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Semantic Role Universals and Argument Linking

Theoretical, Typological, and Psycholinguistic Perspectives

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Semantic macroroles and language processing

Robert D. Van Valin, Jr.

1. Introduction

It is widely assumed in the discussion of both language production and comprehension that semantic roles play an important role in both processes. Yet there are different types of semantic roles proposed in different linguistic theories, and this raises two questions. The first is, exactly what type of semantic role is most appropriate for language processing? Verb-specific roles? Thematic relations? Generalized semantic roles? The second question is, given that the different types of semantic roles are embedded within different grammatical theories, what is the relationship between the grammatical theories and processing models? The relationship of grammatical theories to models of language processing is a controversial one. At the one extreme, Chomsky has always maintained that the study of linguistic competence is logically prior to and independent of the investigation of linguistic performance and consequently that considerations from performance, including psycholinguistic and computational modeling of it, have no bearing on or relevance to theories of competence (see e.g. Chomsky 1965). At the other end of the spectrum stand Kaplan and Bresnan (1982), who maintain that theories of linguistic competence should be tied to testable models, psycholinguistic or computational, of linguistic performance.

The purpose of this paper is to investigate these two questions. It will be argued that the type of semantic role most relevant to language processing is the notion of semantic macrorole, which was originally proposed and developed in the theory of Role and Reference Grammar. Since semantic macroroles do not exist in a theoretical vacuum, this leads to an investigation of the relationship between the syntactic theory that posits them and models of language production and comprehension. Where in the processing model does the grammatical model fit? Does this relationship have any consequences for the grammatical theory?

Role and Reference Grammar [RRG] (Van Valin and LaPolla 1997; Van Valin 2005) is a theory of syntax in which semantic macroroles play a central role and which explicitly attempts to be a grammatical model of both language production and comprehension; this can be seen in Figure 1, which lays out the organization of the theory.

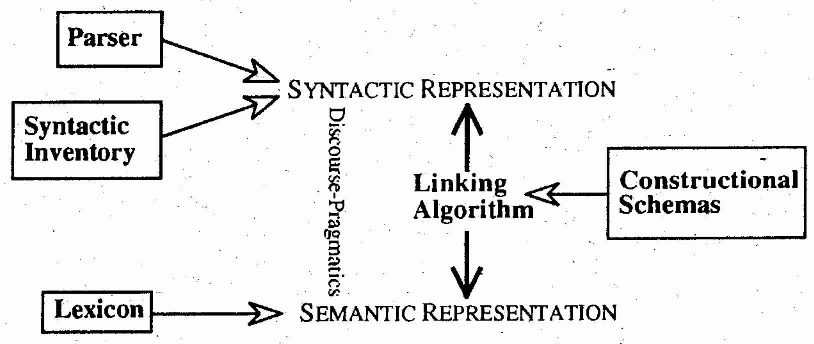


Figure 1. The organization of Role and Reference Grammar

RRG posits only a single syntactic representation for a sentence, which is the overt form of the sentence; there are no underlying syntactic structures, transformational rules or derivations. This syntactic representation is related to the semantic representation of the sentence by a set of rules called the 'linking algorithm'. In Figure 1 the arrow representing the linking algorithm is double-headed; this indicates that it not only links a semantic representation to the appropriate syntactic representation, but that it also links a syntactic representation to a semantic representation. The basics of the linking system will be summarized in section 2. In terms of language processing, it is reasonable to assume that a speaker has some communicative content in mind, that this is translated into a semantic representation and that this is mapped into a morphosyntactic form which is then uttered; in other words, the process of language production involves at least in part a mapping from semantics to syntax, or, in RRG terms, a semantics-to-syntax linking. Conversely, the hearer takes the acoustic (or other) input, parses it into a morphosyntactic structure and assigns a meaning to it; in other words, the process of language comprehension involves at least in part a mapping from syntax to semantics, or, in RRG terms, a syntax-to-semantics linking. It is in this sense that RRG purports to be a grammatical model of language production and comprehension.[1]

The primary question which this paper seeks to address is, how does RRG fit with psycholinguistic models of language processing? An answer to this question is a contribution to the larger issue of the relationship of

grammatical models to processing models. Psycholinguists have often argued for a particular model of language production or comprehension without taking developments in theoretical linguistics into account, and consequently it would strengthen their claims if it could be shown that the components they posit correspond to theoretical constructs developed and justified on the basis of extensive linguistic evidence. And conversely, if the constructs posited by grammatical theorists on the basis of purely linguistic evidence and argumentation correlate with those postulated by psycholinguists on the basis of experimental and other evidence, this supports the claim of the grammatical theory to be a plausible model of a speaker's linguistic competence. A final question to be addressed is, do the processing models have any implications for the grammatical model?

The discussion will proceed as follows. In section 2, the notion of semantic macroroles will be introduced as part of a brief summary of the RRG linking system. In section 3, the RRG system will be compared with Bock and Levelt's (1994) model of grammatical encoding in language production. In section 4, an RRG-based model of parsing and language comprehension will be outlined. Conclusions will be presented in the final section.

2. Semantic macroroles in the Role and Reference Grammar linking system: A brief summary[2]

As shown in Figure 1, the linking algorithm links the syntactic and semantic representations, and accordingly the basics of each of those representations must be introduced. The syntactic representation is known as the 'layered structure of the clause' and consists of two projections: the 'constituent projection' containing the predicating element, usually but not necessarily a verb, its arguments and any modifying adjuncts, and the 'operator projection' containing grammatical categories like aspect, tense, negation and illocutionary force. The constituent projection consists of the 'nucleus' of the clause, containing the predicate, the 'core' of the clause, containing the nucleus and the arguments of the predicate, and the 'periphery' of the clause, housing the adjuncts modifying the core. Each of these layers may be modified by one or more operators. The structure of a simple sentence in English is exemplified in Figure 2 on next page.

A couple of notes are in order. NPs headed by common nouns and adjunct PPs have a layered structure analogous to that of clauses; NPs headed by

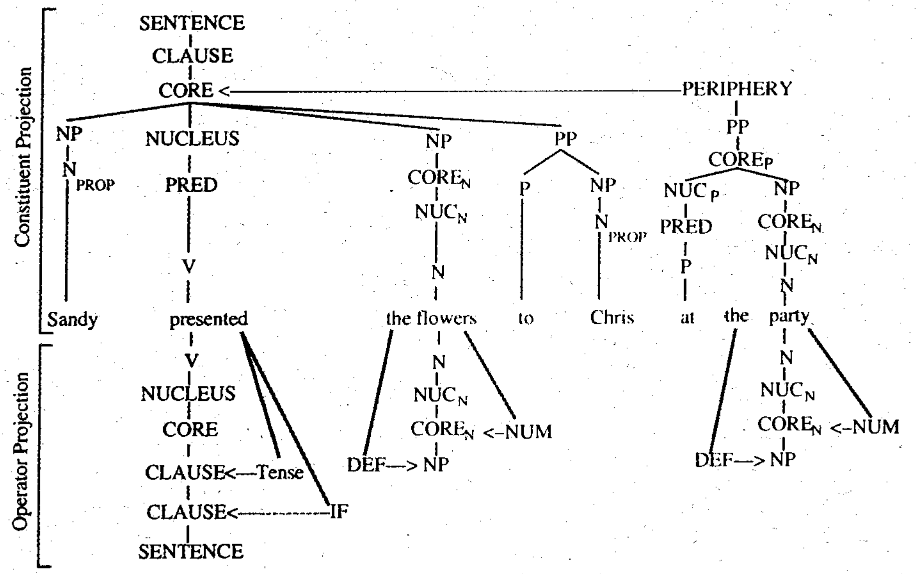


Figure 2. The layered structure of a simple English sentence

proper nouns and pronouns lack a layered structure, as they do not take operators. The PP headed by *to* does not have a layered structure, because *to* is non-predicative, i.e. it does not license its object, *Chris*, which is an argument of the verb *present*, which can be seen clearly in the alternative form *Sandy presented Chris with the flowers*. Illocutionary force in English is signaled by the position of the tense morpheme; when it is linearly core-internal, as in Figure 2, it signals declarative illocutionary force. There are additional possible positions in a sentence not represented here, e.g. the pre-core slot [PrCS], the position in which displaced question words occur in languages like English and German, and the left-detached position [LDP], the position of left-dislocated elements (see Figure 3).

Syntactic structures are stored as syntactic templates in the syntactic inventory in the grammar. Syntactic templates are language-specific syntactic forms which are composed of the universal components of the layered structure of the clause. There are principles which determine the selection of syntactic templates for semantics-to-syntax linking; the default principle is that the core template must have as many argument slots as there are arguments in the semantic representation of the core. Complex structures are composed of multiple templates, as illustrated in Figure 3. (The arrows with filled heads indicate selection of a template from the

syntactic inventory; the arrows with unfilled heads indicate combinatory operations.)

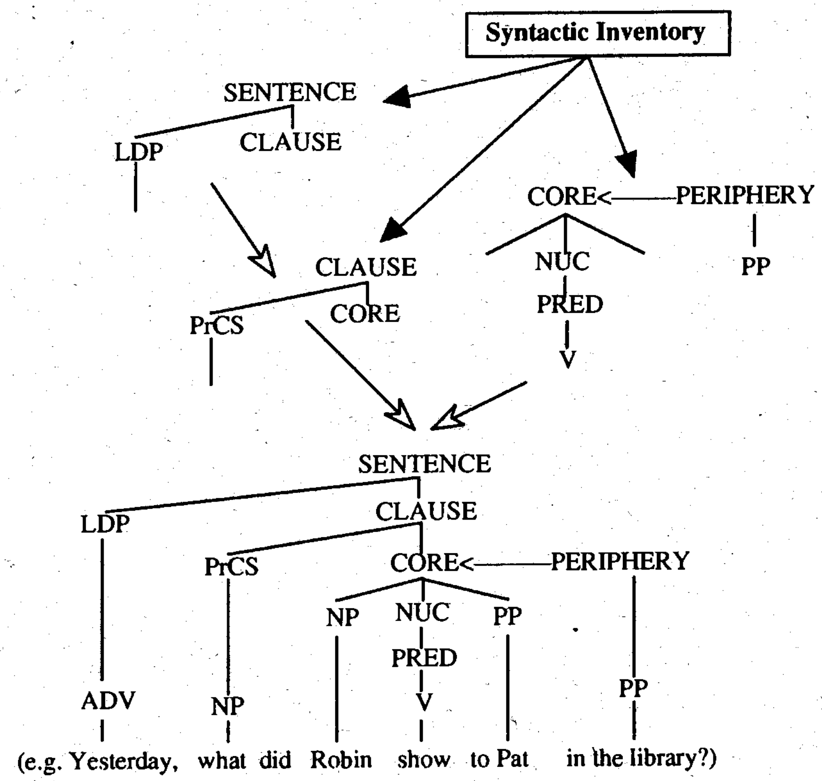


Figure 3. Combining syntactic templates from the syntactic inventory

The semantic representation of a sentence is based on the decompositional representation of the predicate in the nucleus. The decompositional system is based on the *Aktionsart* distinctions originally proposed in Vendler (1967), with some extensions. The classes are given in (1), with example sentences involving each type plus its causative counterpart are given in (2).

(1) a. States: *be sick, be tall, be dead, love, know, believe, have*
  b. Achievements: *pop, explode, collapse, shatter* (intransitive)
  c. Semelfactives: *flash, tap* (the intransitive versions); *cough, glimpse*

d. Accomplishments: *melt, freeze, dry* (the intransitive versions); *learn, receive*
e. Activities: *march, walk, roll* (the intransitive versions); *swim, think, rain, read, eat*
f. Active accomplishments: *devour, walk to the store, eat the pizza*

(2)

(2)	a. State:	*The boy is afraid.*
	a′. Causative state:	*The dog frightens/scares the boy.*
	b. Achievement:	*The balloon popped.*
	b′. Causative achievement:	*The cat popped the balloon.*
	c. Semelfactive:	*The light flashed.*
	c′. Causative semelfactive:	*The conductor flashed the light.*
	d. Accomplishment:	*The ice melted.*
	d′. Causative accomplishment:	*The hot water melted the ice.*
	e. Activity:	*The soldiers marched in the field.*
	e′. Causative activity:	*The sergeant marched the soldiers in the field.*
	f. Active accomplishment:	*The soldiers marched to the field.*
	f′. Causative active accomplishment:	*The sergeant marched the soldiers to the field.*

The decompositional system is adapted from that proposed in Dowty (1979); it is summarized in Table 1.

Table 1. Lexical representations for *Aktionsart* classes

Verb Class	Logical Structure
STATE	predicate′ (x) or (x,y)
ACTIVITY	do′ (x, [predicate′ (x) or (x, y)])
ACHIEVEMENT	INGR predicate′ (x) or (x,y), or INGR do′ (x, [predicate′ (x) or (x, y)])
SEMELFACTIVE	SEML predicate′ (x) or (x,y) SEML do′ (x, [predicate′ (x) or (x, y)])
ACCOMPLISHMENT	BECOME predicate′ (x) or (x,y), or BECOME do′ (x, [predicate′ (x) or (x, y)])
ACTIVE ACCOMPLISHMENT	do′ (x, [predicate$_1$′ (x, (y))]) & INGR predicate$_2$′ (z, x) or (y)
CAUSATIVE	α CAUSE β, where α, β are LSs of any type

Examples of some English sentences with their logical structures are given in (3).

(3)	a. STATES		
		The window is shattered.	**shattered′** (window)
		Fred is at the house.	**be-at′** (house, Fred)
	b. ACTIVITIES		
		The children cried.	**do′** (children, [**cry′** (children)])
		Carl ate snails.	**do′** (Carl, [**eat′** (Carl, snails)])
	c. ACHIEVEMENTS		
		The window shattered.	INGR **shattered′** (window)
		The balloon popped.	INGR **popped′** (balloon)
	d. SEMELFACTIVES		
		Dana glimpsed the picture.	SEML **see′** (Dana, picture)
		Mary coughed.	SEML **do′** (Mary, [**cough′** (Mary)])
	e. ACCOMPLISHMENTS		
		The snow melted.	BECOME **melted′** (snow)
		Mary learned French.	BECOME **know′** (Mary, French)
	f. ACTIVE ACCOMPLISHMENTS		
		Carl ate the snail.	**do′** (Carl, [**eat′** (Carl, snail)]) & INGR **consumed′** (snail)
		Paul ran to the store.	**do′** (Paul, [**run′** (Paul)]) & INGR **be-at′** (store, Paul)
	g. CAUSATIVES		
		The dog scared the boy.	[**do′** (dog, Ø)] CAUSE [**feel′** (boy, [**afraid′**])]
		Max broke the window.	[**do′** (Max, Ø)] CAUSE [BECOME **broken′** (window)]
		The cat popped the balloon.	[**do′** (cat, Ø)] CAUSE [INGR **popped′** (balloon)]
		Felix bounced the ball.	[**do′** (Felix, Ø)] CAUSE [**do′** (ball, [**bounce′** (ball)])]
		Mary fed the pizza to the child.	[**do′** (Mary, Ø)] CAUSE [**do′** (child, [**eat′** (child, pizza)]) & INGR **consumed′** (pizza)

A more complete semantic representation of a clause contains operators as well. This is illustrated in (4) and (5).

(4) Semantic representation of operators

$\langle_{IF}DEC\langle_{EVID}HS\ \langle_{TNS}\ PAST\ \langle_{STA}\ IRR\ \langle_{NEG}\emptyset\ \langle_{MOD}\ OBLG\ \langle_{EVQ}\ SG\ \langle_{DIR}\ \emptyset\ \langle_{ASP}\ PERF\ \langle \mathrm{LS}\rangle\rangle\rangle\rangle\rangle\rangle\rangle\rangle\rangle\rangle$[3]

(5) a. Has Kim been crying?
b. $\langle_{IF}\ INT\ \langle_{TNS}\ PRES\ \langle_{ASP}\ PERF\ PROG\ \langle$ **do′** (Kim, [**cry′** (Kim)])$\rangle\rangle\rangle\rangle$

A key component of the RRG linking system is the semantic macroroles.[4] There are two semantic macroroles, actor and undergoer, which are the two primary arguments of a transitive predication; the single argument of an intransitive predicate can be either one, depending upon the semantics of the verb. This is illustrated in (6).

(6) a. Kim [Actor] ate the bagel [Undergoer].
b. The bagel [Undergoer] was eaten by Kim [Actor].
c. Chris [Actor] jogged in the park.
d. Pat [Undergoer] fell asleep in class.

Actor and undergoer are called 'macroroles' because each of them subsumes a number of more specific thematic relations; this is illustrated in (7).

(7)	Actor	Undergoer
a. The farmer [A] killed the duckling [U].	Agent	Patient
b. The rock [A] broke the window [U].	Instrument	Patient
c. The lawyer [A] received the summons [U].	Recipient	Theme
d. Many tourists [A] saw the accident [U].	Experiencer	Stimulus
e. Sally [A] presented Bill [U] with the award.	Agent	Recipient
e′. Sally [A] presented the award [U] to Bill.	Agent	Theme
f. The mugger [A] robbed Sam [U] of $50.	Agent	Source
f′. The pickpocket [A] stole $50 [U] from Sam.	Agent	Theme
g. The clown [A] amused the child [U].	Agent	Experiencer

The relationship between argument positions in logical structure and actor and undergoer selection is expressed in the Actor-Undergoer Hierarchy; it is given in Figure 4.[5]

ACTOR ——————> UNDERGOER
<——————

Arg of DO	1st arg of **do′** (x,...)	1st arg of **pred′** (x,y)	2nd arg of **pred′** (x,y)	Arg of state **pred′** (x)

[——>' = increasing markedness of realization of argument as macrorole]

Figure 4. The Actor-Undergoer Hierarchy

This hierarchy states that the leftmost argument in the logical structure will be the actor and the rightmost the undergoer. While the actor selection principle is absolute and invariable across languages, there is variation with respect to undergoer selection; namely, with some verbs in some languages, it is possible to select a higher ranked argument as undergoer. This is exemplified in the English dative shift and transfer alternations in (8).

(8) a. Sally gave the flowers [U] to Kim [NMR].
a′. Sally gave Kim [U] the flowers [NMR].
b. Sally presented the flowers [U] to Kim [NMR].
b′. Sally presented Kim [U] with the flowers [NMR].
c. [**do′** (Sally, Ø)] CAUSE [BECOME **have′** (Kim, flowers)]

In an active voice English core, the undergoer is the direct NP that immediately follows the nucleus. In (8a,b) the lowest ranking argument in the logical structure in (8c) is selected as undergoer; this is the default or unmarked selection. In (8a′,b′), on the other hand, the second lowest ranking argument has been selected as undergoer, yielding a marked selection.

Subject selection (or in RRG terms, 'privileged syntactic argument' [PSA] selection), is based on the hierarchy in (9) and the principles in (10).

(9) Privileged syntactic argument [subject] selection hierarchy:
arg of DO > 1st arg of **do′** > 1st arg of **pred′** (x, y) > 2nd arg of **pred′** (x, y) > arg of **pred′** (x)

(10) Privileged syntactic argument ['subject'] selection principles:
a. Accusative constructions: Highest ranking direct core argument in terms of (9)

b. Ergative constructions: Lowest ranking direct core argument in terms of (9)
c. Restrictions on PSA in terms of macrorole status:
   1. Languages in which only macrorole arguments can be PSA: German, Croatian, ...
   2. Languages in which non-macrorole direct core arguments can be PSA: Icelandic, ...

In an accusative language like English, the default choice for subject is the highest ranking macrorole in terms of (9), which would be the actor. It is possible to override this in a passive construction, in which the undergoer functions as subject (cf. (6b)).

The components of the RRG linking system are summarized in Figure 5.

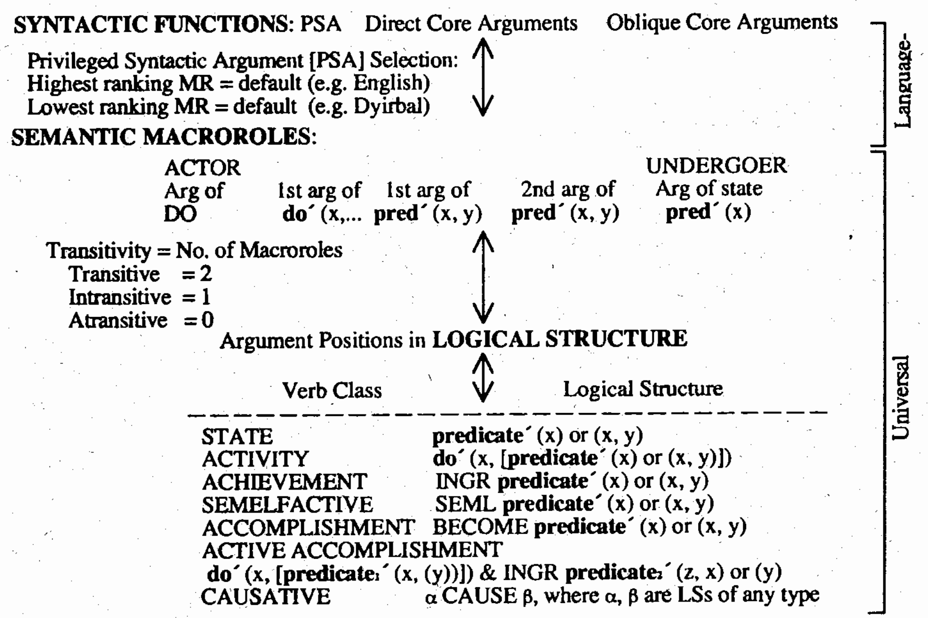


Figure 5. Summary of RRG linking system

The linking between syntax and semantics is subject to a general constraint called the 'Completeness Constraint'; it is given in (11).

(11) Completeness Constraint:
All of the arguments explicitly specified in the semantic representation of a sentence must be realized syntactically in the sentence, and all of the referring expressions in the syntactic representation of a sentence must be linked to an argument position in a logical structure in the semantic representation of the sentence.

In Figure 1, discourse-pragmatics is mentioned, and it plays a significant role in the linking algorithm, one which varies in important ways across languages. The status of the referent in context (e.g. well established, not mentioned but inferable, not mentioned and not inferable) strongly influences the type of linguistic expression used to denote it, and information-structural distinctions such as topic and focus can affect word order, case marking, subject selection and many other grammatical phenomena. See Van Valin and LaPolla (1997), sect. 7.6 for detailed discussion.

The linking algorithm from semantics to syntax is presented in (12). A detailed example will be presented below to illustrate its operation in English.

(12) Linking algorithm: Semantics to Syntax
1. Construct the semantic representation of the sentence, based on the LS of the predicator.
2. Determine the actor and undergoer assignments, following the Actor-Undergoer Hierarchy in Figure 4.
3. Determine the morphosyntactic coding of the arguments
   a. Select the PSA, based on the PSA selection hierarchy and principles in (9)–(10).
   b. Assign the argument(s) the appropriate case markers and/or adpositions.
   c. Assign the agreement marking to the main or auxiliary verb, as appropriate.
4. Select the syntactic template(s) for the sentence.
5. Assign argument(s) to positions in the syntactic representation of the sentence.
   a. Assign the [-WH] argument(s) to the appropriate positions in the clause.
   b. If there is a [+WH] argument, then, depending on the language,

1. assign it to the normal position of a non-WH-argument with the same function, or
2. assign it to the precore or postcore slot, or
3. assign it to a position within the potential focus domain of the clause (default = the unmarked focus position).

c. A non-WH argument may be assigned to the precore or postcore slot, subject to focus structure restrictions (optional).

d. Assign the argument(s) of LS(s) other than that of the predicator in the nucleus to
1. the periphery (default), or
2. the precore or postcore slot, or
3. the left-detached position.

Let's suppose that the message that the speaker wants to convey is that Sandy gave some flowers to Chris at a party and that the verb *present* is selected for the sentence. The output of step 1 in (12) is given in Figure 6.

⟨$_{\text{IF}}$*DEC*⟨$_{\text{TNS}}$*PAST*⟨**be-at′** (party, [[**do′** (Sandy, Ø)] CAUSE [BECOME **have′** (Chris, flowers)]])⟩⟩⟩

Figure 6. Output of step 1 in (12)

The semantic representation of the NPs filling the argument positions is not given, in the interest of space. The next step is to assign macroroles, following the hierarchy in Figure 4. This verb allows variable undergoer assignment, but in this example the default selection will be made. The result is given in Figure 7, in which the logical structure of *present* has been illustrated.

...[**do′** (ACT: Sandy, Ø)] CAUSE [BECOME **have′** (NMR: Chris, UND: flowers)]...

Figure 7. Output of step 2 in (12)

It is important to keep in mind that the representation in Figure 7 is not a new 'level' of representation of any kind; it is an informationally enriched version of the representation in Figure 6. The next step involves adding morphosyntactic information to the representation. The actor will be the PSA ('subject'), yielding an active voice sentence, and then case,

prepositions and agreement are assigned (see Van Valin 2005, chs. 4, 5, for presentation of these rules).

...[**do′** (ACT: Sandy, Ø)] CAUSE [BECOME **have′** (NMR: to Chris, UND: flowers)]...
[PSA: NOM] Active, 3sg [ACC] [ACC]

Figure 8. Output of step 3 in (12)

The next step involves selecting the syntactic templates for the sentence, for the clause as well as for the NPs and PPs in it. Since there are three arguments in the semantic representation, a core with three argument slots is required. There are also NP templates for two proper nouns and two common nouns. The two PP templates are different, reflecting the contrast between a predicative preposition (which acts as a predicate, contributes semantically to the clause, and licenses its object, e.g. *at the party* in this example), which has a layered structure, and a non-predicative preposition (which is basically just a case marking an argument of the verb, e.g. *to Chris*), which does not have a layered structure. The operator slots are determined by the operator values in Figure 6 on next page, including the unrepresented NP operator values which would be represented in a complete semantic representation.

The final step is step 5, which is the assignment of the arguments in the logical structure to positions in the syntactic representation of the sentence. This involves linking referring expressions from the logical structure into the appropriate NP template, linking the objects of prepositions to their prepositional templates, and then finally linking the NPs and PPs to the structural positions in the clause. Step 5a is rather vaguely formulated, because these principles are to a large degree language-specific. In English, the subject (PSA) is the first NP in the core, while the undergoer is the immediately post-nuclear direct NP, followed by any oblique core arguments and then phrasal adjuncts. Step 5d is relevant in this example, because there is a logical structure, **be-at′** (x, y), which is not part of the logical structure for *present* but rather takes the logical structure for *present* as one of its arguments. This is how adjunct PPs are represented semantically. The result of step 5 is the representation in Figure 2. An abbreviated representation of the entire semantics-to-syntax linking process is given in Figure 10; numbers refer to the steps in the linking algorithm.

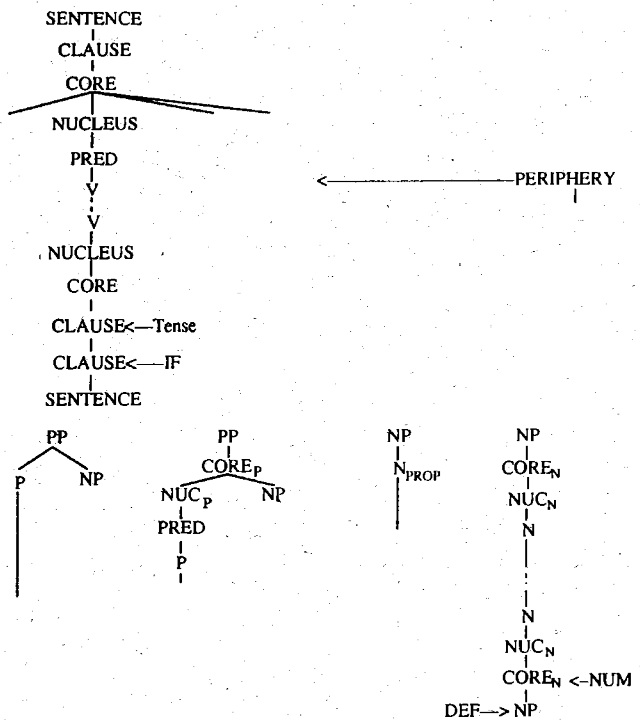


Figure 9. Output of step 4 in (12)

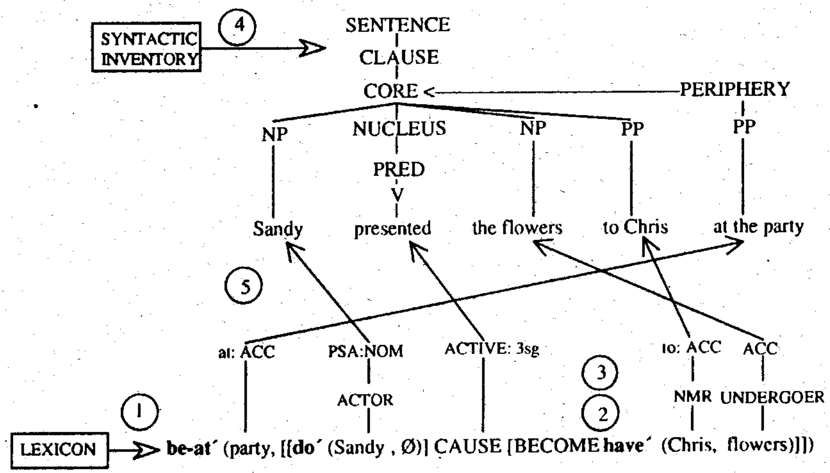


Figure 10. Abbreviated linking diagram summarizing Figures 6–9

Turning to the linking from syntax to semantics, the basic idea of the syntax-to-semantics algorithm is to glean all of the information possible from the overt morphosyntactic cues in the sentence and match that with information from the logical structure of the predicate in the nucleus. Executed properly for a grammatical sentence, the result should be that all referring expressions in the syntax are linked to an argument position in the semantic representation, and all argument positions in the semantics are linked as well, thereby satisfying the Completeness Constraint in (11). The syntax-to-semantics linking algorithm may be summarized as in (13).

(13) Linking from syntax to semantics (summary)
  a. The parser outputs a labeled tree structure.
  b. The first step is to derive as much information from the overt morphosyntactic features of the clause: case marking/word order, the voice of the verb, adpositions.
  c. The second step is to retrieve the LS of the verb from the lexicon and assign macroroles where possible.
  d. The information from these steps should link everything in the core to the argument positions in the LS; if there is an element in the PrCS, it will be linked last, to the remaining unlinked argument position in the LS.

Step (13a) is clearly an idealization that is appropriate for a grammatical theory but not, obviously, for a processing model. The issue of the interaction between the grammar and the parser will be a major topic in section 4.

The linking from syntax to semantics for the simple English sentence *Kim smashed the glass* is illustrated in Figure 11 on next page.

Step 1 involves recognizing the verb and its voice; since this is a transitive clause and the verb is active voice, then the PSA ('subject') is the actor and the postnuclear direct NP must be the undergoer. The second step involves retrieving the logical structure of the verb from the lexicon and assigning macroroles; in this case, the *x* argument is the actor and the *y* argument the undergoer. The third and final step involves matching the information from the first two steps: *Kim* is the actor, and the actor is the *x* argument, therefore *Kim* = *x*, and similar reasoning to arrive at *the glass* = *y*. The values of the operators would be read off the structure as well, yielding a more complete semantic representation.

An example involving a WH-question is given in Figure 12.

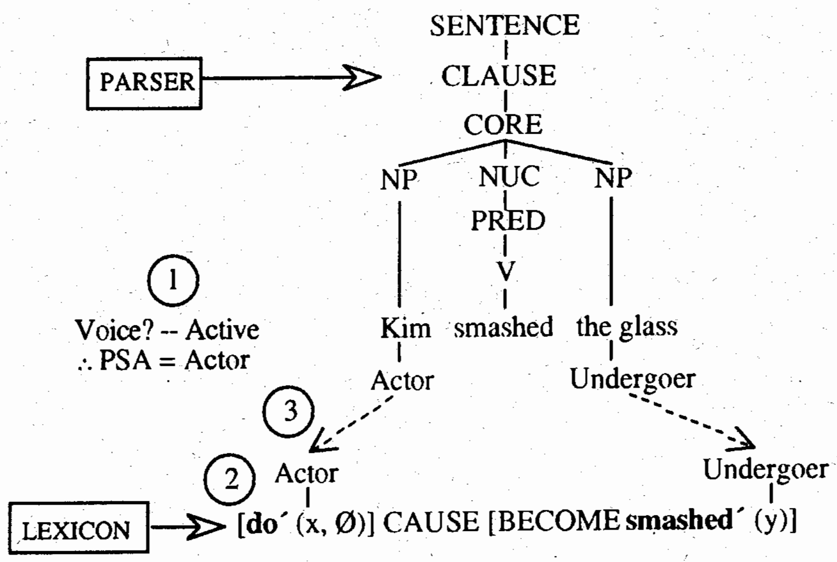


Figure 11. Syntax-to-semantics linking in simple English sentence

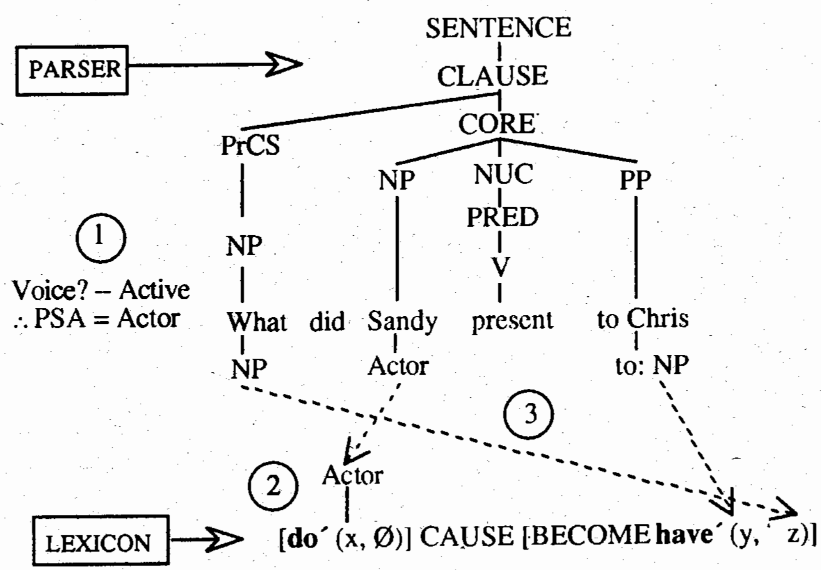


Figure 12. Linking from syntax to semantics in English WH-question

WH-questions in English are challenging, because the WH-word is functionally unmarked; *what, who* or *which X* could be actor, undergoer, or object of a preposition in a simple sentence, and the possibility of long-distance extraction adds even more complexity. The first step yields the following information: *what* is an NP, *Sandy* is an NP and the actor, because the verb *present* is active voice, and *Chris* is the object of the preposition *to*. In the second step the logical structure of *present* is activated, but unlike in Figure 11, the only macrorole that can be assigned is actor to the *x* argument; undergoer cannot be assigned, because this verb allows variable undergoer selection, as in (8). In the third step, the linking of *Sandy* to the *x* argument is straightforward. The linking of the non-actor arguments in this case is determined by the following principle: if the non-macrorole core argument with a three-place verb is marked by a dative or locative-type case or a locative adposition, it is linked to the first argument of ...**predicate**´ (y, z) in the logical structure, otherwise to the second argument position in ...**predicate**´ (y, z).[6] Hence in this example *Chris*, which is marked by a locative preposition (*to*), is linked to the *y* argument position (recipient). All of the XPs in the core have been linked, and there is one NP in the PrCS unlinked and one unlinked variable in the logical structure; in order for the Completeness Constraint to be satisfied, these two must be linked, yielding the correct result: the *z* argument is the thing given (theme), and that is the correct interpretation of *what*.

The semantic macroroles of actor and undergoer are central to both directions of linking; they are crucial interface notions between syntax and semantics, as they are determined semantically but play a vital role in the syntax. In addition to the subject selection principles in (10), the RRG rules governing case assignment, finite verb agreement and preposition assignment all crucially refer to semantic macroroles.

This presentation of the RRG linking algorithm has been highly simplified, but the basic outline of how it works should be clear. It has been applied to a broad range of phenomena in a significant number of languages; see Van Valin and LaPolla (1997), Van Valin (2005) and the references in the RRG bibliography for detailed exemplification. In the next two sections, the issue of how this linking theory fits with psycholinguistic models of production and comprehension will be addressed.

3. RRG and language production

In the discussion of language production the model proposed in Levelt (1989) and Bock and Levelt (1994) will be employed. The model or 'blueprint' for the speaker proposed by Levelt is summarized in Figure 13.

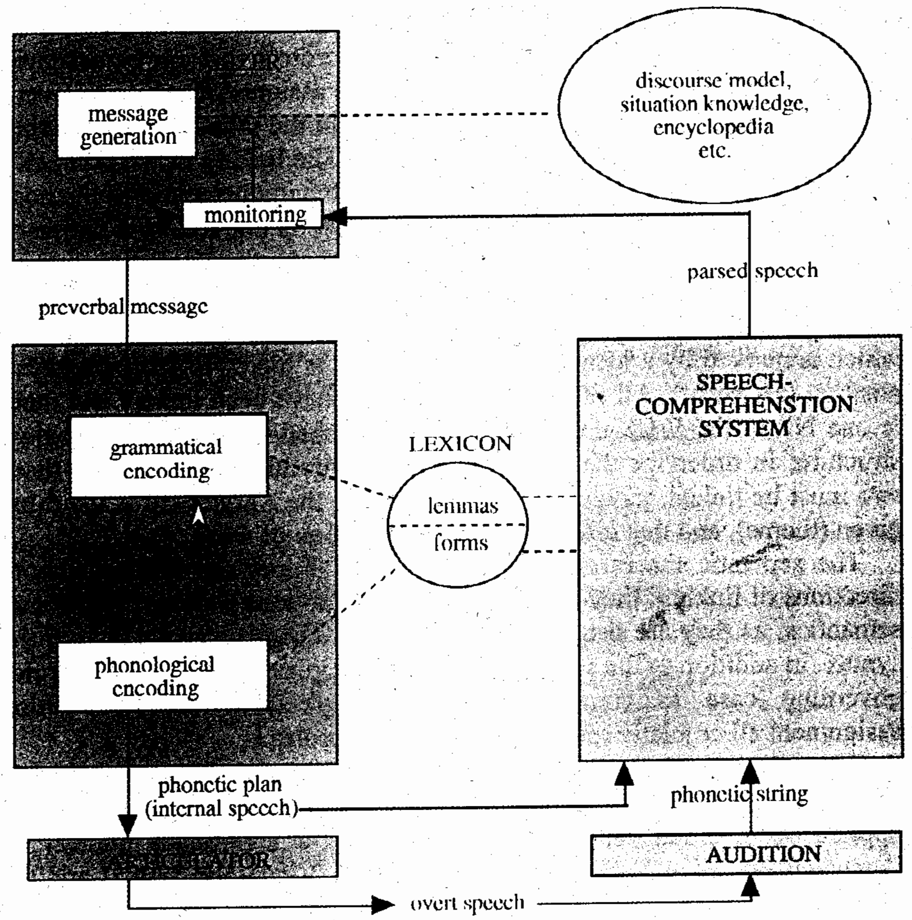


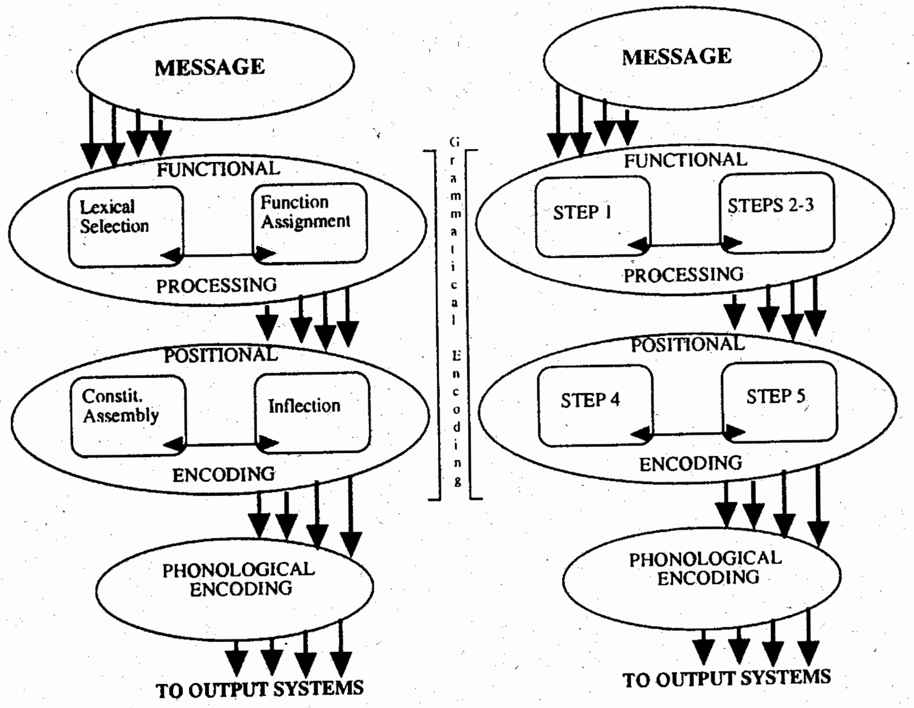
Figure 13. Blueprint for the speaker, from Levelt (1989)

The three grey boxes on the left along with the lexicon represent the components involved in production, and the only parts that RRG is relevant to are the lexicon and the box labeled 'grammatical encoding' in the FORMULATOR.

Bock and Levelt (1994) lay out what goes on grammatical encoding as follows. The first step is functional processing, which has two components: lexical selection and function assignment. Lexical selection is based on the output of the CONCEPTUALIZER, in which the message to be communicated is generated. The appropriate lemmas are activated, and a semantic representation of the message is created. Function assignment involves determining subject, direct object, etc., their case forms, and the inflectional properties of forms in the sentence. It is controlled primarily by what Bock and Levelt call 'event roles', i.e. thematic relations, and 'attentional roles', i.e. information-structural functions like topic and focus.The second major step is positional encoding, which likewise has two components, constituent assembly and inflection. Constituent assembly, as the term implies, involves putting together the syntactic framework for the sentence, and inflection concerns the overt morphosyntactic realization of the grammatical categories such as tense, agreement, and case. In positional processing, the elements that were the output of functional processing are now mapped into positions in a syntactic structure and their inflections morphologically instantiated. The output of this process is sent to the next component for phonological encoding.

The process described by Bock and Levelt is similar to semantics-to-syntax linking in RRG. Lexical selection corresponds to step 1, in which the semantic representation of the sentence is constructed, based on the logical structure of the predicator; see Figure 6. Function assignment corresponds to steps 2 and 3 in (12): macrorole assignment and PSA ('subject') selection, along with the determination of the case and agreement properties of the arguments and predicator. Event roles (as represented by argument positions in logical structure) are an integral part of macrorole assignment, and attentional roles may affect subject selection, case assignment and other morphosyntactic processes in some languages. The information that results from functional processing (see Bock and Levelt (1994: 968), Figure 5) is very close to that given in Figure 8, the output of step 3 in (12). Positional encoding subsumes steps 4 and 5 in (12). Constituent assembly is, in RRG terms, the combining of syntactic templates to create the syntactic framework for the sentence (see Figures 3, 9), and then the elements in the representation in Figure 8 are linked to positions in the syntactic structure and their inflectional properties are realized as well. The output of these two steps is a pre-phonological, morphosyntactic representation of the sentence, just as in Bock and Levelt's model.

Levelt (1989) and Bock and Levelt (1994) argue for the components of their model based on extensive psycholinguistic evidence. The RRG linking algorithm in (12) is the result of research on the clause-internal morphosyntax of a large number of typologically quite diverse languages. Yet the two models parallel each other in a most striking and direct way, and this convergence can be seen clearly in Figure 14. This suggests that RRG is in fact a plausible model of grammatical encoding, i.e. the grammatical facet of speech production, and conversely, this parallel provides strong linguistic support for the Bock and Levelt model.



From Bock and Levelt (1994)

Bock and Levelt model restated in terms of the RRG Semantics-to-Syntax Linking Algorithm

Figure 14. Grammatical encoding in Bock and Levelt (1994) and in RRG

4. RRG and language comprehension

The summary of the syntax-to-semantics linking algorithm in (13) begins with an idealization that is quite reasonable from a grammatical point of view but not from a psycholinguistic point of view: the parser outputs a labeled syntactic tree structure, and then the linking rules apply to interpret it. The evidence from studies of sentence comprehension is overwhelming that speakers do not wait until they hear the entire sentence before they start to interpret it; rather, the interpretation process begins as soon as the first constituents are recognized. Furthermore, the idealization that all core-internal elements are linked before an element in the pre-core slot is linked, as in (13d) and Figure 12, is also not psycholinguistically plausible; rather, the evidence is that speakers try to give the WH-word an interpretation as soon as possible (see e.g. Stowe 1985; Clifton and Frazier 1989; Boland, et al. 1995; Traxler and Pickering 1996; Koenig, et al. 2003. Hence evaluating the RRG syntax-to-semantics linking algorithm with respect to language comprehension is a more complex task than the one in the previous section.

Since parsing and interpretation occur simultaneously, it is necessary to integrate the RRG system into the parser as well as the interpretive mechanism. One way this could be accomplished is suggested by the approach to sentence comprehension put forth by Townsend and Bever (2001). They propose a two-phase comprehension process: the first is called 'pseudosyntax', which is statistical and results in an initial assignment of syntactic structure and thematic relations, and the second, which they call 'real syntax', is a Chomsky (1995)-style minimalist derivation to check the results of the first phase. They adduce a large amount of convincing evidence for the initial phase and very little for the second. Their model as a whole will not be adopted here; rather, the focus will be on the 'pseudosyntax' phase, since it involved parsing and assigning the initial interpretation to the sentence. They characterize it as follows.

> *Pseudosyntax* consists of the immediate initial processes that isolate major phrases, differentiate lexical categories, and assign initial thematic relations. Pseudosyntax involves recognition of function morphemes and lexical categories, which segregate and distinguish phrases and verbs. Assignment of words to syntactic categories and major phrases coincides with the application of frequent sentence patterns that assign these phrases to thematic roles. The sentence patterns that are appropriate for a particular sentence depend on subcategorization properties of verbs.
>
> (Townsend and Bever 2001: 187)

They label the 'frequent sentence patterns' referred to above 'canonical sentence templates', with the statistically dominant one being 'NVN = actor action patient'. They present considerable experimental evidence supporting the role of canonical sentence templates in 'pseudosyntax' (see their Chapter 7). Thus, 'pseudosyntax' involves statistically-driven templatic parsing, in which the templates contain information about the thematic relations of the XPs.

How could 'pseudosyntax' be implemented in RRG terms? The notion of syntactic template was introduced in section 2, and for the purposes of parsing there could be macrorole-augmented syntactic templates. Hence a somewhat simplified version of the RRG equivalent of Townsend and Bever's NVN template would be as in Figure 15.

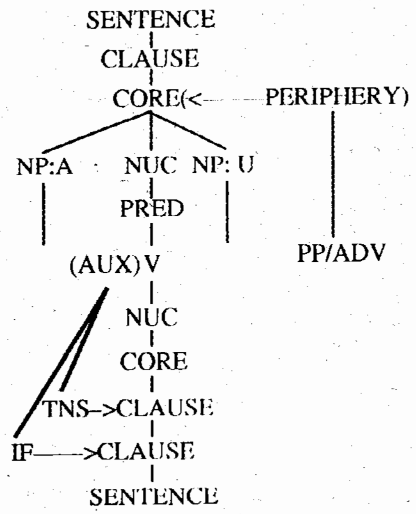


Figure 15. NP-V-NP template

The use of semantic macroroles in the templates has a distinct advantage over thematic relations. If the templates were augmented with thematic relations, then there would not be one NP-V-NP template but many, each with different combinations of thematic relations. For the English sentences in (7a–d,g), for example, five different subtypes of the template would be required, because there are five different combinations of thematic relations in these sentences. But all of them conform to the Actor-V-Undergoer template in Figure 15, which provides the basic interpretation of all of them. Tense and illocutionary force are both included in the operator

projection of each template, because they are the obligatory operators in every English utterance.

Let us further postulate that the logical structures of verb and other predicates are stored in the lexicon with the macrorole assignments of their arguments precompiled as much as possible, in order to expedite interpretation. Verbs such as *present* and *give*, which allow variable undergoer assignment, could have two logical structures, one with each possible assignment. Moreover, the logical structures could also have templates for possible operators. This could be represented as in (14).

(14) Lexical representations for English verbs and other predicates
  a. ⟨IF ⟨TNS ⟨STA ⟨NEG ⟨MOD ⟨DIR ⟨ASP **⟨LS⟩**⟩⟩⟩⟩⟩⟩⟩
  b. e.g. *kill* [**do′** (A: x, Ø)] CAUSE [BECOME **pred′** (U: y)]
  c. e.g. *present* [**do′** (A: x, Ø)] CAUSE [BECOME **have′** (U: y, *with*: z)]
  c′. [**do′** (A: x, Ø)] CAUSE [BECOME **have′** (*to*: y, U: z)]

When there are multiple logical structures for a single verb, as in (14c), each of them would be assigned a statistical value based on their relative frequency of occurrence.

Some additional templates for simple sentences in English are given in Figure 16a and b.

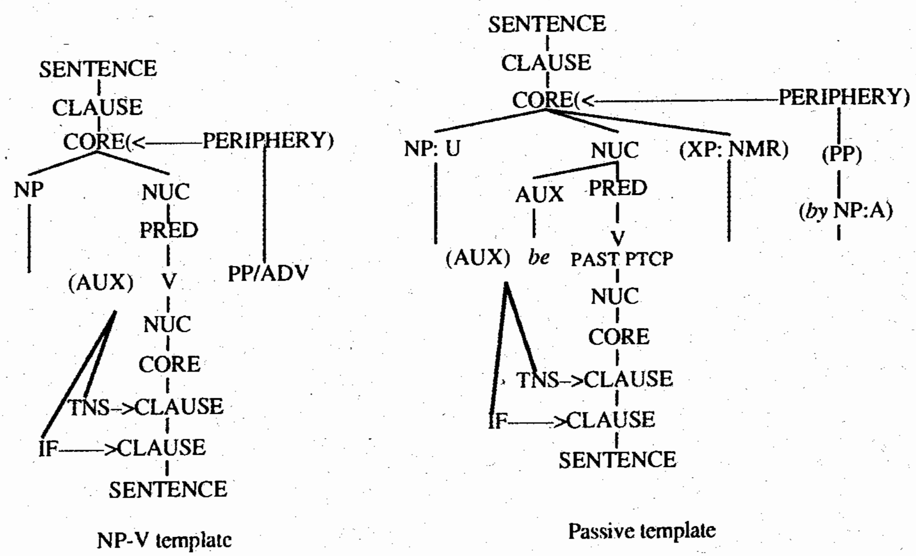
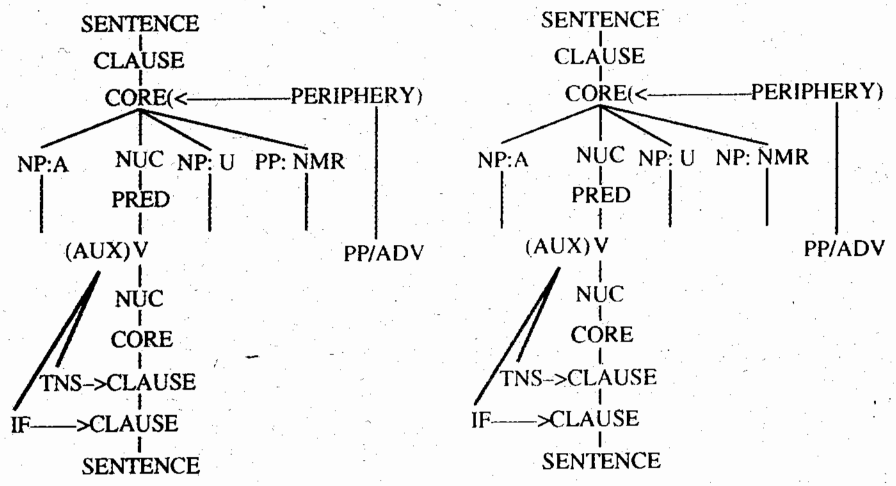


Figure 16a. Additional templates



Three-place verb template | Ditransitive template

Figure 16b. Additional templates

No macrorole information needs to be added to the NP-V template, since the single argument in the syntax will correspond to the single argument in the logical structure by definition.

The final component required is a beam-search algorithm of the kind proposed in Jurafsky (1996). Such a search algorithm considers candidate structures and lexical items within a specific range of probability, dropping candidates that fall outside that range as the process moves forward.

The operation of this system may now be illustrated through a couple of relatively simple examples. The sentence in Figure 11, *Kim smashed the glass,* would be analyzed as in (15).

(15) Simple example: *Kim smashed the glass.*
1. Templates activated.
2. NP-V-NP template selected, yielding Figure 17.[7]
3. LS retrieved from lexicon:
⟨IF ⟨TNS ⟨STA ⟨NEG ⟨MOD ⟨DIR ⟨ASP ⟨ [**do′** (A: x, Ø)] CAUSE [BECOME **smashed′** (U: y)]⟩⟩⟩⟩⟩⟩⟩⟩
4. XPs linked to argument positions in LS via annotations:
⟨IF ⟨TNS ... ⟨[**do′** (A: Kim, Ø)] CAUSE [BECOME **smashed′** (U: the glass)]... ⟩⟩⟩

5. Tense and other operators added:
⟨IF *DEC* ⟨TNS *PAST*⟨[**do′** (A: Kim, Ø)] CAUSE [BECOME **smashed′** (U: the glass)]⟩⟩⟩

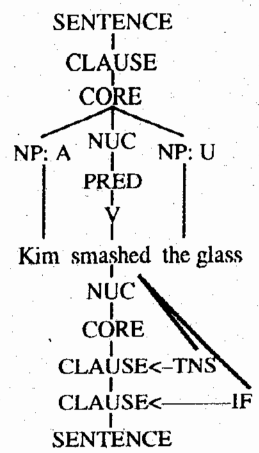


Figure 17. Output of step 2 in (15)

The NP-V-NP template is the only one that completely matches the input string, and so it is selected. The macrorole annotations on the template and in the logical structure for *smash* make interpretation, i.e. linking of the NPs in the sentence to argument positions in the logical structure, virtually instantaneous, once the logical structure is accessed.

A slightly more complex example involving a three-place verb is given in (16).

(16) *Sandy presented Chris with the flowers.*
1. Templates activated.
2. Three-place verb template selected, since it alone fits the NP-V-NP-PP pattern, yielding Figure 18.
3. LS retrieved from lexicon; (14c) selected because of preposition *with*:
⟨IF ⟨TNS ⟨STA ⟨NEG ⟨MOD ⟨DIR ⟨ASP ⟨[**do′** (A: x, Ø)] CAUSE [BECOME **have′** (U: y, *with*: z)]⟩⟩⟩⟩⟩⟩⟩⟩
4. XPs linked to argument positions in LS via annotations:
⟨IF ⟨TNS ... ⟨[**do′** (A: Sandy, Ø)] CAUSE [BECOME **have′** (U: Chris, *with*: flowers)]... ⟩⟩⟩

5. Tense and other operators added:
⟨IF *DEC* ⟨TNS *PAST*⟨[**do′** (A: Sandy, Ø)] CAUSE [BECOME **have′** (U: Chris, *with*: flowers)]⟩⟩⟩

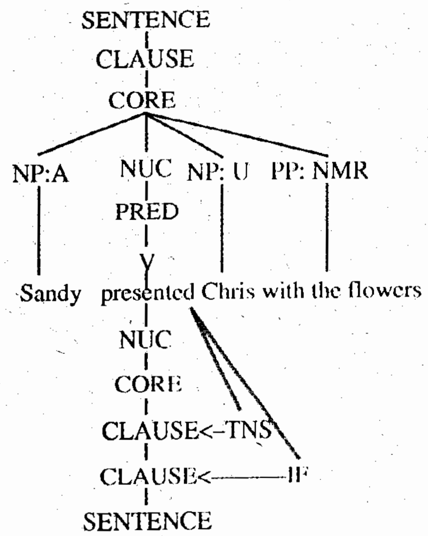


Figure 18. Output of step 2 in (16)

Again, the linking of the XPs in the syntax to argument positions in the logical structure is immediate and straightforward because of the macrorole annotations on both representations. It is worth mentioning again the advantage of using macroroles instead of thematic relations. If the templates were augmented with thematic relations, then the correct template could not be selected until the verb had been identified and its theta-grid or argument structure accessed, since the template for *John saw Mary* would have to be different from the one for *John kissed Mary*, given the differences in thematic relations across the two sentences. In macrorole terms, however, the two are identical, and one template works for both, just as it works for all of the sentences in (7a–d, g). Hence selection of the correct syntactic template does not depend on prior identification of the predicate in the nucleus in an approach utilizing semantic macroroles.

As noted at the beginning of this section, WH-questions pose a problem for a simple adaptation of the syntax-to-semantics linking algorithm to a comprehension model, since speakers do not appear to wait until all of the other elements in the clause are linked before trying to interpret the WH-

expression. The early interpretation of WH-expressions can, however, be handled in terms of annotated templates. The templates for 'subject' and 'non-subject' WH-questions in English are given in Figure 19; active voice is assumed for both.

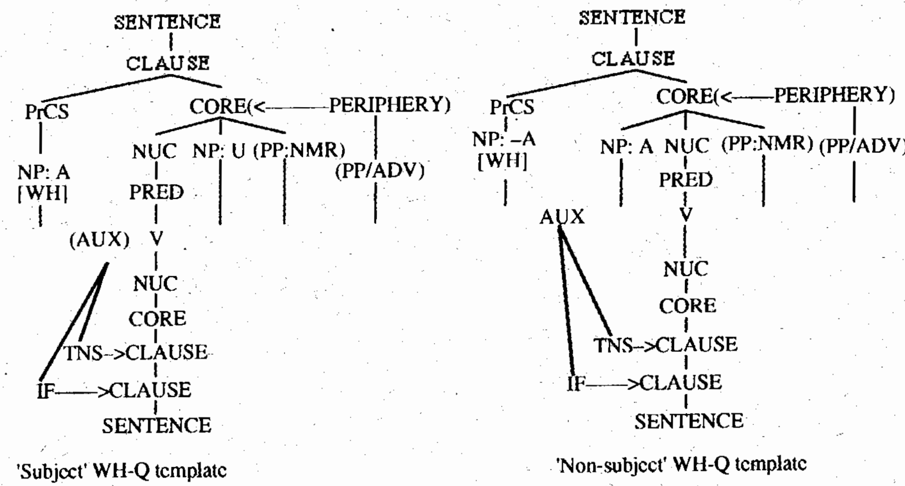


Figure 19. WH-question templates

The templates clearly differentiate 'subject' from 'non-subject' WH-questions; the second template represents only one of the 'non-subject' possibilities. An example of how these templates work is given in (17).

(17) *What did Sandy present to Chris?*
1. Templates in Figure 19 and others activated
2. 'Non-subject' WH-Q template selected, yielding Figure 20:
3. LS in (14c′) retrieved from lexicon:
⟨IF ⟨TNS ⟨STA ⟨NEG ⟨MOD ⟨DIR ⟨ASP ⟨[**do′** (A: x, Ø)] CAUSE [BECOME **have′** (*to*: y, U: z)]⟩⟩⟩⟩⟩⟩⟩⟩
4. XPs linked to argument positions in LS:
⟨IF ⟨TNS ... ⟨[**do′** (A: Sandy, Ø)] CAUSE [BECOME **have′** (*to*: Chris, U: what)]...⟩⟩⟩
5. Tense and other operators added:
⟨IF *INT* ⟨TNS *PAST* ⟨[**do′** (A: Sandy, Ø)] CAUSE [BECOME **have′** (NMR: Chris, U: what)]⟩⟩⟩

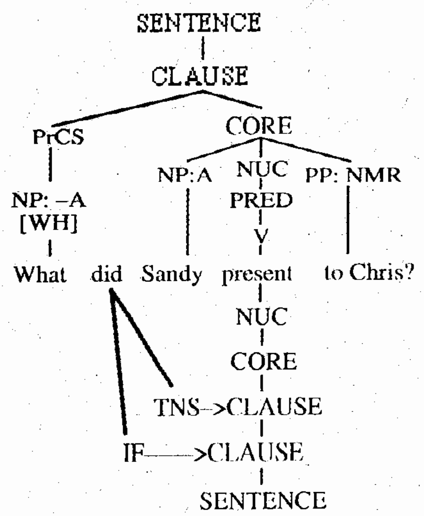


Figure 20. Output of step 2 in (17)

Here again, the interpretation is determined by the annotations on the template and those on the logical structure, and the recognition of the template immediately supplies the interpretation of the WH-expression as actor or non-actor. Obviously, these are very simple examples, but they illustrate how a macrorole-annotated system of syntactic templates could function in a language comprehension system. From an RRG perspective, there is nothing 'pseudo' about pseudosyntax; the syntactic structures and interpretive principles required are taken directly from the grammatical model.

What happens when breakdowns such as garden paths occur? What happens when an unfamiliar structure is encountered? These are situations in which step-by-step reparsing and reinterpretation is required (Fodor and Inoue 1994), and this can be straightforwardly handled in the RRG system: in addition to the kind of templatic processing discussed above, there is also the option of step-by-step processing as well. In this mode, the syntactic representation of the sentence is constructed, and then the steps of the syntax-to-semantics linking algorithm are executed in a deliberate manner which allows for double checking of all relevant features of the construction. In other words, this mode mirrors the procedures depicted in Figures 11 and 12.

The discussion thus far has concerned comprehension processes in a language with fixed word order in which the position of an NP in the clause

determines its interpretation for the most part. The situation is potentially very different in languages with flexible word order which rely on case marking to signal semantic functions, such as German, Russian and Dyirbal. For such languages fixed templates with semantic macroroles assigned to specific positions in the core are not (directly) relevant to the comprehension process. Rather, the macrorole information that is derived from positional information in English-type languages is derived from case marking on NPs. Accordingly, it is necessary to separate the case-to-macrorole mapping relations from the syntactic templates. This can be accomplished by using the kind of 'bare' templates as in Figure 9. An example of a possible German template is given in Figure 21; it includes a precore slot structure for clauses with an initial WH-word or non-WH NP.

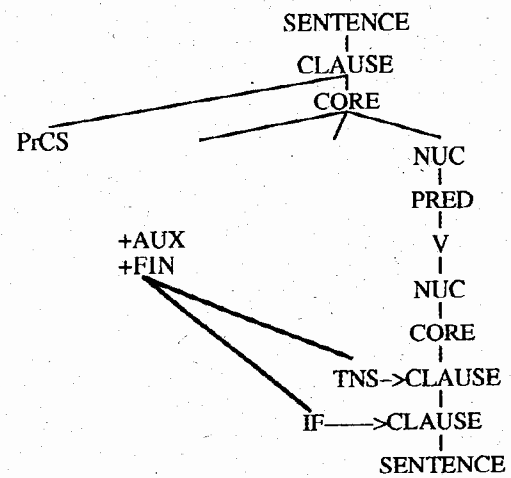


Figure 21. Possible German template

This represents main clauses in which there is either a modal auxiliary element or a tense other than the simple present or past. There is neither syntactic category nor macrorole information in the template. There is no category information because either the precore slot or the pre-nuclear position could be filled by NPs or PPs, depending on the verb, and there is no macrorole information, unlike the templates in Figures 15, 16 and 19, because macrorole interpretation in German is independent of position in the clause.

The case-to-macrorole relations can be captured in terms of what might be called 'case association principles', examples of which are given in (18).

(18) Case association principles for German
  a. NOM [Actor > Undergoer]
  b. ACC [Undergoer]
  c. DAT [NMR]
  d. GEN [NMR]

These case association principles express the interpretation of the different cases in terms of macroroles; they represent the interpretation that would result if one extrapolated back from the different cases using the standard RRG case assignment rules for an accusative language. The nominative case is marked 'Actor > Undergoer' to reflect that the default interpretation of the nominative is as actor, but with passive verbs or with a certain class of intransitive verbs, it can be an undergoer, cf. the English examples in (6). In addition, there is a correlation in German between nominative case and 'subject' (privileged syntactic argument, in RRG terms), and this is independent of the correlation between nominative case and actor, since it applies to cores with passive verbs. In finite clauses the one syntactic property that the 'subject' always has is that it is the controller of verb agreement.

The application of the syntactic template in Figure 21 and the case templates in (18) to a sentence like (19a) is summarized in (19b).

(19) a. *Den Hut* *ha-t* *der Mann*
  the.MsgACC hat have-3sgPRES the.MsgNOM man
  der Frau *geschenkt.*
  the.FsgDAT woman give.PSTP
  'The hat the man gave to the woman [as a gift].'
 b. 1. a. Template in Figure 21 and others activated
   b. Ditransitive with PrCS template selected
  2. Case association principles are applied, yielding Figure 22:
  3. LS retrieved from lexicon;
   ⟨IF ⟨TNS ⟨STA ⟨NEG ⟨MOD ⟨DIR ⟨ASP ⟨[**do**′ (A: x, Ø)] CAUSE [BECOME **have**′ (NMR: y, U: z)]⟩⟩⟩⟩⟩⟩⟩⟩
  4. XPs linked to argument positions in LS via annotations:
   ⟨IF ⟨TNS ... ⟨[**do**′ (A: Mann, Ø)] CAUSE [BECOME **have**′ (NMR: Frau, U: Hut)]... ⟩⟩⟩
  5. Tense and other operators added:
   ⟨IF *DEC* ⟨TNS *PAST*⟨[**do**′ (A: Man, Ø)] CAUSE [BECOME **have**′ (NMR: Frau, U: Hut)]⟩⟩⟩

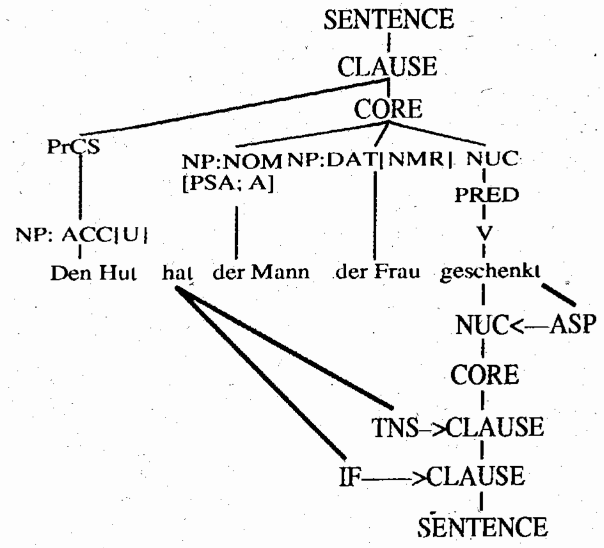


Figure 22. Output of step b2 in (19)

There are situations in German in which the case system breaks down, in the sense that the case markings fail to unambiguously indicate the semantic macroroles of the arguments. This possibility is illustrated in (20).

(20) *Die Frau* *ha-t* *das Mädchen* *gesehen.*
  the.FsgNOM/ACC have-3sgPRES the.NsgNOM/ACC see.PASTP
  'The woman saw the girl,' or 'The girl saw the woman.'

Both of the readings in the translation are grammatically possible, but there is an overwhelming preference for the first interpretation. In light of this preference, the question arises as to what interpretation is being given to the NPs in such a sentence. If the case markings signal semantic macroroles, then the lack of unambiguous case marking entails that no semantic macroroles are being associated directly with these arguments. In other words, no case association principle from (18) can be selected. Rather, it appears that the first NP is being interpreted as the 'subject', i.e. the agreement trigger, and this assignment leads to the interpretation of the NP as the actor, once the voice and meaning of the verb have been processed. This suggests that there is an additional interpretive rule in German, which applies when a case association principle in (18) cannot be selected; it is given in (21).

(21) In clauses with non-distinctive case marking, interpret the first NP as the agreement trigger.

In the processing of a sentence like (20), (21) rather than any of the principles in (18), will guide the interpretation. The macrorole interpretation of the agreement trigger (PSA) is determined from the voice of the verb, as in step 1 in Figure 11.

For a processing model to handle languages like English and like German, it must encompass both position-based and case-based macrorole interpretation. The Argument Dependency Model [ADM] (Bornkessel 2002; Schlesewsky and Bornkessel 2004; Bornkessel and Schlesewsky, this volume) provides for both types of interpretation. It contains three phases, which may be characterized as in (22).

(22) Argument Dependency Model
  a. Phase 1: basic constituent structure and morphological analyses
  b. Phase 2: determination of syntactic and thematic relations among elements in sentence
    1. In sentences with unambiguous case marking, the relational interpretation of NPs is based on the case marking.
    2. In sentences without unambiguous case marking, the relational interpretation of NPs is based on the position of NPs in the clause.
  c. Phase 3: "all of the information types processed separately during phase 2 are integrated with one another and reanalysis processes are initiated if necessary" (Schlesewsky and Bornkessel 2004: 1228).

ADM posits two different interpretive pathways in phase 2, one based on morphology and the other based on word order. In German, the two pathways operate simultaneously, and information derived from the morphology pathway, the case association principles in (18), has priority over the interpretation based on (21), when they conflict. Only the positional pathway yields an interpretation at step 2 when there is insufficient morphological information to determine macrorole assignment, as in (20). The processing in (19b) illustrates morphologically based interpretation. In English, on the other hand, only the second pathway is available, due to the lack of distinctive case marking.[8] This is exemplified in (15)–(17).

ADM builds upon Friederici's (1999, 2002) neurocognitive model of language comprehension, and its three phases correspond to the three phases proposed in Friederici's model. The architecture of ADM and how RRG maps onto it are summarized in Figure 23.

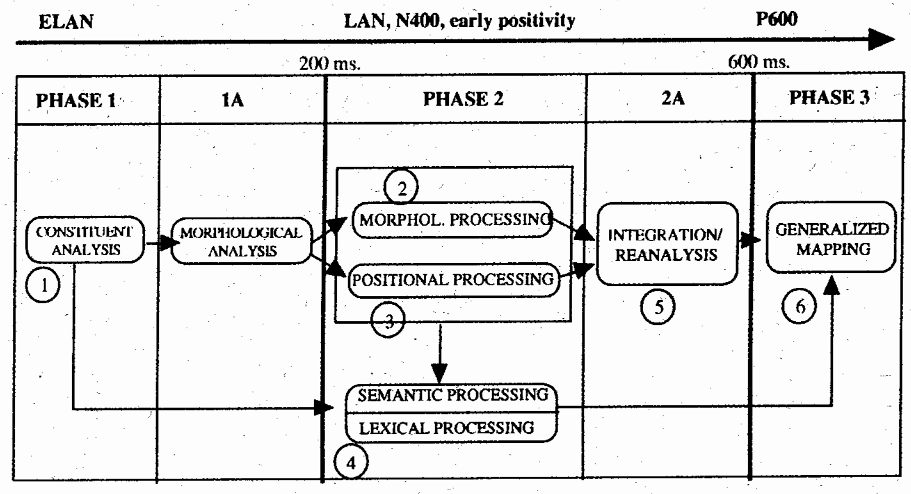


Figure 23. The Argument Dependency Model [ADM] (Bornkessel 2002, Schlesewsky and Bornkessel 2004, Bornkessel and Schlesewsky, this volume)

(1) in phase 1 involves template selection and identification of the verb or predicating element. (2) in phase 2 is the mapping from case marking to macroroles using the case association principles in (18). (3) in phase 2 is the positional interpretation of NPs; in languages like English it involves the mapping from structural positions to macroroles, as in (15)–(17), while in a language like German it involves the principle in (21). In (4) in phase 2, the logical structure of verb/predicating element is selected and skeletal semantic representation of sentence is constructed, i.e. step 3 in e.g. (15) and (16). (5) in phase 2A involves reanalysis of macrorole and other semantic function assignments, when there is a clash between results of thematic and syntactic processing. Finally, (6) in phase 3 finishes off the syntax-to-semantics linking. RRG thus fits rather naturally with ADM, and there are encouraging initial experimental results involving RRG and ADM reported in Bornkessel, Schlesewsky and Van Valin (2004) and Bornkessel and Schlesewsky (this volume).

5. Conclusions

This paper has investigated the function of semantic macroroles in language production and comprehension, and this entailed an examination of the relationship between the linguistic theory in which semantic macroroles play an integral part, Role and Reference Grammar, and specific models of language production and comprehension. Macroroles have been shown to be relevant to both production and comprehension. In terms of Levelt's blueprint for the speaker in Figure 13, it has been argued that the RRG semantics-to-syntax linking algorithm is a good model for the grammatical encoding process in the FORMULATOR in the production process, and that the constituents of the syntax-to-semantics linking algorithm constitute a plausible parsing and interpretation component for the SPEECH-COMPREHENSION SYSTEM. In particular, there seems to be a natural fit between RRG and ADM. This discussion has shown that the components of a linguistic theory can be used directly in psycholinguistic models of language processing. This suggests that RRG has potential as a psychologically real model of the human language capacity, but any firmer conclusions along these lines must be confirmed by experimental testing of predictions generated by RRG analyses, something which is beyond the scope of this paper.[9] This also provides support for the psycholinguistic models: their grammatical components are now supported by the weight of considerable cross-linguistic evidence.

Does the application of a linguistic theory like RRG to language processing have any consequences for the theory itself? The answer seems to be 'yes'. RRG analyses have striven to posit as little idiosyncratic information in the lexical entries of verbs as possible and to derive as many of their properties as possible from general rules and principles. This has meant, for example, having general principles governing macrorole assignment and general rules to assign the prepositions that mark oblique core arguments. While this is desirable from a linguistic point of view, since these general rules and principles capture linguistically significant generalizations, this is not necessarily desirable from a processing point of view. From this perspective, the fewer rules that have to be applied the better, and the more information that is precompiled, the more efficiently the system will operate. The value of precompiling became quite clear in the discussion of comprehension. The parsing templates contain the output of the first step in the syntax-to-semantics linking algorithm precompiled in them, i.e. which argument is actor, which is undergoer, what the preposition marking the oblique core argument is. The logical structures in

(14) likewise contain the information from the next step precompiled: macrorole assignment and preposition assignment. This precompiling reduces the syntax-to-semantics linking to a single step: match the information on the template to the information on the logical structure, resulting in a very fast and efficient comprehension process. Moreover, this eliminates the disparity, noted at the beginning of section 4, between the treatment of WH-expressions in the PrCS in the linking algorithm in (13) and the psycholinguistic evidence that they are interpreted as quickly as possible: with precompiling, the WH-expression is assigned an interpretation right away and not after all of the other elements have been linked. Thus, the comprehension system has taken the syntactic templates and syntax-to-semantics linking rules and precompiled them into semantically augmented syntactic templates and informationally-enriched logical structures, yielding an efficient adaptation of the grammar for parsing and interpretation.

This is not without implications for semantics-to-syntax linking as well. Assuming that the same logical structures are used in both production and comprehension, the precompiling of macrorole and preposition assignment would mean that step 2 and part of step 3 in (12) would fall together into step 1; they are all part of functional processing in Bock and Levelt's model. If the lexicon in an RRG grammar were to be organized in what is possibly the most efficient way for language processing, then macrorole information and prepositions would be precompiled in logical structures. The generalizations about macrorole assignment and preposition assignment would be captured by the general principles and rules which hold across all entries in the lexicon.

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Notes

1. It might be suggested that this would be true of any syntactic theory, and in a very general sense that is correct: to the extent that processing models contain a grammatical component, any grammatical model could in principle be plugged in. However, RRG is different from most other grammatical models by explicitly being bidirectional in its linking system: from semantics to syntax, and from syntax to semantics. Since it is quite clear psycholinguistically and neurolinguistically that production and comprehension are quite distinct processes, there is no reason to suppose that the two directions of linking should be identical, either. However, most grammatical theories are not bidirectional, positing a unidirectional relationship or mapping between syntax and semantics; this is particularly true of derivational theories.
2. For detailed presentations of RRG, see Van Valin and LaPolla (1997) and Van Valin (2005). A bibliography of work in RRG can be found at http://linguistics.buffalo.edu/research/rrg.html.
3. Abbreviations: A, ACT 'actor', ACC 'accusative', ASP 'aspect', DAT 'dative', DEC 'declarative', DIR 'directionals', EVID 'evidentials', EVQ 'event quantification', HS 'hearsay', IF 'illocutionary force', INT 'interrogative', IRR 'irrealis', LS 'logical structure', MOD 'modality', NEG 'negation', NMR 'non-macrorole', NOM 'nominative', OBLG 'obligation', PASTP 'past participle', PERF 'perfective', PRES 'present', PROG 'progressive', PSA 'privileged syntactic argument', STA 'status', TNS 'tense', U, UND 'undergoer'.
4. See Van Valin (1999, 2003) for detailed discussion of semantic macroroles.
5. Certain complications arise in what are called 'primary-object languages' (Dryer 1986); see Van Valin (2005) and Guerrero and Van Valin (2004) for detailed discussion.
6. This is not an English-specific principle; as shown in Van Valin and LaPolla (1997) and Van Valin (2005), it applies to a wide range of languages, including Dyirbal and Croatian.
7. The selection of the NP-V-NP template in Figure 15 is the endpoint of a process of activating compatible templates, ranking them (Gorrell 1987) in terms of frequency (Jurafsky 1996) and other factors, such as minimality (Schlesewsky and Friederici 2003), and selecting the most highly ranked template at each constituent. In this way templatic parsing is compatible with incremental parsing. Detailed discussion of the factors in template ranking and selection are beyond the scope of this paper.
8. The case marking differences among English pronouns are basically irrelevant, as they are completely redundant with respect to the information supplied by word order, which is the same for full NPs and pronouns.
9. Work on language acquisition using RRG is supportive as well; see Van Valin and LaPolla (1997), Epilog, and Van Valin (1998, 2001, 2002), Weist (2002).

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