastiaanse 1998, for Dutch; Kiss 2000, for Hungarian; De Bleser and Kauschke 2003, for German; Dragoy and Bastiaanse 2010; for Russian). These studies have largely supported what Thompson (2003) termed *Argument Structure Complexity Hypothesis,* a strict lexicalist hypothesis of argument structure which postulates that (a) more complex verbs are more difficult to produce (at least in agrammatism), and

(b) complexity is a function of number and type of arguments—in which case verbs are deemed more complex if they encode more arguments or if they encode "argument structures that trigger movement operations" (p. 163). Bastiaanse and Platonov (Chap. 7) present an extension of this hypothesis, including *tense* and *aspect* as factors affecting verb retrieval in agrammatism.

The neurological implementation of argument structure has also been investigated in neuroimaging studies with two main goals: to determine specific brain areas involved in verb-argument structure representation and processing, and to investigate particular contrasts between argument-structure variables. For instance, using fMRI, Thompson et al. (2007) investigated the neural correlates of verbs with one- (*die*), two- (*kill*), and three- (*put*) argument verbs in a lexical decision task. They found that while verbs with two and three arguments did not differ from each other in terms of activation clusters, both showed greater activation than one-argument verbs mostly at the left angular and supramarginal gyri (AG, SMG, respectively; see Fig. 1.1a). A follow-up fMRI study by Thompson et al. (2010) obtained similar effects (activation near the left AG) but only in the contrast three arguments vs. one argument, in a whole-brain analysis (Fig. 1.1b). Finally, Meltzer-Asscher et al. (2013), also using fMRI with a lexical decision task obtained small but significant greater activation for verbs that can alternate (or shift) between two structures (e.g., *break,* as in *John broke the vase/ The vase broke*) compared to unergatives (e.g., *laugh*) at a similar region (see Fig. 1.1c).[12] In principle, one could claim that (a) verb-argument structure complexity engages the AG and adjacent areas, thus that is primarily where argument-structure complexity is computed, and (b) there are neurological correlates for linguistically proposed contrasts. However, it is not the case that this area is *only* involved in argument-structure processing, or that the obtained activation contrasts are univocally attributable to linguistic differences.

Clearly, these studies are important to understanding the neurological correlates of argument structure and related processes, on the assumption that different neuronal peaks of activation and different neuronal networks correlate with contrasts between linguistic/semantic variables. But as Binder et al. (2009) show, conceptual ("content") processes involve vast networks and foci of activation, with great variability due to methodological differences between studies. In their review, Binder et al. point to several studies involving knowledge of "actions" and knowledge of "artifacts" also activating areas such as the left AG implicated in the studies on verbs mentioned above. Thus, while it is possible that more fine-grained distinctions between verb types and other semantic knowledge are computed at that general area (which in fact includes portions of the anterior occipital lobe, or BA 19; see Binder et al. 2009; and Fig. 1.1b, c, in particular), other semantic processes also engage those areas. It is also important to note that the experimental studies we reviewed do not seem to dissociate argument-structure complexity from thematic roles and

[12] Interestingly, Meltzer-Asscher et al. (2013) also found activation for alternating verbs in a small cluster in the anterior cingulate cortex, an area that has been implicated in conflict resolution and in indeterminate sentence processing (see de Almeida et al. 2014).

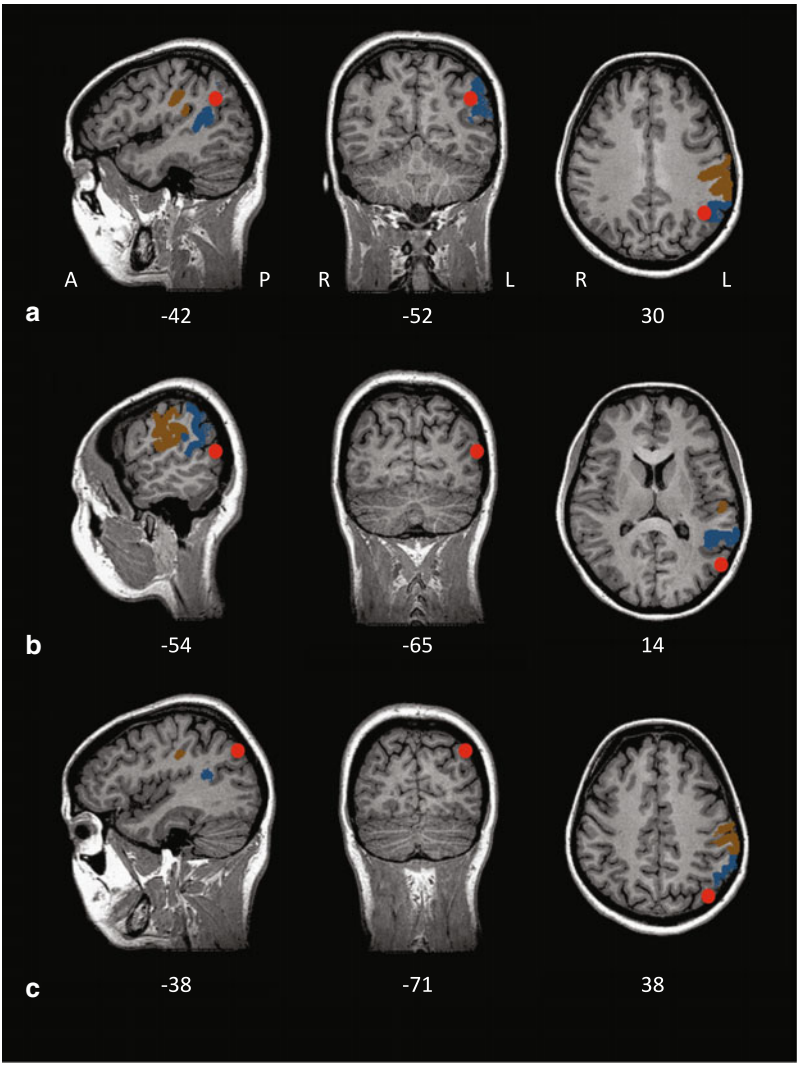


Fig. 1.1 Activation maxima for verb-argument structure contrasts based on data from (**a**) Thompson et al. (2007), (**b**) Thompson et al. 2010 (healthy control subjects), and (**c**) Meltzer-Asscher et al. (2013) shown in sagittal (*left column*), coronal (*middle column*), and transversal (*right column*) orientations. *Red dots* represent activation loci. *Colored areas* are Broadman Areas (BAs) 39 (*blue*) and 40 (*brown*). Data are plotted based on reported Talairach coordinates (in **b** and **c** these were transformed from MNI coordinates) to show approximate location of highest peak of activation for the contrasts (center of *red dots*), leaving out clusters of activation where voxels reached significant threshold. Also, choice of BAs was based on the most reported anatomical areas where contrasts occur. The activation in (**a**) represents the contrast between three- and two-argument verbs > one-argument verbs. The activation in (**b**) represents the contrast between three-argument verbs > one-argument verbs. And the activation in (**c**) represents the contrast between alternating > nonalternating (unergative) verbs. Legends: *A* anterior, *P* posterior, *R* right, *L* left

other "content" information. In fact, Thompson et al. (2010) suggest that these areas (Fig. 1.1) might not be involved in argument-structure building but in the integration with semantically selected (content) arguments. Thus, it remains to be seen whether or not there are neuronal correlates of verb-argument *structure* that are independent of content (the *linguistically inactive* aspects of meaning).

Returning to methodological issues on the investigation of argument structure, as we have seen, evidence is rarely, if ever, straightforward—be it in psycholinguistic experiments or cognitive neuroscience studies. As it happens with competing linguistic theories and their empirical support, many of the experimental studies we cited are subject to methodological and, more importantly, theoretical disputes. For instance, in a series of studies (reported preliminarily in Di Sciullo et al. 2007), we found that a sentence such as (4) takes longer to process than those in (5). In principle, this shows behaviorally that the two sentence types engender different processing routines. Clearly, the parser is sensitive to processes that go beyond sentence linear order and taps perhaps their structural differences. But it is not clear, though, if the obtained difference provides evidence for a *shift* in argument structure or for a syntactic operation like move-α. The behavioral difference between these conditions, however, could also be attributed to a reanalysis of the external, subject position argument in (4), which might be canonically interpreted similarly to those in (5). Our follow-up eye-tracking experiment with modified materials shows that the difference between (4) and (5) disappears when the middle clause (4) is preceded by adjectival predicative clauses, such as in *That novel is unpopular but this book sells well*..., suggesting a *structural priming* between clauses. This priming effect might indicate that the middle clause is parsed as an unergative (as in (3b)), supporting the argument shift hypothesis.[13] And yet there is the possibility—ever so present in psycholinguistic and cognitive neuroscience experiments—that tasks are *cognitively penetrable* (Pylyshyn 1984) and thus observed regularities might be due to "semantic" or "knowledge-level" processes: in the present case, when effects of argument structure might in fact be attributable to the overt interpretation of the sentences (including here frequency, plausibility, expectations, preference judgments, and the like) or, more specifically, when structural effects are confounded with content effects.

As we will see in the next section, there are good reasons for believing that argument structure—but in particular information about the semantic nature of arguments, their prominence as well as realization (thematic hierarchy)—seems to play an important role in verb representation and sentence processing.

[13] We offer our *middles* experiments as an example of how behavioral studies can lead to alternative theoretical accounts, much like most in the field, such as the ones we cite above. We are thus avoiding getting into a lengthy methodological and theoretical discussion on all those experimental studies. Of course, the theories that motivate such experiments are also subject to change and thus the interplay between types of evidence and theoretical proposals might lead to progress in our understanding of linguistic and conceptual phenomena.

1.4 Thematic Roles

Thematic roles have given rise to numerous controversies in linguistics. Before sampling some of these controversies, let us say roughly what "thematic roles" mean in standard usage. Simply put, thematic roles specify the semantic nature of the different arguments, which are participants in the events/states denoted by verbs. These roles are usually assigned by the verb to each of its arguments and are supposed to constitute a basic set of semantic properties—by hypothesis ontologically primitive—characterizing "who did what to whom" in the event/state. Thus, bringing back example (1) above, the specification of the roles played by the constituents represented by the variables would entail understanding the event that the verb refers to as involving two "participants," the one who drinks and the thing drunk as in (6).

(6) drink ($Agent_x$ ($Patient_y$))

The notion of thematic/semantic role has been part of modern linguistic theory at least since Gruber (1965) and Fillmore (1968), and also since Jackendoff (1972) and Katz (1972). In Chomsky's (1981) theory, thematic roles were incorporated as a form of semantic licensing of constituents (semantic selection or *s-selection*), at the interface between syntactic structures and semantic interpretation. The semantic properties assigned by lexical heads to their s-selected constituents were subject to the *theta* criterion, which governed their assignment. The *theta* criterion in fact constituted a series of principles governing the assignment of thematic roles—such as the assignment of roles to constituents in argument positions, and the assignment of only one role per argument. Notice that the thematic roles as in (6) are, in principle, independent of the actual content of the elements occupying *theta* positions. If verbs carry information about the thematic roles that they assign to *theta* positions, even semantically anomalous cases such as in (7) are assigned the thematic roles in (6).

(7) The table drank the sandwich

That is, from the perspective of syntax, the *theta* criterion is blind to the *content* of arguments, serving mainly to inform semantic interpretation about the nature of the constituents in argument positions. Several other theories have also made use of thematic roles to characterize the nature of participants in events. For instance, Parsons (1990) introduced thematic roles at the logical form (LF) representation of the event denoted by the sentence, as in (8b), with a reading such as in (8c).

(8) a. Brutus stabbed Caesar
b. $(\exists e)$ [Stabbing(e) & *Agent*(e, Brutus) & *Theme*(e, Caesar) & $(\exists t)[t <$ now & Cul(e, t)]]
c. There is an event which is a stabbing, the *Agent* of the event is Brutus, and the *Theme* of the event is Caesar; and there is a time, the time is before now, and the event culminated at that time.

The so-called neo-Davidsonian view represented by Parsons (1990) is just one example of how event structures combine with information about thematic roles to

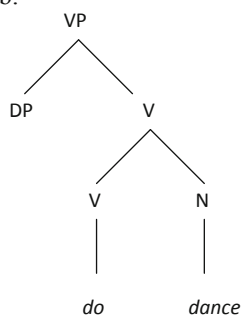
convey the meanings of predicates and their carrier sentences. Another is Engelberg's (2004) *lexical event structures,* in which thematic roles are also included with event-structure information, although in this theory lexical conceptual information is kept separate from the verb event structure. And, as we will see in the next section, lexical semantic theories have also incorporated the notion of thematic roles by turning them into conceptual primitives of verb conceptual templates (Jackendoff 1990; Levin and Rappaport Hovav 2005; Randall 2010).

Although the use of thematic roles to convey information about event participants was and still is common to many semantic approaches to verb meaning, several proposals coming from syntax have put into question the explanatory power of lexically driven thematic assignment. For instance, the reduction of the syntactic machinery brought about by the minimalist program in syntax (Chomsky 1995) relegated thematic assignment to representations at LF. Much of what was taken to be the *theta* criterion was shown to be dealt with by syntactic computations proper without the need for a grammatical module assigning semantic roles to argument positions, thus eliminating the redundancy between lexically driven and syntactically driven structures. This of course does not mean that arguments do not bear thematic roles but thematic roles and the *theta* criterion lose their explanatory status as a module of the grammar, becoming largely a descriptive tool (see Harley (2011) for discussion on these issues).

But, even for those who assume a lexically driven form of argument structure, thematic roles have been under question. Hale and Keyser (1993) were perhaps one of the first to attempt to reduce thematic roles to syntactic positions governed by properties of their host predicates. Thus, for instance, Hale and Keyser (1993, 2002) suggested that several thematic-role effects could be attributed to lexical syntactic structures, involving operations such as "conflation" (or incorporation) of predicates. They proposed, for example, that unergative structures (akin to (4b) above) have in fact a *transitive* (4c) structure, with an argument in the object position that corresponds to the morphologically related noun. In order to illustrate this operation, consider the sentence in (9a) and the (simplified) structure in (9b), with roughly the interpretation in (9c).

(9) a. Isadora danced

b.



c. Isadora did a dance[14]

For Hale and Keyser, verbs that are derived from nouns (i.e., denominal verbs) incorporate a light verb (*do* in (9)). It is this hidden verb that, by hypothesis, would assign the *Agent* thematic role to the subject position (*DP, Isadora*). If all unergative verbs have such structure, then they all assign the same roles and thus thematic roles could perhaps be superseded by operations that are purely syntactic (L-syntactic or part of lexical structure). Hale and Keyser identified other similar operations that turn thematic properties into syntactic and morphological properties of predicates. Relevant for the present purposes is that, in their view, thematic roles can be dispensed with by the regularities brought about by lexical structures.

But it is not clear if we are ready to fully reject a taxonomy of roles based on the hypothesis that some verb classes conflate a covert light predicate; if we were to adopt this theoretical position, then in fact thematic roles would be reduced to syntactic operations rather than being verb-specific (or class-specific) projections of arguments bearing thematic content. One problem with the analyses that Hale and Keyser put forward is that they rest on the hypothesis that there is a hidden verb in the zero-derived denominal verb. An analysis of Hale and Keyser's arguments show that what they are arguing for is that verbs have roughly a definitional structure (viz., that *dance* means DO A DANCE or that *shelve* means PUT ON THE SHELF, among others). But as Fodor and Lepore (1999) noticed, Hale and Keyser's periphrastic (i.e., decomposed) versions of their conflated structures were not synonymous with their lexicalized structures, following many of the arguments that Fodor (1970) mounted against the decomposition of *kill* into CAUSE TO DIE. We will return to this issue in Sect. 1.5. For now, suffice it to say that we suspect that if the analyses of predicate argument structures proposed by Hale and Keyser cannot be sustained, their conclusions about the fate of thematic roles should be seen with caution.

As we have seen so far, a discussion of thematic roles cannot be entirely dissociated from predicate arguments, which are supposed to be the bearers of thematic role content. However, we can approach the nature of thematic roles from a "higher" stance, i.e., by evaluating the role they play in the content of the predicates that assign them. Let us assume that verbs do have lexically encoded argument structure, *contra* some evidence we discussed in the last section. Let us also assume that the meaning of a predicate is tied not only to the verb's content (see Sect. 1.2) but also to the very nature of the participants that the verb licenses. Taking both assumptions into account, we can say that thematic roles provide *content,* i.e., information that enables us to represent whole event/state *types,* beyond token verb meanings. That is to say that the content of an event/state lexicalized by the verb goes beyond the verb's content and spills over its arguments. In our discussion of argument structure,

[14] To be consistent with our metalanguage, the interpretation in (9c) should be roughly [ISADORA DID A DANCE], corresponding to the concepts constituents of (9a), assuming this sentence is in fact structured as in (9b). Of course, this conceptual interpretation would be the same had the natural language expression been what it is in (9c).

above, we said that arguments might be specified as variables devoid of content, corresponding to the syntactic constituents that the verb makes obligatory. If we assume that thematic roles are content-bearing entities, carrying necessary information about events/states, then arguments are not simply structural positions devoid of content, but structural or syntactic manifestations of obligatory meaning components. This position is compatible with other views of thematic roles—e.g., Reinhart's (2002) who sees thematic role *features* as an essential component of the interface between language and the conceptual system.

Assuming that some form of thematic role system still plays a role at the interface between linguistic and conceptual representations, let us now examine a few issues that have motivated experimental studies in cognitive science.

One advantage of *theta*-role grids such as in (6) is that they allow for verb classifications based on the number, kind, and positions of the roles that verbs assign. Thus, verbs such as those in (10a) may all be analyzed as having a thematic structure such as the one in (10b).

(10) a. fear, admire, despise, hate, dread, prize, deplore, appreciate
b. ($Experiencer_x$ ($Theme_y$))[15]

There is no major agreement on these labels and it is often difficult to figure out the actual role played by some arguments in events. In fact, those were some of the reasons that lead Hale and Keyser to seek alternative analyses in lexical-syntactic projections. However this plays out in terms of labels, there seems to be some agreement on a few of these labels as well as on what they stand for. Recall that when we presented the standard view of argument structure we also mentioned that in Grimshaw's (1990) theory, argument structures (such as (6) and (10b)) are representations of prominence relations among arguments, which are based in part on what has been called a *thematic hierarchy*.

There have been several proposals for thematic hierarchy, all sharing the basic assumption that meaning-to-form mapping follows some form of hierarchical relations between thematic roles. Table 1.1 presents a sample of thematic hierarchies. As observed by Levin and Rappaport Hovav (2005), thematic hierarchies have an explanatory value in accounting for the mapping between semantic roles and grammatical relations, allowing for a particular argument to be referred to in terms of its relative position in the hierarchy rather than in terms of its semantic role proper. Consider the sentences in (11a–c) with their respective thematic grids.

(11) a. The boy_x opened the $door_y$ ($Agent_x$ ($Patient_y$))
b. The key_x opened the $door_y$ ($Instrument_x$ ($Patient_y$))
c. The $door_y$ opened ($Theme_y$)

When a verb allows for these thematic alternatives, the hierarchy specifies which argument takes the external (subject) position. Fillmore (1968, p. 33), for instance,

[15] We will not dwell here on the proper labels—e.g., whether the object is a *Stimulus,* a *Causer,* or a *Theme* that the subject experiences. The same applies to example (11) below—whether the internal argument of *open* is a *Patient* or *Theme*.

Table 1.1 Sample thematic hierarchies

Study	Thematic hierarchy
Fillmore (1968)	*Ag* > *Ins* > *Th*
Jackendoff (1972)	*Ag* > *G/S/L* > *Th*
Givon (1984)	*Ag* > *Ben* > *Pat* > *L* > *Ins*
Belletti and Rizzi (1988)	*Ag* > *Exp* >*Th*
Baker (1989)	*Ag* > *Ins* > *Th/Pat* > *G/L*
Grimshaw (1990)	*Ag* > *Exp* > *G/S/L* > *Th*
Van Valin (1990)	*Ag* > *Eff* > *Exp* > *L* > *Th* > *Pat*
Jackendoff (2002)	*Ag* > *Rec* > *Th* > *L* > *Pred NP*

Ag Agent, *Exp* Experiencer, *Ins* Instrument, *Pat* Patient, *G* Goal, *S* Source, *L* Location, *Rec* Recipient, *Th* Theme, *Eff* Effector, *NP* Predicate (e.g., a genius)

suggested that the presence of an *Agent* makes it the subject of a sentence (as in (11a)), with an *Instrument* taking up this role in the absence of an *Agent* (11b). Although there is considerable variability in the rankings of thematic roles, as can be seen in Table 1.1, they all agree that whenever there is an *Agent*, it occupies the subject position.

Several studies have investigated the general hypothesis of a thematic hierarchy and, more specifically, if deviations from thematic hierarchies have a processing correlate. The goal in most cases is to understand how the processor deals with noncanonical mappings from thematic to syntactic structure and how this mapping might break down in populations with impaired semantic systems. The importance of this topic is manifested by the fact that several experimental studies have given rise to models of language comprehension/production making reference to a processing level involving the checking of thematic roles or their proper assignment to sentence constituents (e.g., Frazier and Clifton 1996; Bornkessel and Schlesewsky 2006). A common assumption is that the types of arguments required by a verb and their possible thematic roles are taken into account during the very early stages of processing. For instance, Bornkessel and Schlesewsky (2006) formulated the argument dependency model (ADM) which aims to provide an account of hierarchy mismatches in sentence comprehension. ADM is based on the incrementality of sentence comprehension assuming that hierarchical thematic dependencies are immediately set, even before the verb is encountered. As a consequence, the initial argument is interpreted as thematically higher ranking, according to hierarchical demands. In case there is a mismatch between the thematic structure and the hierarchical thematic relations, reanalysis occurs. The prediction of such model is that verbs with noncanonical argument realization, such as object-*Experiencer* verbs (e.g., *frighten*), should be harder to process and they should trigger thematic reanalysis on the assumption that *Experiencer* should be assigned canonically to an earlier argument in subject position. Indeed, it seems that various studies that have manipulated argument realization

have found increased reaction times in the locus of the predicted reanalysis. (e.g., Ferreira 1994, 2003; Manouilidou and de Almeida 2013; Verhoeven 2014).

Language impairment studies examining the correspondence between thematic roles and syntactic properties have demonstrated that patients have difficulties processing sentences with deviations from canonical structure (e.g. Zurif and Swinney 1994; Burchert et al. 2008; Thompson and Lee 2009; Manouilidou et al. 2009; Dragoy and Bastiaanse 2010). Our study (Manouilidou et al. 2009) involved Alzheimer's patients, who are known to have affected semantic memory systems. Few studies have shown that Alzheimer's patients have linguistic (i.e., syntactic, argument-structure) problems other than higher-level semantic deficits (e.g., Bencini et al. 2011). We investigated whether deviations from thematic hierarchy (e.g., no *Agent*) would affect patients' production and comprehension of sentences, on the assumption that greater deviations from hierarchical order would engender worse performance. Moreover, we hypothesized that noncanonical argument realization would engender greater difficulty than canonical realization. In the main experimental conditions, we employed two classes of psychological verbs, subject-*Experiencer* (*fear*) verbs, which by hypothesis assign no *Agent* role and object-*Experiencer* (*frighten*) psych verbs which entail noncanonical argument realization (mismatch between the thematic hierarchy and the actual realization of the arguments, with *Theme* preceding *Experiencer*). For each sentence frame (e.g., *The boy____the thunder*), patients were required to select a verb, among four alternatives, that would best fill in the frame. The alternatives included the target (e.g., *feared*), a semantic competitor (*frightened*) and two distractors. Results showed that patients had difficulties completing the sentence when the target verb was a subject-*Experience* (*fear*) and even greater difficulty when the frame required an object-*Experience* (*frightened* for a sentence frame such as *The thunder____the boy*). Interestingly, patients had near-normal performance (compared to a group of age- and education-matched controls and a group of young controls) with sentences that took canonical *Agent–Theme* verbs (e.g., *kick*). When we looked at the pattern of errors for the psych verb conditions, we also found that patients selected the competitor about 70 % of the time, suggesting that while patients were able to discard the unrelated distractors, the difficulty choosing between target and competitor (e.g., the near reversible pair *fear/frighten*) could be due to the proper thematic roles assigned by these verbs. It is important to note that the difficulty was not with the linear order of constituents because the same pattern of results was obtained with passive sentences (e.g., *The thunder was ____by the boy, The boy was_____by the thunder*). See Fig. 1.2 for the Alzheimer's patient data. We suggested that the pattern of performance by patients with Alzheimer's was not entirely consistent with extant thematic hierarchy proposals (e.g., Belletti and Rizzi 1988). For instance, patients had difficulty with sentences lacking *Agent,* even when the argument realization was canonical (e.g., in *Experience–Theme* frames) but had no difficulty with some noncanonical structures (e.g., *Theme–Agent*; see also Manouilidou and de Almeida (2009) for discussion).

Although thematic roles are among the most controversial types of linguistic representations bearing on verb meaning (see, e.g., Newmeyer 2002), they also seem

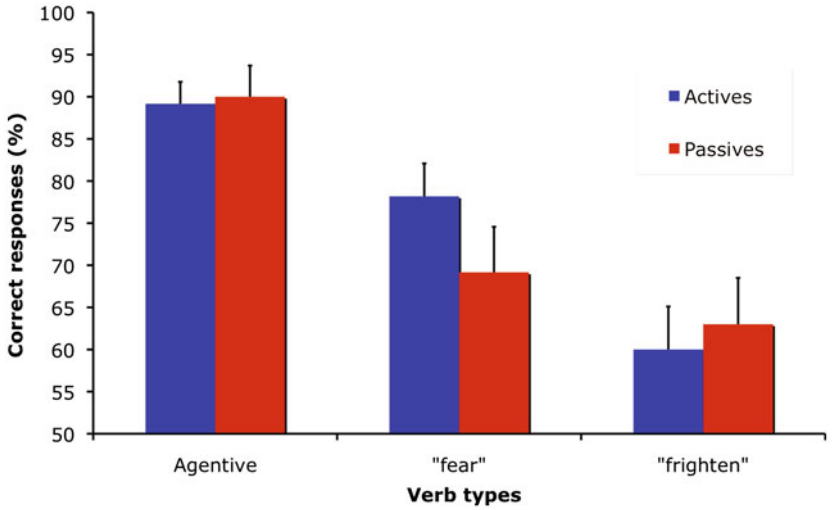


Fig. 1.2 Alzheimer's patient data from Manouilidou et al. (2009). The bars show correct selection of verb type per sentence condition (see text). *Error bars* represent standard error

to account consistently for effects in sentence processing. In fact, most of the evidence we presented for argument-structure effects cannot be easily dissociated from thematic-role effects; nor can we easily discard the role of a thematic hierarchy in accounting for the pattern of semantic impairment. What seems to be an important point of contention is the proper characterization of thematic roles and in particular their level of representation. While Newmeyer (2002, p. 71) appears to discard thematic roles from the "core" mechanisms of the language faculty due to inconsistencies in hierarchies and their realization, as well as the proliferation of thematic-role labels, we think their status is yet to be determined. What is clear is that until other grammatical or semantic constraints account for the thematic-role effects found in the linguistic and experimental data, we can claim their psychological reality. Even if it turns out that they are not part of the "core," thematic roles might have a role to play most likely at the interface between linguistic and conceptual systems, assisting in the mapping of form to meaning.

1.5 Conceptual Structure

The final and "highest" level of verb representation we would like to discuss is what is generally called *conceptual structure*. This label covers at least two possibly opposing views: one assumes that concepts are simplex (or atomic) and the other, that concepts are complex (or molecular). From this latter perspective, concepts themselves are structured representations, but the machinery responsible for combining concepts might also involve a fair amount of structuring, perhaps akin to natural language

syntax or predicate logic. From the former perspective, that concepts are atomic, the basic units of representation are not themselves structured, but to a large extent what the conceptual structure does is to combine concepts, also deploying something akin to a logical or a syntactic structuring system. One could as well call it a *conceptual system,* or the *language of thought,* assuming that concepts are the elements of thoughts (Fodor 1998; Fodor and Pylyshyn 2014).[16] In Sect. 1.2, we alluded to the idea that verbs are lexicalizations of "happenings" (Levin and Rappaport Hovav 2005) and much of what we represent (and, thus, lexicalize) are properties of events and states out there in the world, including those that are beyond the perceptual circle. The conceptual representation of a verb thus conceived stands for the ultimate codes serving for other cognitive processes—not only linguistic interpretation and production but also those involving actual events and states.

A fair question at this juncture is whether what we have presented so far about conceptual structure characterizes in any sense a *linguistic* level of representation. When one surveys theories of verb meaning, it is not always clear at which level the purported representations are encoded. While Jackendoff (1983 and subsequent work) assumes that verb conceptual structure does not constitute a level of linguistic representation (see below), others such as Levin and Rappaport Hovav (2005) assume a certain degree of autonomy for verb-conceptual representations, interacting with syntax. It has been a long tradition in linguistics to attribute to the semantic system its proper level within the language faculty. The work by Katz (1972) typifies this latter perspective. For him, ". . . the semantic component of the grammar contains a dictionary that formally specifies the senses of every syntactically atomic constituent in the language" (p. 33). What Katz had in mind for the semantic system was akin to syntax: ". . . a specification of the form of the dictionary and a specification of the form of the rules that project semantic representations for complex syntactic constituents from the dictionary's representations of the senses of their minimal syntactic parts" (p. 33).

Clearly, when one thinks about issues of "semantic" representation—the level of LF and other representations bearing meaning—much of the groundwork comes from semantics conceived as a level of linguistic analysis, perhaps with its own principles, interfacing with syntax and other linguistic representations. Work on the logical properties of linguistic expressions, including lexical representations and compositional processes are properly semantic. But one could well see LF, for instance, as a system responsible for structuring representations at the conceptual level, whether these representations are linguistic—output from the language faculty—or whether they are nonlinguistic (such as in the output of visual perception). Thus, the

[16] And yet there are those who do not believe there is a conceptual system, but only "conceptual processes" (Barsalou et al. 2003) implemented by linguistic and other input/output systems, including action. We will have to restrain our discussion to those who assume there is some form of cognitive system enabling conceptual processes. But see, e.g., Chap. 9 for a discussion on how a distributed account of verb meaning might be implemented.

conceptual representation in (8) above is not about the sentence (exclusively) but an encoding of the event of Brutus killing Ceasar at a certain point in time.[17]

This semantics tradition in linguistics, in particular in generative grammar, and much of what has followed, were attempts—explicit or not—to meet Quine's challenge according to whom "... pending a satisfactory explanation of the notion of meaning, linguists in semantic fields are in the situation of not knowing what they are talking about" (Quine 1953, p. 47). For him, "the idea of the mental counterpart of a linguistic form is worse than worthless for linguistic science" (p. 48). Consistent with this view, in subsequent work, he famously defended a behaviorist view of language acquisition and use (Quine 1960). However, much of the contemporary work in semantics (and on concepts) and related fields are aimed at characterizing the very idea that meaning *is* mentally represented and that the codes represented in the mind/brain serve for other cognitive processes, including but not exclusively, language.

The current work on conceptual structure born out of linguistics has been instigated mainly by Jackendoff (e.g., 1983, 1990) as well as by researchers working in generative semantics and cognitive linguistics, broadly speaking (see, e.g., McCawley 1972; Croft 2012, Chap. 5). This work amounts to a large constellation of ideas on what the conceptual level is, and how it interfaces with other systems, such as language, vision, and action. From Jackendoff's (1983) early conception, conceptual structure is seen as a central cognitive system, operating at the outputs of diverse input systems such as vision and language. In Jackendoff's theory, the algebraic language that operates on conceptual representations is a development of Fodor's (1975) *language of thought* hypothesis; except that, contra Fodor's perspective, the algebraic language of conceptual structure also serves for structuring concepts themselves from a set of innate primitives.

There are numerous views on the representation of verb meaning, more specifically, many seemingly compatible, sharing common properties as semantic primitives and variables standing for the linguistic arguments of a verb. In order to motivate our discussion—and some of the experiments reviewed below—in (13) we present a brief example of different notations used to convey verb meanings, according to three theories of verb representation (see Engelberg (2004, 2011a) for a review of several theories of verb meaning decomposition).[18]

(13) a. Conceptual Semantics (Jackendoff 1990)
dress: [CAUSE ([ ]$_i$, [GO ([ ]$_j$, [TO [IN [CLOTHING]]$_k$])])][19]
Mary$_i$ *dressed John(/herself)*$_j$

[17] For a more in-depth discussion on the representation and processing of events see Chap. 6, 8. For a perspective on the encoding of events by bilinguals, see Chap. 11.

[18] Also see Engelberg (2011b) for a comprehensive review of issues involved in lexical decomposition, most of which we cannot begin to discuss here.

[19] We present a simplified version of these templates. The conceptual templates in Jackendoff's theory (at least in his 1990 work) involve also several features, assuming that even CAUSE is decomposable or that it entails different events. They also contain an *action tier* specifying whether or not the object is *affected*. We will not get into these details here.

b. Lexical Conceptual Structure (Levin and Rappaport Hovav 2005)
break: [[*x* ACT] CAUSE [BECOME [*y* < *BROKEN* >]]
John$_x$ *broke the vase*$_y$
c. Lexical Decomposition Grammar (Wunderlich 1996)
dry: λxλyλe $^{<P,T>}$ CAUSE(x, BECOME(DRY(y))) (e)
Mary$_x$ *dried (off) her clothes*$_y$

These theories differ in significant ways (e.g., from the level of the purported representation, to the kinds of features that enter into the templates), but they are in general agreement about the very idea that surface verbs are represented more deeply (or at a "higher" level) by other, perhaps conceptually primitive, predicates. All the verbs in (13) and their corresponding decompositions are taken to be *causatives,* i.e., verbs denoting an agent's act which brings about a change of state in an entity or a patient. This form of "defining" causatives is, of course, inherent to theories that assume that the event/state that the verb labels is represented by certain regularities involving participants (namely, the fillers of arguments) and predicates making explicit what these participants do and what they cause. The very idea that causative verbs are represented by templates such as those in (13) came from generative-semantic analyses, which introduced semantic primitives into the tree-structural representations of sentences (e.g., McCawley 1972). According to this proposal, two main processes were involved in the transformation of the complex semantic expression involving predicates such as CAUSE and BECOME into a surface verb such as *close:* predicate raising and lexicalization. Transformations would successively raise predicates in the *deep* structure of a sentence and adjoin them next to the immediate higher ones, which would then be lexicalized into a verb such as *break* at surface structure. What is important to note regarding McCawley's proposal is that CAUSE and other predicates were taken to be semantic primitives that form complex structures underlying simple morphologically unmarked forms as *break*. The proposal that semantic primitives form the basic ingredients in the analysis of verb meaning was adopted by many semantic theories past and present, as can be seen in (13).

It is interesting to note that if verbs have a conceptual-structure representation such as those in (13), their representations encode, among other properties, information about the roles played by different arguments. For instance, if *break* is represented as in (13b), the role played by the argument (*x*) in the subject position is determined by a predicate *ACT*; similarly, *BECOME* represents the role played by the object (*y*) argument. Thus the mapping from syntax to conceptual-structure template can dispense with thematic roles if we encode verb meanings as templates.

The theories exemplified in (13) have many interesting characteristics. First, they account for our intuitions on the nature of the events denoted by the verb in terms of relations between participants and their roles in the events/states referred to by their carrier sentences. Second, the postulation of common predicates and similar template structures is taken into account for the categorization of "happenings," similar to that obtained for "things" (see Smith and Medin 1981); more specifically, this enables the conceptual system to represent classes for purportedly similar verb types based on the idea of shared constituents and structure the same way two concepts or categories

are supposed to share their sets of features or properties. By the same token, verb meanings represented as sets of primitives and their relations allow for a typology of events/states, thus enabling verb classifications within and across languages. In addition to some of these arguments for decompositions such as in (13), there is also some experimental evidence supporting this type of theoretical account of verb meaning. We discuss this evidence below.

Despite some of the advantages of verb decomposition theories, there have been many challenges to the views represented in (13). First, there are the arguments (and distributional evidence) against the synonymy of *kill* and *cause to die*. Second, there are many reasons for rejecting (and, apparently, lack of criterion for) the analytic/synthetic distinction upon which these theories rest. And finally, there is also some experimental evidence *against* the lexical decomposition hypothesis more generally, and against the decomposition of causatives, more specifically. We will address the first two challenges before discussing experimental work.

The arguments—and evidence—against the synonymy of *kill* and *cause to die* were first developed by Fodor (1970) and rely on distributional analyses of sentences containing the verb and its periphrastic counterpart. First, we should say that the assumption is that if the lexical item *kill* is semantically represented by something like CAUSE TO DIE (with a template such as (13b)), so is the overt linguistic expression *cause to die,* unless there are reasons for assuming that, e.g., *cause* does not mean CAUSE and *die* does not mean DIE. Leaving aside this eerie possibility, Fodor's arguments were based on the effects that replacing *kill* for *cause to die* have on the resulting semantic representation of sentences as well as on their entailments. Consider two of the arguments, one exemplified in (14a–d), and the other, in (15a, b).

(14) a. John caused Mary to die and it surprised me that he did so
b. John caused Mary to die and it surprised me that she did so
c. John killed Mary and it surprised me that he did so
d. *John killed Mary and it surprised me that she did so

(15) a. John caused Bill to die on Sunday by stabbing him on Saturday
b. *John killed Bill on Sunday by stabbing him on Saturday

As can be seen in (14), while *Mary* (*she*) is the subject of the elliptical verb in (14b), *Mary* cannot be the subject of the elliptical verb *kill* in (14d) showing that at least the surface predicates in (14) have different distributional properties and that the sentences are not synonymous. In (15a), the event that ultimately led to Bill's death on Sunday could have happened on Saturday. But *kill* in (15b) allows for only one adverb because *kill,* but not *cause to die*, points to one event. While it is clear that the surface predicates have different "behaviors," what is important for the present discussion is that their semantic translations carry different properties: If we were to translate *kill* for CAUSE TO DIE, the semantic representations of those sentences would inherit the anomalies that their linguistic equivalents carry. In essence, these examples show that to assume that one-predicate sentences can be represented by two-predicate structures leads to representations that do not preserve the meaning that the sentences are supposed to express.

Although these arguments have gone virtually unchallenged (see, e.g., Jackendoff 1990, 2002 for exceptions)[20], there is an even older reason to suspect of the lexical decomposition project. We invoked Quine's "challenge" to semantics only to motivate our presentation of the current view of semantics—the discipline—as part of the endeavor aiming to understand the ultimate mental representation codes carrying conceptual information. But if on matters of semantics *representation,* Quine's view has been to a large extent deflated, some remnants of his critique remain en vogue: the lack of a clear criterion for establishing an analytic/synthetic distinction (Quine 1951). Roughly speaking, lexical semantic theories such as the ones exemplified in (13), assume a form of representation (the templates with their predicates and features) that embody ideas born out of definitional theories (e.g., Katz 1972): they require a criterion for sorting out the features (or predicates) that are *necessary* from the ones that are contingent on experience. Not having such a criterion—and in fact not being able to sort out between necessary and contingent ones—leads to a semantic dead end. Not all of those who are committed to lexical decomposition neglect these difficulties, but surprisingly many do.

Among the psycholinguistic studies investigating the nature of verb-conceptual representation, some have supported the predicate decomposition theory (Gennari and Poeppel 2003; Gentner 1981; McKoon and Love 2011; McKoon and McFarland 2000, 2002) while some others have failed to find evidence for decomposition (e.g., de Almeida 1999a; Fodor et al. 1975, 1980; Kintsch 1974; Manouilidou and de Almeida 2013; Rayner and Duffy 1986; Thorndyke 1975). These studies vary widely in terms of methods, materials, and in particular the predictions on what should count as evidence for and against decomposition.

We start off with experiments supporting the long-held idea of decomposition. To our knowledge, the first experimental support for decompositional structures came from studies by Gentner (1975, 1981) which assumed that more complex structures were deemed more memorable because they had more components upon which to create meaningful connections (e.g., verbs such as *receive* and *borrow* are supposed to share constituents such as CAUSE and CHANGE OF POSSESSION). Although her study employed a small number of materials, and the results were based on a small proportion of recall errors committed by the subjects, greater confusions were obtained with items that supposedly share more constituents. Two more recent studies supporting the decompositional hypothesis are also of note here. In one (McKoon and McFarland 2000), participants were presented with two types of change-of-state

[20] Although we cannot address all arguments posed by Jackendoff (e.g., 1990, 2002) for the decomposition of lexical causatives (or more properly *against* the view that lexical concepts *do not* decompose), it is important to note that Jackendoff assumes that the best course for semantics (or the study of conceptual structure) is to rely on the ample analytic possibilities that decomposition affords, for decomposition "... is a richly textured system whose subtleties we are only beginning to appreciate (...). It does remain to be seen whether all this richness eventually boils down to a system built from primitives, or if not, what alternative there may be. And it does remain to be seen whether lexical meaning can be exhaustively constituted by the techniques discussed here" (Jackendoff 2002, p. 377).

sentences, denoting an externally caused change-of-state event as in (16a), and an internally caused change-of-state, as in (17a) (semantic templates such as (16b) and (17b) represent their analyses). They found that the more complex type of sentence, (16a), took longer to accept than the simplex type, (17a).

(16) a. The cement crumbled
b. [[*x* ACT] CAUSE [*y* BECOME < *crumbled* >]]
(17) a. The potatoes rotted
b. [*x* BECOME < *rot* >]

It is important to note that these two types of verbs are usually represented by different *argument structures/transitivity properties*; and they also differ with regard to semantic properties: e.g., while many things *crumble,* only a few things *rot* (Levin and Rappaport Hovav 2005).[21] Thus, it is possible that differences in response times between these two conditions reflect other aspects of the verbs' content rather than their templates.

Another study supporting decomposition (Gennari and Poeppel 2003) found similar effects of template complexity: sentences with eventive verbs such as (18a) took longer to read (self-paced) at the verb position than sentences with stative verbs such as (19a), supposedly because these constructions are represented by templates such as those in (18b) and (19b) (based on their analyses/notation).

(18) a. The young boy bullied his parents
b. [x CAUSE [y BECOME < *bullied* >]]
(19) a. The young boy adored his parents
b. [*x adore y*]

With regard to evidence against decomposition, although there have been a few other studies (as early as Kintsch's 1974), perhaps the most persuasive was by Fodor et al. (1980) who employed a variety of sentence types. Relevant to the present discussion is their contrast between lexical causatives (e.g., *close*) and other verb types deemed semantically simplex (e.g., *sell*), as in (20).

(20) a. Despite protests from the manager, the owner closed the theater
b. Despite protests from the manager, the owner sold the theater

In one of their experiments, Fodor et al. (1980) employed a related-intuitions task in which subjects had to judge how closely related the main arguments of the verb (e.g., *owner* and *theater*) were in the sentence. The task is supposed to capture the underlying semantic representation of the sentence. Under the decomposition hypothesis,

[21] As we briefly mentioned above (fn. 9), Putnam (1975) argued against meaning representation—at least against definitions—mostly because he assumed correctly that the definition of natural kind terms (*gold, tiger*) could only be given in scientific terms (viz., the tiger DNA), thus definitions could not be the representations upon which we rely when we entertain the meaning of such terms. We mention this motivated by the puzzle of the internally/externally caused distinction, which must rest on a mentally encoded knowledge of how molecules of potatoes and cement might behave upon rotting or crumbling, respectively.

owner and *theater* should be judged less related in the causative (20a) sentence than in the simple transitive case (20b). This is because there is supposed to be a "shift" in the predicate-argument relations if indeed the surface *close* is represented as something like [[*x* ACT] CAUSE [*y* BECOME < *CLOSED* >]]: namely, *x* becomes the "agent" of the causative predicate, while *y* becomes the thing undergoing a change of state. Fodor et al. found no difference between (20a) and (20b), while showing that the technique was sensitive to underlying semantic relations, using a control experiment. This effect was replicated by de Almeida (1999a) using a larger set of sentences than Fodor et al.'s and also employing the same related intuitions paradigm as well as different response–time techniques.

Experimental studies investigating the predicate decomposition hypothesis are rather few compared to the number of studies investigating argument structure and thematic roles. We do not think that this discrepancy is because most people stand against decomposition. On the contrary, it is possible that the paucity of experimental studies in this area reflect a tacit understanding—if not a general consensus—that decompositions are the standard or, as Jackendoff (2002) suggested, that lexical decompositions represent a more fertile ground for making progress in semantic/conceptual representation. It could also be that, similar to the psychological study of concepts and categorization, most researchers believe that decomposition is the *only* way to encode the meanings of verbs, or the only way to capture generalizations about verb classes as well as linguistic properties affecting the linguistic behavior of predicates (the linguistically active aspects of meaning). On the methodological side, it also be pointed out that experimental designs employed in the investigation of verb decomposition (or lack thereof) also differ substantially: Studies supporting decomposition (see above) have in general employed simple designs (e.g., simple vs. complex templates), which of course begs the question of the outcome of the studies, had differences between the two conditions been null. On the other side of the spectrum, experiments that have failed to find support for decomposition have usually employed more experimental conditions—the ones comparing the variable of interest (hypothetically simple vs. complex predicates) in addition to conditions designed to show that complexity effects would have been found in the variables of interest had they existed—i.e., that null effects are not due to methodological confounds.

While these considerations are important in the evaluation of the theories and experimental findings on both sides, there is yet a question of alternatives to verb decomposition. Perhaps one such alternative—adopted by few but perhaps one that appears to be equally powerful in terms of accounting for a wide range of phenomena that decompositional theories appear to account for—is what has been called "meaning postulates." This approach, inspired in Carnap (1956) and later supported by diverse theoretical and empirical works (e.g., de Almeida 1999a, b; Fodor et al. 1975; Fodor 1975; Partee 1995), appears to have some of the advantages of decomposition without some of its potential pitfalls. Crucial to this approach is its potential for accounting for the *entailments* between causatives and change-of-state events as well as relations between (verb) concepts belonging to different conceptual classes without committing to the conceptual constituency typical of semantic templates.

That is, the sets of entailments or inferences that a predicate (or other concept) triggers are not *analytic* entailments but constitute (nonlogical) inferential relations. This is not simply a notational variant of predicate decompositions because, contrary to templates, these entailments are not obtained by *necessity* as the constituents of templates are.

As we remarked in the previous sections, an understanding of conceptual structures should come from the interplay between diverse theoretical and experimental approaches. It is from this methodological stance typical of cognitive science—rather than from a commitment to the "richness" of decompositions—that a better understanding of verb semantic/conceptual phenomena might come.

1.6 Overview of Chapters

The chapters constituting the present volume address some of the above outlined issues but also go way beyond, either by contributing new theoretical insights (Chaps. 2, 3, 5) or by providing theoretical and experimental evidence from sentence processing (Chaps. 4, 8, 10), patient studies (Chap. 7), neuroimaging studies (Chaps. 6, 9), bilingualism (Chap. 11), as well as acquisition (Chaps. 12, 13). We present the chapters here by "method" but have organized them in the volume by proximity of topic, aware that no linear order would do justice to their intricacies.

Bill Croft's chapter proposes an analysis of event lexicalization and argument realization within the framework of force dynamics. He argues that the contributions of causal (force-dynamic) and aspectual structure can be most clearly identified by using a representation of event structure that includes both causal and aspectual structure but clearly distinguishes the two. The chapter also introduces the category of *directed change*, an aspectual category that, according to Croft, appears to play the most important role in understanding event lexicalization. Brendan Gillon focuses on the optionality of some verb complements and extends his proposal to adjectives. After providing a typology of intransitives, Gillon argues that optionally transitive verbs should not be taken for *ambiguous verbs* as previous research has considered them to be. Rather, he develops his account considering optionally transitive verbs unambiguous. Paul Pietroski, on the other hand, using a more philosophical approach stemming from formal semantics sees verbs as instructions to fetch monadic concepts which can be conjoined with others for composition. This perspective leads to a nonstandard conception of how words and the process of lexicalization are related to human thought and communication. It also helps make sense of some otherwise puzzling phenomena which suggest that lexical items do not themselves have fixed arguments. The chapter concludes by locating the specific proposal in the context of Chomsky's (1986, 1995) conception of distinctively human languages as biologically instantiated procedures, I-languages, whose expressions make contact with other cognitive systems.

1.6.1 On-Line Processing

Several chapters contribute not only experimental evidence but also theoretical analyses regarding aspect and event structure (Chap. 8), thematic roles (Chap. 4), grammar and semantic processing resources (Chap. 10). Matt Husband and Linnaea Stockall present a review of linguistic aspect from two perspectives: linguistic theory and on-line language comprehension. They touch upon issues related to event comprehension and the syntax–semantic interface. Their experiments provide a detailed look at the time course of aspectual interpretation and the processing of compositional structures more generally. Results argue for incremental commitment to aspectual interpretation, placing the commitment point for telicity at the VP, which is the first point when all the information needed to construct an aspectual interpretation has been provided to the system (i.e., both the verb and the internal argument). Gail Mauner's chapter also contributes data from processing about verb participants. The studies which she reports on (employing self-paced reading and visual world paradigms) indicate that whether participant role information is used predictively or instead is used later in the course of understanding a sentence depends upon constraints from both the linguistic and real-world contextual environments. Thus, while participant roles are rapidly activated upon verb recognition, whether participant role information is used anticipatorily depends in part on the availability of processing resources, which can be modulated by, among other things, referential contexts. Jean-Pierre Koenig and colleagues addressed the question of what causes the difference in the kind and amount of information used by the human parser and the human "grammar maker." They report on some computational models of on-line reading experiments which suggest that a distinct and much larger kind of event knowledge is used by the human parser. They propose an explanation for the difference in the use of event knowledge. Specifically, Koenig et al. conclude that grammars and parsers use different kinds of event knowledge because the tasks that listeners and grammar learners must perform are quite distinct.

1.6.2 Clinical, Electrophysiological, and Neuroimaging Studies

The study by Bastiaanse and Platonov involving data from aphasia brings evidence regarding the interaction between aspect and telicity. The authors contribute evidence from agrammatic aphasia in Russian-speaking individuals trying to delineate the observed verb deficit in agrammatic aphasia crosslinguistically. Results of a sentence–picture matching task support the predictions made by the *Aspect Assignment Model* which relates the observed difficulties with argument structure to difficulties in time reference, highlighting the role of aspectual selection.

Telicity (Chap. 6) and verb classes (Chap. 9) are the issues under investigation by two electrophysiological and neuroimaging chapters. Evie Malaia and colleagues focus on another semantic feature of verbs—*telicity*. The authors present electrophysiological and neuroimaging data on the processing of telic versus atelic verbs

in spoken American English as well as in American and Croatian sign language. Combined results from both experiments point to early interaction of syntax and semantics in human languages, and suggest telicity correlates with neural resources used for language processing. David Kemmerer's chapter focuses on the idiosyncratic root-level semantic features of action verbs (*running, hitting, cutting, putting, throwing* verbs). His main goal is to show how recent developments in cognitive neuroscience have begun to illuminate the representational character of these aspects of verb meaning. By discussing fMRI, Kemmerer explores specific hypotheses within the Embodied Cognition Framework, that is, whether the visual motion features of action verbs and the motor features of action verbs depend on different cortical areas. Results from these studies suggest that distinguishing between, say, *running* verbs (e.g., *stroll, jog, run, sprint,* etc.) requires access to experience-based knowledge stored in modality-specific cortical areas. These areas partially overlap with those involved in perceiving and producing the designated types of actions.

1.6.3 Bilingualism and Acquisition

Finally, one chapter contributes new data from verb representation and processing in bilinguals, and two chapters approach the process of acquiring verbs. Vicky Lai and Bhuvana Narasimhan investigated how Spanish–English bilinguals represent and process path and manner of motion, on the assumption that different languages might encode and express these properties differently thus affecting how they are used in understanding/describing events. They provide evidence for the influence of verb-specific representations on "thinking-for-speaking." Sudha Arunachalam's chapter explores the persistent question of the relation between lexical (semantics) and syntactic structure in relation to acquisition. Arunachalam shows that any of the available theories can be more or less equally compatible with the acquisition data—this is to some extent expected as experiments are primarily designed following certain theoretical assumptions. In some cases, but not all, the same results can be made compatible with different theories, since they present alternative points of view. The challenging data then are those that are compatible with one kind of analysis but problematic for others. The study by Alexandra Marquis and Rushen Shi investigated the question of verb morphology and acquisition. The authors, who conducted their experiments in French-speaking children, argue for a decompositional view of infants' morphological development. In particular, they suggest that infants at the initial learning stage parse verb stems and affixes without relying on semantics but on the basis of high-token frequency of affixes and high-type frequency of stems (i.e., regular morphological operations).

While all these studies rely on linguistic-theoretical claims to motivate their theoretical or empirical investigations, they all employ multiple methods and draw from different disciplines constitutive of cognitive science. It is this interdisciplinary endeavor that might propel a shift—if not already happening—in the investigation of linguistic constructs as well as on the nature of the interface between linguistic and conceptual representations.

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