A cognitive approach to reference

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1996

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Introduction

When we talk about something, we need to indicate what we talk about. Sometimes we can use pointing gestures but mainly we have to rely on words. A pointing gesture can direct attention in perceived space, but how do we direct attention with words? What can we do with speech sounds we hear, to find out what somebody wants to tell us about something and what that something is?

Questions about reference could be posed in different ways. To formulate such questions in the way done above, as questions about how reference relations are established when we use language for communicative purposes, is to pose them within a cognitive perspective. The reference problem conceived cognitively concerns how cognitive processes in which reference relations are established should be characterised.

Uses of language

Language is used for identification of referents not only in communication but also in reasoning. If it is an ambition in communication to avoid ambiguities that can lead to misunderstanding, it is still more so in logical reasoning. In order to make a reasoning as consistent as possible, it is useful to state its premises clearly from the outset, which includes identification of referents and unambiguous names for them. Having established a *knowledge base* in this way, it is then possible to try to draw conclusions from it, referring to the referents identified via their names and to the postulated premises.

These two ways to refer to something, the *introducing* way, when a new reference relation is established, and the *predefined* way, to refer via a given knowledge base, are clearly separated in formal logic as two phases, but they are not separated as distinct phases in communication. When we need to identify and introduce new referents, we do so as freely as we refer to something in a common knowledge base. Furthermore, when we refer to individuals already introduced, we sometimes use names, unambiguous possibly in context but not in general, but we also use pronouns or other nominal expressions. Thus, not only when we refer to something that can be found through perception, but also when a referent is identified in a knowledge base, we have to *find out* what an expression may refer to, we have to *find* a referent, and not just 'pick' an object uniquely identified by a name.

Categories

Linguistic categories are used in different ways when reference relations are established and when established relations are used in reasoning. In the first case it is a question of finding something that might fit a certain category and to judge or test whether it does. In the second case new categorisations could be inferred from those that are already given. If one categorisation is applicable, another one could be excluded or implied.

These kinds of relations between categories is the background to Kant's concept of analytical sentences – sentences that can be judged whether true or not solely on the basis of language and without any empirical investigation. Even though such relations between linguistic categories play a role in language use, they are generally not fixed to such an extent that they could serve directly as premises in logical reasoning without any risk for ambiguities arising, as Quine 1951 has shown.

This degree of freedom in linguistic precision is essential for the flexibility with which language can be used in new situations. Fresh application of linguistic categories to empirical reality is as important as the use of already established categorisations in our way of dealing linguistically with what we come across.

Numbers as referents

The term *reference* in connection with identification of specific entities was introduced by Ogden & Richards 1923. In the traditional syllogistic logic this aspect of meaning was not in focus. Syllogistic logic is a logic of categories, of relations among categories and of relations between categories and instances of categories. Whether such instances can be identified as specific, individual entities or not, is not essential for the application of the syllogisms. There was a 'doctrine of distribution' in syllogistic logic, not developed by Aristotle but later. This theory to some extent dealt with questions of reference, but it was not very clear (Geach 1962:ch. 1).

Logical reasoning in terms of specific, individual entities was first developed in a distinct way within mathematical logic. The first attempts to develop set theory followed the traditional pattern of classes as denotations of concepts though, and did not make a difference between elements of a set and subsets of a set. Could something be subsumed under a certain class or could it not? That was the question, as it was first posed.

While subset relations can be discussed without any specific elements involved, as in syllogistic logic, the membership relation, however involves every specific element separately. While numbers cannot be differentiated by using qualitative categories (as for instance species of living beings can), they are certainly nevertheless different from each other. Thus, in mathematical logic a notion of individual identity is needed, although it cannot be connected to physical or in some other way qualitative identity.

The distinction between subset relations and membership relations was important for Peano, and for Frege 1895, and it is fundamental in set theory. Instead of a logic of categories (and instances of categories) Frege 1884:ch. III, 1892b developed a *logic of individual objects* (*Gegenstand*) as well as of predicates, a theory which thus takes into account not only categories and their denotations, but also individual identities. The most obvious way to signify individual entities is to use names, and that is the term Frege 1892a:26, 1892b:199-200 used for this purpose. A later term for an expression that uniquely specifies one particular individual entity is *referring expression*.

The autonomy of these individual elements can be conceived in different ways. One way is to attribute some kind of existence to them as in Frege's ontological interpretation of the autonomy, while for others logical existence is something logical, rather than some kind of existence. (See correspondence between Frege and Hilbert 1899-1900, reproduced in Frege 1976:55-80).

Facts and cognitive processes

The distinction which exists in logic between a preparatory phase in which premises and references are fixed and a phase in which these fixed associations are used in reasoning was sharpened by Frege. He strongly opposed empiricist, psychological explanations of logical regularities, like Mill's attempts to show how logical laws can be derived from experience (Frege 1884:1-51; Resnik 1980:25-50, 137-60).

Frege's concern was not reasoning in connection with empirical questions but in connection with mathematical questions. In order to develop a logic for mathematical proofs he borrowed the Aristotelian logic of syllogisms and generalised it into predicate logic with quantifiers (Frege 1879:22-24; Gillies 1992). In this transfer, the differences between language as used for abstract mathematical reality and language as used for empirical reality were very much disregarded.

Knowledge can be seen from two different perspectives. Knowledge can be seen as knowledge about something, as representation of *facts*. As it happens, we do not know all facts, but that is another story. Knowledge can also be seen as something that we have access to, something that is ours, something that we can *use* in *reasoning*, something which is not perfect, but which can be developed in *experience*. In the first perspective the question of correspondence between knowledge and facts is not posed, the correspondence is taken for granted, stipulated in premises. In the second perspective the correspondence is an open question, open for investigation, whether computational or empirical.

The attempts that have been made to develop semantics in general as a kind of mathematical proof theory have essential limitations, due to the differences in character between on the one hand axiomatic reasoning and on the other hand empirically related reasoning and language use in general. One important point concerns *truth conditions* (Tarski 1956). A truth condition is a condition that some other condition holds, not a condition that is applied in empirical judgements; a condition that something *is* true, not a condition of *how* something could be true.

In *cognitive processes* on the other hand, conditions are *applied*, and there is one cognitive situation *before* and another cognitive situation *after* a condition has been applied. Beforehand, there is a question, and afterwards, there is a result of the application of the test or condition, an answer to the question. Unlike facts, knowledge can be affected by computational and other cognitive efforts.

A *cognitive operation* can only be performed on something that we have *access* to. Hypothetical facts, considered as facts rather than as explicitly stated premises, have no such limitations. We do not need access to some domain where we can check or judge whether a condition holds or not in order to assume that it holds. Hypothetically, facts are facts, whether we know them or not, and whether or not we will ever have any chance of knowing them.

Indefinite numbers

The background to the development of a logic in which access to specific facts and referents is not relevant was the situation in mathematics at the time when one tried to count the uncountable and to master the paradoxes that emerged when one tried to (Russell 1919; Heijenoort 1967).

Even if our cognitive efforts have limits, there are no limits to numbers, in theory at least. Mathematicians and logicians tried to deal with notions such as ‘the set of all natural numbers’, the set consisting of the numbers 1, 2, 3, ... *ad infinitum*, even though it is not possible to specify all these numbers individually, and even though it will be without the slightest significance how far one counts, since one will still have just as many, that is, infinitely many numbers left to specify. In order to deal with such ideas, the distinction was blurred between specific enumerations and non-specific or general characterisations. From a factual perspective such cognitive distinctions can be disregarded. It makes a significant cognitive difference though, whether a set is characterised by an enumeration of its elements or by a specification of conditions, even if it does not matter from a factual point of view.

A theory that could deal with numbers in general was developed in mathematical logic. The Aristotelian, non-mathematical logic of syllogisms contained reasoning in terms of general categories and so it was a natural solution to the problems in mathematical logic to transfer that logic to the mathematical realm.

The relationship between the new mathematical logic and the old syllogistic one is thus a complex relationship. On the one hand, the disregard of specific, individual elements was seen as a deficiency of syllogistic logic, and the logical autonomy of these elements was recognised in mathematical logic. On the other hand, once these independent identities were there, the old non-specific framework was used again. The difference is that now one deals with quantities of individuals rather than of denotations that need not be individuated.

In this conception it is essential that there are assumed to exist connections between specific, although not necessarily distinctly specified, elements and non-specific characterisations of elements. These connections are generally implicit, they are facts, known or unknown, possible to express explicitly with finite cognitive means or not.

The new logic deliberately excluded empirical applications and aimed at solving problems in mathematical theory. A mathematical logic was created, but the empirically oriented logic was lost. The relations between the hypothetical truth conditions and conditions that are applied are very different in mathematical computations and in empirical judgements, since access to the domains of application is gained in different ways.

Cognition in logic

Frege 1892a:26 distinguished facts and cognitive processes. Facts remain facts whether our judgements and reasoning captures them or fail to do so. Frege 1884:vi, x, 33-38, 1899 preferred facts as a basis for logic and arithmetic rather than cognitive processes.

There is another side of this coin however. Even Frege was not content with just facts. He did not just let the facts be facts, forever true, whether known or not. He was not content with just knowing facts, he was deeply engaged in cognitive processes, he tried to solve problems, he tried to prove even basic well-known facts of arithmetic.

On the one hand our cognitive processes are fallible, but on the other hand, we do not have general access to facts. In order to know anything at all and to perform logical reasoning, we have to rely on cognitive processes. We have to devise and perform our cognitive processes as good as we can. Frege emphasises the difference between *descriptions* of reasoning as *psychological* processes, and *norms* for reasoning in a *logical* perspective (Kitcher 1979:246). He gave contributions to cognitive processing too, first by devising his *Begriffsschrift* ('conceptual script') 1879.

Other logicians have been more interested in the cognitive aspect of logic than Frege was, focusing more on logic as a science of *inferences* than as a science of *truths*. Among these one can find not only Mill but also Boole. When Frege formulated and argued for his fact-oriented, ontological approach in mathematical logic, Boole's computational approach was already influential in this field.

Mathematics could be seen, and has been seen, as a science of quantities. When new kinds of numbers entered mathematical computations, like negative numbers and imaginary numbers, new ways of thinking about numbers slowly emerged. Numbers were thought, more and more, in terms of mathematical *operations* (Nagel 1935). Boole 1847, 1854 was one of those who gave a clear expression of this view (Kneale 1948).

Boole influenced the development of group theory in mathematics from conceptions of specific groups into the general approach of combinations of operations in abstract group theory as it was first formulated by Cayley 1854, 1878 (Wussing 1984:168f, 230f). A group is a system of elements, basically operations, represented by symbols, and related through *composition*, such that if two elements of the group are combined in the way that characterises the group, another element of the group will be the result of the composition.

The mathematician Hilbert, who like Frege tried to deal with infinite mathematics using finite linguistic means, approached language from another point of view than Frege did, from the point of view of form rather than of conceptual content (Hilbert 1922, 1927; Resnik 1980:76-118). During the first decades of the century formal syntax was developed into a powerful tool for logical research.

Ideas from the theory of groups were also incorporated into formal syntax. A group may have a set of basic elements from which all the other elements of the group can be *generated* by repeated application of the compositional operation (Dyck 1882, 1883; Post 1936, 1944; Wussing 1984: 238-243).

Gradually a scientific field of *ideal cognition* emerged out of the questions of mathematical logic. This was done within the fact-oriented framework formulated by Frege, in which mental cognitive processing, thinking, is treated as something outside of logic. The *third* realm conceived by Frege 1918:69, 1884:28-30, 1892a:29-32 as distinct from the *physical, empirical* reality and as distinct from the *psychological processes* of reasoning, was a realm of facts identified in terms of ‘thoughts’ (*Gedanken*). It was an ideal world of cognition in which facts and thoughts could match each other one to one, i.e. practically coincide.

Computation

Well, what could be done within mathematical logic using finite linguistic means? This question was developed within computability theory by Gödel, Turing, Church, Post and others (Davis 1965; Herken 1988). The theory constitutes an important background to later cognitive science, not only since the questions that were posed were questions about cognitive operations but also since the theory was used for the construction and development of computers.

Computability theory emerged from questions in mathematical logic, but computers can be and are used for a lot of purposes other than mathematical ones, and even though psychological cognitive processes and ideal, mechanised cognitive processes are different in many ways, they also have important characteristics in common. Computer science has approached cognitive psychology and in Artificial Intelligence computer programs are used as ideal models of human cognition.

Computers can be used to perform different kinds of cognitive processes, to the extent that the organisation of such processes can be described in detail and be performed mechanically. They can be used for *solving problems*, mathematical ones or others. When one tries to solve a problem, one is *searching* for something that fits a *specification*. Different possibilities are *generated* or *produced* and it is *tested* whether the specified conditions apply (Newell 1990; Simon 1969).

Ordinary language use is much more like problem solving than like logical deduction in this respect, that correspondences between categories or conditions and individual entities are searched for and established rather than predefined. The change from a consideration of one type of cognitive process, logical deduction, to a broader range of cognitive processes, can be seen not only in the rise of computer science and cognitive science, but also in the development of generative grammar, first expressed in terms of derivations inspired from logical deduction but now described in terms of computations, in which domains of application for different criteria are important (Chomsky 1992).

Functions

As has been discussed above, a condition is not the same thing in a hypothetical perspective as in an application perspective. The same can be said about *functions*. In Frege's conception a function is an element-to-element correspondence between two sets, a correspondence that may be stated explicitly in terms of pairs of elements, or, alternatively, in some general way as all pairs that fit a certain condition, whether we know something specifically or not about which pairs that fit the description (Frege 1904:661-2; Russell 1919:ch. V).

Functions in the Fregean sense can not be used in computations, or in cognitive processes in general. In computations one needs algorithms, one needs methods to compute values, one needs *computable functions* (Church 1936; Turing 1936-37; Post 1936; Gandy 1988; Kleene 1988). In a Fregean perspective the computable functions constitute just a subset of all functions. Just as some facts happen to be known and others not (Frege 1918:74), it is an accidence, a matter of discovery, that some functions are computable while others are not.

From a cognitive point of view though, the two kinds of 'functions' are two very different kinds of entities. Functions *defined in terms of facts* are in general *cognitively empty*, since facts are in general unknown, while functions *defined in terms of cognitive operations* can be *computed*, using these operations.

Reference

Application of categories

It is perhaps not a decisive point in mathematics to make a distinction between a cognitive perspective and a hypothetical-factual perspective and the different character that conditions and functions have in the two perspectives. Opinions are divided – intuitionists do not find it meaningful to work with hypothetical unidentifiable entities as specific entities (Brouwer 1923) – but mathematics does not seem to be affected in a decisive way by the standpoint taken. Certainly the difference is evident enough between a problem that can not be solved, at least presently, and a problem that one has found a solution to.

In semantics oriented towards empirical reality the distinction between the two perspectives is crucial though. When referents and facts are introduced hypothetically in premises, and this phase of reasoning is seen just as a preparation for the deductions that could be done from the premises, there are *two* kinds of entities to deal with: the individual *referents* and the *facts*, in terms of categorisations, assumed about them (Frege 1884:77). From a more general cognitive perspective that includes the premise-stating phase as well and includes other kinds of language use than deductive reasoning, there are *three* kinds of entities to take into consideration: (1) *domains* to which there can be *access*, (2) *categories* that can be applied to accessible domains and (3) the *individuals* discerned, that can be *found* in some domain and that could fit one or more of the categories.

The domains in which categories are applied are comparatively few in mathematics, and the most important of them are searched over and over again: the domains of natural numbers, of rational numbers, of real numbers, of complex numbers. The number of elements that could be found in any one of them is not finite, but the relation between categories and individual elements is simplified by the circumstance that the same domains are used all the time.

Empirical applications of categories are very different. We apply categories empirically in *situations* where we are, to what we can perceive around us. Empirically accessible domains and what we find in them are often similar to domains and entities we have come across earlier, but sometimes they are not. Neither is similar the same as identical, and whether the similarities or the differences are the most relevant is a matter for the language user to decide rather than a logical matter of identity or non-identity.

The possibility to count with situations in logical semantics has been introduced in Situation semantics (Barwise & Perry 1983). It is not possible to discuss the question of categorisation within this framework though. It is just hypothetically assumed that categories in language correspond directly to 'uniformities across situations'. In this respect Situation semantics is a mathematically rather than an empirically oriented theory, directly applicable to conceptually defined possible situations, to 'abstract situations', but only hypothetically, via the uniformity premise, to actual situations. On the other hand, when the uniformity premise is dismissed, the relations between abstract situations and actual situations are open for investigation.

To take a step from a linguistic presentation, from *a way that something is given*, *Sinn*, to that which is thereby referred to, the *Bedeutung*, in Frege's terms 1892a:26, is to take a *cognitive step*. How such steps are taken, how one could 'advance'[1] from *Sinn* to *Bedeutung* is not discussed. What is important in Frege's considerations are the correspondences that should hold, as matters of fact, between a linguistic characterisation and that which is thereby hypothetically identified, not how it would be possible to establish such correspondences.

From a cognitive point of view it is a significant difference whether a reference relation can be established in a computation, using cognitive operations, or whether empirical judgements have to be performed. In Frege's factual perspective this difference is insignificant.

Computational operations can be performed *within one cognitive domain*. Digital computations basically use only the natural numbers. There is no difference in character between *Sinn* and *Bedeutung* for these numbers. There is no need to advance from one domain to another of a different kind in order to get from a specification to that which is specified. Only when approximate answers are sought more than one domain comes into play. One can make a specification that fits a real number that can not be presented in a finite way and one can search among finite numbers nevertheless. One will never find the specified number, but by testing the specified conditions on the finite, accessible numbers one could successively narrow the search domain and get better and better approximations for the specified number.

In the empirical case the cognitive categories used do not coincide with the reality they are applied to. The reality that we live in and experience exists there whether we categorise it or not and whether we categorise it one way or another. Empirical domains *exist* on their own, but entities in them are *identified* with cognitive means.

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[1]Frege's words 1892a: 33-35 are: *fortschreiten, vordringen, Schritt, gelangen*.

Indefinite reference

One may wonder why Frege 1884:79-81 did not use the conceptual relations already in use in the mathematical theory of groups in order to demonstrate the conceptual foundations of mathematics but turned to syllogistic logic and linguistic concepts instead. Frege's background in Kantian philosophy could perhaps give one part of an explanation, mathematical conceptual relations not being recognisable as conceptual in this tradition, at least not immediately.

More important though, may be the circumstance that Frege was interested in mathematical proofs rather than in mathematical computations. The interest for proofs was shared by Hilbert who had introduced a new method for geometrical proofs. It was based on the assumption that lines and planes could be conceived as infinite sets of points. Proofs could then be stated as facts about sets of points (Hilbert 1899).

While computations aim at finding specific answers to specific questions, proofs aim at stating general facts, in which relations between elements occur but in which specific elements are just special cases and not interesting as such.

Frege's transfer and generalisation of the Aristotelian non-mathematical logic to mathematical logic constitutes a break-through in mathematical logic, but this logic, as mentioned above, although very useful in mathematical contexts, is not adequate in connection with empirical reality. While mathematical indefinites belong to definite domains, what makes nominal phrases indefinite in ordinary language use is often the *absence* of access to a domain.

A speaker who has a specific referent in mind can use an indefinite phrase to indicate that the listener does not have access to a domain where this referent can be found. From the hearer's point of view, such an introduction has to be a *cognitive construction*: an entity is generated as an instance of a conceptual category.

Entities that are introduced through stipulation can also be used directly by the speaker, speaking about a hypothetical situation, typically in the future. After the introduction a definite phrase can be used about a hypothetical individual since this hypothetical 'referent' is now known to the listener as well, if not from an original context, so from the context of discourse. This gives rise to the paradoxical situation that one can have *coreference without reference*. The situation has been discussed by Geach 1962 in connection with generic sentences. In such sentences a stipulated instance of a species can be used to represent the species as a whole. To cover such hypothetically introduced instances of categories the notion *discourse referent* has been used, initially by Karttunen 1976 and Kamp 1981.

Questions of coreference are studied within a cognitive perspective in Discourse Representation Theory. When a nominal phrase occurs in a discourse that is analysed, the phrase gets represented semantically by a variable and it is then a matter of problem solving to find out whether an entity already in the discourse memory should be associated to this variable (Kamp & Reyle 1993:59-73).

Coreference relations have been discussed from a different but also cognitive point of view in generative grammar. The gaps that result when phrases are moved in transformations were seen to have referential characteristics comparable to those of pronouns. The syntactic rules that are used to establish coreference relations do not follow patterns of logical necessity, but have a more general character. Rules do not apply unconditionally. Rather, if one rule is used in normal, *unmarked cases*, others can be used in marked, more unexpected cases (Chomsky 1977:86).

Empirical reference

Not only establishing of coreference relations can be described by problem solving cognitive processes. Such processes can also be appropriate for the characterisation of how correspondence relations between sound and meaning are established lexically (Platzack 1993; Josefsson 1995:29-41). My suggestion in this article is that this kind of cognitive processes is appropriate for the characterisation of how reference relations are established also in empirical contexts, also at the interfaces between language and extralinguistic reality.

A basic distinction for empirical reference can be made between reference accessible for the interlocutors in the situation that is *present* for them, and reference that has to be established through earlier experience, accessible in *memory*. The first kind of identification normally needs less specification, reference in the present situation being the unmarked case, and deictic terms can be used for recurring aspects of present situations.

Deictic identification is not relevant in Frege's and Russell's approach in mathematical logic, for which there is only one, general, eternal domain of facts and individual objects. When Strawson 1950 compares this approach to the way language is normally used, that is, in specific contexts, Russell in his reply 1957 characterises problems concerning situation-determined, or in his terms 'egocentric' aspects, as being distinct from problems of definite descriptions.

In Russell's *On denoting* 1905, that Strawson argues against, definite descriptions are explicated in terms of assertions: "the author of Waverly" as a subject in a sentence would be rendered in a more exact way as "one and only one entity wrote Waverly and that one…". Such a paraphrase may be good enough for the purposes of mathematical logic, but it disregards a basic distinction in communicative and empirical semantics. As Strawson 1950 points out, the distinction between reference and assertion is basic in ordinary language use, even if Frege could abolish it in mathematical logic and have predicates with arguments instead. In any case, the knowledge base is relevant, whether you bring it into the meaning of the asserted sentence as Russell suggested, or treat it as presupposed as Strawson argued.

Scope relations

Grammatical structure, including subject-predicate distinctions, expresses scope relations. A definite description in a subject position would normally be interpreted independently of the part of the sentence asserted about it, while an assertion has a more dependent status. An assertion has to be an assertion about something, the grammatical subject, a discourse topic or a situation if it should be an assertion at all.

This kind of *anchoring* could be very general, and pertain to one, total universe of discourse as in Frege's and Russell's conception. Alternatively, and normally in communicative language use, we narrow the anchoring, we narrow the domain to which an assertion is applicable. Some times this narrowing of the anchoring will fail, as for a phrase like 'the present king of France', or the anchoring will remain open, as when someone uses the phrase 'the author of Waverly' and doesn't know where the specification would be applicable.

Scope relations are expressed in two different ways in predicate logic. Scope of quantification is expressed in a transparent way. When there are two quantifiers in one sentence, the one with wider scope is put outside and in front of the one with narrower scope. It is not so apparent however, that names, expressions for constants or specific objects also take part in scope relations. In the notation of predicate logic they could be placed in the innermost layer, while they actually have a wider scope than the quantifiers, and from that point of view would have to be outside the quantifiers instead. Certainly they have a place outside and independent of a quantified expression they may occur in, since the names refer back to the premises, where they have to be declared.

A fact can be represented in many ways, all thus equivalent in terms of the fact they represent. Whether some element of the representation is introduced before or after another element does not matter from a factual point of view. From a cognitive point of view on the other hand, order is crucial, since it is an order of cognitive processing. Computational procedures are to a large extent characterised by the order in which parameters are opened and set.

When the domains of application vary, as when people communicate and only part of their knowledge is in a common universe of discourse, and when linguistic categories are applied empirically in new situations, different cognitive orderings cannot be compared with respect to a preestablished world of facts and referents. The facts and the referents have to be identified, and an outcome will be a result of an interactive process in which specifications, including their *order of identification*, and the domains that the specifications are applied to both contribute.

Scope relations are important not only in connection with reference, but in grammar generally. Order of identification can be indicated with different, interacting grammatical devices and is relevant for instance for existential sentences and for aspectual interpretation.

Conclusion

In logical reasoning assumptions concerning what linguistic categories apply to have to be stated in the premises. This demand characterises logical semantics. In order to describe language as used in communication and in judgements in empirical situations one also needs to have the possibility to describe open relations between linguistic categories and domains where they could apply. One needs the possibility to describe identification of referents as an open question, as something that can be done, using a specification in an accessible domain.

As for identification in memory, people who communicate may share a universe of discourse, but to some extent they also have different knowledge bases to make identifications in. As for empirical identification, we have the possibility not only to talk about empirically identifiable referents, earlier known as well as new ones, but also to talk about hypothetical situations with hypothetical discourse referents, and about situations which we assume that they exist or that they have existed, but situations which we don't have access to and therefore have to keep the identification open for.

When specifications and domains in which they could be applicable are described separately and are possible to combine in cognitive processing, the conditions in a specification can not be truth conditions, since the application of conditions is an open question not fixed in premises. The conditions have to be conditions that could be applied in cognitive processing, not conditions that hold hypothetically. The ordering between parts of a cognitive process is an essential characteristic of such processes, while, when related to a fixed knowledge base, it could be rather a matter of an optional variation of stating the same facts.

References

Barwise, Jon & John Perry. 1983. *Situations and attitudes*. Cambridge, Mass.: The MIT Press.

Boole, George. 1847/1948. *The mathematical analysis of logic*. Oxford: Basil Blackwell.

Boole, George. 1854/1958. *An investigation of the laws of thought*. New York: Dover Publications.

Brouwer, Luitzen Egbertus Jan. 1923/1967. ‘On the significance of the principle of excluded middle in mathematics, especially in function theory’. Translated from German in Heijenoort (ed.) 1967, 335-341.

Cayley, Arthur. 1854. ‘On the theory of groups, as depending on the symbolic equation $\theta^n = 1$. In Cayley 1889-98, vol. 2, 123-132.

Cayley, Arthur. 1878. ‘On the theory of groups’. In Cayley 1889-98, vol. 10, 324-330.

Cayley, Arthur. 1889-98. *The collected mathematical papers*. Cambridge.

Chomsky, Noam. 1973. ‘Conditions on transformations’. In Stephen Anderson & Paul Kiparsky (eds.), *A Festschrift for Morris Halle*, 232-86. New York: Holt, Rinehart and Winston. Also in Noam Chomsky 1977, *Essays on form and interpretation*, 81-160. New York: Elsevier North-Holland.

Chomsky, Noam. 1992. ‘A minimalist program for linguistic theory’. *MIT Occasional Papers in Linguistics* 1. Cambridge, Mass.: MIT.

Church, Alonzo. 1936. ‘An unsolvable problem of elementary number theory’. *The American Journal of Mathematics* 58, 345-363. Also in Davis (ed.) 1965, 88-107.

Davis, Martin (ed.). 1965. *The undecidable*. New York: Raven Press.

Dyck, W. van. 1882, 1883. ‘Gruppentheorethische Studien’. *Mathemathische Annalen* 20, 1-44; 22, 70-108.

Frege, Gottlob. 1879/1964. *Begriffsschrift*. Hildesheim: Georg Olms Verlagsbuchhandlung.

Frege, Gottlob. 1884/1950. *Die Grundlagen der Arithmetik/The foundations of arithmetic*. Oxford: Basil Blackwell.

Frege, Gottlob. 1892a. ‘Über Sinn und Bedeutung’. In Frege 1962, 38-63.

Frege, Gottlob. 1892b. ‘Über Begriff und Gegenstand’. In Frege 1962, 64-78.

Frege, Gottlob. 1895. ‘Kritische Beleuchtung einiger Punkte in E. Schröders Vorlesungen über die Algebra der Logik’. In Frege 1966, 99-112.

Frege, Gottlob. 1899. ‘Über die Zahlen des Herrn H. Schubert’. In Frege 1966, 113-38.

Frege, Gottlob. 1904. ‘Was ist eine Funktion?’. In Frege 1962, 79-88.

Frege, Gottlob. 1918. ‘Der Gedanke’. In Frege 1966, 30-53.

Frege, Gottlob. 1962. *Funktion, Begriff, Bedeutung*. Günther Patzig, ed. Göttingen: Vandenhoeck & Ruprecht.

Frege, Gottlob. 1966. *Logische Untersuchungen*. Günther Patzig, ed. Göttingen: Vandenhoeck & Ruprecht.

Frege, Gottlob. 1976. *Wissenschaftlicher Briefwechsel*. Ed. by G. Gabriel, H. Hermes et. al. Hamburg: Felix Meiner Verlag.

Gandy, Robin. 1988. 'The confluence of ideas in 1936'. In Herken (ed.) 1988, 56-111.

Geach, Peter Thomas. 1962. *Reference and generality*. Ithaca, New York: Cornell University Press.

Gillies, Donald. 1992. 'The Fregean revolution in logic'. In D. Gillies (ed.), *Revolutions in Mathematics*, 265-305. Oxford: Clarendon.

Heijenoort, Jean van (ed.). 1967. *From Frege to Gödel*. Cambridge, Mass.: Harvard University Press.

Herken Rolf (ed.). 1988. *The universal Turing-machine, A half-century survey*. Oxford: Oxford University Press.

Hilbert, David. 1899/1977. *Grundlagen der Geometrie*. Stuttgart: B. G. Teubner.

Hilbert David. 1922. 'Neubegründung der Mathematik'. In *Gesammelte Abhandlungen*, vol. 3, 157-177. Berlin 1935: Springer Verlag.

Hilbert, David. 1927. 'Die Grundlagen der Mathematik'. Translated as 'The foundations of mathematics' in Heijenoort (ed.) 1967, 464-479.

Josefsson, Gunlög. 1995. 'The notion of word class and the internal make-up of words'. *Working Papers in Scandinavian Syntax* 56, 1-45.

Kamp, Hans. 1981. 'A theory of truth and semantic representation'. In J. Groenendijk, T. Janssen & M. Stokhof (eds.), *Formal methods in the study of language*, vol. 1, 277-322. Amsterdam: Mathematisch Centrum. Also in *Truth, Interpretation, Information*, GRASS 2, 1983, by the same eds. Dordrecht: Foris.

Kamp, Hans & Uwe Reyle. 1993. *From discourse to logic*. Dordrecht: Kluwer Academic Publishers.

Karttunen, Lauri. 1976. 'Discourse referents'. In *Syntax and Semantics* 7, 363-385.

Kitcher, Philip. 1979. 'Frege's epistemology'. *The philosophical review* 88, 235-262.

Kleene, Stephen C. 1988. 'Turing's analysis of computability, and major applications of it'. In Herken (ed.) 1988, 17-53.

Kneale, William. 1948. 'Boole and the revival of logic'. *Mind* 57, 149-175.

Nagel, Ernest. 1935. ' "Impossible numbers": a chapter in the history of modern logic'. In *Studies in the history of ideas*, vol 3, 429-474. New York: Columbia University Press.

Newell, Allen. 1990. *Unified theories of cognition*. Cambridge, Mass.: Harvard University Press.

Ogden, C. K. & I. A. Richards. 1923. *The meaning of meaning*. London: Routledge & Kegan Paul.

Platzack, Christer. 1993. ‘A triune lexicon: An approach to a lexical description within the minimalist program’. In M. Herslund & F. Sørensen (eds.), *The Nordlex Project: Lexical Studies in the Scandinavian Languages* (*Lambda* 18), 306-318. Copenhagen: Institut for Datalingvistik, Handelshøjskolen i København.

Post, Emil L. 1936. ‘Finite combinatory processes. Formulation I’. *The Journal of Symbolic Logic* 1, 103-105. Also in Davis (ed.) 1965, 288-291.

Post, Emil L. 1944. ‘Recursively enumerable sets of positive integers and their decision problems’. *Bulletin of the American Mathematical Society* 50, 284-316. Also in Davis (ed.) 1965, 304-337.

Quine, Willard V. O. 1951. ‘Two dogmas of empiricism’. *The Philosophical Review* 60, 20-43. Also in Quine, 1953, *From a logical point of view*, 20-46. Cambridge, Mass.: Harvard University Press.

Resnik, Michael D. 1980. *Frege and the philosophy of mathematics*. Ithaca: Cornell University Press.

Russell, Bertrand. 1905. ’On denoting’. *Mind* 14, 479-93.

Russell, Bertrand. 1919. *Introduction to mathematical philosophy*.

Russell, Bertrand. 1957. ‘Mr. Strawson on referring’. *Mind* 66, 385-89.

Simon, Herbert A. 1969. *The sciences of the artificial*. Cambridge, Mass.: The MIT Press.

Strawson, Peter Frederick. 1950. ‘On referring’. *Mind* 59, 320-44.

Tarski, Alfred. 1936/1956. ‘The concept of truth in formalized languages’. Translated from German to English in Tarski, *Logic, semantics, metamathematics*, 152-278. Oxford 1956: Clarendon Press.

Turing, Alan M. 1936-37. ‘On computable numbers, with an application to the Entscheidungsproblem’. *Proceedings of the London Mathematical Society*, ser. 2, vol 42, 230-265. Also in Davis (ed.) 1965, 116-163.

Wussing, Hans. 1984/1969. *The genesis of the abstract group concept*. Cambridge, Mass.: The MIT Press. Translation of *Die Genesis des abstrakten Gruppenbegriffes*, Berlin.