A "Distinctive" Logic for Ontologies and Semantic Search Engines

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Abstract We present here the theoretical basis of the "Semantic Prompter Engine", a hypothetical program which, when applied to popular online search engines, enriches them with a semantics. Other applications lie in the field of translation and de/encoders. The query language of the "prompter" (realized through synonymy and new relationships) and the construction of its related ontologies (structured universes of discourse) are based on the "distinctive predicate calculus". This logic, designed by the author, is close to natural language and common intuition and is easily represented by means of Venn diagrams or numbered segments. It is a blend of past (quantification of the predicate, syllogistic, Vasil'ev's logic of notions) and contemporary (fuzzy logic, N-oppositional theory) logical systems. With this approach it is possible to build a bridge between artificial (machine) and natural (human or animal) representations of concepts and reality.

1 Introduction

The rock on which many online search procedures founder, with all attendant losses of time and information, is formed by the absence of "semantic" search machines operating on the basis of semantic similarities of the terms involved rather than on the basis of formal (phonological or spelling) similarities. For example, the word form "ship" is more similar to the form "slip" than to "vessel". Take the case of an official site of a public body. A citizen needs information about certain provisions and places a request for "administrative measures". If his search leads him to, say, "ordinance" or "specify", the poor citizen is not helped much, frustrating the efforts made by the public body to make the procedures simpler and more transparent.

Some progress has been made. Some search engines are now beginning to suggest synonyms, hyponyms or hyperonyms. However, the attempts have remained incoherent. Synonymy is understood in too vague a sense: if "horse" is

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synonymous with “equine”, and even a zebra is called equine, are “horse” and “zebra” synonyms?

The difficulty lies in the development of semantics for the search engines. This semantics requires the setting up of an “ontology”—an organic network of semantic relations between words—in a logically coherent way, not, for example, on a purely statistical basis but on a formally checkable axiomatic-deductive basis (see [1]). This engine should, moreover, be economical and synthetic but maximally extended and “friendly” not only for the computer scientists who created the ontology but also, and especially, for the users of the search machine. If realized, a semantic search engine would certainly have vast application possibilities in many fields of knowledge, such as dictionaries, translators, library science (indexing systems) and thesaurus making.

To solve this type of problem, we propose the creation of a database program that can do the work of a semantic search engine, the Semantic Prompter Engine. The guidelines for the construction of the ontological database—a structured archiving system of notions, terms and data—will have to come from the definitions of notions such as synonym or antonym, based on a logico-linguistic approach closely following natural language and natural intuition. Querying the system, one will receive suggestions for further searches to be forwarded to the traditional engines. The output of the combined two systems will be equivalent to the output of a semantic search engine.

2 Synonymy and Distinctive Logic

The point of departure of our entire construction consists in the conception of a word/concept/term as a name for a nonnull aggregate or set of listable characteristics/qualities that are sufficient for a differentiation from other words. This nonnull aggregate is, moreover, distinct from a “universe of discourse” containing all possible characteristics of all concepts.

The setting off of the elements of two such “word aggregates” against each other will establish the semantic relations between the two words concerned,[1] showing whether they are fully or partially or not at all interchangeable, or whether they are similar or opposed. Or else, by choosing a term and a relational type, we can find out which other terms satisfy the relation. As such logics come to fruition, we will see to what extent we will be able to refine these semantico-linguistic considerations. For pragmatic and computational purposes, this approach to concepts is reductionist. What we wish to develop amounts, in fact, to a “calculus ratiocinator” that lends itself to applications such as search engines, dictionaries, catalogs or

[1]Such an operation uses an intensional definition of the concepts involved. This might look like a reversal to efforts at developing an intensional predicate calculus, frequently witnessed in the history of logic but always without success. Here, however, the qualities/characteristics are treated as mere elements and the concepts as sets; hence, the resulting calculus is extensional.

similar structures. It is obvious that we are thinking of a small-scale "ars characteristica universalis" as envisaged by Gottfried Wilhelm Leibniz.

At this point we must clarify a fundamental aspect of the extensions of sets and those of concepts. In our perspective, a concept/word/term is defined by a set whose elements are its (essential) attributes or features. A proper subset will thus contain a smaller number of those very features. As one goes from a set to one of its proper subsets, certain features will get lost, which means a *generalization* or *abstraction* of the initial set. Such a restriction of features will correspond to an increase of referential extensions. For example, the set of characteristics associated with the concept "lion", such as having retractable nails, feral canines and suckling their young, corresponds extensionally to all lions. The subset of these features containing the feature "suckling their young", corresponding to the term "mammal", has a larger extension comprising not only lions but also, for example, whales or elephants. The inverse procedure, the passing from a set to a superset, represents a specialization or particularization. Therefore, when one engages in the development of concrete applications, such as dictionaries, ontologies or databases, it will be necessary to specify whether the definitions or relations defined are to be interpreted at a connotational-intensional or a denotational-extensional level. And one will have to be consistent in this respect, on pains of a total collapse of the system. For example, when it is said that the step from mammal to vertebrate is restrictive, one is at the level of features, whereas when it is said that this step is expansive, one is at the level of extensional referents, that is, of individual entities carrying the features at issue.

Thus, taking an ordered pair of sets ba, we can use categorical predications to express the various possible cases. That is, we have:

every b is a = Aba universal affirmative (inclusion/to be) (e.g. the tables are furniture)
no b is a = Eba universal negative (denial/to be not) (e.g. the tables are not chairs)
only some b is a = Yba *distinctive* or *partial* or *exclusive* particular (intersection/to be in part = to be fuzzy) (e.g. only some tables are wooden objects).

The quantifier Y represents the intuitive natural language *some* and not the existential *some* of classical predicate logic. The latter means "at least some, perhaps all", not excluding the universal quantifier, whereas the former stands for "only some" or "at least one but not all", "all but for some", "neither all nor no".[2]

[2]The adjective "distinctive" alludes to the necessity to distinguish, in the subject of the particular, those elements for which the predicate delivers truth from those for which it does not. Partial *some* may be considered to be the logical product of the classical affirmative particular Iba (at least some a is b) and the classical negative particular Oba (at least some a is not b). Elsewhere [2] I have presented the "distinctive" predicate calculus. The partial one has been studied by many logicians, amongst whom I can mention N. A. Vasil'ev (1880–1940), A. Sesmat (1885–1957) and R. Blanché (1898–1975); see [2–9, 12, 27, 28]. The concept of a partial (ἐν μέρει) quantifier goes back to Aristotle [10] himself, even though he eventually chose for the rival concept of existential particular, thus conditioning logical research for many centuries to follow.

From a set-theoretical and diagrammatical point of view (Euler, Gergonne, Venn), there are five distinct possible cases of possible relations between two sets:

I. Identity or equivalence
II. Proper inclusion of the first in the second
III. Proper inclusion of the second in the first
IV. Mutual proper (nonnull and nonexhaustive) intersection
V. Exclusion or incompatibility.

As shown in Fig. 1, owing to the three categoricals, we obtain an exhaustive tripartition of the five cases, something which would not be possible using the traditional partials (for example, the cases I or II can validate Aba as well as Iba). At the same time, there is a gain in economy.

From the classical point of view, the three categoricals are mutually *contrary*. Yet in the wake of certain observations made by Aristotle (Metaphysics X.4, 1055a19–23), we prefer to reserve this term (Greek: ἐνάντιαι) for the two universals. The term *intermediate* (μεταξύ, μέσον) seems to be more suitable for the "partial". The classic *square of oppositions* is thus replaced with the distinctive segment (see Fig. 1b, c). Figure 2 shows that the redundancy of the square of opposition (a) may be absorbed into the distinctive segment (b). The "U" quantifier means "all or no", and it is the negation of the "Y" quantifier.

On these bases we have built the Distinctive Predicate Calculus (DPC) (see [2]). This system reflects the need to follow as closely as possible natural language usage without any loss of logical rigor. And from a semantic point of view, it enables us to express intermediate or "fuzzy" concepts, essential for a proper account of linguistic communication, which is what our project is about. As shown elsewhere [2], it is in fact possible to interpret the distinctive system metalogically in terms of nonstandard logics. For example, a sentence like "Only some x is P" (where "some x" stands for a set of individuals and *P* for a predicate) can also be expressed as "It is

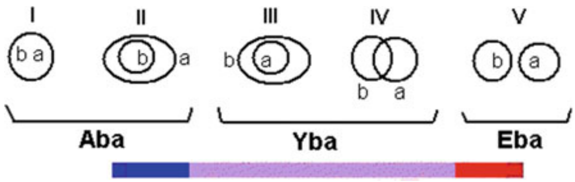


Fig. 1 Tripartition of the five cases

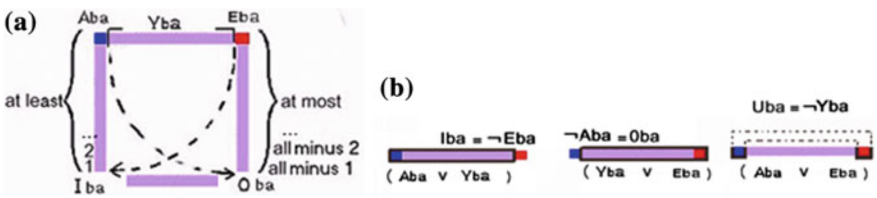


Fig. 2 Square of opposition and distintive segment

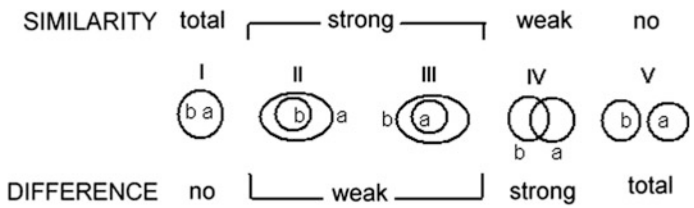


Fig. 3 Scales of similarity and difference

only partially true that the x's are P". In particular, the five cases lend logical support to the common notions of *similarity* (*affinity*) and *difference*. These may form two inversely proportional scales in the sense that the more two terms are similar, the less they are opposed, and vice versa. Using the five cases, we could thus establish the correspondences laid out in Fig. 3.

In [5] the different types or degrees of opposition[3] became a new logical-geometric theory: the *N-oppositional theory*, probably strongly connected with our DPC: see [12].

Further refinements of the analysis presented here can be realized by means of a predicate calculus with numerical quantifiers, sketched but not fully elaborated by the author, which may possibly bridge the gap between classical and fuzzy logics [2, 13].

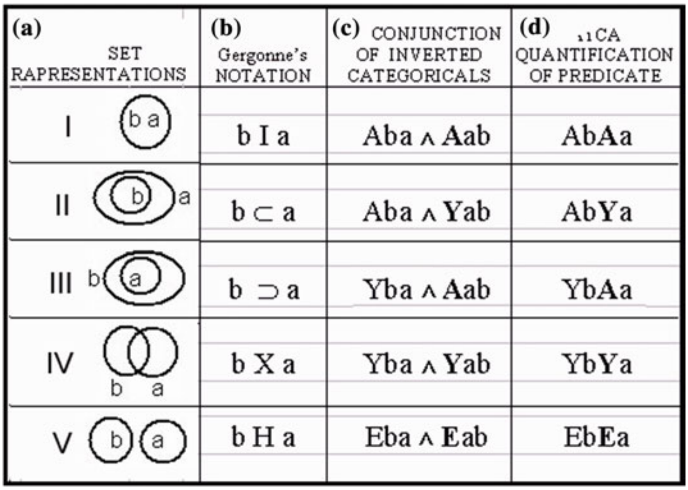
We are thus in a position to trace a linguistic-semantic parallel (in boldface) of ordinary language usage (in italics) of the five logical relations:

I. **Synonymous** or *Equivalent*
II. **Hyponymous** or *Restriction* of the first in the second
III. **Hyperonymous** or *Expansion* of the first in the second
IV. **Meronymous "sui generis"** or *Connected*
V. **Antonymous (or Contrary) "sui generis"** or *Disconnected.*

The cases I, II and III are commonly known in linguistics and semantics. However, in these disciplines, the notions of *meronymy* (from the Greek word *méros* "part") and *antonymy* have a wider and vaguer meaning than is intended here. In particular, for *meronymy "sui generis"* of case IV, there is a special restriction: b is only partly a, but, symmetrically, a is only partly b—that is, we speak of mutual partial intersection, whereas in the literature the expression *b is meronymous to a* does not exclude the asymmetrical case II.

At this point it is necessary to establish a complete logical interpretation of these semantic/linguistic concepts.

[3]About this theme see [6, 7, 11].



(a) SET RAPRESENTATIONS	(b) Gergonne's NOTATION	(c) CONJUNCTION OF INVERTED CATEGORICALS	(d) ıCA QUANTIFICATION OF PREDICATE
I	b I a	Aba ∧ Aab	AbAa
II	b ⊂ a	Aba ∧ Yab	AbYa
III	b ⊃ a	Yba ∧ Aab	YbAa
IV	b X a	Yba ∧ Yab	YbYa
V	b H a	Eba ∧ Eab	EbEa

Fig. 4 Gergonne's five cases and their interpretations

It is to Joseph Diez Gergonne (1771–1859), in his study of 1816, that we owe the first creation of five distinct logical symbols for each of the five relations[4] (see column b of Fig. 4). From these five relations Gergonne distilled the first valid logical calculus exceeding the expressive and deductive power of classical syllogistic logic (see [14]). The only problem is that this symbolism takes us farther away from ordinary linguistic usage.

At the same time, as theorists of the "quantification of the predicate" (QP)[5] found out, the three categoricals are insufficient to pick out uniquely the five situation classes to which they can refer. For example, if it is true to say "All boys got promoted" for a particular school, this does not exclude the converse affirmation "All those who got promoted were boys" (case I), but neither does it exclude "Only some of those who got promoted were boys" (case II). Even so, in order to describe uniquely each of the five cases in predicative form, we can add, by means of the conjunction *and*, to the three predications over the pair *ba* those generated by the inverted predicative pair *ab* (see column c in Fig. 4).

Case A If every b is a, there are two possibilities: every a is also b (case I), or only some a is b (case II).

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[4]He provided a more determined representation than the diagrams produced by men like Wilhelm Gottfried Leibniz (1646–1716), Johann Heinrich Lambert (1728–1777) or Leonard Euler (1707–1783).

[5]The first in modern history to design a QP system was Gottfried Ploucquet (1716–1790) in his study of 1763. Other QP logicians were Georg Johann von Holland (1742–1784), George Bentham (1800–1884), William Hamilton (1788–1856) and Charles Earl Stanhope (1753–1816). See [15, 16, 29].

Case Y If only some b is a, there are two possibilities: every a is b (case III) or only some a is b (case IV).
Case E If no b is a, then no a is b (case V).

A more synthetic, though also less grammatical, way to express such conjunctions is that of quantification of the predicate[6], as in column d of Fig. 4.

3 The Seven Relations

What is typical and relatively new in our approach is the simultaneous comparison not only of two sets but also of their two complementary sets. By definition, the latter collect the features that are present in the universe but were left out of consideration for the former. This way, the comparison of two terms will implicitly clarify the context of the universe of discourse. There exists, indeed, a more complete way of dealing with concepts, whereby the negation plays a role, as in *not-b*, shown in yellow in Fig. 5.

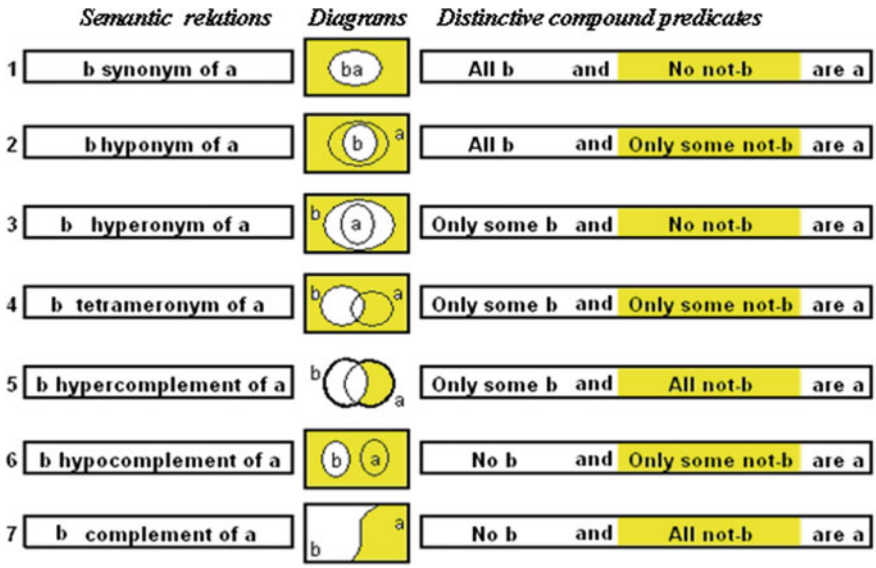


Fig. 5 The seven relations

[6]To "quantify the predicate" we use the quantifier of the second categorical, which we have defined in terms of the inverted pair; E.g. case III can be read "only some b are all a". Various logicians have followed this path, committing various errors.

I 7 Cases	II Explicit forms	III Equivalent forms	IV D7c	V Tri-relational	VI Iconic
1	Aba ∧ Eb'a	Aba ∧ Ab'a'	AbaA,,	b Ọ̇ a	**b Ọ̇ a**
2	Aba ∧ Yb'a	Aba ∧ Yb'a'	AbaY,,	b))a	**b))a**
3	Yba ∧ Eb'a	Ab'a' ∧ Yba	Ab'a'Y,,	b'))a'	**b((a**
4	Yba ∧ Yb'a	Yba ∧ Yb'a'	YbaY,,	b)( )(a	**b)( )(a**
5	Yba ∧ Ab'a	Ab'a ∧ Yba'	Ab'aY,,	b'))a	**b( )a**
6	Eba ∧ Yb'a	Aba' ∧ Yb'a	Aba'Y,,	b)) a'	**b) (a**
7	Eba ∧ Ab'a	Aba' ∧ Ab'a	Aba'A,,	b Ọ̇ a'	**bʕa**

Fig. 6 Equivalent interpretations of the seven cases

The possible diagrammatic representations are then seven in number[7].

In the diagrams, the surrounding square represents the universe of discourse (UD). Only in case 5 is this missing, as the union of the two sets *a* and *b* form the UD.

We still have the possibility to characterize each case uniquely by conjoining two categoricals, but now we need a second conjunct that is distinctive with the same subject (and possibly also the same predicate) as the first, but in the negative. In Fig. 6, column II we have the synthetic formulae expressing the double predications of Fig. 5. Column III of Fig. 6 provides equivalent expressions not using the quantifier E. Column IV simplifies, with a view to deductive rules, the preceding column, implying the second pair of variables (which are the negation of the first). The distinctive predicate calculus **D7c**, which can be developed on this basis, is the subject of another study by the present author [2].

In the linguistic-semantic literature, as well as in dictionaries of synonyms and contraries, most of the terminology used in Fig. 4 is known and used. By analogy, we may complete this casuistry by coining new expressions such as *tetrameronymous* for (4), or *hypercomplement* for (5) or *hypocomplement* for (6)[8]. Instead, however, we will use expressions taken from more ordinary language, which are much more appropriate for our applicational purposes. Thus, a given term, with regard to a second, can be (from an extensional point of view and within a given UD):

[7]The seven cases remain when all cases involving the null set or sets coinciding with the universe of discourse, in pure combinatory logic, are discarded (see [17], Chap. 3, Sect. 27). Obviously, given the cases 2, 4 and 5, the set a must contain at least two members and likewise for b in the cases 3, 4 and 5. Augustus de Morgan [18] came to the seven cases on the basis of a more complex calculus. Further elements of our system converge on De Morgan syllogistic systems, from the concept of universe of discourse to the use of parentheses. Recently, Pieter Seuren [9] came to the seven cases (Chap. 8), on the basis of his theory of natural logic.

[8]In some particular contexts, some dictionaries of synonyms and antonyms call case 6 “cohyponymous”, which would be an invitation to call, by analogy, case 5 “cohyperonymous”. The latter, however, is found nowhere.

1. An **equivalent** of the second. Ex.: UD = triangles, equilateral–equiangular; or: UD = animals, donkeys–asses;
2. A **restriction** of the second. Ex.: UD = triangles, equilateral–isosceles; or: UD = animals, donkeys–equines;
3. An **expansion** of the second. Ex.: UD = quadrilaterals, rectangles–squares; or: UD = animals, equines–horses;
4. A **limited connection** of the second. Ex.: UD = quadrilaterals, rhombi–rectangles; or: UD = animals, oviparous–mammal (platypuses are both, protozoa are neither) or: UD = horses, females–foals; all four combinations are possible;
5. An **integrative connection** of the second. Ex.: UD = polygons, polygons with fewer than five edges–polygons with more than three edges; or: UD = hot-blooded animals, oviparous–mammals;
6. A **limited disconnection** of the second. Ex.: UD = polygons, triangles–squares; or: UD = African equines, donkeys–zebras;
7. An **integrative disconnection** of the second. Ex.: UD = triangles, isosceles–scalene; or: UD = autochthonous European equines, horses–donkeys.

One should consider the relevance of the specifications *integrative* and *limited*, meaning, respectively, that the two sets do or do not exhaust the universe of discourse, and thus permitting a distinction of the cases 5 and 6 from the cases 4 and 7, respectively.

A Boolean interpretation of the seven cases is illustrated below:

1. $$[(b \cap a) \neq \varnothing] * \left[(b \cap a') = \varnothing\right] * \left[(b' \cap a) = \varnothing\right] * \left[(b' \cap a') \neq \varnothing\right] \text{ that is } b = a$$

2. $$[(b \cap a) \neq \varnothing] * \left[(b \cap a') = \varnothing\right] * \left[(b' \cap a) \neq \varnothing\right] * \left[(b' \cap a') \neq \varnothing\right] \text{ that is } b \subset a$$

3. $$[(b \cap a) \neq \varnothing] * \left[(b \cap a') \neq \varnothing\right] * \left[(b' \cap a) = \varnothing\right] * \left[(b' \cap a') \neq \varnothing\right] \text{ that is } b \supset a$$

4. $$[(b \cap a) \neq \varnothing] * \left[(b \cap a') \neq \varnothing\right] * \left[(b' \cap a) \neq \varnothing\right] * \left[(b' \cap a') \neq \varnothing\right]$$

5. $$[(b \cap a) \neq \varnothing] * \left[(b \cap a') \neq \varnothing\right] * \left[(b' \cap a) \neq \varnothing\right] * \left[(b' \cap a') = \varnothing\right] \text{ that is } b \supset a'$$

6. $$[(b \cap a) = \varnothing] * \left[(b \cap a') \neq \varnothing\right] * \left[(b' \cap a) \neq \varnothing\right] * \left[(b' \cap a') \neq \varnothing\right] \text{ that is } b \subset a'$$

7. $$[(b \cap a) = \varnothing] * \left[(b \cap a') \neq \varnothing\right] * \left[(b' \cap a) \neq \varnothing\right] * \left[(b' \cap a') \neq \varnothing\right] \text{ that is } b = a'$$

For all cases, the condition $[b \neq \varnothing] * [b' \neq \varnothing] * [a \neq \varnothing] * [a' \neq \varnothing]$ applies.

4 Semantic Prompter Engine

The Semantic Prompter Engine or SEM.PR.E (Italian *sempre* means "forever") that I propose [27] is a *program/database* that can be realized by an informatics programmer supported by a precise *archiving method* and a specific *question-answer algorithm*, designed by the present author[9].

When some search engine delivers unsatisfying or dubious results on a given word, SEMPRE can be queried on this term. It can be queried, for example, with regard to the restrictions, limited connections, etc., or with regard to possible other terms validating totally, partially or not at all the relation with the given term, within the terms of a given UD. From a logical point of view, such queries correspond to the multiple request for the truth value resulting from the application of all possible categorical predicates to the term in question compared with other terms in the database, in combination with their negative counterparts. The subject class is definite—that is, without a quantifier—but the predication and the resulting truth value, as shown above, are definable on the grounds of the mere comparison of the features (attributes) of the two terms in question, whereby it is specified, if necessary, in terms of what UD the query is processed, with or without its complement. This comparison is carried out by means of the Boolean operators over feature sets. Once the answer list has been obtained, one will proceed to the selection of the new input term for the same search engine. The answers provide the *alternative terms* for new searches ordered by type (and relative grade) of similarity (or difference) according to the seven typologies (weak similarity in cases 4 or 5 and no similarity for 6 or 7)[10]. So we generate the *intermediate values* with regard to pure but flexible synonyms typical of human cognition and human language. The seven relations are expressible linguistically or iconically (the bracket notation of R7), as one wishes.

The user will thus not have to memorize or call up all correlated terms, at the risk of forgetting important ones, but will make his or her choice among the most promising options suggested, perhaps, if one wishes, till all options are exhausted. The combined action of the prompter and the traditional search engine amounts to that of a *semantic search engine* with minimal human intervention. It represents both a limit and the opportunity to direct the search, as well as the possibility to discover unforeseen affinities or new associations based on objective common characteristics of concepts mostly thought to be far removed from each other.

To avoid the risk of lists becoming too long, answers will be organized hierarchically according to the level of generality desired or specified in the query. If so wished, the answers can be indexed according to level (0 horse, 1 equine, 2 mammal …). A further option, meant to simplify the selection of alternative terms, may consist in combining the output with a database that reorders the output terms on the basis of frequency coefficients in the language or texts concerned.

[9]There is already a rough prototype (a "demo"), resulting from the collaboration of the present author with Daniele Ingrassia, informatics engineer (University of Palermo, Italy).

[10]The five cases of Gergonne mean the loss of the distinction between contraries and complements.

5 Database Implementation

A preliminary condition of the prompter is well-structured archiving of the terms, notions and data in the database. It will not be easy to find the right person or persons to do is job, as a combination of interdisciplinary competences is required that is hardly ever realized in one single person or even in two or three. On the one hand, the implementer must be competent in the relevant aspects of logic, linguistics and philosophy; on the other, competence is required in programming and information technology; and finally, expertise is needed in the specific terminology of the discipline (or text sample) involved, so that a beginning can be made with the testing of the machinery. Take, for example, a logician, a computer specialist and a pharmacologist. The first two will establish a friendly interface that will allow video technicians to carry out hierarchical insertion, according to precise rules, of all the terms in the pharmacologist's discipline. The resulting semantic network is called an "ontology". Each term will be provided with its own features under the supervision of an expert of the discipline involved in his or her language.

To disambiguate polysemic (or homographic) words, namely those that allow more than one meaning (e.g. "set" in mathematics or in tennis; "function" in mathematics or in religion) one can make use of indexes, and matrices have been tested in projects such as the lexical ontology named "WordNet" (see Fig. 7).

Some ontologies (semantic networks) such as WordNet have a big limitation in terms of the relations, observable on two levels:

1. The logical relations between any pair of terms are just attributable to the simple or double inclusion/implication; there are no relations of intersection or complementation (if they appear, they do not interact with the other relations);
2. The totality of nodes or vertexes (= word—term—set) of the structure constitutes a hierarchical scheme, with each term being such a parent (or predecessor)–son (or successor): the topological structure is a tree graph; there are no circuits, no cyclical arcs or network structure. If there are more trees, they are not connected with each other (see [19]).

Such a tree structure, with logical relations of implication/equivalence, is useful in the early stages of cataloging, structuring data and acquisition of concepts. The transitivity of implication and equivalence allows one to deduce automatically any hierarchical knowledge which was not explicit during the insertion.

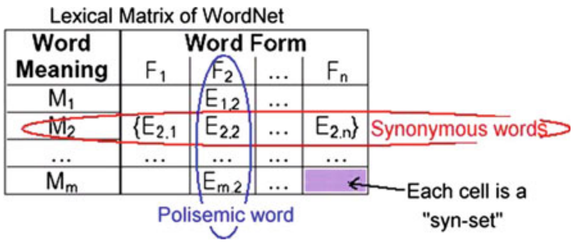


Fig. 7 A lexical matrix of WordNet

When we need to enrich the tree with new data, restructuring extension of the model, be neccessary. The tree becomes a network through the introduction of two new logical relations: intersection and complementation. In terms of natural language, they are similar to the concepts of "comparable/analogous/in-law" and "alternative/negative/outsider", respectively. These two relations together with simple/double inclusion constitute a powerful logical triad. It is formally solid in the classical bivalent logic, but also readable into fuzzy or trivalent logics.

The method for the construction of such a semantic (or ontological) network requires a category name for each node. There are two phases, both updatable:

(a) the tree (b) the creepers.

Phase a (inspired by Plato's method of *diaeresis* or analysis) allows one to *economize on time* and to avoid unnecessary repetitions in the data input, in that a feature (analytical key) inserted at any given node is inherited by all its dependent ramifications, all the way down to the terminal "leaves". In this phase, the model functions as a Porphyrian tree, as designed by Porphyry (233–305) or as contemporary cladistics (biological taxonomy) (see Fig. 8a). To enhance economy of use and avoid errors, the principle is to start from the most general or common categories among the concepts dealt with.

Phase b provides the opportunity to let other features "lean" on to the branches or to the final "leaves", thus fitting out each term with all its required essential features. As the creepers attach themselves to branches that may be quite distant from each other, we have the possibility to attach the same feature to leaves and branching nodes on different branches. Thus *Whale*, which, we assume, will be on the *Mammal* branch along with, say, *Kangaroo*, will share the feature *Aquatic* with *Shark*, which will be located on the *Fish* branch (see Fig. 8b).

There is obviously no pretence to render the metaphysical "essence" of things or thoughts. All we aim for is an appeal to pragmatic or conventional attitudes and beliefs: all that is meant with "ontology" is an underlying structuring in terms of a restricted "universe" for logical purposes. As a matter of principle, the interlaced network that comes into being via this method has no privileged "routes" and the subdivision into tree and creepers rests on an arbitrary choice made for the purpose of convenience, at both the insertion and the successive user stage.

To avoid ambiguities, the program must, in both phases, signal any possible inflow of data already present. In such a case, either the inflow is recognized as

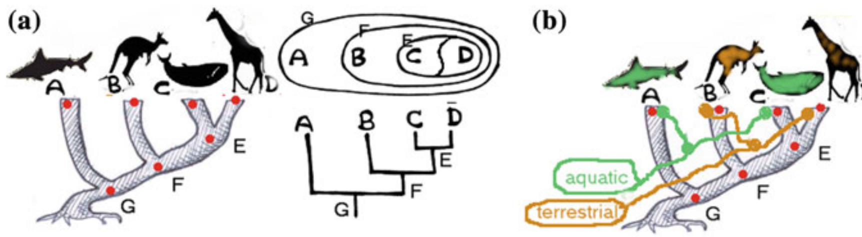


Fig. 8 A tree/creepers structure

being superfluous or the machine recognizes that it has made a "categorial" mistake, which can then be corrected at the highest hierarchical level so that corrections at lower levels are made automatically. The database will thus expand and update itself indefinitely, maintaining applicability in each phase. This allows it to integrate with other disciplines structured in analogous ways in other databases. The possibility of integrating a variety of disciplines will over time enhance the usage scope of the prompter, turning it into a continuously updatable and improvable encyclopedia.

6 Iconic Distinctive Calculus ID7

As a more iconic—that is, more visual and diagrammatic—alternative to the verbal-predicative system for the specific description of the seven cases, one may consider the iconic distinctive calculus ID7. Column VI in Fig. 6 shows a symbolic transposition of the seven topological situation classes. Symbols have been chosen (the brackets) that indicate, by their disposition and their direction, in an intuitively accessible way the extensional conditions of the terms to which they refer. Thus, the grapheme "))" evokes the situation in which the first set is an internal part of the second; ") (" stands for the situation in which two sets do not know each other but with something standing between them; in "( )" each set enters the other's territory, together occupying the entire UD; finally, ")( )(" creates not only a reciprocal territorial transgression but also a space not occupied by either.

Column III (Fig. 6) presents the translation from D7c expressions to a new iconic relational symbolism, through the equivalence based on this translation code (the dots stand for variables):

A..A becomes ọ̇ that means ***equals***

A..Y becomes)) that means ***enclosed in***

Y..Y becomes)( )(that means ***tetraconnects***

The *immediate inferences* are obtained by the simple rule of *mirror rotation* of the parentheses or other grapheme together with the inversion of the quality of the adjacent term. Depending on the pair in question, we thus have four equivalent versions of diagrams and notation. For example, b))a = b) (a' = b' ((a' = b'( )a (see Fig. 9).

The ọ̇ (*equals*) relation consists of two hemicycles, the right and the left ones, each of which can refer to a term: if only one part rotates around its upper extremity, it results in a sort of ⸢⸥ or mirror ⸣⸤ (*integrates*) relation; if they both rotate, the *equals* relation ọ̇ is restored. Instead, the rotation of the (*tetraconnects*) relation) ( )(is not affected by free changes in the quality of the terms (Fig. 10).

This way our (distinctive) complex predicates, or even De Morgan's [18], as well as immediate inference rules, find easy translation into diagrams (Fig. 11).

In Fig. 12 we can see the mediate deductions of this system.

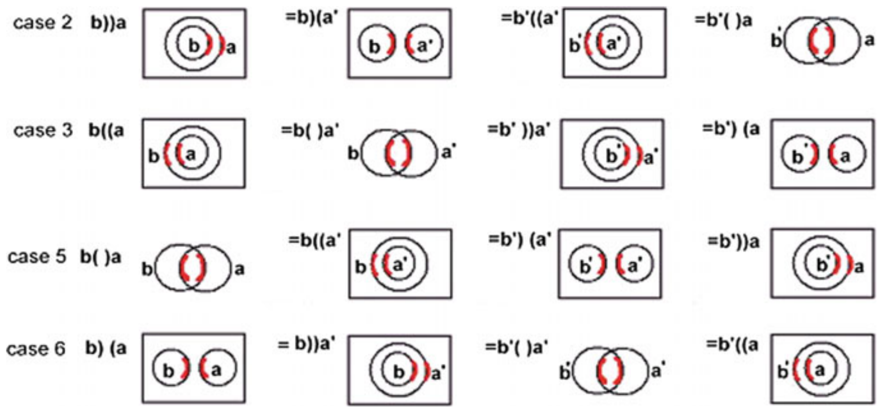


Fig. 9 Equivalent diagrams and notation of cases 2, 3, 5, 6

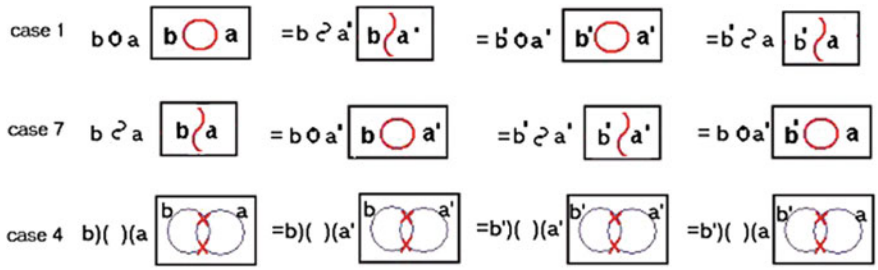


Fig. 10 Equivalent diagrams and notation of cases 1, 7, 4

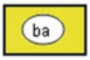
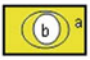
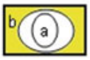
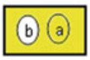
7 cases (b' is yellow)		Distinctive Predicate Calculus		De Morgan (1847)	
		Iconic	compound predicates	compound predicates	synthetic
1		bOa	Aba * Ab'a'	Aba * Ab'a'	D
2		b))a	Aba * Yb'a'	Aba * Ob'a'	D,
3		b((a	Yba * Ab'a'	Ab'a' * Oba	D'
4		b)()(a	Yba * Yb'a'	Oba * Ob'a' * Iba * Ib'a'	P
5		b()a	Yba' * Ab'a	Eb'a' * Iba	C'
6		b)(a	Aba' * Yb'a	Eba * Ib'a'	C,
7		bʔa	Aba' * Ab'a	Eba * Eb'a'	C

Fig. 11 Translation of the 7 cases in compound predicates (DPC/De Morgan)

		1	2	3	4	5	6	7
		b O a	b)) a	b((a	b)()(a	b( ) a	b) (a	b ( ) a
1	a O c	b O c	b)) c	b((c	b)()(c	b( ) c	b) (c	b ( ) c
2	a)) c	b)) c	b)) c	Ibc	Ycb	b ( ) c	Ib'c	b( ) c
3	a((c	b((c	Ib'c'	b((c	Yc'b	Ibc'	b) (c	b) (c
4	a)()(c	b)()(c	Yb'c	Ybc		Ybc	Yb'c	b)()(c
5	a ( ) c	b( ) c	Ib'c	b( ) c	Ycb	Ibc	b)) c	b)) c
6	a) (c	b) (c	b) (c	Ibc'	Yc'b	b((c	Ib'c'	b((c
7	a ( ) c	b ( ) c	b) (c	b( ) c	b)()(c	b((c	b)) c	b O c

Fig. 12 Table of mediate deductions of the iconic system

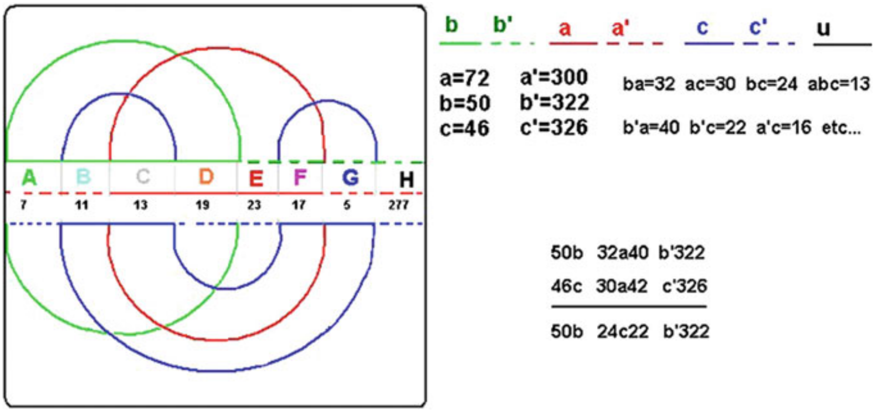


Fig. 13 A numerical diagram

A numerical development of the iconic system is also possible (the subject is work in progress by the author, see [8, 27]). We may assign a number to each of the sectors separated by the parentheses or other icons. For example:

b8 ọ a 5 => b and a are equivalent and 8 at all, the remaining are 5
b8)3)a 6 => b are 8, a are 11, not-b not-a are 6
6 b(3(8a => not-b not-a are 6, b are 11, a are 8
b5)(3)(7a 9 [or b(5(3)7)a 9] => b are 8, a are 10, not-a not-b are 9, ba are 3
b 5(3)7 a => b are 8, a are 10, not-a are 5, not-b are 7
b8) 2 (11a => b are 8, a are 11, 2 elements are neither a nor b
b4 }{ 3a => b are 4, a are 3

A numerical calculus can be inspired by Hacker and Parry [20, 21]: see [22, 23]. This can be considered the first step towards a fuzzy logic in the sense of [24, 25]: see [2, 27]. Numerical predicates and distinctive segment can be represented by diagrams, which can help numerical inferences (Fig. 13).

7 Distinctive Icons for Dictionaries of Synonyms, Contraries and Intermediates

ID7 can be applied to dictionaries of synonyms, contraries, with the possible addition of intermediates, as well as to machine translation programs, so as to counter cognitive anomalies in the translations. The adoption of the seven icons (or, if one prefers, only the five proposed by Gergonne) in an innovative bilingual dictionary will immediately bring to evidence which of the seven relations links the original term with each of the possible translations or descriptions (and a numerical quantifier will be an indicator of use frequency or probability of an appropriate use). For example, the Chinese term 屁股 is translatable as “donkey”. We can thus establish that 屁股 is *synonymous* (with ọ̇ relation) with donkey. The term 斑馬, literally meaning “spotted horse”, stands for “zebra”, whereas 馬 is translatable as “horse” but also as “equine sui generis”: *expansion* of horse, *expansion* of zebra, *restriction* of equine. In the UD of equines it is *complement* of donkey, or non-donkey. In symbols and diagram (Fig. 14) the term 馬 can be translated this way:

((horse; ((zebra ọ̇ 斑馬;)) equine;)(donkey ọ̇ 屁股 [*UD equine*]; ọ̇ not-donkey [*UD equine*].

The “distinctive” relations have a powerful “gestalt”, which can easily be generalized and applied, not only to the nominal concepts, but also to verbs, adjectives and adverbs, providing a single logical background to subdomains of ontologies. It can probably even promote the axiomatization of dictionaries.

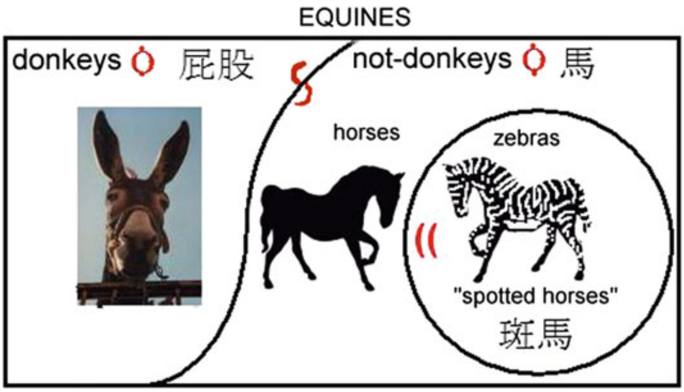


Fig. 14 A semantic diagram for zebras/equines in chinese terms

8 Cultural and Scientific Perspectives

In view of the recent multiplication of hyperspecialist languages and terminologies of subdisciplines, scientific institutes will feel the need to produce reliable translations for synthesis or interaction. The generalized adoption of the prompter will improve the quality of all translations in a wide sense, not only of texts in the general usage of a natural language but also for specialist jargons, interdisciplinary codes, glossaries of technical manuals, thesauri and library indexes of all kinds.

In cataloging of subjects in librarianship we find relations with the same logic structure as the five cases:

(I) HSF “**Head Subject For**” or UF “**Use For**” or “ = ” all–all relation
(II) BT “**Broader Term**” all–some relation
(III) NT “**Narrower Term**” some–all relation [this and the former are called “hierarchical” relations]
(IV) “**Almost Generic**” or “[:]” some–some relation
(V) “**Related Term**” (but **if and only if** the related term is an *antonym*).

In many circumstances the **symbol** “ < > ” encompasses the matter or field of interpretation of the term, playing a role similar to that of our **UD**, linguistically interpretable as “**conceptual background**” or “**lexicographical environment**”.

In rhetoric/poetry [Liège’s group, T. Todorov, see [26]], we can assimilate some “tropes” or analogies (logon) to the five cases: **Definitio** or periphrasis or tautology for I, **generalizing synecdoche** for II, **particularizing synecdoche** for III, **metaphor** for IV (product of II and III) and **litotes** or antithesis or irony for V.

The distinctive system will be helpful in the development of new approaches to numerous, often unexpected, problems, as it combines rigor with flexibility, and might even lead to a conceptual innovation. Precisely because of its closeness to natural language and the intuitiveness of its iconic-diagrammatical structure, it will be helpful not only in the more humanistic fields of philosophy, law, history, linguistics or psychology, but also, and perhaps even more so, in more scientific fields, such as logic or mathematics, computer science, engineering, the medical sciences, etc. We think that a semantic prompter can make a contribution to the organization of knowledge in all these areas. For example, it is possible to build a bridge between artificial (machine) and natural (human or animal) concepts, which are the alphabet of the representations of reality. In the case of animal representations, we should make a list of plausible elements that constitute an “animal” concept (reduced to set) analogous to that human one (the behavioral acts revealed by the animals will be the pragmatic test for the satisfactory choice of the elements). The concepts of an animal “mind” will be comparable with those of a human one, each highlighting terms of the distinctive or common features. On the same basis, we may create databases for these “mental” elements and programs to manage them.

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