Syntax and Semantics: Relationship

The question of the relation between syntax and semantics originates with the modern syntactic conception of grammar, as developed in the tradition of American structuralism (see *American Structuralism*). In this tradition, which began in the early 1920s, a grammar of a language **L** is an exhaustive description or specification of all the combinations of atomic elements (called 'morphemes' in linguistics) that are permissible in **L**. A combination (construction) is permissible just in case it is, or is part of, a well-formed (grammatical) sentence of **L**. This syntactic concept of grammar is found not only in linguistics but also in logic, where it relates to the formal or symbolic languages in which logical calculi are conducted.

Before the 1920s, as far as linguistics is concerned (and before the 1940s, as regards logic), there was hardly any explicit notion that the syntax and the semantics of any language, natural or formal, could or should be distinguished at all. A language was seen as a system manifesting itself in the use of meaningful signs or symbols, whose form and meaning were, so to speak, hand in glove with each other. It was only with the discovery, in the context of modern structuralism, of the relative autonomy of form versus meaning that the distinction could be properly made. The distinction was made more quickly and more clearly in logic than in linguistics.

As regards the notion of semantics there is hardly any common ground between the linguistic and the logical traditions in the twentieth century. In linguistics, due to the enormous influence of behaviorism (see *Behaviorism*), the notion of meaning, and thus also of semantics, remained, for a long time, ill understood and badly defined, if at all. This situation has improved a little but the effects are still clearly felt. In logic, on the other hand, much greater clarity was achieved about what was (is) meant by 'meaning' and 'semantics,' and thus also about the relation between syntax and semantics in formal logical languages.

When these logical notions were, after 1960, transferred and applied to the study of natural language (where they proved useful in many ways but defective in others) linguists were faced with an entirely novel way of looking at the facts of grammar and meaning. And although there is now a lively and fruitful dialogue between representatives of both traditions, the division is still clearly marked. It is, therefore, necessary to consider the question of the relation between syntax and semantics from two different angles. This question will be considered first in the light of the more strictly linguistic tradition of the twentieth century. It will then become clear that there are two main schools of thought in linguistics concerning the status of syntactic and semantic descriptions. After that the question will be considered in the light of the logical tradition.

1. The Linguistic Tradition

In the structuralist conception, a 'grammar' of **L** is a full specification of all permissible (grammatical) constructions in **L**. Most authors in the linguistic tradition (e.g., Bloomfield 1933: 184; see also *Bloomfield, Leonard*) distinguish two parts of grammar, 'syntax' and 'morphology,' defining morphology as the complete specification of all constructions that form words, and syntax as the full specification of all constructions that consist of words and form sentences or parts of sentences (phrases). But often the term syntax is also used, in a wider sense and perhaps a little sloppily, to cover the totality of all constructions of **L**, both the morphological and the strictly speaking syntactic ones. Unless otherwise specified the term syntax will be used, in this article, in this wider sense.

Semantics, on the other hand, is taken to consist of the description or specification of the meanings of the morphemes and the constructions that the morphemes enter into to form larger structures (words, phrases, sentences). It is normally taken for granted in an implicit way that meanings, whatever they may be, are themselves structured in certain ways and that there exist regular, systematic relations between grammatical (syntactic) and semantic structures. A full description of **L** will thus consist of both a grammar (syntax) and a semantics of **L**, the latter being a (full) specification of the meanings of the structural elements distinguished and specified in the former.

Whereas the notions of grammar (syntax), grammatical construction and grammatical structure appeared reasonably manageable and lent themselves without too many serious problems to operational treatment in the form of formally precise specifications, this was not so for the notions of meaning and semantic structure. In fact, as a result of the then extremely influential movement in psychology known as behaviorism, Bloomfield and many of his students and followers proclaimed that a semantic description of a language was scientifically unattainable because, in their view, meaning was either of a mental nature and hence not a proper object for scientific investigation, or, if it were to be scientifically investigated, required a pairing of all morphemes and grammatical structures occurring in actually uttered sentences with a scientifically exact description of all objects, properties, and states of affairs referred to or specified by them. And such a pairing is intrinsically impossible, if only because it would require a description of objects, properties, or states of affairs referred to or specified in *future* utterances.

This idea that a semantic description of a language is either scientifically improper or at least scientifically unattainable is now universally considered erroneous. Yet it led to a situation where all attention was focused on the specification of syntactic structures, their semantic description being entirely neglected and even considered illegitimate. This extreme position reached its brief apogee in the work of Harris (Harris 1951; see also *Harris, Zellig S.*), one of Bloomfield's more prominent students. This work was written between 1945–48, and at the time of its eventual publication, in 1951, antisemanticism in linguistics was already beginning to wane. In structuralist linguistic publications throughout the 1950s a certain category of semantic phenomena was rapidly gaining recognition: structural ambiguities, such as are found in constructions like *old men and women*, or *the fat major's wife* were provided as examples of the disambiguating power of structuralist syntactic analyses, which allowed one to associate different tree diagrams with each of the different readings.

After 1960 behaviorism rapidly declined and was replaced by a new and richer theoretical basis known as cognitivism in psychology. The difference from behaviorism consisted mainly in the admission that behaviorist theory, which explains all behavior in terms of associative mechanisms linking stimuli and responses, is inadequate and needs to be replaced by an essentially richer set of assumptions including the postulate of rich and powerful 'computational mechanisms' in the mind. Insofar as the concept of 'mind' can be made explicit in terms of such machinery it is now no longer considered unscientific to operate with that concept.

In this context, understandably, the linguistic world largely freed itself from its previous semantic fears. Around 1960 it was again fully acceptable to mention meaning in linguistic writings. In Chomsky (1957), semantic criteria, in particular ambiguity phenomena, are exploited more systematically than in other structuralist writings of that period. They are now used as a formal means of testing the adequacy of a syntactic description and of the general theory in terms of which it is cast. Since Chomsky came up with cases of ambiguity that could not be made to correspond to different tree diagrams, such as the famous 'the shooting of the hunters,' it was felt that a grammar whose power was restricted to the direct generation of tree diagrams for sentences was bound to be inadequate. This semantic criterion greatly contributed to the birth of transformational generative grammar (TGG) in the late 1950s.

Soon after, in the early 1960s, an algorithmically precise description of the constructions of a language L, i.e., a generative grammar of L, came to be regarded as a scientific hypothesis aiming at an explicit specification of a (native) speaker's competence in L (see *Generative Grammar*; *Competence and Performance*). This way of looking upon grammar or syntax immediately led to the insight that a generative grammar specifying just well-formed structures can only be a partial description of a native speaker's competence in L, since 'competence' or 'knowledge' of a language L involves not only the ability to distinguish between structures (sentences) that are well-formed and those that are not, but, obviously, also a knowledge of what the well-formed structures mean. Hence it was concluded (Katz and Fodor 1963; Katz and Postal 1964), that an adequate hypothesis (theory) describing a native speaker's competence in L must comprise at least two distinct components, a 'syntactic component' specifying the wellformedness constraints on the structures of L, and a 'semantic component' specifying the meanings of the structures defined by the syntax. The syntactic component, it was felt, was more or less available in the shape of the existing model of transformational generative grammar, but the semantic component had yet to be designed.

In the then current theory of TGG a sentence S is specified ('generated') first in terms of its 'deep structure' (DS), and then in terms of its 'surface structure' (SS). The DS of a sentence is produced by a set of 'formation rules,' standardly called 'phrase structure rules' (PS-rules), which specify the set of all possible DS trees in L. A different set of rules, the 'transformations' (T-rules; see *Transformations*) convert the DS into the SS of S. The PS-rules and the T-rules together form the syntax of L, which is thus seen to be a device for generating all and only the well-formed sentences of L, at the same time assigning a structure to each sentence generated.

In Katz and Fodor (1963) it is proposed that the semantic component of the full description of L should be conceived as consisting of 'projection rules' (see *Projection Problem*) which take as their input syntactically defined structures and produce meaning descriptions or 'semantic representations' (SRs) as output. Each sentence S of L will thus have a double specification, in terms of its SS and in terms of its SR. The specific proposal contained in Katz and Fodor (1963) is that DSs 'project' certain semantic elements of sentences while SSs 'project' other elements. They thus envisage two kinds of projection rules, P1-rules which take DSs as input, and P2-rules which take SSs as input. Both sets of rules contribute to the one intended output, the SRs of the sentences of L. A full, 'integrated' description of L will thus have the overall structure presented in Fig. 1, where the triangles stand for sets of structures and the boxes for sets of rules. The symbol 'S' (sentence) at the top specifies the class of the products delivered as output by the apparatus.

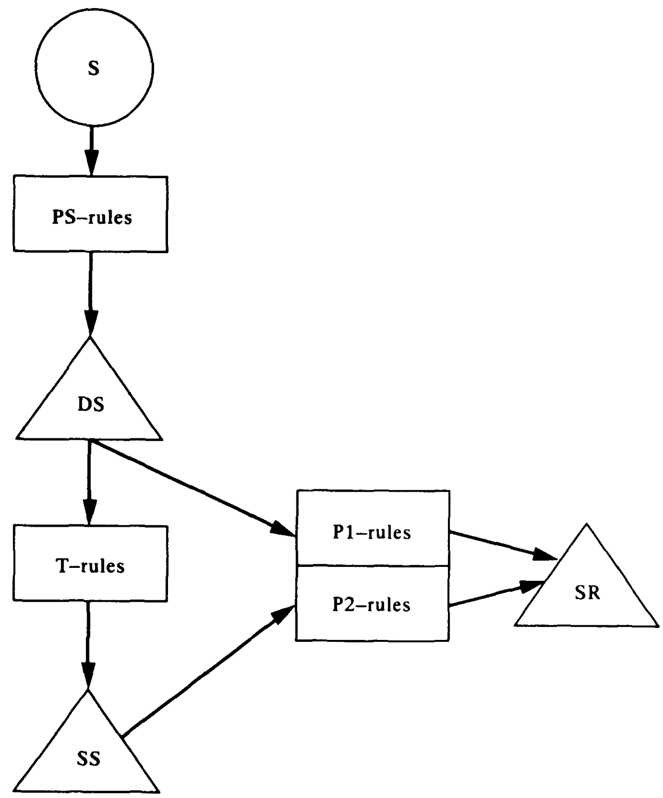


Figure 1.

In contrast to this, it is proposed in Katz and Postal (1964) that all projection rules of the semantic component should take DSs as their sole input, so that the P2-rules disappear from the model and only P1-rules remain. The argument supporting this proposal is that the syntactic description of any language L is simplified, and hence improved, if it is assumed that all semantic information carried by a sentence S is contained in the DS of S. This amounts to postulating that the T-rules of the grammar are 'meaning invariant': no semantic change may be induced by the application of a transformational rule. Thus, the then current T-rule for negation (Klima 1964), inserting a negation word ('not') transformationally in any appropriate position in the sentence, was declared illicit, since it changes meaning. If, on the other hand, the negation word is introduced as part of DS, in the form of a sentential operator, then the negative meaning of the sentence is fixed at DS level and a subsequent T-rule will then assign it its proper position in the sentence. This pays off in the syntax, according to Katz and Postal (1964), because negation controls a number of other syntactic phenomena in sentences (see *Polarity Items*), and it is simpler to formulate such conditions on the basis of one single well-defined structural position of the negation word, as in DS, than from the rather many different possible positions of the negation word in surface structures. Similar arguments were developed for other cases as well.

In a remarkably short time the proposal made in Katz and Postal (1964) swept through the linguistic world. By 1965 it was universally accepted by those who worked in the theoretical framework of TGG, notably also by Chomsky (1965). The principle of the semantic completeness of deep structures, and hence the meaning–invariance of T-rules, came to characterize what was later called (Chomsky 1972: 66) the 'standard theory.'

Meanwhile, however, due mainly to the unhappy behaviorist past, the actual nature of meaning, and in particular the precise form of the output of the semantic projection rules, the semantic representations, remained unclear. As far as the semantic specifications were concerned, the standard theory remained, for a few years, just a program. Until the late 1960s it hardly produced any substantive descriptions. But this began to change when McCawley showed (1967; most accessible in McCawley 1973: 99–120) that, if anything, SRs must be considered to be *syntactic* structures in some semantic descriptive formal language, probably closely akin to known languages of logic. (This argument was independently presented in Seuren 1969: 219–24, where the term 'favorite synonymous language' is used.)

At the same time some linguists (e.g., Ross 1986; McCawley 1967; Seuren 1969; Lakoff 1971) realized that if the DS of any given sentence S contains all semantic information carried by S, then it is a priori plausible to assume that the DS of any S *is* the semantic representation of S. The burden of proof lies with whoever claims that the two are distinct. Since no proof or argument to that effect could be presented these linguists proposed that *all* projection rules, and hence the whole semantic component, should be eliminated from the descriptive model. The syntax itself provides the SRs required for a specification of meanings. This led to a conception of linguistic description as rendered in Fig. 2. It became known, first, as generative semantics (see *Generative Semantics*), and later, with some authors (in particular Seuren 1974), as semantic syntax.

The requirement of meaning invariance of T-rules soon resulted in the realization that DSs must be taken to be far more 'abstract' (in the sense of being remote from SS) than had hitherto been assumed. It became clear, notably, that this conception of grammar required a factorizing out of those elements that are known as 'operators' in predicate logic, i.e., elements that take sentences (propositions) or sentential (propositional) functions (i.e., structures dominated by a node labeled 'S') as input (usually called 'scope') and deliver sentences (propositions), i.e., again S-dominated structures, as output. The negation word 'not'

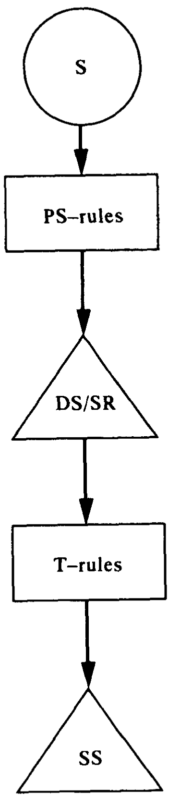


Figure 2.

for example, takes an S (its scope) to form an S, and likewise for the quantifiers (see *Quantifiers*), the modalities (see *Modality*), and even the tenses (see *Tense*). The factorizing out of such operator elements amounts to setting up structures that unite an operator and its scope as sisters under one dominating S-node. A subsequent transformational rule, operator lowering (see Seuren 1984), will then assign the operator its proper place in the scope-S (see also *Operator*).

The unavoidability of such factorizing out appears, for example, when one considers the passive. In early standard TGG, which worked with a T-rule 'passive' and with structures proposed in Klima (1964) and Chomsky (1965), the passive of (1a) would come out as (1b):

Not every student has read two books. (1a)

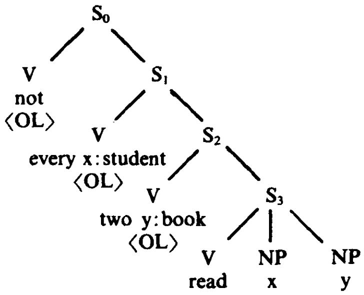
Two books have not been read by every student. (1b)

Clearly, these two sentences differ in meaning, the difference being expressible in different scopes for the operators 'not,' 'every student,' and 'two books.' Regardless of how passive is accounted for (whether by rule or as a separate DS production), a provision must be built in to ensure that the relative order of the operators in (1a) is maintained in the passive version, so that the passive will not be (1b) but rather something like the, admittedly rather awkward, sentence (1c):

Not by every student have two books been read. (1c)

And if the language in question, for independent structural reasons, does not allow for the preservation of the relative order of operators, then there must be a provision ensuring that no output is delivered.

Generative semanticists proposed to achieve the desired result by assigning to a sentence like (1a) a DS of, in principle, the following form (disregarding tense) (2a):



(2a)

One notes that the operators are categorized as V, i.e., verb, as proposed by McCawley (1973: 247, 277–319). This is semantically correct, since they are functions to S. Moreover, DS has the order Verb–Subject–Object, in accordance with McCawley (1970).

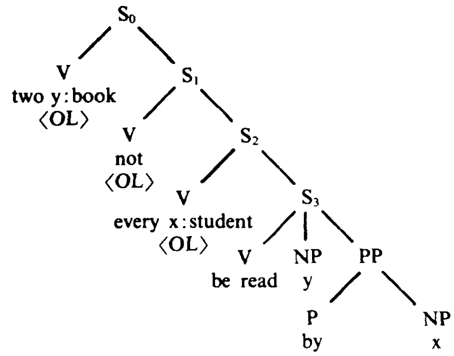
Each of the three operators, the negation 'not,' the universal quantifier 'every x: student,' and the existential quantifier 'two y: book,' induces the cyclic T-rule of operator lowering (OL). OL is constrained in such a way that, barring certain compensatory conditions, in principle no operator can be lowered into a position to the right of that occupied by a previously lowered operator ('scope ordering constraint' or SOC). The compensatory conditions just mentioned allow SOC to be overridden. One such condition is special lexical choice (e.g., 'some' instead of 'any' after negation indicates higher scope for 'some'). Another is tree hierarchy: *Every morning I read two poems* has no scope for ambiguity, but *I read two poems every morning* does have two readings that differ in scope. This is because in the latter sentence the constituent 'every morning,' though to the right of 'two poems,' is a very high, major constituent in the sentence and can thus take scopal precedence in spite of word order. Intonation may also override SOC. An often quoted case (Horn 1989: 226) is *All that glitters is not gold,* which means literally *not all that glitters is gold.* But note that in *All the King's horses and all the king's men could not put Humpty Dumpty back on the wall again,* SOC is again observed. The difference corresponds with different intonation contours, which probably express different topic–comment modulations. The correct syntactic analysis of such phenomena still has not been provided.

It should be stressed, in this connection, that the correspondence of scope hierarchies with left-to-right ordering in surface structures is a real fact of language, expressed in SOC, despite the conditions allowing an overriding of this principle. This fact must be stressed because it has been consistently denied in the formal semantic literature of Montagovian signature, where semantic interpretations are standardly allowed for all mathematically possible permutations of scope bearing operators in sentences (see *Montague Grammar*).

Variable binding operators, such as quantifiers, are lowered categorically onto the position of the bound variable. 'Not' is normally lowered onto the lower V but stays to the left of previously lowered operators if forced by SOC. Thus, on the S_2-cycle, 'two y: book' is lowered into the position of *y* in S_3, giving 'two books.' On the S_1-cycle, 'every x: student' is lowered into the position of *x*, giving 'every student,' and on the S_0-cycle, 'not' is lowered into the position just left of 'every student,' resulting in 'not every student' in subject position.

Passivization must now be restricted to the lowest S, i.e., S_3, which contains no operators. The same repeated cyclic application of OL on a passive S_3 will yield (stretching the resources of the grammar of English) sentence (1c), where the left-to-right order of the three operators is unchanged.

Sentence (1b), on the other hand, is generated from an underlying (2b):



(2b)

Here the relative scope of the operators is reflected again in the left-to-right order of their SS representatives. Interestingly, with S_3 in the active form, i.e., as $_S[_V[\text{read}]_{NP}[x]_{NP}[y]]$, OL is blocked on the S_0-cycle, since the existential quantifier 'two y: book' would have to be lowered into a position to the right of the previously lowered 'not every student.' In order to express in an active sentence what is said by (2b) one has to resort to a drastic reformulation and say something like *There are two books that not every student has read.*

A significant factor in this method of analysis is the fact that the DSs of natural language sentences display structures which are directly related to well-known structures in certain forms of predicate calculus, in particular the variety known as restricted quantification theory (see, for example, McCawley 1973: 246, 264). This means that generative semantics was the first theoretical development in linguistics since the beginning of the twentieth century to bring about a serious rapprochement between logic and linguistics. The ties traditionally linking these two disciplines had been severed with the advent of modern standard predicate calculus (classical quantification theory, CQT; see *Predicate Calculus*) as developed mainly by Russell (see *Russell, Bertrand*), since it looked as if the analyses that figure in CQT lack any relevance with respect to the analyses required in grammar. Linguists thus decided that logic was no longer for them. In the context of generative semantics, however, some linguists came to the pleasantly surprising insight that, after all, even modern logic must be taken to be relevant to grammatical analysis and description. What remained unclear for the time being was the use this new logic could have for a proper semantics of natural language.

In the early 1970s generative semantics was pushed from its dominant position in theoretical linguistics by the MIT-centered development of autonomous syntax, which has so far resulted in the theory of government and binding (GB) (see *Government*; *Binding*). This theory is characterized by the denial of Katz and Postal's 1964 argument that the theory of syntax gains by the assumption of the semantic invariance of T-rules, so that all semantic information of sentences is contained in their DS representations. Autonomous syntax, in fact, reverts to the position advocated in Katz and Fodor (1963), i.e., the model sketched in Fig. 1, but with much improved notions of semantic representation and projection rules. Autonomous syntax follows generative semantics in regarding SRs as syntactic structures in a formal semantic language closely akin to known logical languages. GB now speaks of the logical form (LF) of a sentence, rather than its semantic representation. It likewise follows generative semantics in concluding that, therefore, the projection rules are, in fact, transformations mapping sss and SRS onto each other. However, while generative semantics holds that these T-rules are constitutive of the syntax, autonomous syntax distinguishes strictly between syntactic and semantic T-rules. Moreover, whereas the syntactic T-rules are usually formulated as taking a DS input and yielding an SS output ('top–down' ordering), the semantic T-rules are usually formulated as taking an SS input and giving an LF representation as output ('bottom–up'). In generative semantics, of course, no such distinction can exist. There, all T-rules are formulated as taking a DS input and yielding an SS output, i.e., in the top–down format (though the directionality of the rules is not essential).

The difference between these two schools amounts to the empirical question of whether the transformational operations required for the mapping of SRS, (LF), and sss onto each other are also instrumental in the purely syntactic definition of well-formedness conditions of sentences. Autonomous syntax gives a negative, but generative semantics a positive answer. Other than this, the differences are not essential, since generative semantics does not exclude the existence of meaning-independent structural principles or 'filters' in the grammar of a language, and Autonomous Syntax cannot exclude the possibility that the T-rules hitherto considered to be purely semantic will turn out to have a function in the syntax of the language under analysis as well, or vice versa. In fact, to the extent that the semantic component has been elaborated in GB, the mappings relating sss and LF are remarkably similar to what was proposed earlier in generative semantics, though they are, of course, presented in the format of bottom–up directionality (cf. May 1977, where one finds quantifier raising in lieu of operator lowering).

No matter which of the two approaches, if either, will turn out to be empirically more successful, it is important to realize that the debate is more about two competing conceptions of syntax than about the relation of syntax and semantics. Yet, in the days when generative semantics was coming into its own, the question was consistently presented as being about syntax and semantics. McCawley, for example, writes (1973: 99), while commenting on his article (1967): 'It is to my knowledge the first work published . . . in which anyone argued for abolishing the distinction between syntax and semantics in transformational grammar.' It is now accepted that abolishing that distinction is an analytic impossibility of the same order as, for example, abolishing the distinction between the specification of a room and that of its temperature. All an 'integrated' transformational grammar, whether of the generative semantics or of the autonomous syntax persuasion, can do is relate sentence forms, sss, to some synonymous form, the corresponding SR, formulated in a formal language that avoids ambiguities and expresses certain logical properties. The semantic function of a transformational grammar of **L** is, in other words, restricted to the translation of the sentences of **L** into a formal language which is expected to be somehow semantically relevant or 'favorite.' The question of what the meaning is of the forms or structures themselves that occur in the 'favorite' formal language of SRS is not answered. This is why some linguists prefer to speak of 'semantic syntax' rather than 'generative semantics' (see Seuren 1972 for a detailed exposé).

What is obtained is thus, in principle, nothing more than a paraphrase, not a meaning specification. In other words, a linguistic description in terms of TGG alone remains caught in a vicious 'synonymous circle.' What a semantic specification independent of paraphrases or translations could amount to was, and to a large extent still is, a question not answered in the context of linguistics proper. For an answer to that question one has to go to formal semantics, with its model theory, or, as has become clear since the early 1980s, to 'discourse semantics,' where meaning is defined as the cognitive contribution made by a linguistic element to any current domain of discourse.

2. The Logical Tradition

While linguists were caught up in their own struggles with and about meaning, a totally separate development took place in logic, a development which was soon to be applied to the semantic analysis and description of natural language. This development, known as the 'semanticization of logic,' began in the 1930s and consisted essentially of the introduction of mathematical model theory (see *Model*) as an enrichment of logical proof theory. A 'model' is an independently defined or described state of affairs in some real or imagined 'world' whose elements are related, by means of an 'interpretation function,' to the structural elements of a language **L**. This new model theory naturally led to a definition of the notion of 'meaning of a sentence S' in terms of the conditions to be fulfilled by any world for S to be 'true.' In any world failing to fulfill these conditions S is false. In other words, the meaning of a sentence S is, in this view, exhaustively specified by a full statement of the truth conditions of S.

Moreover, the 'truth value' ('true' or 'false') of S in any one specific model **M** is, in the standard model-theoretic approach, considered to be 'computable' from the syntactic structure of S. This syntactic structure is taken to be a 'tree structure,' i.e., a hierarchically ordered set of n-tuples (usually pairs or triples) of linearly ordered constituents, precisely as defined and used by Bloomfield (1933) and his students in the more strictly linguistic tradition (see *Tree Adjoining Grammars*). The computation of the truth value of S, so to speak, 'works its way' through the tree **T** associated with S in the following way. Any subtree of **T** consisting of a dominating node A and dependent nodes $A_1, \ldots, A_n$ is treated as a computational unit with one of the dependent nodes, A_i ($1 \leq i \leq n$), doing the work of a (set-theoretic) 'function' **f** and the remaining nodes providing the 'arguments' to **f**. The 'value' of **f** is passed on to the dominating node A. This value will then again become an argument to another function **f'** associated with a sister node of A, and the new value will be passed on to the node dominating A, and so on until the highest node is reached. The calculus must be organized in such a way that the eventual value assigned to the highest node in the tree **T** is the truth value of the sentence S with respect to the world specified in the model **M**. In standard formal semantics this calculus is generalized over all possible worlds (intensionalized), with the result that the final value yielded is not just one truth-value for one world but a truth-value for any one of the possible worlds or, in other words, a set of possible worlds (see *Characteristic Function*). We thus have what is called a 'compositional calculus' yielding a truth value for any sentence S of the language **L** once a model (a world plus an interpretation function) is provided, or, in intensionalized form, a denotation for the set of possible worlds in which S is true.

Whereas this logical model theory was restricted, at first, to the formal languages devised in logic and mathematics (a restriction strongly advocated by the logician Alfred Tarski; see *Tarski, Alfred*), some of Tarski's more daring successors, in particular Donald Davidson (see *Davidson, D.*) and Richard Montague (see *Montague, Richard*), applied it to natural language, hoping thus to lay the foundations for a mathematical theory (calculus) of natural language meaning. This development is known as formal semantics (see *Formal Semantics*).

One feature that has consistently characterized formal semantic theories and analyses is the systematic rejection of a separate semantically and logically regular and transparent (deep structure) level of representation for sentences. The calculi are all devised for and grafted upon surface structure representations. Consequently, the grammar envisaged in formal semantic theories is entirely without transformational rules. This rejection is not essential in the sense that no formal semantics would be possible if it were given up. On the contrary, as has been said, the origins of formal semantics lie in model theory which was devised in the first place for formal logical languages such as, for example, the language of DS representations. The motivation for this rejection is, in principle, as follows. On the one hand there is the ockhamist consideration minimalizing theoretical assumptions. On the other, it is felt that the evidence for a separate level of semantic representation, with the concomitant inconvenience of T-rules, is insufficient to warrant their postulation. The more so since the formal resources afforded nowadays by logic and mathematics are sufficiently powerful to get rid of the complications that in the linguistic tradition are meant to be overcome by the assumption of DS representations and T-rules. There is no need to emphasize that the two traditions still have a great deal to sort out between themselves.

As in the structuralist linguistic tradition established mainly by Bloomfield, syntax is defined in formal semantics as the full specification of all constructions admissible in the language **L**. Unlike Bloomfieldian structuralist linguistics, however, formal semantics considers the notion of meaning to be a fully legitimate object of scientific investigation, it being captured by the notion of truth conditions. The semantics proper of a language **L**, in this view, consists of the (compositional) calculus yielding, in principle, a truth value for any given sentence of **L** in any given world with respect to which the sentence is interpreted.

It is thus clear that formal semantics has the advantage of not having been influenced by behaviorism in the way linguistics was. It, moreover, avoids the synonymous circle mentioned above, by virtue of the notions and techniques provided by model theory. The result is much greater clarity on semantic matters and also a much enriched insight, if not into the nature of human language, at least into the computational possibilities offered by tree structures.

It is also clear that, from the perspective of formal semantics, there can be no confusion about the relation between syntax and semantics: the syntax of **L** defines the combinations of form elements into all and only the well-formed sentences of **L**, whereas the semantics of **L** defines the truth conditions for all the sentences of **L** as they are defined by the syntax. It is, in effect, the distinction between specifications of objects on the one hand and of their properties on the other, or, as has been said above, very much like the distinction between the specification of a room and that of its temperature.

Despite its obvious successes it has consistently been doubted by many linguists whether formal semantics actually contributes to an improved insight into the nature of human language. These doubts are based mainly on two considerations. First, there is the fact that, due to the ungraspable character of notions like 'possible world' or, worse, 'set of possible worlds,' the values envisaged by the compositional calculus for sentences are not effectively computable in terms that specify actual worlds or situations. All that formal semantics can give is abstractions over, or schemata of, such specifications. There is, in other words, a problem of 'psychological reality.' Then, formal semantics is just too often in conflict with what linguists perceive as facts of language. The analyses are inspired by and follow modern logic, in particular CQT, i.e., its 'unrestricted' variety. And, as is well known, these analyses clash with straightforward linguistic intuitions on many different points. An example was mentioned above in connection with scopal phenomena of operators. Another example is the inability of formal semantics to come to terms with 'presuppositional phenomena' (see *Presupposition*).

It is now widely accepted in formal semantic circles that objections of this nature must be taken seriously. As a result, several attempts have been made in the 1980s and early 1990s to remedy this situation. What these attempts have largely in common is a recognition of the 'context-dependency' of semantic interpretation of natural language sentences in actual use, and, in tandem with this, of the structural features that ensure a proper semantic linking up of sentences with their context (such as anaphoric devices and presuppositions). These new theories tend to incorporate a notion of 'discourse representation,' mediating between sentences and what they are about. They moreover involve a much restricted notion of 'world,' more like a 'situation' or 'verification domain.' The compositional calculus, applied to syntactic trees of sentences, no longer produces truth values with respect to possible worlds, but specifications of the changes ('increments') brought about by the sentences in the representation of whatever discourse they occur in. Accordingly, the notion 'meaning of a sentence' is equated with that of its change potential with respect to any given discourse representation (for further details see, in particular, *Situation Semantics*; *Discourse Representation Theory*; *Discourse Semantics*). Still, however, no confusion can arise, in these newer semantic theories, between the syntax and the semantics of a language, since the syntax still specifies only the possible structural combinations, and the semantics still consists of the computational procedures carried out on the syntactically defined structures.

See also: Generalized Phrase Structure Grammar; Situation Semantics; Morphology; Grammar, Descriptive versus Formal; Formal Semantics; Generalized Phrase Structure Grammar; Situation Semantics.

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