3 Semantics and Syntax

In defining the semantic component for the small fragment of English we considered in the previous chapter, we followed the traditional method of writing a special semantic rule for each syntactic configuration that we encountered in our trees. There was a rule for Ss dominating an NP and a VP, a rule for VPs dominating a V and an NP, a rule for VPs dominating just a V, and so on.[1] But if Frege's Conjecture is right, and all non-trivial semantic composition is functional application, then we shouldn't need all these construction-specific interpretation rules. It should be sufficient to specify the denotations of the lexical items, and the rest should follow automatically.

We begin the present chapter by implementing this attractive suggestion. Then we proceed to some reflections about the place of the semantic component within the grammar, especially its relation to the syntactic component. Our Fregean approach gives us an interesting perspective on the relation between a verb and its arguments, which has been discussed from more syntactic points of view throughout the history of generative grammar.

3.1 Type-driven interpretation

The term "type-driven interpretation" was coined by Ewan Klein and Ivan Sag, whose paper "Type-Driven Translation" criticized the construction-specific interpretation method of classical Montague Grammar and proposed essentially the same revision that we present in this section.[2]

We continue to assume that the input for the semantic component is a set of phrase structure trees. But we no longer allow semantic rules for specific types of subtrees like the ones we wrote in chapter 2. Instead, we posit three very general principles:

(1) *Terminal Nodes* (TN)
If α is a terminal node, $[\![\alpha]\!]$ is specified in the lexicon.

(2) *Non-Branching Nodes* (NN)
If α is a non-branching node, and β is its daughter node, then $[\![\alpha]\!] = [\![\beta]\!]$.

(3) *Functional Application* (FA)
If α is a branching node, $\{\beta, \gamma\}$ is the set of a's daughters, and $[\![\beta]\!]$ is a function whose domain contains $[\![\gamma]\!]$, then $[\![\alpha]\!] = [\![\beta]\!]([\![\gamma]\!])$.

Notice that (3) does not specify the linear order of β and y. Nevertheless, it applies in a unique way to each given binary branching tree. If α is of the form $[_S$ NP VP], we have to apply it in such a way that the right-hand daughter corresponds to β and the left-hand daughter to γ. How do we know? Because this is the only way to satisfy the condition that $[\![\beta]\!]$ must be a function whose domain contains $[\![\gamma]\!]$. If α is of the form $[_{VP}$ V'NP], it's the other way round: β must be the left node, and γ the right one. Here you can see, by the way, what is behind the name "type-driven interpretation": it's the semantic types of the daughter nodes that determine the procedure for calculating the meaning of the mother node. The semantic interpretation component, then, can ignore certain features that syntactic phrase structure trees are usually assumed to have. All it has to see are the lexical items and the hierarchical structure in which they are arranged. Syntactic category labels and linear order are irrelevant.

During the course of the book, we will add one or two additional principles to the above list, but we will strive to keep it as parsimonious as possible. When we look at a new construction for which we don't yet have a semantic analysis, we always try first to accommodate it by adding only to the lexicon.

Our current set of lexical entries is just the beginning of a long list that we will extend as we go:

(4) Sample of lexical entries:
(i) [Ann] = Ann
(ii) [smokes] = hx $\in D_e$. x smokes
(iii) [loves] = hx $\in D_e$. [hy $\in D_e$. y loves x]
(iv) [and] = $\left[\begin{array}{l} 1 \rightarrow \left[\begin{array}{l} 1 \rightarrow 1 \\ 0 \rightarrow 0 \end{array}\right] \\ 0 \rightarrow \left[\begin{array}{l} 1 \rightarrow 0 \\ 0 \rightarrow 0 \end{array}\right] \end{array}\right]$

or, using the h-notation:

[and] = hp $\in D_t$. [hq $\in D_t$. p = q = 1][3]

etc.

Given the lexicon, the three interpretive principles TN, NN, and FA should suffice to derive all the predictions that were made by our old semantic component from chapter 2. For the most part, it is transparent how this works out. The semantic rules (S2)-(S5) in chapter 2 are evidently special cases of NN, and (S1) and (S6) are special cases of FA. What is *not* covered by the new theory is the interpretation of ternary trees, like those we initially assumed for sentences with "and" and "or". The semantic rules from the exercise on connectives in section 2.1 cannot be seen as special cases of any current principle. (Our formulation of FA above stipulates that a has no more than two daughters.) But rather than worry about this limitation, we will henceforth assume (mainly for pedagogical reasons) that phrase structures in natural language are at most binary branching.[4] If necessary, it would not be too difficult to adjust our system of composition rules so that it could interpret a more realistic range of input structures.

3.2 The structure of the input to semantic interpretation

We have been assuming that the entities which are assigned denotations by the semantic component are phrase structure trees, and that these are somehow generated by the syntactic component of the grammar. We have not committed ourselves to any concrete assumptions about the kind of syntax that does this. Indeed, a variety of views on this matter are compatible with our approach to semantics and have been entertained. According to the so-called "Standard Theory" of early generative grammar, the input to semantic interpretation consisted of the Deep Structures generated by the base component of the syntax, essentially a context-free grammar.[5] In Generative Semantics, Deep Structures were representations that resembled formulas of the Predicate Calculus, and could involve decomposition of predicates. From a more modern Chomskyan perspective, the inputs to semantic interpretation are Logical Forms, which are the output of transformational derivations. Many other syntactic theories can be, and have been, combined with the same kind of semantic theory – for instance, categorial grammars and monostratal phrase structure grammars.[6] The only requirement for the syntax is that it provides us with phrase structure trees.

When we say "(phrase structure) trees", what exactly do we mean? According to standard definitions, a phrase structure tree consists of a (finite) set of *labeled nodes* which are ordered by a *dominance* relation and a *linear precedence* relation.' Many structural concepts can be defined in terms of dominance and precedence, among them the ones that happen to be referred to by our interpretation principles TN, NN, and FA: namely, "(non-)terminal node" " (non-)branching", and "daughter". This being so, phrase structure trees in the standard sense are suitable structures for our semantic rules to apply to them.

We mentioned already that certain somewhat more impoverished structures would be suitable as well. Nothing in our semantic component – in particular, none of our principles TN, NN, and FA – makes any direct or indirect mention of non-terminal node labels or linear precedence. "(Non-)terminal node", "(non-)branching", and "daughter" are all definable in terms of the dominance relation alone, and these are the only syntactic notions that have been mentioned. We therefore conclude that our semantics can also be combined with a syntax that provides unlinearized structures without syntactic category labels instead of standard phrase structure trees.[8] If the syntactic theory you are working with is of that kind, you may tacitly ignore the syntactic category labeling and linearization information encoded by the tree diagrams which we will be drawing in this book. It won't make any difference.

Even though our semantics does not rely on syntactic category labels, we will normally employ at least some commonly used labels when we present phrase structure trees. Using syntactic category labels makes it easier for us to talk about particular nodes or types of nodes in a tree. We want to emphasize, however, that our choice of labels does not have any theoretical significance; the semantic component doesn't have to see them. Here is an overview of the lexical category labels that we will be using most often:

syntactic category	label
verb	V
noun	N
adjective	A
preposition	P
determiner	D
inflectional elements	I
("do", tense, modal auxiliaries, etc.)	
complementizer	C

Labels for phrasal categories are coined in the usual way. A maximal verbal projection is a VP (verb phrase), for example. An intermediate verbal projection is a $\overline{V}$ (V-bar). We will be using "S" or "IP" (inflection phrase) as labels for sentences. Other labels may be introduced as we go along.

The kind of semantic theory we are developing here is compatible with a wide range of approaches to syntax. It may be worth pointing out, however, that it is nevertheless fundamentally incompatible not only with many conceivable proposals regarding the structure of the input to semantic interpretation, but even with some that have actually been made. For instance, Jackendoff[9] and other representatives of the Extended Standard Theory argued that meaning depended on both Deep Structure and Surface Structure. Roughly, Deep Structure was to determine predicate–argument relations, and Surface Structure scope and binding relations. In our terms, this would mean that the domain-of the interpretation function ⟦ ⟧ should consist of (or include) something like *pairs* of phrase structure trees. What this would amount to in concrete detail is far from clear, and our current conception of semantic composition would have to be substantially altered and/or enriched to make it work.[10]

3.3 Well-formedness and interpretability

Montague's view of the role of syntax was that the syntactic component served to generate *exactly* the trees to which the semantic component assigned denotations. In such a framework, there is no such thing as a tree generated by the syntax but not in the domain of the interpretation function ⟦ ⟧, or a tree in the domain of ⟦ ⟧ but not generated by the syntax. Syntactic well-formedness and semantic interpretability coincide completely. This was just the situation that philosophical logicians were used to from their work on formal languages.

But linguists have questioned this set-up for a long time. Even before the word "modularity" became common, it was widely agreed that the grammars acquired by human beings do not just divide the set of all possible expressions into the well-formed, meaningful ones versus all the rest. Sentences or near-sentences may be judged deviant for a variety of independent reasons. It is easy to find examples that speakers reject as ungrammatical despite perfectly clear and definite intuitions about what they mean. Considering how general and universal our principles of interpretation are, of course, it is only to be expected that they will apply not only to those structures that happen to represent grammatical English sentences, but to many others besides.

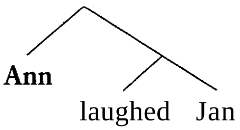
The existence of the reverse case – that is, of uninterpretable but otherwise completely well-formed examples – is harder to establish without already presupposing a certain amount of theory, but there is certainly no reason to rule it out a priori either. The following examples might be cases in point.

(1) *Ann laughed Jan.

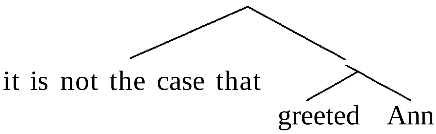
(2) *It is not the case that greeted Ann.

Suppose the syntax of English provides derivations for these which are not ruled out by any syntactic (or phonological) principle and which assign them the following phrase structures.

(1′)



(2′)



What happens if we try to calculate denotations for these trees by means of our current composition rules and lexicon?

In (1′) we obtain a truth-value for the constituent "laughed Jan" (by applying the function [[laughed]], of type <e,t>, to Jan, of type e). But at the next higher node, we can't apply any of our rules. FA demands that either [[Ann]] or [[laughed Jan]] be a function. Since one is a person and the other a truth-value, it cannot apply. In (2′), we obtain a function of type <e,t> for the node dominating greeted Ann (by applying [[greeted]], of type <e,<e,t>>, to Ann, of type e). There again we are stuck at the next node up: [[it is not the case that]] is a function of type <t,t> and [[greeted Ann]] a function of type <e,t>. Neither has the other in its domain, so FA cannot apply.

Thus, in both cases we are looking at trees that don't receive any denotation by our semantic component. That is, they are not in the domain of the ⟦ ⟧ function as defined by our current lexicon and composition rules. It is reasonable to hypothesize that this – and this alone – is what accounts for the deviance judgments that we represented by the asterisks in (1) and (2). We have not shown, of course, that there isn't something else wrong with these structures in addition to their failure to receive denotations. But let's suppose for the sake of the argument here that there isn't.

Structures which, like (1′) and (2′), fail to receive denotations will be called *uninterpretable*. We take it that uninterpretability is one among other sources of ungrammaticality. Uninterpretable structures are those filtered out by the *semantic* component of the grammar. Here is a more precise formulation of our set of semantic rules, which explicitly takes into account the possible existence of uninterpretable (sub)trees. We define the interpretation function ⟦ ⟧ as the smallest function that fulfills the following conditions:

(3) *Terminal Nodes* (TN)
If α is a terminal node, then α is in the domain of ⟦ ⟧ if ⟦α⟧ is specified in the lexicon.

(4) Non-Branching Nodes (NN)
If α is a non-branching node, and β is its daughter node, then α is in the domain of $[\![\ ]\!]$ if β is. In this case, $[\![\alpha]\!] = [\![\beta]\!]$.

(5) Functional Application (FA)
If α is a branching node and $\{\beta, \gamma\}$ is the set of α's daughters, then α is in the domain of $[\![\ ]\!]$ if both β and γ are and $[\![\beta]\!]$ is a function whose domain contains $[\![\gamma]\!]$. In this case, $[\![\alpha]\!] = [\![\beta]\!]([\![\gamma]\!])$.

Notice that each of (3)–(5) gives sufficient (but not necessary) conditions for α being in the domain of the interpretation function $[\![\ ]\!]$. But by defining $[\![\ ]\!]$ as the smallest function that meets all these conditions, we say, in effect, that a tree is not in the domain of $[\![\ ]\!]$ unless one of (3)–(5) implies that it is. We could have achieved the same result, of course, by using "iff" rather than "if" in (3)–(5).

Finally, let us make explicit the filtering function of the semantic component:

(6) Principle of Interpretability
All nodes in a phrase structure tree must be in the domain of the interpretation function $[\![\ ]\!]$.

In sum, we are adopting a view of the grammar as a whole on which syntax and semantics are independent modules. Each imposes its own constraints on the grammatical structures of the language, and we expect there to be structures that are interpretable though syntactically illegitimate, as well as structures that are syntactically correct but uninterpretable.

3.4 The Θ-Criterion

In the syntactic literature, the ungrammaticality of examples like (1) and (2) has sometimes been attributed to the so-called Θ-Criterion (Theta-Criterion).

(1) ***Ann laughed Jan.**

(2) ***It is not the case that greeted Ann.**

Chomsky gives the following formulation.11

(3) *Θ-Criterion*
Each argument bears one and only one Θ-role, and each Θ-role is assigned to one and only one argument.

What are @-roles? The term "Θ-role" ("theta-role") is an abbreviation for the more commonly used term "thematic role". If an event of greeting takes place somewhere, then there is a greeter and someone who is greeted. Greeter and greetee are two *specific* 0-roles. If a kicking takes place, then there is a kicker and someone who is kicked. Kicker and kickee are again two *specific* 0-roles. A verb like "greet" requires one argument that is interpreted as the greeter, and another argument that is interpreted as the one that is greeted. We may say, then, that it assigns these two specific 0-roles to its arguments. A verb like "kick" requires one argument that is interpreted as the kicker, and another argument that is interpreted as the one that is kicked. Again, we may say that it assigns those two specific 0-roles. Kicking and greeting are both actions, kickers and greeters are both agents, and whatever is greeted or kicked is a patient or theme according to a common terminology. Usually, when you hear about 0-roles, it's *general* 0-roles like "agent", "theme", "patient", or "experiencer" that are being talked about.[12] General 0-roles are potentially interesting, since there are generalizations linking them to syntactic positions in a systematic way. As far as the Θ-criterion is concerned, however, only specific 0-roles are relevant. Now, what does the 0-criterion do?

One part of the Θ-Criterion says that whenever a lexical element requires an argument with a certain 0-role, then there must be such an argument somewhere in the syntactic representation. And there can be only one. There couldn't be two NPs, for example, that are both interpreted as the greeter argument for the verb "greet". The other part of the Θ-Criterion says that whenever there is a "candidate" for an argument, like an NP or what have you, then this element must be in fact an argument of a lexical element that assigns it a 0-role. That it can't be assigned more than one Θ-role means that it can't fill more than one argument position at once.

The @-Criterion is meant to exclude the following kinds of cases:

(4) ***Ann laughed Jan.** (= **(1)** above)

(5) * Greeted Ann.

(4) is ruled out by it since one of the NPs cannot be assigned a 0-role. "Laugh" has only one 0-role to assign, and since this one Θ-role cannot be assigned to two NPs, (4) cannot possibly mean that Ann and Jan both laughed. *(5)* is ruled out by the Θ-Criterion since "greeted" assigns two 0-roles, but there is only one NP present. Since no NP can receive two 0-roles, *(5)* cannot mean that Ann greeted herself.

We saw above how similar examples are treated by our current semantic theory: (4) came out as simply uninterpretable; that is, it receives no denotation.

In other words, it is predicted to have no truth-conditions at all, neither those of "Ann and Jan both laughed" nor any others. As far as (4) is concerned, then, the predictions of our semantics coincide fully with those of the @-Criterion.

May we conclude that the @-Criterion is – apart from differences in terminology – just a corollary of our current theory? In other words, does every Θ-Criterion violation reduce to a case of uninterpretability in the sense we specified above? Or is there merely a certain overlap in predictions? Let's take a closer look at this question.

What about (5)? The Principle of Interpretability succeeds (just like the Θ-Criterion) in ruling out examples like (2) above, in which (5) appears as an embedded constituent. But (5) all by itself isn't actually uninterpretable according to our semantics. It gets, in effect, the denotation of the VP "greeted Ann" (which is the function $\lambda x \in D_e$. x greeted Ann). We therefore predict correctly that "greeted Ann" cannot be used to make a statement – that is, is not capable of truth or falsity.

Summarizing the discussion so far, we still haven't seen any predictions of the Θ-Criterion that were not covered by the Principle of Interpretability in our current theory. But it would be premature to stop looking. In fact, the following abstract consideration shows that the @-Criterion is a genuinely stronger constraint than Interpretability.

Suppose we have a predicate a with one 0-role to assign. In our terms, suppose that ⟦α⟧ is of type <e,t>. According to the @-Criterion, *a* must appear in the vicinity of something which receives its @-role. That means *a* has to have a sister node with a meaning of type e. According to our Interpretability principle, on the other hand, a sister node of type e is not strictly required. It would provide one suitable environment for a, but not the only kind. Imagine instead that a has a sister node whose meaning is *a function with domain* $D_{<e,t>}$. (For instance, it might be of type <<e,t>,e>.) In that case, the next higher node could be interpreted by applying this sister's meaning to *[a]*. So we could have an interpretable structure which does not contain an argument for a! a would not be assigning its Θ-role to any phrase, in violation of the Θ-Criterion. Yet Interpretability would be fulfilled, in virtue of a being a suitable argument for its sister node.

The question now is: Can we find concrete instances of this sort of situation? And if yes, are they in fact grammatical (as predicted by Interpretability) or ungrammatical (as predicted by the stronger @-Criterion)?

In the following chapter, we will propose that common nouns like "barn" are 1-place predicates (type <e,t>). In other words, they have a Θ-role to assign, and thus the @-Criterion requires the presence of an argument. In certain examples (predicative uses), this is unproblematic:

(6) **This is a barn.**

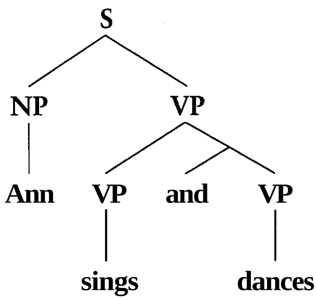
The required argument here is the subject NP "this". (6) is true if and only if the object referred to by "this" has the property of being a barn. But consider the following sentence:

(7) The barn burned down.

(7) contains no phrase that receives the Θ-role of "barn". It thus seems to violate the @-Criterion. Yet it is perfectly fine, and we will see below how it can be interpreted by assigning "the" a meaning of type $<<e,t>,e>$, suitable to take **[barn]** as an argument. So this is the sort of case we have been looking for. The Interpretability Principle and the Θ-Criterion make different predictions here, and if the analysis we will give for (7) is on the right track, then the empirical facts favor the former.13

Another case which *prima facie* points in the same direction arises with coordinated predicates. So far, all our examples involving "and" and "or" had these connectives combining with sentences, as in propositional logic. But English apparently also allows these connectives to conjoin subsentential constituents, such as two VPs, as in (8).14

(8)



To interpret this, we need a new lexical entry for the homonym of "and" that we encounter here. (The familiar meaning of type $<t,<t,t>>$ evidently doesn't work here.)

(9) **[and]** $= \lambda f \in D_{<e,t>} . [\lambda g \in D_{<e,t>} . [\lambda x \in D_e . f(x) = g(x) = 1]]$

You can verify that, given *(9)*, the tree in (8) is interpretable by our general principles and receives intuitively correct truth-conditions. What interests us here is that this is another interpretable structure which seems to violate the @-Criterion, in that there are not enough arguments to go around for all the Θ-roles that need to be assigned in (8): "Sing" and "dance" each have a 0-role to assign, but only one potential argument (the NP "Ann") is present. Once more, we tentatively conclude that the weaker requirements imposed by our Interpretability Principle make the better empirical predictions.

These two arguments against the @-Criterion are not beyond question, of course. They are only as good as the syntactic and semantic analyses we have sketched. It might very well turn out upon closer inspection that there is more than meets the eye to the structures of examples (7) and (8). Specifically, we might find evidence for non-overt constituents which provide just the superficially missing arguments that are demanded by the Θ-Criterion. In that event, these examples might not only cease to be counterexamples, but might ultimately turn out even to support the @-Criterion. We will set this possibility aside for now, but in principle it remains open.

3.5 Argument structure and linking

Some syntactic theories posit a syntactic representation of a verb's argument structure that is distinct from the representation of the verb's denotation. ***Argument structure*** representations are meant to encode "the syntactically relevant argument-taking properties of a verb"[15] (and any lexical item that takes arguments). Argument structure representations play a role in theories of ***linking*** – that is, theories about how a verb's arguments are linked to syntactic positions in a tree. In this section, we will look at some proposals that have actually been made for argument structure representations and linking. We will see that some of the information that has been attributed to argument structure representations and linking principles turns out to be redundant, given the semantic theory we have been developing.

Minimally, the argument structure representations found in the syntactic literature list the arguments a verb takes. This information has been thought to be relevant to the syntax, because of the deviance of sentences like (1) or (2):

(1) *Ann laughed Jan.

(2) *Greeted Ann.

In the previous section, we discussed the possibility that the deviance of (1) and (2) might actually be accounted for in the semantics. (1) fails Interpretability, and (2) receives a VP-denotation, hence cannot be used to make a statement capable of truth or falsity. If this view of the syntax–semantics interface should turn out to be correct, there is no need for separate syntactic representations of argument structure, unless they provide more information than a mere list of the verb's arguments.

In her book Argument Structure,16 Jane Grimshaw explores the hypothesis that argument structure representations also reflect prominence relations among arguments. The verb "introduce" would be given the following argument structure representation, for example:17

(3) **introduce** (agent (goal (theme)))

(3) says that "introduce" has three arguments that are hierarchically ordered: the agent argument is the highest, the goal argument comes next, and the theme argument is at the bottom. Grimshaw emphasizes that the general thematic role labels "agent", "goal", or "theme" have no theoretical status; they merely serve to identify the verb's arguments. She could have used labels for specific thematic roles instead. A prominence relation among arguments is part and parcel of our Fregean verb denotations. The Fregean denotation of "introduce" is

(4) $hx \in D_e$. [$hy \in D_e$. [$\lambda z \in D_e$. z introduces x to y]]

Like (3), (4) encodes the information that the agent argument of "introduce" is most prominent, the goal argument is next, and the theme argument fills the lowest position. If we apply the function in (4) to an individual, Sue, for example, we get *(5)*.

(5) $hy \in D_e$. [$hz \in D_e$. z introduces Sue to y]

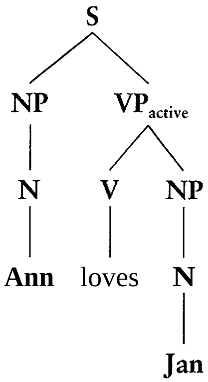
The first argument to be processed, then, is given the role of the person who is introduced (the theme). Next, if we apply the function in (5) to Ann, the result is (6): Ann is assigned the role of the person who Sue is introduced to (the goal):

(6) $\lambda z \in D_e$. z introduces Sue to Ann

If we finally apply the function in (6) to, say, Pat, we end up with a truth-value: "True" if Pat introduces Sue to Ann, and "False" otherwise. That is, the last argument to be processed is understood as the agent of the introduction event. We can conclude, then, that we do not need separate argument structure representations to display prominence relations among arguments. This information is already provided by the representation of the verb's denotation.

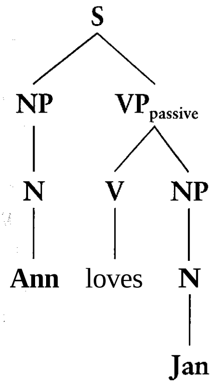
Our system of type-driven interpretation principles implies a rather strong claim about the linking of a verb's arguments to syntactic positions. The lexically determined prominence relations must be preserved in the syntax.[18] This means that there couldn't be a natural language that has structures like (7) as *well as* structures like (8), with the truth-conditions (7') and (8') respectively.

(7)



(7') Truth-conditions
⟦7⟧ = *1* iff Ann loves Jan.

(8)



(8') Truth-conditions
⟦8⟧ = *1* iff Jan loves Ann.

Since the V-denotation must combine with the denotation of its direct object by Functional Application, the lexical meaning of "loves" determines that "Jan" is interpreted as the one who is loved in both *(7)*and *(8)*. Consequently, *(7)*and *(8)*cannot have different truth-conditions. If we allowed construction-specific interpretation rules, we could in principle have rules like *(9)*and *(10):*

(9) If *a* has the form $\overset{\text{VP}_{\text{active}}}{\beta \quad \gamma}$, then *[a]*= ⟦β⟧(⟦γ⟧).

(10) If *a* has the form $\overset{\text{VP}_{\text{passive}}}{\beta \quad \gamma}$, then *[a]*= [hx ∈ D_e . ⟦β⟧(x)(⟦γ⟧)].

Keeping our earlier rules for the interpretation of lexical, non-branching, and S-nodes, both *(7)*and *(8)*would now be assigned the intended truth-conditions.

Active structure (7)

$[\![VP_{active}]\!] = [hy \in D_e \,.\, [\lambda z \in D_e \,.\, z \text{ loves } y]](Jan) = [hz \in D_e \,.\, z \text{ loves Jan}].$

$[\![7]\!] = [hz \in D_e \,.\, z \text{ loves Jan}](Ann) = 1 \text{ iff Ann loves Jan.}$

Passive structure (8)

$[\![VP_{passive}]\!] = [\lambda x \in D_e \,.\, [hy \in D_e \,.\, [\lambda z \in D_e \,.\, z \text{ loves } y]](x)(Jan)]$

$\qquad\qquad = [\lambda x \in D_e \,.\, \text{Jan loves } x].$

$[\![8]\!] = [Ax \in D_e \,.\, \text{Jan loves } x](Ann) = 1 \text{ iff Jan loves Ann.}$

Many syntactic theories consider it necessary to stipulate principles that prevent a language from having *both* structures like *(7)and* structures like (8). Take Mark Baker's Uniformity of Theta Assignment Hypothesis (UTAH):[19]

(11) *The Uniformity of Theta Assignment Hypothesis (UTAH)*
Identical thematic relationships between items are represented by identical structural relationships.

The UTAH can be given a weaker or stronger interpretation. On the weaker interpretation, the UTAH says that NPs that bear the same *specific* thematic role bear the same syntactic relationship to their verb. The stronger interpretation requires that all NPs that bear the same *general* thematic role (given some inventory of general thematic roles) bear the same syntactic relationship to their verb. The weaker version of the UTAH requires that all arguments that bear the lover role must be syntactically realized in a uniform way, and the same is true of all arguments that bear the role of the one who is loved. The stronger version of the UTAH might require, for example, that all arguments that bear the experiencer (of an emotion) role appear in the same syntactic position, and likewise all arguments bearing the theme, patient, or agent role. Both versions exclude the hypothetical situation described above. If (7') states the correct truth-conditions for *(7)*,then the truth-conditions (8') are ruled out for **(8),**and if (8') states the correct truth-conditions for **(8),** then the truth-conditions (7') are ruled out for (7).

We have just seen that some of the work done by principles like the UTAH is automatically taken care of by our semantic component. In fact, the weak version of the UTAH is at least close to becoming superfluous. What about the more interesting strong version? What about *general* thematic roles in our framework? It is fairly obvious that the prominence relations among a verb's arguments do not have to be learned separately for each verb. There are generalizations involving general thematic roles. Agent arguments are generally higher than theme or patient arguments, for example. The exact nature of such generalizations is still a matter of debate. The most worked-out proposal is that of Dowty,[20] whose argument selection principles are stated on the basis of thematic proto-roles. Dowty assumes that thematic roles like agent or patient are cluster concepts like the prototypes of Rosch and Mervis.[21] According to him, the argument with the greatest number of proto-agent properties is selected as the lexically most prominent argument, for example. With ditransitive verbs, the argument with the greatest number of proto-patient properties would be the lowest argument. The middle argument would have fewer proto-patient properties than the lowest argument and fewer proto-agent properties than the highest argument. Be this as it may, whatever the correct generalizations about lexical prominence relations are, our semantic interpretation system automatically imposes them on the hierarchical line-up of arguments in the syntax. The syntactic component, then, does not have to worry about thematic roles, be they specific or general. What appear to be generalizations about the syntactic realization of arguments might in fact be rooted in uniformities of prominence relations across lexical items.

Does this mean that we can dispense with syntactic linking principles altogether? Not quite yet. There is an important syntactically relevant distinction between a verb's arguments that does not yet fall out from our semantics. Syntactic work that was most vigorously pursued within Relational Grammar has established that not all arguments that are lexically most prominent show the same syntactic behavior.[22]

(12) Unaccusative verb: [die] = $\lambda x \in D_e$. x dies
Unergative verb: [work] = $\lambda x \in D_e$. x works

(13) Transitive agentive verb: [greet] = $\lambda x \in D_e$. [$\lambda y \in D_e$. y greets x]
Transitive experiencer verb: [worry] = $\lambda x \in D_e$. [$\lambda y \in D_e$. y worries x]

As far as lexical prominence relations are concerned, there is no difference between "die" and "work", and the same is true for "greet" and "worry". Yet syntactically, unaccusative verbs behave differently from unergative verbs, and agentive verbs do not pattern with (object) experiencer verbs in important respects. Using the terminology of Williams,[23] the most prominent argument of unergative and agentive transitive verbs is an *external* argument. The most prominent argument of unaccusative and (object) experiencer verbs is an *internal* argument. According to Williams, the external argument is located external to the maximal projection of the verb, whereas internal arguments appear within the maximal projection of the verb (at some level of representation). In one way or other, the difference between external and internal arguments has been held responsible for the fact that subjects of unaccusative and (object) experiencer verbs show certain properties of objects, unlike the subjects of unergative and agentive transitive verbs.

The syntactic impact of the distinction between external and internal arguments cannot be directly derived from our semantics as is. To be sure, there are plenty of proposals which try to correlate the distinction with some semantic property. But that's not enough. This all by itself will not spare us the stipulation of a special linking principle. Our semantic composition rules only impose hierarchical relationships on the syntactic representation of arguments. There is no way for them to influence whether a most prominent argument is realized within or outside a VP, for example. One possible conclusion, then, is that the distinction between external and internal arguments might be the only piece of information about a verb's argument structure that has to be taken care of in the syntax. This is not a necessary conclusion, however. Marantz[24] has argued that external arguments are not arguments of their verbs at all. Within our current semantic framework, it is hard to see how to even make sense of such an idea. It is possible, however, to implement it within a theory that construes verb denotations along the lines of Donald Davidson.[25] Kratzer shows how this move eliminates the need for a syntactic representation of the distinction between external and internal arguments.[26] All information about a verb's argument structure, then, would be directly derivable from its denotation. There would be no syntactic theory of argument structure or linking. While this line of research might have promise, it goes way beyond what we can and should pursue in an introductory text.

Notes

1 This is similar to the method of "rule-by-rule interpretation" (so dubbed by Emmon Bach) which you find in Montague's papers, for example. Suppose we described the set of phrase structures that are interpretable by our current semantics by means of a context-free grammar. Then each of our semantic rules would correspond to exactly one of the phrase structure rules – hence the name "rule-by-rule". See E. Bach, "An Extension of Classical Transformational Grammar," in *Problems of Linguistic Metatheory*, Proceedings of the 1976 Conference at Michigan State University, 1976, pp. 183–224.

2 E. Klein and I. Sag, "Type-Driven Translation," *Linguistics and Philosophy*, 8 (1985), pp. 163–201. For a recent approach along similar lines, see M. Bittner, "Cross-Linguistic Semantics," *Linguistics add Philosophy*, 17 (1994), pp. 53–108. Bittner uses an intensional semantics and covers a much greater range of constructions than we do here.

3 Note that we can't write "$\lambda p \in D_t$. [hq $\in D_t$. p and q]". "p" and "**q**" are variables for truth-values, so the "and" in "p and q" would have the same status as the "and" in "1 and 0", for example. Without further conventions, it is not clear what this would mean.

4 This has been argued for, e.g., by R. Kayne, *Connectedness and Binary Branching* (Dordrecht, Foris, 1984).

5 See B. H. Partee, A. ter Meulen, and R. E. Wall, Mathematical Methods in Linguistics (Dordrecht, Kluwer, 1990), chs 16–22, for definitions of this and other types of formal grammars.

6 The question whether and, if yes, what kind of phrase structure trees are actually constructed during sentence processing has been at the center of debates in psycholinguistics. See L. Frazier, "Sentence Processing: A Tutorial Review," in M. Coltheart (ed.), Attention and Performance, vol. 12 (Hillsdale, NJ, Lawrence Erlbaum Associates, 1987), pp. 559–86. Also J. D. Fodor, "Comprehending Sentence Structure," and M. Steedman, "Computational Aspects of the Theory of Grammar," in L. R. Gleitman and M. Liberman (eds), Language, vol. 1 of D. N. Osherson (ed.), An Invitation to Cognitive Science, 2nd edn (Cambridge, Mass., MIT Press, 1995), pp. 209–46 and 247–81 respectively.

7 For a precise definition, see e.g., Partee et al., Mathematical Methods, pp. 443–4.

8 The phrase markers contemplated by Chomsky in recent work, for instance, don't have linear order. They do have syntactic category labels, though. See N. Chomsky, "A Minimalist Program for Linguistic Theory," in K. Hale and S. J. Keyser (eds), The View from Building 20 (Cambridge, Mass., MIT Press, 1993), pp. 1–52.

9 R. Jackendoff, Semantic Interpretation in Generative Grammar (Cambridge, Mass., MIT Press, 1972).

10 Similar comments apply to N. Hornstein, Logic as Grammar (Cambridge, Mass., MIT Press, 1984).

11 N. Chomsky, Lectures on Government and Binding (Dordrecht, Foris, 1981), p. 36.

12 An important modern reference is J. S. Gruber, "Studies in Lexical Relations" (Ph.D. dissertation, MIT, 1965). See also J. S. Gruber, Lexical Structures in Syntax and Semantics (Amsterdam, North-Holland, 1976).

13 We might stress that this objection is directed at the specific formulation of the Θ-Criterion that we have quoted. It does not apply to all versions of the Θ-Criterion that you find in the literature. James Higginbotham, in particular, has proposed to replace the second part of the Θ-Criterion by the more flexible requirement that every thematic role must somehow be discharged. See J. Higginbotham, "On Semantics," Linguistic Inquiry, 16 (1985), pp. 547–93; idem, "Elucidations of Meaning," Linguistics and Philosophy, 12 (1989), pp. 465–517. In the latter he spells out a list of different discharge mechanisms (pp. 475f.).

14 Recall our pedagogical decision to avoid ternary branching – hence the somewhat arbitrary right-branching structure.

15 B. Levin and M. Rappaport Hovav, Unaccusativity. At the Syntax–Lexical Semantics Interface (Cambridge, Mass., MIT Press, 1995), p. 21.

16 J. Grimshaw, Argument Structure (Cambridge, Mass., MIT Press, 1990).

17 Ibid., p. 4, with "announce" instead of "introduce".

18 This is actually not quite true. Our semantics doesn't force us to assume that there is no way to change the argument structure of a verb. It does imply, however, that if there are such changes at all, they have to be brought about by specific morphemes. We could have a morpheme of the following kind, for example:

$$[\![\textbf{passive}]\!] = \lambda f \in D_{\langle e,\langle e,t\rangle\rangle} . [\lambda x \in D_e . \text{ there is some } a \in D_e \text{ such that } f(x)(a) = 1]$$

[[**passive**]] operates on transitive V- or V-denotations, and eliminates the highest argument. An analysis of this kind for the participle affix "-en" was proposed by D. Dowty, "Governed Transformations as Lexical Rules in a Montague Grammar," Linguistic Inquiry, 9 (1978), pp. 393–426. We will not take a stand here as to whether natural languages have items like passive. All we are interested in right now is to point out that our framework requires any change in argument structure to be brought about by some morpheme.

M. C. Baker, Incorporation. A Theory of Grammatical Function Changing (Chicago, University of Chicago Press, 1988), p. 46. Baker's condition includes the requirement that UTAH is a principle for Deep Structure representations. At the present stage of our investigation, we are not presupposing a multistratal syntax, so we left out the level-specification in Baker's original formulation of the UTAH. Baker's UTAH is a stronger version of Perlmutter and Postal's Universal Alignment Hypothesis (UAH), which states that "there exist principles of universal grammar which predict the initial relation borne by each nominal in a given clause from the meaning of the clause" (D. M. Perlmutter and P. M. Postal, "The 1-Advancement Exclusiveness Law," in D. M. Perlmutter and C. G. Rosen (eds), Studies in Relational Grammar, vol. 2 (Chicago, University of Chicago Press, 1984), pp. 81–125). Principles like UAH or UTAH are defended in a very sophisticated way in D. Pesetsky, Zero Syntax, Experiencers and Cascades (Cambridge, Mass., MIT Press, 1995), but have been argued to be untenable by Carol Rosen, "The Interface between Semantic Roles and Initial Grammatical Relations," in Perlmutter and Rosen (eds), Relational Grammar, pp. 38–77.

20 D. Dowty, "Thematic Proto-Roles and Argument Selection," Language, 67/3 (1991), pp. 547–619.

21 E. Rosch and C. B. Mervis, "Family Resemblances: Studies in the Internal Structure of Categories," Cognitive Psychology, 8 (1975), pp. 382–439.

22 A good collection of relevant work is found in the three volumes of Studies in Relational Grammar published by the University of Chicago Press: vol. 1, ed. D. M. Perlmutter (1983); vol. 2, ed. D. M. Perlmutter and C. G. Rosen (1984); vol. 3, ed. P. M. Postal and B. D. Joseph (1990). For unaccusativity, consult also Levin and Rappaport Hovav, Unaccusativity. For experiencer verbs, an important recent reference is A. Belletti and L. Rizzi, "Psych-verbs and Θ-theory," Natural Language and Linguistic Theory, 6 (1988), pp. 291–352. See also the discussions in Grimshaw, Argument Structure, and Pesetsky, Zero Syntax.

23 E. Williams, "Argument Structure and Morphology," Linguistic Review, 1 (1981), pp. 81–114.

24 A. Marantz, On the Nature of Grammatical Relations (Cambridge, Mass., MIT Press, 1984).

25 D. Davidson, "The Logical Form of Action Sentences," in N. Rescher (ed.), The Logic of Decision and Action (Pittsburgh, University of Pittsburgh Press, 1967), pp. 81–95. See also the neo-Davidsonian verb meanings of T. Parsons, Events in the Semantics of English. A Study in Subatomic Semantics (Cambridge, Mass., MIT Press, 1990).

A. Kratzer, "Severing the External Argument from its Verb," in J. Rooryck and L. Zaring (eds), Phrase Structure and the Lexicon (Dordrecht, Kluwer Academic Publishers, 1996), pp. 109–37.