Chapter 3

What Every Psychologist Should Know about Grammar

The preceding chapter presents the classical evidence that when a word sequence is organized into a sentence, it takes on a special psychological status. Some of the evidence suggested that this status was not only dependent on the fact that sentences have independent meanings, but that they also have a rigorous and characteristic syntactic structure. Psycholinguistic research between 1960 and 1975 focused on the role of a transformational grammar in language behavior. The ultimate conclusion was that while grammatically defined representations appear to be computed during language behavior, the grammatical rules that define them may not be used.

This conclusion reminds us that the process of understanding sentences may be very different from the representation of linguistic knowledge. It cleaves grammatical knowledge from comprehension and sets the problem we address in this book: How should the grammar be embedded in a comprehension theory? This question requires that we have a more specific notion of grammar than the past one we have assumed up to this point. However, it is difficult and risky to rest a comprehension model on any particular syntactic architecture. Linguistics is the producer of detailed grammatical theories, and the production of generative syntactic theories has evolved rapidly over the last half century. Psychology is a consumer of generalizations about grammars, but especially in the last two decades, the rapid changes in syntactic theories have left psychologists in large part baffled as to how to integrate grammatical knowledge and behavior in rigorous models.

We think that syntactic theory in the last few years has returned to a model that is more tractable as a component of behavioral models (Chomsky 1995). However, in this chapter we first review certain features of syntactic theory that have remained a critical part of most generative models of grammar. This will help the reader focus on durable features of syntax and will help ensure the longevity of our specific proposals about the architecture of a comprehension model that includes grammatical knowledge. In the second section of the chapter we review the history of different architectures of grammar that relate to meaning, and we end with a more discursive presentation of the current syntactic theory, ''minimalism.''

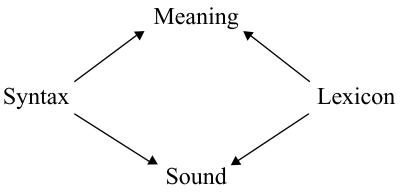

Figure 3.1
The components of grammar and their interfaces.

3.1 The Architecture of Syntax

Language relates meanings to sounds. Meanings themselves are closely linked to general cognitive and perceptual structures; sounds are closely liked to motoric properties of the mouth and acoustic properties of the ear. Thus, the domains of meanings and sounds are constrained by their output interface to other psychological structures, as shown in figure 3.1. The structures and processes that relate meanings and sounds in orderly ways comprise the grammar. The lexicon maps meanings onto sounds by memorized connections; the syntax operates on words to compose meaning-sound relations that are not already memorized in the lexicon. Arguments in linguistic theory often revolve around how much of the mapping is carried out by structures memorized in the lexicon, how much by syntactic operations. But it is commonly accepted that sentence-level meanings are compositional, modifying the impact of the isolated meaning of the individual words. Consider the meaning of the verb *call* in different sentential contexts.

(1) a. Mary called Bill.
b. Mary called Bill over.
c. Mary called Bill, "Bill."
d. Mary called Bill a fool.
e. Mary called "Bill."
f. Mary called Bill up.
g. Mary called Bill on his phone.
h. Mary called Bill on his mistake.
i. Mary called Bill on the carpet.

Native speakers of English have a vague feeling that there is a central core of the meaning of *call* that is elaborated in different ways, depending on the sentential context. This core meaning of *call* has something to do with verbal expression to get another's attention, but that is about as precise as one can be. Because of that difficulty, one might argue that these examples only show that *call* is lexically ambiguous between a variety of meanings, and the sentential context serves only to select one or

another of the predefined meanings. But careful analysis of apparently unambiguous words shows that the sentence level can play a role in refining and focusing the compositional meaning in a particular direction. Consider the following words in isolation:

(2) a. hate
    b. Sparta
    c. Athens

Hate at root is a state in which some entity has a negative attitude toward another; Sparta is an ancient Greek city, known for its warlike behavior; Athens is an ancient and current Greek city, known for its philosophers. If we now put those words into a sentence, the whole entity has a particular meaning that picks out certain aspects of the root meanings of the words and composes them into a new whole.

(3) Sparta hated Athens.

The likely interpretation is now limited to ancient times, by virtue of the fact that Sparta is best known as an ancient city. The notion of *hate* is now enriched by general contextual knowledge of how hatred might be effected by one city-state against another (for example, this hatred could not result in a suit in the world court, but rather a disposition to send an army to its the city walls). The sentence level arrangement not only isolates certain meanings of the words; it provides a structure that can access conceptual knowledge to yield a new and specific sense.

3.2 Constant Features of Syntactic Structures

We now review essential features of syntax that set constraints on how to integrate a grammar within a comprehension theory. Our syntactic theory of reference is the Minimalist Program (Chomsky 1995). However, we emphasize the features of syntactic description that are shared among a number of theories that compete within the framework of purely linguistic research. It is inevitable that the details of our comprehension theory will be influenced by the syntactic theory we choose. But the architecture of how syntax is embedded in a comprehension model transcends those details and holds for a wide range of syntactic approaches.

3.2.1 Lexical Categories

The most basic syntactic information is the category information on each lexical item. Every word in the lexicon must have a categorization that describes how it can fit into syntactic frames, regardless of its meaning. This kind of information not only includes traditional categories, such as Noun and Verb, but also information about subcategories, defined by particular patterns of categories that define its allowed

contexts. For example, *hate* is not merely a verb; it is a verb that ordinarily requires exactly one noun phrase object within the verb phrase, which we indicate with the following ''subcategorization frame'' inside angle brackets:

(4) hate = verb
⟨NP hate NP⟩

This subcategorization frame is justified with an example ungrammatical sentence, indicated by *:

(5) *Sparta hated.

Even when the object appears to be missing, it is implied. For example, the fact that *the* is required with *victim* below shows that it is presupposed somewhere prior in the sentence.

(6) a. ?Sparta hated frequently, but that never impressed the victim.
b. *Sparta hated frequently, but that never impressed a victim.

The postulation of basic lexical categories is one of the driving theoretical concepts of syntactic theory, whether described as units or as collections of syntactic features. The most essential distinctions are between words that characteristically select arguments (for example, verbs and prepositions), words that characteristically serve as arguments (such as nouns), and words that characteristically are predicated of other words (i.e., modify them, such as adjectives and adverbs). Argument-taking words are incomplete and uninterpretable without their argument—for example, *hate* requires both a subject and an object.

(7) a. *hated
b. *Sparta hated
c. *hated Athens
d. *Xenophon went into

Nouns serve as arguments while adjectives and adverbs, which appear in parentheses below, modify other words.

(8) a. The city (violently) hated the other (rich) city.
b. Xenophon (quickly) went (almost) into the city.

It is important to be clear about the fact that the syntactic aspects of lexical categories are not derived from their conceptual attributes. The distinction between words that have argument positions and words that fill argument positions is strictly formal and resides within the framework of syntax alone. As we will see, the substantive generalization and corresponding formal requirement that verbs and prepositions must fill their argument positions has unexpected and interesting consequences for more abstract levels of syntactic description.

3.2.2 Morphology

Words also have cases and inflections assigned by their position in the syntactic configuration. In English, the presence of case is revealed by pronouns that carry different forms. For example, in (3), which we repeat here

(3) Sparta hated Athens.

Sparta has subject case and *Athens* object case, as revealed by the different forms of the pronoun in (9). Note that *they* is the normal subject or nominative form, while *them* is the normal object or accusative form.

(9) a. they hated them
    b. *them hated they
    c. *them hated them
    d. *they hated they

It is important to note that we cannot make complete decisions about the lexical or syntactic structure assigned to single sentences. As in the case of *Sparta hated Athens*, even to determine the morphological-case assignment status of a sentence, we may have to refer to other similar sentences to extract a complete picture. This reflects the fact that even a relatively obvious property of sentences, such as lexical category and morphology, is actually an abstract layer of representation that cannot always be directly observed on the surface of a particular sentence.

Morphological units assist in the representation of functional categories, categories that are purely syntactic and provide the structural skeleton of sentences. Thus, case, auxiliaries, and other morphological structures serve in part as the glue that binds different components of a sentence. In languages with relatively free word order, morphological agreement cues can be critical.

3.2.3 Phrase Structure

It is intuitively clear that lexical sequences are segregated into larger units.

(10) The city hated Athens.

It is obvious that *the city* is a unit in some sense different from *city hated*. This is represented by a higher bracketing that defines a phrase. At first, it might seem obvious that such a level is discovered directly because it is often so clearly marked in such overt features as pronunciation, with explicit pauses allowed between phrases more readily than within them. But, technically, the evidence that a sequence is a phrase also depends in part on examination of related sequences that are and are not allowed. Evidence for a phrase typically rests on the integrity of the sequence when the unit is placed in other syntactic contexts.

(11) a. Sparta hated Athens.
b. It was Athens that Sparta hated.
c. Sparta hated the city.
d. *It was the that Sparta hated city.
e. *It was city that Sparta hated the.
f. It was the city that Sparta hated.

The cases in (11) show that *the* cannot be stripped from the rest of its phrase, as in (11d) and (11e), but can be moved together with *city*, as in (11f). Similar sorts of data show that *hated Athens* is a phrase, more closely knit than *Sparta hated*:

(12) a. It was hate Athens that Sparta did.
b. *It was hate that Sparta did to Athens.

The phrasal unity of a verb with its object does not depend on the fact that *hate* must have an object somewhere in the sentence. For example, *attack* may or may not have an explicit object, as shown by

(13) a. Sparta attacked.
b. Sparta attacked Athens.

Nevertheless, any explicit object it does have is still carried with the verb, while the subject is not.

(14) a. It was attack Athens that Sparta did.
b. ?It was attack that Sparta did to Athens.
c. *It was Sparta attack that happened to Athens.

Thus, the fact that phrases exist is crucially confirmed by the fact that phrases tend to move together in alternate structures.

Another more traditional kind of evidence for phrase structure is that phrase sequences of varying lengths can be shown to serve the same function in a given sentence context.

(15) a. *Sparta* attacked Athens.
b. *The city* attacked Athens.
c. *The ancient city* attacked Athens.
d. *The ancient city known to be warlike* attacked Athens.
e. *The ancient city said to be known to be warlike* attacked Athens.

Each of the italicized initial noun phrase sequences intuitively serves as the subject of the verb. Thus, phrases come in different "kinds," defined by their function in the sentence. While the italicized phrases above are all called *noun phrases*, from a functional standpoint they are *determiner phrases*, defined by the functional category determiner, which includes words like *the* and *a*. The other salient kind of phrase is

traditionally the *verb phrase*. The verb phrase too can actually be defined in terms of its functional role in the sentence, namely, as predicate that carries tense/aspect and modal information.

3.2.4 Sentence-Internal Reference between Nouns, Pronouns, and Positions

Sentences have syntactic devices to cross-refer from one part of the sentence to a phrase in another part. In the examples below, elements with common subscripts indicate reference relations:

(16) *Reflexive*
When Sparta_i attacked itself_i, Athens_j did not survive long.

(17) *Pronoun*
When Sparta_i attacked it_j, Athens_j did not survive long.

The difference between a reflexive such as *itself* and a normal pronoun such as *it* plays a large role in syntactic investigations. This is because a pronoun must have "exogenous" reference—that is, it must refer to some antecedent not immediately in the domain of its own sentence. The reflexive has "endogenous" references—that is, its antecedent is strictly limited to the domain of its own clause. The difference between exogenous and endogenous reference allows syntactic theorists to identify the domain of the scope of various kinds of syntactic rules. These domains do not always depend on relative proximity, but to "locality" that is defined in terms of a hierarchical phrase structure.

(18) a. Bill_i was believed by Mary_j to be speaking to her_j.
b. *Bill_i was believed by Mary_j to be speaking to herself_j.
c. Bill_i was believed by Mary_j to be speaking to himself_i.
d. *Bill_i was believed by Mary_j to be speaking to him_i (= Bill).

The sentences in (18) show that *Bill*, but not *Mary*, falls within the structural domain of the verb *speaking*. For our purposes, the important feature of sentence-internal reference is that it is an example of a purely syntactic device. Thus, phrases can be related to other phrases at an arbitrary surface distance, so long as certain functional relations are maintained.

The syntactic structures we have discussed so far are technically "abstract," but they often have overt local reflexes. Thus, case, functional categories, phrase structure, and pronouns can have specific indicators in certain cases. But sometimes case, functional categories, and phrase structure information can be inaudible in the pronunciation of sentences. The same is true of anaphoric devices. Consider first the problem of verbs without subjects.

(19) a. Sparta_i attacked Athens, and it_i also hated Athens.
b. Sparta_i attacked Athens, and also hated Athens.

Where is the subject of *hated* in the second sentence? Intuitively, it is understood to be present, but its absence appears to violate the grammatical generalization that all verbs have subjects. One kind of solution to this is to postulate an empty pronoun, which can stand in for the generic subject under certain syntactically defined circumstances. This is an instance of a so-called empty category.

(20) Sparta_1 attacked Athens, and also e_1 hated Athens.

In these sentences, the subject of *hated* can be an overt pronoun, or the covert pronoun, PRO, coindexed with its antecedent in the same way as an overt pronoun. This can get complicated:

(21) a. Sparta_1 not only attacked it_2, but it_1 also hated Athens_2.
b. Sparta_1 not only attacked e_2, but e_1 also hated Athens_2.

Once the notion of an empty unit that coindexes to an explicit unit is established, it becomes available for the treatment of certain kinds of sentential complements.

(22) a. It was easy for one to hate Athens.
b. It was easy to hate Athens.
c. It was easy PRO to hate Athens.

In this case, the empty unit labeled PRO accounts for free variation between verbs with and without explicit subjects with a potential referent external to the sentence. That is, in these cases PRO is "exogenous." But, once postulated, PRO can also account for the existence of constructions in which PRO is "endogenous." In these cases, its referent is restricted to a phrase elsewhere in the sentence, in which a verb may not ever be allowed to have an overt subject, as in:

(23) a. Sparta_i wanted (itself) $[\text{PRO}_i]$ to attack Athens.
b. Sparta_i was eager (for itself) $[\text{PRO}_i]$ to attack Athens.

Complement constructions such as those above pose a threat to the generalization that verb arguments are always filled with something. PRO and analyses like those given preserve this fundamental property that differentiates the lexical category of verbs from nouns.

3.3 Arguments, Movement, and Derivations

Up to now, we have assumed that each verb has a canonical set of arguments. The theoretical situation is a bit murky with respect to how large the stock of arguments actually is. In English, every verb requires an overt subject, as in (24a). Most also require an object within the verb phrase as in (24b), and some also require an indirect object within the verb phrase (see (24c)).

(24) a. He ran.
Ran: ⟨intransitive⟩ (i.e., requires a subject only)
b. He attacked them.
Attack: ⟨NP⟩ (requires an object)
c. He donated them to her.
Donate: ⟨NP PP⟩ (requires both direct and indirect object)

Semantically, it is intuitive that every verb must have an agent or experiencer of some kind:

(25) a. John left.
b. *left
c. John is sad.
d. *is sad

Transitive verbs by definition have patients, and certain verbs can have goals as well.

(26) a. John hates carrots.
b. *John hates.
c. John gave the carrots to his sister.
d. John gave his sister the carrots.

It is tempting to enumerate the argument roles in terms of their semantic/thematic properties. The difficulty with this is that there is no semantic criterion for deciding whether a particular thematic argument is also a syntactic one. One standard method of distinguishing syntactic arguments is to limit them to instances that require case marking. In English, however, case marking is not overt except for pronouns. In the preceding examples, every position is directly case-marked by the verb alone, which justifies positing those arguments as syntactic. This is explicit only when pronouns are used:

(27) a. He hates them.
b. He gave them to her.
c. He gave her them.
d. *He gave them (except elliptically).
e. *He gave her (where *her* means *to her*).

In general every obligatory syntactic argument position must always be filled with something. We saw above that in some cases an inaudible pronoun, PRO, can serve that purpose. PRO is like an overt pronoun, in that it is coindexed with an antecedent, possibly one outside the current sentence.

(28) Sparta attacked at twilight, but Athens was ready.

The object of *attack* most likely is Athens, as shown by the use of the antecedent-dependent article *the* in the subject of the second clause:

(29) a. Sparta attacked at twilight, but the city was ready for it.
b. ?Sparta attacked at twilight, but a city was ready for it.
c. Sparta attacked Carthage at twilight, but Athens was ready.

However, the object of the attack could be some other city, as paraphrased in (29c).

Pronouns also serve a crucial role in linking phrases to modifying propositions. It is a vital part of language that it be possible to infinitely modify noun phrases. This property of language plays a role in the ability of language to provide a sentence for every sense. For example, (30a) to (30c) form a short discourse that can be more directly and unambiguously expressed in (30d):

(30) a. A city attacked a city.
b. The first city was from the North.
c. The second city was from the South.
d. A city (that was) from the North attacked a city (that was) from the South.

Each relative pronoun *that* appears to serve as subject of an embedded modifying clause. At the same time, each *that* is coindexed with the appropriate head noun in the main clause. It appears on the surface that *that* is actually in the subject position of the embedded clause. Analysis of other constructions, however, suggests that this may not be quite right. In general, relative pronoun connectors can be drawn from many locations in an embedded clause. The generalization is that they must always appear at the front of the embedded clause.

The cases below raise a puzzle:

(31) a. The church which the rich parishioner gave [X] the found money, is poor.
b. The money which the rich parishioner gave the church [X], was found.

If obligatory argument positions must be filled, the relative clauses should be ungrammatical, since one argument position in each is unfilled [marked by X]. *Give* ordinarily requires both a direct and an indirect object. Intuitively, we know that the relative pronoun itself stands for the missing argument. But how do we account for the fact that it is in the wrong position? One possibility might be to assume that the argument position is filled with a PRO, which is coindexed with the relative pronoun and the head noun:

(32) The church which the rich parishioner gave PRO the found money, is poor.

There is a problem with this solution. PRO characteristically occurs as an optional filler for a missing coreferring argument, which could be explicit, but an explicit pronoun is ungrammatical in the case of relative clauses:

(33) a. *The church that the rich parishioner gave it the found money, is poor.
b. *The church that the rich parishioner gave the hospital the found money is poor.

One crucial point is that PRO is characteristically an optional filler for an explicit noun phrase (see section 3.2.3). Another crucial point is that the referent of PRO can have more than one thematic role. In *Sparta wanted to attack Athens*, *Sparta* is agent/experiencer of both *wanted* and *attack*. Finally, PRO remains in the location that assigns its thematic role. In relative clauses the argument position is obligatory but must *not* be filled with an explicit pronoun. Furthermore, the referent of this category has only one thematic role. In this representation the referent pronoun appears in two positions but receives its thematic role from the position it does not occupy on the surface. We need to find some device other than PRO to account for the superficially missing arguments in relative clauses.

A natural solution is to link the relative pronoun to the argument position syntactically, rather than by coindexing. Graphically, we want something like the following:

(34) The church that the member gave [NP] the money is poor.

It is not possible to establish this link between the pronoun and the argument position within the framework of simple phrase structures. To do so, we would have to have some kind of tree structure with crossing trees, but such a structure would violate the strict hierarchical nature of phrase structure organization. Thus, we need a mechanism that transcends the power of phrase structure.

Several current syntactic theories offer mechanisms that establish a syntactic link between the overt relative pronoun and its related argument position. The exact details may not matter for psychological theory. Syntactic theories appear superficially to be very different, but they share a property that is crucial for behavioral models of language: they involve "movement" and a logical "derivation" during which movement occurs. Consider first Head-driven Phrase Structure Grammar (HPSG) and Generalized Phrase Structure Grammar (GPSG), which are elaborated versions of phrase structure theory (Bennett 1995; Gazdar et al. 1985; Sells 1985 section 2.5). The structure of a simple declarative sentence in GPSG appears in figure 3.2. In this diagram V0 indicates that the lexical category of *hates* is verb, N2 indicates that the syntactic category of *Sparta* and *Athens* is noun phrase, and V2 indicates that the syntactic category of *hates Athens* is verb phrase. The critical elaboration in GPSG is the introduction of features and elements that can pass up (and down) the phrase structure tree as part of the computation of a grammatical sentence. For example, the feature that the head noun *Sparta* is singular must match or "percolate" up to the noun phrase.

Another example of a feature that passes up the phrase structure tree is "missing an argument NP," or MNP. A feature like this is "satisfied" when it finds a noun phrase that is not an argument of a verb. This device offers a neat solution to the syntactic description of relative clauses. The initial tree description of a relative

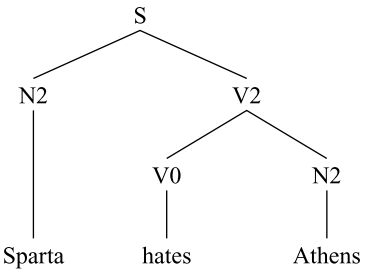

Figure 3.2
The structure of *Sparta hates Athens* according to Generalized Phrase Structure Grammar.

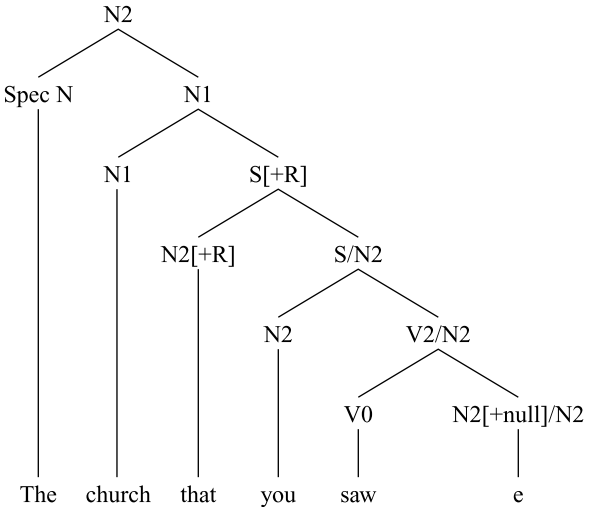

Figure 3.3
The structure of a relative clause in Generalized Phrase Structure Grammar (adapted from Bennett 1995:153).

clause includes markers of argument positions that require a noun phrase, as shown in figure 3.3. In the canonical case of declarative sentences, the argument positions are filled directly by noun phrases (see figure 3.2). But with relative clauses, the special feature MNP is part of the description of the verb. In figure 3.3, the feature [+null] allows insertion of the empty lexical item e. V2/N2 reads a verb phrase with a missing noun phrase, and it indicated that the phrase that contains the transitive verb *saw* is missing an object noun phrase. One way to compute this is to ''pass'' the feature up the tree. If it finds a noun phrase that is not already taken by some other verb or preposition as an argument, that noun phrase can fill the MNP feature so the

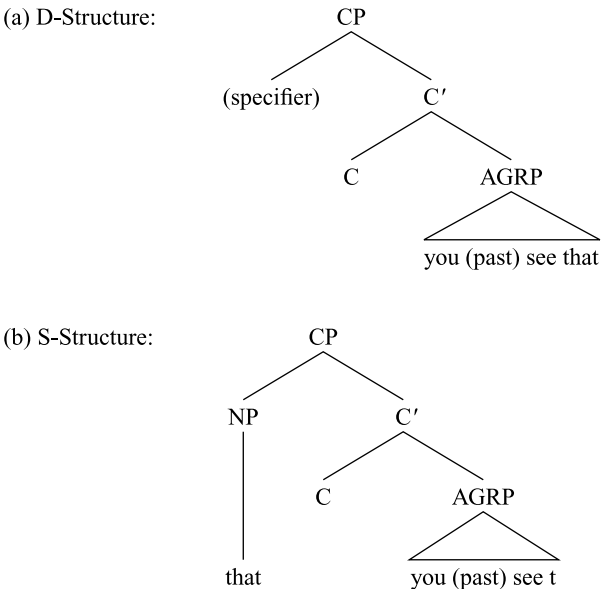

Figure 3.4
The movement in a relative clause according to government-and-binding theory (adapted from Cook and Newson 1996:200).

NP is no longer missing. In the case of relative clauses, the relative pronoun, N2[+R] in figure 3.3, itself can serve as such an argument, thus completing the structure syntactically.

A somewhat different but critically similar solution uses "transformations" to move the crucial noun phrase. It assumes that initially there is a noun phrase in the canonical argument position. That is, the position is filled at the beginning of the syntactic computation, as shown in figure 3.4. In this framework, some NP from elsewhere in the sentence must be attached to the relative pronoun: movement of the NP and attachment of it to the relative pronoun position affect this attraction. The moved NP leaves behind a 'trace" *t* of its original position, coindexed with it.

These solutions to the problem of verb arguments-at-a-distance appear superficially quite different, and indeed, the theories from which they spring are often pitted against each other in linguistics debates. Yet, when considering the potential behavioral implications, they are identical for our purposes. Each assumes that there is a special marker for the missing canonical argument position. Each assumes that an element is computed from the unfilled argument position in relation to the relative pronoun position. And, most important for us, each assumes a computational hierarchy or ordering—that is, terminological differences aside, each assumes a

derivation. The computation calculates well-formedness by starting with a structure, recursively moving or relating elements and checking the well-formedness of the resulting structure.

3.3.1 Clausal Locality of Movement

Once we allow movement of syntactic elements as part of syntactic computation, it is important for behavioral modeling to know what the constraints on movement are, if any. If we are to take syntactic theory as the framework for hypotheses about processing, constraints on distance or structural barriers to movement may be a part of a behavioral model. In fact, a principle potentially of great interest restricts possible movements: roughly, *movement is as local as it can be*.

Consider the following sentence, which has several layers of embedded clauses:

(35) a. Sparta was the city which the Athenians that we attacked hated.

On either syntactic theory, the source structure for this looks like:

(35) b. Sparta was the city which the Athenians that we attacked NP hated NP.

In the example above, we have not indexed the noun phrases and the relative pronouns with their correct interpretation. But we need a principle to guarantee the correct outcome as in (35c).

(35) c. Sparta was the city_1 which_1 the Athenians_2 that_2 we attacked NP_2 hated NP_1.

In the case of a theory with overt movement, it is required that the most embedded sentence be treated first. This ensures that the noun phrase that is moved to a given relative pronoun is in the same sentence domain. Thus, the notion of ''local'' movement is not defined serially, but in terms of domains delineated by phrase structure. A similar treatment follows within the HPSG framework. The first MNP feature that is filled by a *wh*–noun phrase must be the innermost empty noun (36a). Since relative clauses modify nouns, they are the more embedded structure and must be treated first.

(36) a. Sparta was the city_1 which_1 [the Athenians_2 $\text{that}_2 + \text{NP}_2$ we attacked] t_2 hated NP_1.

Then the remaining noun phrase in the matrix sentence can be correctly related to the remaining, higher, empty relative pronoun (36b).

(36) b. Sparta was the city_1 $\text{which}_1 + \text{NP}_1$ the Athenians_2 $\text{that}_2 + \text{NP}_2$ we attacked t_1 hated t_2.

We see that fairly simple facts motivate the notion of a syntactic derivation. The treatment of relative pronouns requires a notion of some kind of displacement from

the canonical position of an argument. This recovers the generalization that verb arguments must always be filled in their canonical position. In HPSG, generative syntactic theory, and other theories the relative pronoun is attached to the canonical position by an element that (logically) moves from one position in the syntactic tree to another. In HPSG, the linking element (MNP) is related leftward and up the syntactic tree, until it merges with the *Wh*–noun phrase. In a generative treatment, the linking element moves leftward and attaches to the *Wh*–noun phrase, which is automatically higher in the tree at that point. Thus, the underlying notion of movement is a notion of a derivation in which the syntactic structure starts in one form and changes to another, or is computationally related to another, by the application of computational processes. We will see that the notion of an element that links one location in a sentence to another has implications for processing models.

The proposal that there is a special behavioral status for noun phrases linked to relative pronouns is not radical. First, the local form of the sentence often appears completely to lack the canonically required arguments. For example, *hate* requires an object, and one is obviously missing below:

(37) The city *Athens hated* attacked it.

Second, relative pronouns are characteristically overt lexical items; they are deleted only in certain clearly recognizable cases. Thus, while they are often not in the canonical argument position that they are linked to, it is relatively easy to construct comprehension models that look for a gap when a relative pronoun is encountered and to fill a likely gap position. This processing strategy is enhanced by the third fact: relative pronouns are pure syntactic elements. Relative pronouns have only sentence-internal status and always acquire their semantic interpretation from other phrases within the sentence (hence, the term *relative* pronoun). Other pronouns sometimes can derive their interpretation from the sentence, but that is a coincidence since they may also acquire it from information external to the sentence. For example, in (38a)

(38) a. Harry said he wanted to win.
b. Harry said she wanted to win.

the *he* may refer to Harry, but the interpretation of *she* in (38a) must come from outside the sentence.

There is another kind of displaced argument construction in which the canonical position is not overtly filled and can never be filled. Consider the passive construction (39a).

(39) a. Athens was attacked by Sparta.

In this case, there is no overt object of *attacked*, nor is one optionally allowed (see (39b)).

(39) b. *Athens was attacked it by Sparta.

Rather, the distributed passive morphology, ... *was V + ed by* ..., indicates the correct arrangement, in which the apparent subject is the object of the verb and the prepositional noun phrase is the agent of the action. It is also characteristic that these kinds of constructions are always superficially similar to canonically well-formed ones that occur elsewhere in the language. For example, true passives are superficially similar to complex predicate constructions with lexical adjectives. Consider the sentences below. In each of these sentences except the first, *was* can be replaced with *remained*. Thus, the predicate modifier is an adjective-like state rather than a particular action with an agent.

(40) a. Athens was attacked by Sparta.
b. Athens was unattacked by Sparta.
c. Athens was ruined by Sparta.
d. Athens was located near Sparta.
e. Athens was insecure near Sparta.

In brief, the object in the passive does not have an optional overt pronoun of any kind that can be linked to the empty argument position. Nor does it reveal its special status by having a unique and superficially defective argument structure. It is primarily for these reasons that certain syntactic theories treat the unusual location of the verb object in passives as essentially a lexical rather than a syntactic phenomenon. Such solutions essentially argue that certain lexical items, such as the passive forms of verbs, raising verbs such as *happen ... to*, and adjectives such as *likely ... to*, can lack standard argument positions and fill them with unusually located arguments. For this exposition we will adopt the alternative treatment from generative grammars, in which such constructions involve movement, with a resulting empty trace.

The true passive construction expresses an event that apparently is missing an object. The apparent patient is in subject position, while the apparent agent is in an auxiliary phrase. That is, the passive has no obvious object, its "subject" is not the agent, and the actual agent is outside the verb domain. This is all very puzzling from a structural standpoint and appears to violate the core lexical the requirement that verb arguments be filled. But it can be neatly described with the kind of mechanisms we have seen that allow movement of a noun phrase from one position to another. Suppose we start with a structure like (41b):

(41) a. Athens was attacked by Sparta.
b. NP was attacked Athens by Sparta.

Athens is initially generated as the object of *attack*, and then can move to fill the empty noun phrase in apparent subject position (41c):

(41) c. Athens$_1$ was attacked [t$_1$] by Sparta.

Similar kinds of descriptions apply to conventional raising constructions. For example, (42a) follows from raising *John* in the source structure in (42b) to produce the trace in (42c):

(42) a. John was likely to leave.
b. NP was likely John to leave.
c. John$_i$ was likely [t$_i$] to leave.

3.3.2 Upward Movement and the Syntactic Cycle

We now can see how delicately sequenced the syntactic operations must be. Consider the interaction of raising and passive, as in (43a):

(43) a. This horse is likely to be raced tomorrow.

This sentence derives from something like (43b):

(43) b. NP$_1$ is likely NP$_2$ to be raced this horse$_i$ tomorrow.

It is clear that before NP$_2$ can raise to NP$_1$, *this horse$_i$* must first raise to NP$_2$ as in (43c):

(43) c. NP$_1$ likely NP$_1$ + this horse$_i$ to be raced t$_i$ tomorrow.

Then NP$_2$ can raise to NP$_1$ as (43d):

(43) d. NP$_1$ + NP$_2$ + this horse$_i$ is likely [t$_i$] to be raced [t$_i$] tomorrow.

This example is another illustration of the principle that syntactic processes occur cyclically. They first start with the most embedded verb domain and then work up to the less embedded ones. In the case of relative clauses and *wh*-attachment, we have considered object relatives because it is easy to see that the object phrase must be moved to the *wh*-position. Technically, there is movement as well in subject relatives. However, movement of the subject phrase in a subject relative sentence is more obscure because the *wh*-phrase appears to be in the subject position. Certain cases, though, show that the *wh*-phrase in a subject relative is not actually in the subject position. For example, adverbs can regularly appear between the subject phrase and verb, and also before the subject phrase.

(44) a. This horse frequently raced.
b. Frequently this horse raced.

But in a relative clause, adverbs cannot appear before the relative pronoun:

(45) a. This is the horse that frequently raced.
b. *This is the horse frequently that raced.

Such examples show that the relative pronoun is outside the regular domain of the subject position. The derivation begins with a structure like the structure in (46a).

(46) a. This is the horse WH NP frequently raced.
b. This is the horse WH + NP_i t_i frequently raced.

Then the noun phrase is moved and attached to the *wh*, leaving a trace behind in subject position, as in (46b).

3.4 The Architectures Relating Meaning and Syntax

We have sketched the overlapping components of the syntactic description of sentences. These impose constraints on what structure is assigned to sentences as they are understood. Every sentence must have some form of phrase structure, a verb with arguments, an agreement/case system, and so on. But a complete account of the assignment of such structures is not an account of how meaning is related to them. Our concern is sentence comprehension, not just sentence recognition, so we must include a sketch of how sentence meaning is connected to sentence form. Since generative grammar is our chosen grammar of reference, the question is, how is meaning derived from the structures that generative grammar assigns?

The first problem is, what are the important aspects of meaning as we focus on sentence comprehension? Intuitively, a sentence can "mean" many things, depending on our purposes. Consider the following sentence:

(47) I'm happy to meet you.

This can be taken in its "basic meaning" as predicating pleasure on the part of the speaker at meeting the listener. But it also can have other interpretations. On the one hand, it is potentially a formulaic idiomatic greeting, meaning "hello." More broadly, it might be a signal inviting further contact. Thus, there are three general kinds of interpretation of a sentence, which can be thought of as its "meaning" (see (48a) to (48c)). An operational demonstration is that each of the three kinds of meaning could be the only one retained a week after it was uttered and heard: one could legitimately recall that the speaker was happy, or said hello, or indicated further interest, even though the speaker might have meant only one of those.

(48) *Basic meaning*
a. The speaker is pleased to meet the listener.

Idiomatic meaning
b. Hello.

Intention
c. I hope we see each other again.

For our purpose, and for much of psycholinguistics and linguistics, the focus has been on the "basic meaning." We recognize that this addresses only a subset of the complete panoply of communicative functions of sentences. And we also note, as will come up in later chapters, that some current psycholinguists believe that it is not possible to separate idiomatic and intentional uses of sentences from the processing of their basic meaning. We agree that this is an important question. Our approach follows the convention in linguistics, as in many fields, that separates components for analysis, in the expectation that understanding them will lead to a larger integration with other components.

What, then, is the "basic meaning" of a sentence? There are three main components, which we will briefly sketch:

(49) a. The interpretation of verb arguments, in "thematic roles"
b. "Binding" relations between anaphoric elements and their antecedents
c. "Scope" relations among quantifiers and similar units

Thematic roles have a formal and an intuitive aspect. Intuitively, they correspond to basic conceptual participants related by a predicate. The canonical predicate has an "agent" and a "patient," as in (50a); this reflects the idea that the basic concept conveyed by a sentence is that "somebody does something to somebody," and that understanding a sentence generally involves grasping "who did what to whom." Much psycholinguistic research on sentence comprehension has concentrated on this specific kind of sentence. But some verbs have only agents, as in (50b); some have more than one kind of patient (see (50c)); some have an "experiencer" instead of agent, as in (50d), or patient (see (50e)).

(50) a. Sparta(agent) attacked Athens(patient).
b. Athens(agent) left.
c. Sparta(agent) sent Athens (beneficiary) a message (patient).
d. Sparta(experiencer) disappeared.
Sparta(experiencer) was rich.
e. Sparta surprised Athens(experiencer).

Formally, the number and kind of roles a predicate can have can be used to define classes of predicates: it is an object of ongoing research to determine the relationship between what a verb means, the kind of thematic roles it can have, and the influence of that on syntactically specified argument positions. For example, the verb *attack* implies both intent on the part of the subject and some kind of patient that is the recipient. Thus, *attack* must have an agent and (at least an implied) patient, and is syntactically a transitive verb, requiring both a subject and object. *Leave*, on the other hand, assumes intent but does not require a patient, and hence is syntactically "intransitive." In general, it is appealing to think that once we know the meaning of a verb, we (and children) can derive its thematic and argument structure from

that and vice versa. We certainly agree that there is a great deal of statistically valid predictive power, and in chapter 5, we will outline how this might be an important factor in comprehension. But there are several issues that indicate that thematic roles may not be the fundamental source of all the other types of relations verbs enter into. First, there seem to be a large number of thematic-role types, and it is not clear that there is any interesting limit on them. Consider the different kinds of experiencer relations in (51) alone.

(51) a. Sparta was rich.
b. Sparta was aggressive.
c. Sparta was a winner.
d. Sparta was old.

Second, verbs with quite similar thematic roles can nonetheless have quite different syntactic argument structures.

(52) a. Sparta sent Athens a message.
b. Athens got a message from Sparta.

Third, verbs with quite distinct thematic roles can share syntactic argument structures. Consider the different kinds of roles that *Athens* has in (53).

(53) a. Sparta supported Athens.
b. Sparta pleased Athens.
c. Sparta destroyed Athens.
d. Sparta preceded Athens.

It is an object of ongoing research how specific and how independent the set of thematic roles really are. But, whether independent or not, the notion of thematic role captures an intuitively important aspect of meaning, which is a significant factor in sentence comprehension.

Binding and scope have played a relatively minor role in psycholinguistic studies of sentence comprehension. But we include them here for completeness and because certain facts about them have played a critical role in the evolution of the architecture of syntax. *Binding* basically refers to the determination of coreference between antecedents and anaphors. In (54a), the subject and object must be coreferenced, in (54b) each member of a group in the subject is coreferenced with everyone but that member in the object, and in (54c) there is an ambiguity between those two kinds of relations between subject and object. (Did all the men like all the men, or did each man like himself?)

(54) a. Harry liked himself.
b. The men liked each other.
c. The men liked themselves.

Scope refers to relations to between quantifiers and between quantifiers and verbs. In (55a), the subject has a relation to every person, in (55b) to some.

(55) a. Harry disliked every man.
b. Harry liked some men.
c. Harry liked many men, but he did not like every man.
d. Harry liked many men, but he liked not-every man.

In (55c), the scope of the negative *not* is not the verb *like* that it seems to modify, but is the object noun phrase, as shown by (55d). This fact turns out to be important to certain theoretical developments that we discuss below.

3.4.1 The Evolution of Generative Architecture and the Source of Meaning

The classic findings reviewed in chapter 2 document our assumption that comprehension involves both syntactic and semantic representations. In general, most researchers who think syntax is relevant at all, think it is logically and often behaviorally prior to semantics. That is, syntax is assigned to a sentence first, and then semantic analysis is a function of some operations on the syntactic representation. To understand the history of psycholinguistics and at least its near future, it is useful to review the last fifty years of evolution of architectures that describe how semantic and syntactic representations interact.

In chapter 5 and later chapters, we are going to argue that the process of comprehension is more iterative than this traditional "syntax-first" view: comprehension involves an early stage of crude syntax, then an initial semantic assignment, with a final syntactic derivation filling in missing components. But for the moment, we start with architectures that have the more traditional view that semantic analysis is a direct function of syntactic representations. In doing this, we choose particular stages in the evolution of grammatical theory that enjoyed stability and influence for a number of years. This inevitably means that we will gloss over most specifics and ignore most of the intermediate steps between models. Our goal is partly to inform the psychological reader about the history of generative grammar. But most important, we hope it gives a rounded picture of the nature of syntactic architecture and the kind of relations it can have with semantic representations.

***Syntactic Structures* (Chomsky 1957)** The first modern model involving explicit derivations was laid out by Chomsky in *Syntactic Structures*. Schematically this model started with basic phrase structure rules, then filled in lexical items to create the "deep structure" forms, clause by clause: generalized transformations merged one clause into another, and singular transformations rearranged word orders and assigned case. Semantic interpretation was assumed, but not specified within the model itself. The general idea was that semantic analysis would be based on the

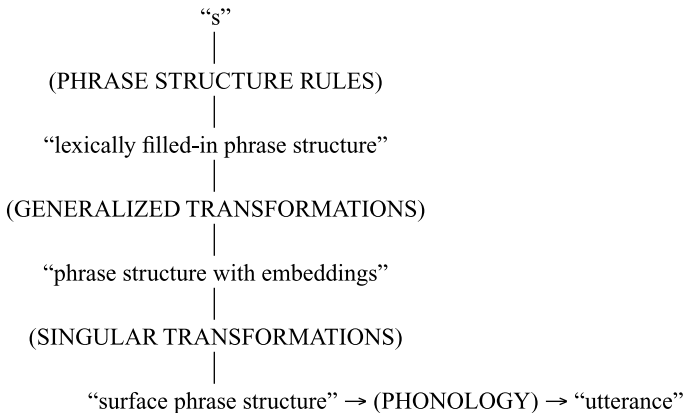

Figure 3.5
The architecture of grammar in *Syntactic Structures*.

"kernel structures"—individual clauses—but it was less clear how to analyze the meaning of complex sentences with more than one clause; the model did not present, in any single place, all the information needed to analyze the meaning of such sentences. The technical problem was that as sentences are embedded within higher sentences, movement transformations must apply to the embedded sentence, thereby distorting the canonical form of underlying structures. That is, singular transformations applied to each embedded clause, immediately after the generalized transformation merged it into a higher clause. This reflects, at an early stage, the kind of upward-moving cycle of operations discussed in the first section of this chapter. It is not surprising that the initial burst of classic psycholinguistic research focused almost entirely on single-clause sentences, and on the effects of a small number of singular transformations. In the sketch of the architecture in figure 3.5, we use (CAPITAL LETTERS INSIDE PARENTHESES) to indicate rule types, and "lowercase letters inside quotation marks" to represent intermediate and final representations produced by the rules. We do not articulate a particular representation that provides meaning information in this scheme, because it was never really resolved. It was taken for granted that the kernel structures somehow provide basic meaning information, but the integration of multiple clauses was less clear.

***Aspects of the Theory of Syntax* (Chomsky 1965)** About a decade after *Syntactic Structures*, Chomsky presented a reformulation of the *grammatical* architecture, which solved many technical problems and also afforded a natural level for semantic analysis. In this model (see figure 3.6), phrase structure rules generate a hierarchical scheme that includes all the embedded clauses: a so-called super phrase marker. The

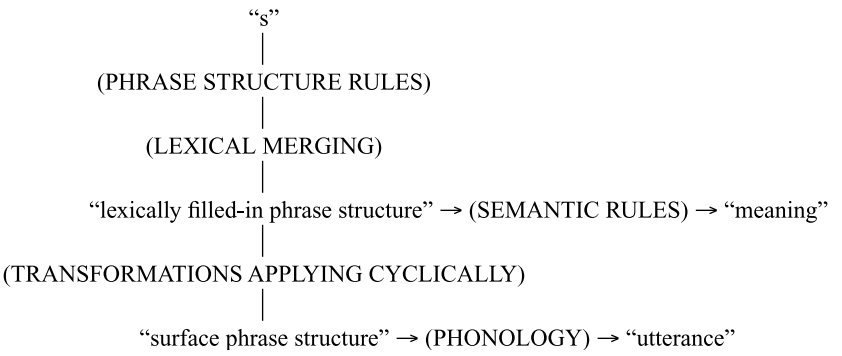

Figure 3.6
The architecture of grammar in *Aspects of the Theory of Syntax*.

terminal nodes of this tree are not lexical items but lexical categories: Noun, Verb, Determiner, and so on. Immediately subsequent lexical transformations merge lexical items with the categories—for example, when a terminal node is a noun, any lexical item (or other phrase structure tree) headed by "noun" can merge with the category label. This results in a lexically filled-in deep structure tree that has all the words and phrases in canonical positions. Further transformations and indexing processes then apply to each level, cyclically from the most to least embedded: the cycle is motivated by the kind of considerations we outlined earlier in this chapter. For example, an object noun in a relative clause has to be moved to the front of the clause first, to provide a structural basis for coindexing it with the relative clause marker in the higher clause.

This model was integrated with a proposal by Katz and Postal (1964) that the deep structure provides all the information required for a semantic analysis of basic meaning—that is, meaning is a function of lexically filled-in deep structure. Katz and Postal then spelled out a set of functions that operate on deep structures to create a semantic representation. This model offered a clear, unequivocal answer to the question about the syntactic level that provides all information needed for the semantic interpretation of sentences.

Generative Semantics (McCawley 1976; Lakoff and Ross 1976) We have already touched on the historical fact that "abstract," "autonomous" mental structures have always posed a problem for behavioral scientists. The transformational model, in particular, postulates many "hypothetical variables" and processes not directly observable. This was an immediate challenge within academic linguistics to the older taxonomic program we outlined in the preceding chapter. But for about a decade, all was quiet within the generative camp. There was general acceptance that syntax is

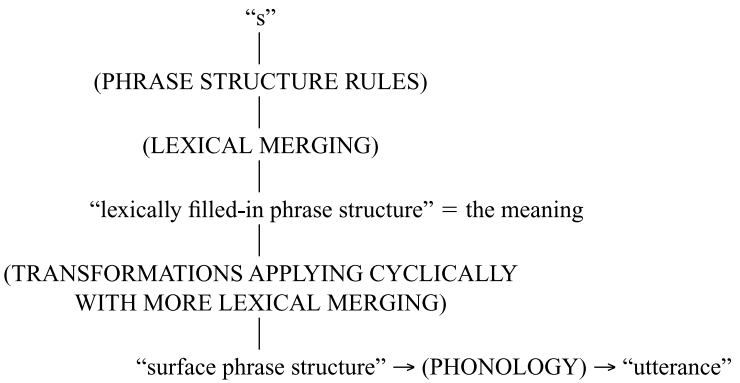

Figure 3.7
The architecture of grammar in generative semantics.

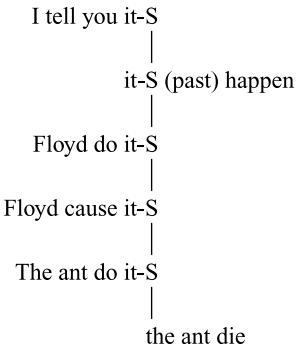

Figure 3.8
The deep structure of *Floyd killed the ant*.

"autonomous" from both meaning and sound—that is, that syntactic principles are sui generis and not reducible to other systems of linguistic knowledge.

As we have seen and will see, behavioral scientists feel a constant pressure to return to some form of behaviorism when an apparent opportunity arises. In the late 1960s a group of young syntacticians working within the Aspects framework developed the idea that the underlying structure actually is the semantic representation: in that view, transformations gradually coalesce features and predicate structures into a linear string of words and surface structure (see figure 3.7). A famous example (Ross 1974) exemplifies how rich the deep structure was according to this view. The sentence in (56) has a deep structure like that schematized in figure 3.8.

(56) Floyd killed the ant.

This view had great appeal for a variety of reasons. First, it offered a possibility that semantic representations could be generatively defined. Second, it avoided the view that syntax includes a deep structure representation that intervenes abstractly between meaning and sound: rather, the process fluidly connects meaning to sound. Since meaning is obvious (if hard to define or operationalize) and sound is physical, this schema seemed to meet the behaviorist stricture against intervening, "abstract" structures. The abstract verbs like *happen*, *do*, *cause* were drawn from a small set of basic semantic primitives. They are merged with lexical primitives, via upward transformations. For example, at a later stage in the derivation of (56) it would appear as something like (57). At that point, the abstract verbs are deleted or replaced by surface correspondents: in this case, *cause-die* is represented in the lexicon as *kill*, which has actually not appeared before in the derivation.

(57) Floyd ((past (cause-die)) the ant)

These proposals generated a great deal of controversy among generative grammarians. This is a bit puzzling in light of the deep similarity between the architectures, once one strips away the behaviorist and rationalist rhetoric. Figures 3.6 and 3.7 differ only in that lexical items can be selected after some transformations have merged components, as in merging *cause* and *die* into *cause-die*. Otherwise, the main substantive difference lies in the richness of the recursively defined initial phrase structures, and the use of abstract verbs. Generative grammarians made much of the claim that their proposal did away with "autonomous" syntax. But really it was primarily concerned with the question of when lexical items are introduced. They replaced "super-p-markers as deep structure" with such notions as "abstract verbs" and with license for extremely rich (and intuitively, extremely abstract) initial hierarchies.

Unfortunately, the potential for lasting and substantive contribution was lost in the noisy rhetoric, which presented generative semantics as a radical alternative to current theory, as opposed to an interesting variant. As we see below, the latest versions of transformational grammar have certain similarities that are intriguing.

Interpretive Semantics Up to this point, meaning was viewed as based on an initial hierarchical structure. But certain facts emerged, suggesting that some aspects of meaning depend also on surface structure. Classic examples showed, for example, that reordering major phrases with stylistic variants, like the passive, can change scope relations (Jackendoff 1969).

(58) a. One arrow hit every target during the match.
b. Every target was hit by one arrow during the match.

For many native speakers, (58a) indicates that there was a particular arrow that hit every target at least once during the match; (58b) indicates that every target was

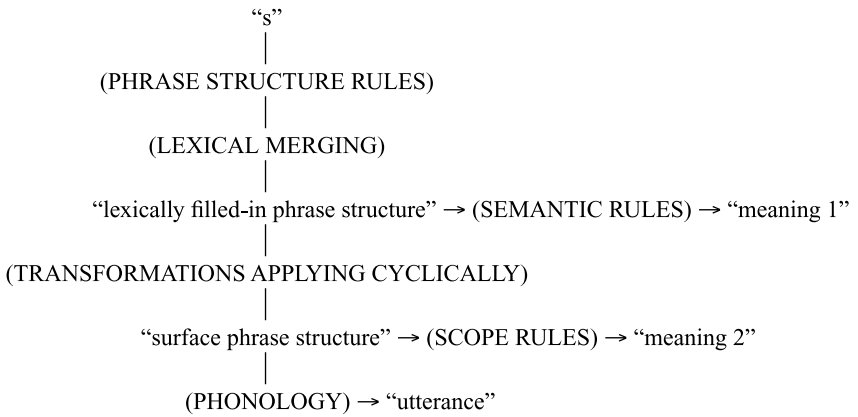

Figure 3.9
The architecture of grammar in interpretive semantics.

hit by at least one arrow (but not the same one): a formal account of this is that the first-appearing quantifier dominates a later-appearing quantifier. This was deeply puzzling within the context that meaning is derived entirely from a deep structure. How can surface order determine something as fundamental as scope? This and other facts suggested that the input to meaning was both deep and surface structure: deep structure provides information about basic thematic relations, and surface structure provides scope information (see figure 3.9).

Government and Binding Theory (Chomsky 1981) The elevation of surface phrase structure as a contributor to meaning became part of a more general exploration of formal properties of surface phrase structure. One long-standing puzzle was how it can be that a verb can be missing its arguments at any given level of representation. For example, in (59), there is no actual object of the verb *hate* that is lexically coded as requiring an object.

(59) a. Athens was hated [ ] by Sparta.
b. Athens was rich enough for Sparta to hate.

And correspondingly, there is no subject for *hate* in (60).

(60) a. Sparta seemed [ ] to hate Athens.
b. Sparta was likely [ ] to hate Athens.

Our informal discussion of grammatical mechanisms from the first section of this chapter already introduced the notion that ''traces'' left behind from movement can

fill such positions. An important feature of traces is that they fill required argument positions in surface structure. This allows one to maintain the principle that every argument is filled at every level of representation.

The presence of traces has another implication. By hypothesis, traces are automatically coindexed with their original head phrase. Since they are coindexed, binding relations can also be read off of surface structure rather than deep structure. The net result of such considerations was a radical increase in constraints on surface structures rather than constraints on particular transformations. The ultimate conclusion was that the main transformation was basically unconstrained movement. Structural constraints on possible movement took over the force of limits on what can occur. Movement transformations such as the passive were formerly described in specific terms, requiring the presence of the passive morphology (*be* + *en*) and a specific marker. In the reformulation, the only movement transformation was "move [constituent]", with all the descriptive and formal work done by constraints on when such movement is required. For example, the passive transformation was now expressed in terms of the requirement that a subject position be filled with an actual noun of some kind during the derivation. Thus, the underlying structure of the passive would become (as discussed above).

(61) NP be hated Athens by Sparta

The requirement that the subject position be filled requires movement, or the derivation is not successful and is blocked.

(62) Athens_1 be hated t_1 by Sparta.

The opportunity grew to derive more aspects of meaning from the surface structure, but certain kinds of facts motivated the invention of a new level of representation, *logical form*, which reconstitutes a semantic analysis that contains the information about both scope and binding. The need for a distinct level of representation that feeds off of both deep and surface structure was motivated by structures that required "reconstitution" of some aspects of deep structure after rearrangement for surface structure organization. For example, in (63), it is not possible to correctly assign the coreference relations based on the surface structure, because the subject position is higher in the hierarchy yet it contains a pronoun coreferenced with the object. This violates the otherwise universality of the principle that pronouns are always lower in their tree than their antecedents.

(63) His_1 mother praised John_1.

Examples like this (and many others, much more sophisticated) motivated the idea that the actual semantic representation that derives from surface structure can result from rearrangement transformations, which reconstitute certain relations originally stated in the deep structure. In the case of (63) the structure might look something

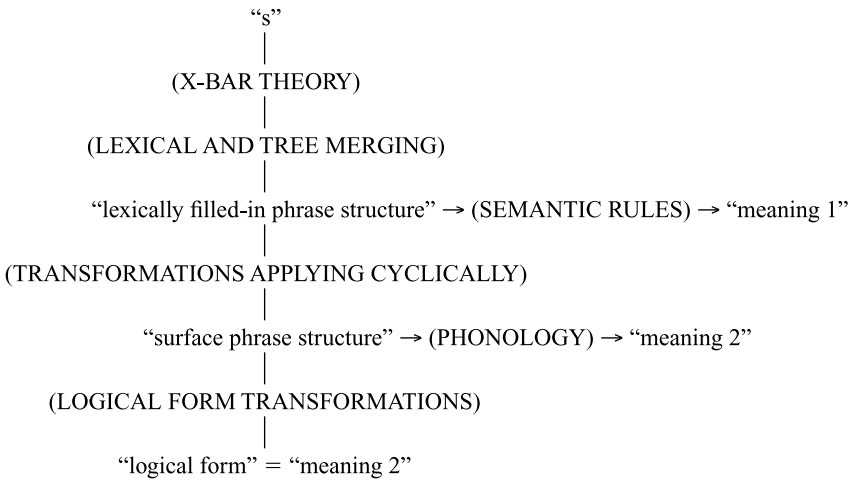

Figure 3.10
The architecture of grammar in government-and-binding theory.

like (64). In this case, there are also traces that result from the ''inverse'' movement that reconstructs the proper government relations.

(64) John's$_1$ mother praised t_1.

The result is a schema that looks like figure 3.10.

The simplicity of the transformational operation of movement in this model is balanced against a family of constraints that restrict what movements and other processes can actually occur. First, phrase structures can now be defined as the same, regardless of whether they are in the deep or surface structure: so-called *X-bar theory* formulates the notion that a phrase structure subtree can be projected upward from the lexical category of its head noun. For example, *dog* is a noun, which can automatically be projected onto a tree, (Spec(N))np, in which ''specifier'' is interpreted as some kind of determiner. This means that phrase structure ''rules'' are no longer required to generate the deep structure. Rather, subtrees are projected from lexical heads and then joined by merging with other trees. Possible trees are constrained by the limits on X-bar theory and merging operations.

A second constraint on derivations involves the *projection principle*, the principle discussed above that requires every argument position of a verb to be filled at every defined level of representation. This motivates the postulation of traces, and other features of derivations as well. Other systems of constraints include *case theory*,

which requires every noun to be marked for case, and *theta-role theory*, which requires every argument of a verb to be assigned a thematic role. These and other constraints were intended to capture natural generalizations about language, each within its own subset of constraints. Derivations wended their way through the maze of constraints, with only the correct derivations becoming complete.

***The Minimalist Program* (Chomsky 1995)** The architecture was becoming quite ornate. A derivation started with phrase structure, then transformations to create surface structure, then other transformations to undo some of what the first set of transformations had done, as part of logical form. Nature has exhibited stranger architectures than this, but a paramount goal of linguistic theory is to capture generalization with the greatest clarity and simplicity possible. In addition, the collection of sets of constraints was becoming increasingly unwieldy, sometimes contradictory, and less and less revealing of generalizations. Recently, Chomsky proposed a paradigm that captures elements of the preceding architectures, while giving a rather different model of the relation between semantic representations and syntactic structures. (A good introduction to the minimalist model appears in Radford 1997.)

The theory states the following: a linguistic derivation consists of lexical items (i.e., content words like *boy*, *run*, and so on) and functional categories that glue those words together. Functional categories are reflected in elements like *the*, *-ed* for past tense, and *-ing* for progressive tense, and also in unpronounced elements. The meaning of a sentence is a result of the way content words combine with each other through functional elements. In figure 3.11, the domain of the verb, the VP (verbal phrase), contains all the content words that are arguments of the verb. The functional component, also called inflection, is located above the VP. The inflectional component of a sentence carries information specific to that particular sentence (whether the sentence is third person, past, and so on).

Functional categories head their own projections, similarly to nouns and verbs. These projections have some features that may be pronounced (*-ed*, *-s*) and structural features such as Case that are unpronounced in English. These are called *formal features*. In figure 3.11, for instance, Tense, a functional category, projects onto Tense Phrase and has the formal features [+present], [+3rd person sg] and [+nominative]. Formal features of functional projections must be checked for agreement by a content word in the sentence. For instance, in a derivation like the *boy runs*, as we said, the Tense Phrase contains the features [+present], [+3rd person], among others. For the sentence to be grammatical, there must be a verb in the third-person present form (i.e., with a third-person present morpheme) among the lexical items of the sentence. The content word and the functional category must agree in features or the derivation will crash. If the verb were inflected for past tense or for first person, the derivation would have to stop for lack of agreement between

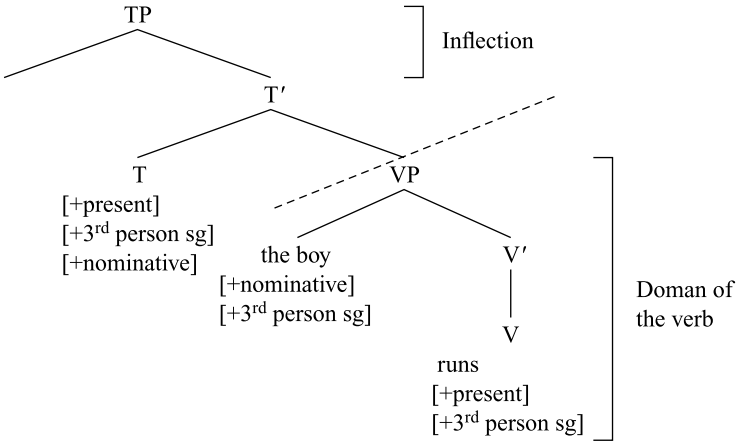

Figure 3.11
The underlying structure of *The boy runs* (adapted from Sanz and Bever 2000).

the features of the functional component and those of the content word. This is called *checking of features*. To check the features of a functional category, the verb must move to the functional projection (Tense Phrase in this case) that needs to be satisfied. In this way, formal features of functional categories are the cause of syntactic operations like movement of lexical categories. In figure 3.12 both *the boy* (a projection from a lexical item) and *runs* (a verb) move to the functional component of the sentence.

Formal features are, therefore, those that must be pronounced in the form of morphemes or that cause visible syntactic operations, like movement of lexical items. Figure 3.12 exemplifies the checking of Tense in the sentence *the boy runs*. The verb checks third-person present, and the noun checks Nominative. In the end, both noun and verb are contained in the same functional projection (Tense Phrase). Within formal features, a distinction is established between purely formal (like structural Case) and interpretable features (e.g., number). The model establishes that a derivation must be interpreted at two interface levels. One is the interface with the sensorimotor systems (Phonological Form or PF as shown in figure 3.13). The other is the interface with the cognitive-intentional system (Logical Form or LF). A derivation is computed from a set of elements or numeration by merging those elements with each other. At some point, it must be sent to both interface levels and be interpretable at both. The point at which the derivation is sent to the interface levels is called *spellout*. The purely formal features must be checked and erased from the derivation before spellout, because they are not interpretable at either PF or LF. This is overt checking of features, which leads to overt movement of elements within

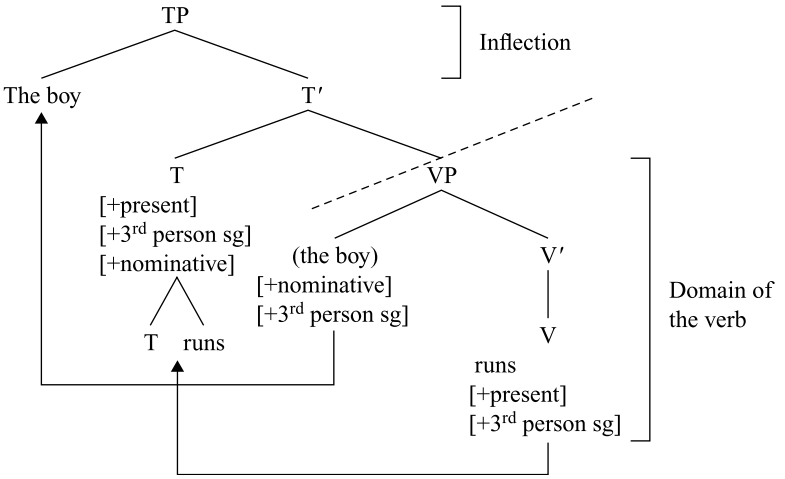

Figure 3.12
The movement of lexical categories in *The boy run* (adapted from Sanz and Bever 2000).

a sentence, as we exemplified in figure 3.12. Interpretable features, on the other hand, must survive until LF, since they bear on the meaning of the derivation. They are checked covertly and do not cause visible operations of movement.

Some of the interpretable features are also formal features (e.g., number in figure 3.12). They must be checked in the computation prior to spellout, but they are not erased. Purely formal features and features that are interpretable but formal at the same time (i.e., that must be checked prior to spellout) are called *strong*. The features that are interpretable and do not cause overt syntactic operations are called *weak*. The connection with semantics is established because only functional projections with some semantic import are allowed in the structure (Chomsky 1995). That is, projections like AgrO, which were postulated in the previous government-and-binding framework and contain purely formal features only (features whose only purpose is to be accessed by the syntactic computation before spellout) are not justified under minimalist premises. This is so because language design is assumed to be motivated by the conditions imposed by the systems with which language interacts (the sensorimotor or the cognitive system). Language mechanisms should have the shape they have in response to the conditions imposed from external systems. If there is no motivation from those systems for a certain construct or operation, minimalist considerations force us to discard it from the model.

This means that understanding the syntax/semantics interface under minimalism involves determining what functional projections there are in the inflectional component and what formal features (including interpretable features) are embedded in

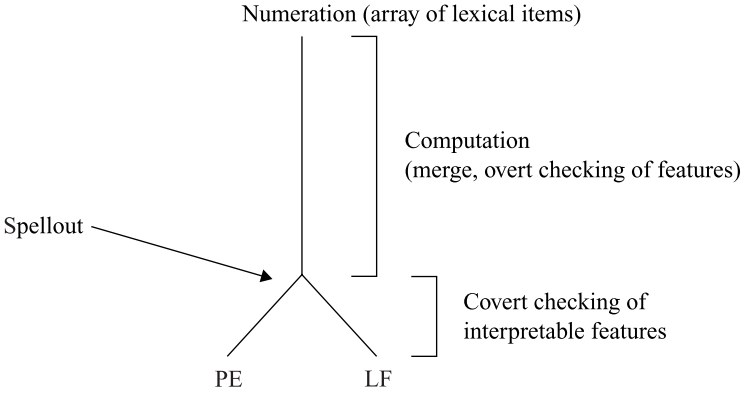

Figure 3.13
Computations and representations in the Minimalist Program (adapted from Sanz and Bever 2000).

them. Variation between languages is attributed to the difference in strength of features between languages. As stated above, a feature of a functional projection is strong when it requires that a lexical category in the sentence with the same feature moves overtly to the functional projection to check it. A feature is weak when it does not hold such a requirement. The next section presents the case of a parameter between English and Spanish that hinges on features related to events. The parameter will be illustrated through the different syntactic (visible) consequences that these features have in both of those languages.

So far we have been using the term *interpretable* to refer to features that must be interpreted at LF. It is crucial to understand the difference between conceptual and interpretable features in this sense (which we will call *semantic* from now on, for clarity's sake). *Conceptual features* or just concepts are assumed to be common to all human beings. For instance, the difference between a young individual and an old one is a universal that applies to all languages: *youth* is a concept that humans share. Likewise, normal adults understand the concept of time as being past, present, or future. *Semantic features*, on the other hand, are linguistic features: they represent the concepts that must be encoded in the grammar of many languages for sentences to be grammatical. For example, the concept of sexual identify gets encoded into the grammar of languages as gender. Sex is a concept. Gender features are semantic features. If we found a language in which the sentence *the boy runs* were grammatical but the sentence *the man runs* were not, we would have to posit that the concept of youth becomes grammaticalized as a semantic feature in the syntax of languages. In the absence of any such evidence, we assume that youth is a concept with no grammatical relevance: it is not a semantic feature. Words are stored with their

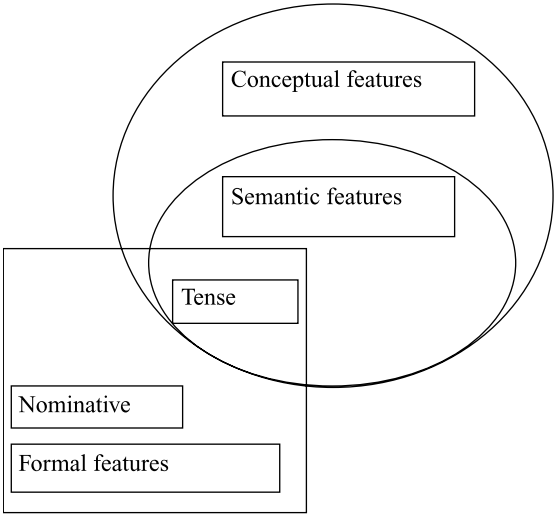

Figure 3.14
Types of features (adapted from Sanz and Bever 2000).

conceptual features. The word *boy* in English refers to a young (male) individual. This word (or its equivalent in other languages) has the conceptual feature *youth*, which does not get grammaticalized as a semantic feature. Figure 3.14 illustrates the types of features under the model we are presenting. Semantic features are a subset of conceptual features. Some of these semantic features are formal features of syntax causing syntactic operations. This is the case of Tense, which is semantic but must be pronounced through morphemes. This theory of the mapping of semantic onto syntactic structures poses the following question: Which conceptual features need to be encoded as semantic features in the grammar of languages?

In this section we provide partial answers to this question, which we think will become increasingly important in psycholinguistic research. We outline a minimalist analysis of the semantic literature on events (Davidson 1967; Dowty 1979, 1991; Tenny 1987, 1994; Kratzer 1995; Harley 1998; Higginbotham 1996, among others), which involves semantic features that vary in strength in English. We develop this as an example of a concept that we claim must be encoded in the syntax of languages through semantic features: the difference between *states* and *events* and the various action types that sentences can express. This difference explains certain syntactic phenomena involving unaccusative verbs and passive constructions in English.

This model gives a new character to the relation between semantics and syntax. In particular, there is no longer a specific deep structure tree that can be identified. Lexical items and phrase structure subtrees are successively merged in an upward

direction, and elements of a lower tree are successively checked against elements in a higher tree. This kind of process iterates until a complete tree dominated by *S* is formed. The "meaning" of the sentence is built up out of various kinds of lexical items and features that are checked or passed through the derivation to logical form. The end result is that the final linguistic meaning is represented in logical form, which serves as the interface between linguistic meaning and other cognitive structures.

This model is also striking in that the initial input numeration includes a listing of the actual words, with inflections, as they appear morphologically. This results in an interesting three-faced model, which interrelates the three aspects of sentences that are most salient: words, meaning, sound. Behaviorists may find this model more acceptable because it does not present seriously "abstract" entities at its interfaces. But, like every preceding architecture (including that of generative semantics), the internal mechanisms are extremely abstract, not just the operations of merge and of movement, but also the postulation of abstract nodes and verbs. The model is missing a single coherent "deep structure" level of representation, but this is replaced with a fluid set of processes and a model driven by abstract features.

The Classification of Verbs by Action Type This model involves some changes in the role of verb-argument structure. The explicit role of conceptual features opens up the possibility that the semantic structure of verbs can have direct implications for their potential derivations. Verbs themselves come in types, not just expressed in the specific roles their arguments can have but in the kind of action they describe, the so-called action type. This is a relatively new area of large-scale research in semantic theory and as yet has had little impact on psycholinguistic investigations of language learning and sentence behavior. We present an initial description of some aspects of it here, because we think it is in fact a very important factor in early stages of sentence comprehension; it plays a potential role in the comprehension model we present in chapter 5.

In the last three decades, there has been an increasing interest in the semantics literature about the nature of the differences between the predicates in figure 3.15 (Vendler 1967; Dowty 1979, 1991; Tenny 1987, 1994; Davidson 1967; Carlson 1977; Parson 1990; Kratzer 1995; Higginbotham 1996, among others). The sentences in the upper part of figure 3.15 contrast with those in the lower part in that they are events. It is a property of events that they can be telic (i.e., they can have a specific end point in time) or atelic. The progressive aspect distinguishes events from nonevents: whereas one can say *He is writing a letter* or *He is running*, **He is knowing math* is ungrammatical. Thus, the progressive morpheme in English (*-ing*), a grammatical operation, is sensitive to the semantic distinction between events and nonevents.

The distinction between telic and atelic events is reflected in the possible modifiers allowed in the VP. The sentence *He wrote a letter in two hours* is grammatical, in

EVENTS [+eventive]	[+telic]	[+measure]	write a letter drink a lemonade	accomplishment
		[−measure]	cross the finish line recognize John	achievement
	[−telic]		run drink lemonade	activity
NONEVENTS [−eventive]	[+permanent state]		know math be tall	individual-level property
	[−permanent state]		be tired be here	stage-level property

Figure 3.15
The classification of sentences according to their action type (adapted from Sanz and Bever 2000).

contrast with the ill-formed **He ran in two hours*. The former is an accomplishment, a telic event, because the letter is completed at the end. Observe what happens when the adverbial phrase is changed to *for two hours*. In this case, *He ran for two hours* and *He wrote a letter for two hours* pattern together in their grammaticality. But the sentence *He wrote a letter for two hours* has a different meaning from *He wrote a letter in two hours*: it does not express an accomplishment. It simply indicates that the subject engaged in the activity of letter writing for a period of time, without specifying whether he finished the letter or not. Applying this kind of durative adverbial phrase to the other telic type of event (achievement) yields ungrammaticality: **He finally crossed the finish line for two hours*. Crossing the finish line is an instantaneous event and thus cannot last any amount of time.

Three conclusions can be drawn from the previous facts. First, events have different properties from nonevents, and telic events are different from nontelic events. Second, accomplishments have two components (an activity and an end in which a new state of affairs is reached), whereas achievements do not have any internal structure of this sort. Third, the telicity of accomplishments is different from the telicity of achievements. In particular, the role of the object or delimiting goal phrase is crucial in determining whether the final end is reached in accomplishments. If the letter is completed, we have an accomplishment and the adverbial *in two hours* is allowed to appear in the VP. If the letter is not completed, the sentence expresses an

atelic activity. In that case, modification with *in two hours* is out, but phrases of the type *for two hours* are grammatical, as is the case with *run*. Tenny (1987, 1994) refers to this as measuring out of the event by an object. In contrast, achievements do not transpire over time and the object cannot measure out the event. The sentence *I crossed the finish line in two hours* means that it took two hours to arrive at the moment of crossing the finish line, not that the actual crossing lasted so long. But the object is obligatory in this sentence. We will call this *delimitation (without measure) by an object*. In the next section the concepts of measuring out and delimitation by objects are developed further.

Measuring out (Tenny 1987, 1994) works as follows: a verb that is underspecified for telicity takes an object that, by its nature, measures out the event and makes it telic. The event travels through the object until it finishes. As we pointed out above, activity verbs are atelic. However, observe the following pair of sentences:

(65) a. *I ran in two hours.
b. I ran the race in two hours.

The object *the race* provides what the verb *run* lacks: a beginning and an end to the action. In sentence (65b), *run* has been measured out and hence delimited by its object. The verb in this particular construction is not underspecified anymore for telicity: it has acquired the semantic feature [+telic] by having been measured out by the right kind of object in a syntactic configuration.

Not all objects are capable of measuring out an event. For instance, the verb *drink* (unspecified for telicity) is measured out in (66a) but not in (66b) in the following pair of examples:

(66) a. John drank a lemonade. (accomplishment)
b. John drank lemonade. (activity)

The subevents of drinking a lemonade cannot be described with sentence (66a), whereas the subevents drinking lemonade (a mass noun) are all describable with sentence (66b) (Dowty 1991). Mass nouns are not measurers because they are unlimited.

The object in transitive achievements does not measure out the event in the same way. However, observe the obligatoriness of the object in (67a).

(67) a. John crossed the finish line.
b. *John crossed.

The object in this case delimits the event by providing an entity on which the event can take place, but the event does not progress through the object and there is not change in the object at the end. The event of crossing simply cannot take place unless the agent crosses something. But since there are no intermediate steps to this event, we cannot interpret the object as a measurer.

There are syntactic consequences of the distinction between action types. The difference between accomplishments and achievements exemplified through the use of adverbs above has syntactic consequences for the grammar of English (Sanz 1996). The next pairs of sentence illustrate them:

(68) a. The blacksmith pounded the metal flat. (accomplishment)
a′. *The blacksmith crossed the finish line dirty. (meaning that he made the finish line dirty by crossing it)
b. This bread cuts easily. (accomplishment)
b′. *This wall hits easily. (achievement)
c. John ran (*in two hours). (activity)
c′. John ran to the store in two hours. (accomplishment)

The sentences in (68a) contain a resultative (an adjectival phrase that expresses the new state of the object after the action has been completed). The adjectival is ungrammatical unless we consider the object of the sentence a measurer of the action. Resultatives disambiguate an expression that could be atelic or telic and make it definitely telic: when the resultative is present, we must interpret the object as a measurer.

3.5 Conclusion and Implications

Classic research on comprehension has suggested that grammatical information is computed as part of the process. This makes us turn to linguistic theories to gain information about what grammatical information is made of. The role of syntax in linguistic theory is to mediate between sound and meaning. Most theories of syntax include notions of lexical category, morphology, phrase structure, and some kind of sentence-level organization. All theories must deal with some degree of iterative processes, since sentences can be embedded within other sentences. Generative grammars have consistently included a notion of derivation, in which a source structure is built up and modified until it fills out a complete utterance. For fifty years, the primary structure-building mechanisms have been ''merging'' of constituents where there is a formal category overlap, and ''movement'' of words or features, almost always upward in a phase structure hierarchy.

The conclusion regarding the derivational theory of complexity was that the processes (transformations) might not be ''real,'' but the levels of representation are, most critically, the deep structure. What are we to make of that claim in light of minimalist syntax? First, we may want to argue that the point in a derivation just before spellout has some special behavioral role, it may turn out that the prior data are best explained as a reflection of logical form. In the worst case, it may turn out

that the prior data are not a natural kind and have a compound explanation, drawing on different features of the grammar.

So, comprehension models aside, what do we test today, if we want to explore the behavioral implications of syntax? Our review of what has consistently played a role in generative theories suggests that we should consider examining the psychological basis for the two primary and ever-present operations, merge and move. They may be unique to linguistic computations, or a reflex of more general computations involving symbols.

Perhaps we can move toward some answers by considering the narrower question of comprehension and how a grammar can be embedded in a model of understanding sentences. The next chapter reviews a range of recent and current theories of how that works, and chapter 5 presents our model. We conclude that because derivations are not built left to right, nor necessarily top-down, nor from meaning to form, the logically best architecture for a comprehension model is analysis by synthesis. In that model, the grammar is allowed to generate syntactic representations, using its own processes, operating independently from the input stream.

Note

Portions of section 3.4, including figures 3.11 through 3.15, are based on Sanz and Bever (forthcoming).