RRG—Abstract grammar vs. processing model

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Introduction

—Role and Reference Grammar strives to be a component of a model of the communicative competence of a native speaker of a human language.

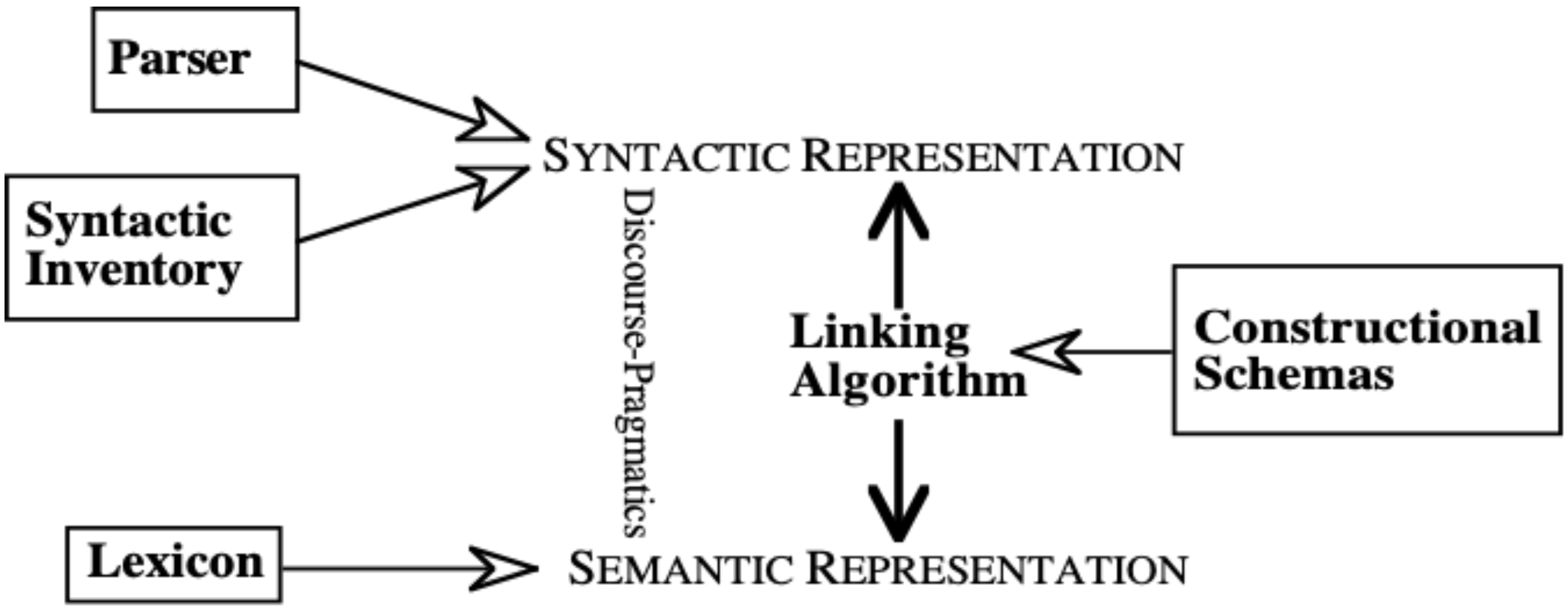
— Following Kaplan & Bresnan (1982) it is incumbent upon theories making such a claim to be implementable in testable models, psycholinguistic or computational, of language processing.

—There has been substantial work on the computational implementation of RRG by Elizabeth Guest, Brian Nolan and colleagues in Dublin, Laura Kallmeyer and colleagues in Düsseldorf, and John Ball and colleagues at Pat, Inc.

—Less work has been done on developing psycholinguistic and neurolinguistic processing models based on RRG, despite some promising early work by Ina Bornkessel-Schlesewsky and Matthias Schlesewsky and by Marijan Palmović.

—RRG would appear to be a good basis for a neurocognitive model of language processing because of its bi-directional linking algorithm.

Introduction



The organization of RRG

—One of the primary motivations for the bidirectional linking algorithm is that it is an idealization what speakers and hearers do:

—Speakers formulate a meaningful message, map it into the appropriate morphosyntactic form and utter it.

—Hearers analyze the utterance and map it into a representation of its meaning.

Introduction

—Because it is an idealization, it does not capture some important aspects of real-time sentence processing, e.g. the incremental nature of interpretation.

—Van Valin (2006) attempted to make RRG compatible with the results from psycholinguistic investigations of sentence processing, but it left some important questions unanswered.

—The discussion will proceed as follows:

§1. A review of the RRG linking algorithm.

§2. RRG and language processing: production and comprehension.

§3. Unresolved issues.

§4. Production revisited

§5. Conclusions

1. The RRG linking algorithm: a review

—Sentence processing includes both production and comprehension, and the emphasis in the 2006 paper was on comprehension.

—There was, however, a brief discussion of production, which would involve the semantics-to-syntax linking algorithm, which is exemplified using the sentence *Max was interviewed by CNN during the insurrection.*

Step 1: Construct the semantic representation of the sentence, based on the LS of the main predicator.

be-during´ (insurrection, [**do´** (CNN, [**interview´** (CNN, Max)])])

Step 2: Determine the actor and undergoer assignments, following the A-U Hierarchy.

```
                                     Actor                Undergoer
                                       |                      |
be-during´ (insurrection, [do´ (CNN, [interview´ (CNN, Max)])])
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1. The RRG linking algorithm: a review

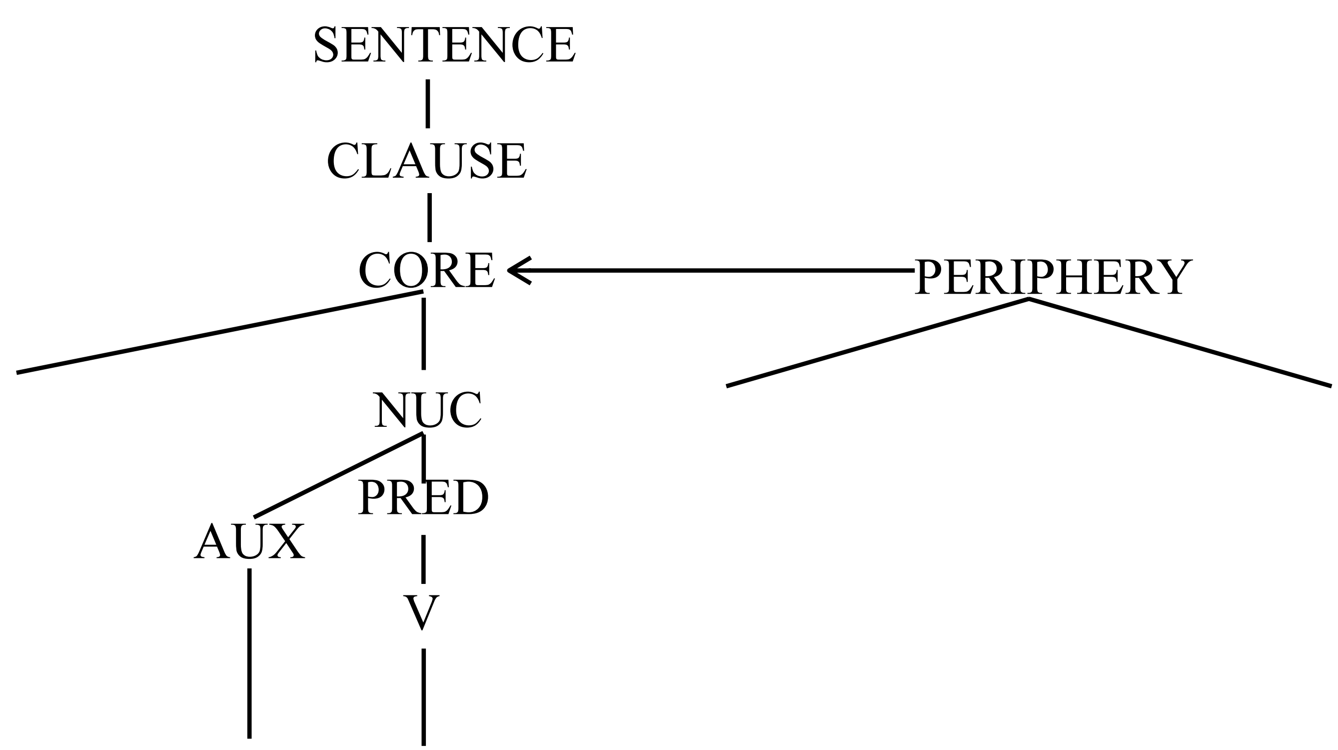
Step 3: Determine the morphosyntactic coding of the arguments (PSA selection, case assignment, adposition assignment).

Actor / Passive / Undergoer

[*during*:ACC] [*by*: ACC][*be*:3sg, PPT] [PSA:NOM]

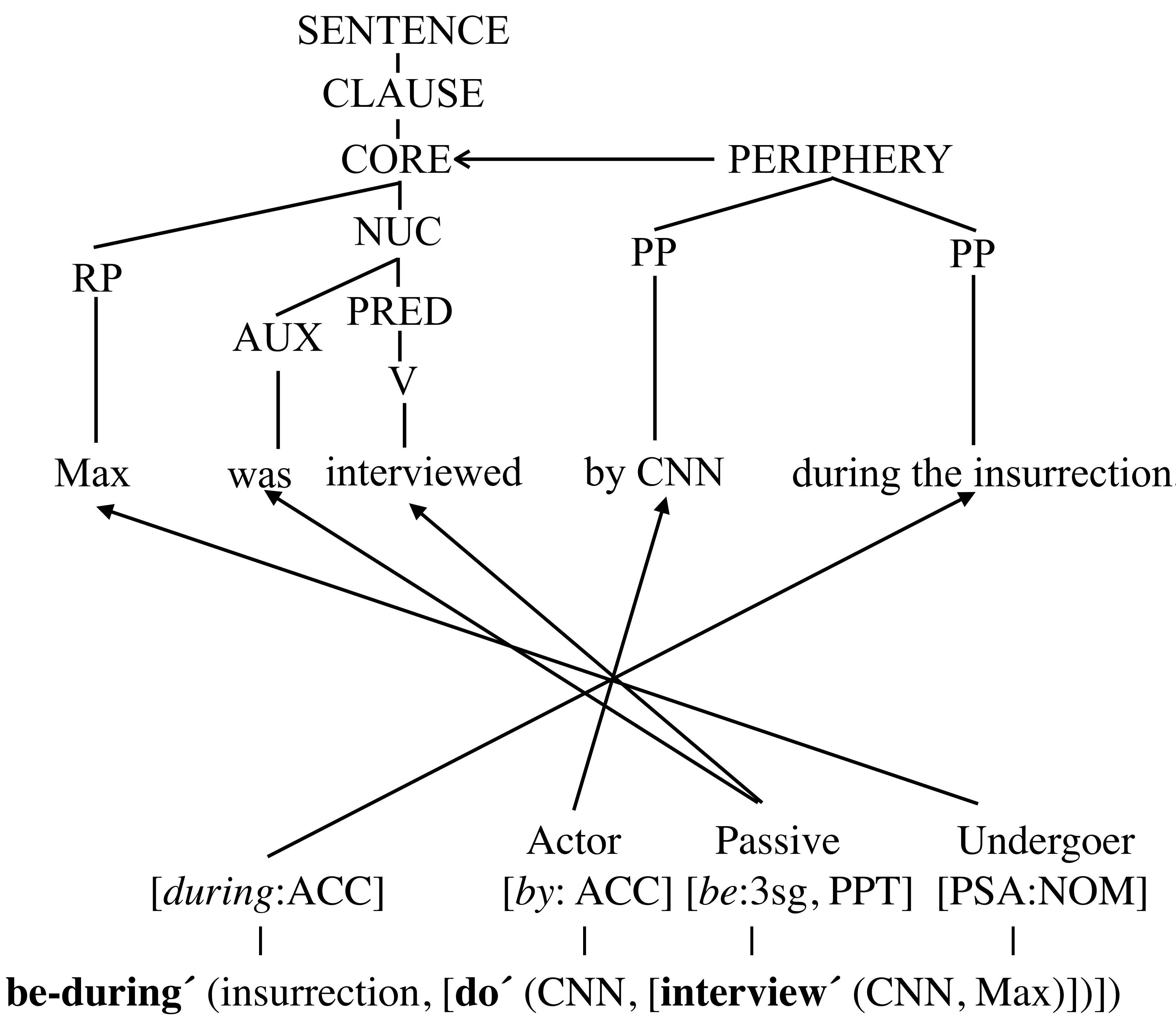
be-during´ (insurrection, [**do´** (CNN, [**interview´** (CNN, Max)])])

Step 4: Select the syntactic template(s) for the sentence following the template selection principles.



1. The RRG linking algorithm: a review

Step 5: Assign units to positions in the syntactic representation of the sentence.



1. The RRG linking algorithm: a review

—Sentence comprehension is modeled by the syntax-to-semantics algorithm, which is summarized and illustrated below.

—Preliminary: The parser outputs a labeled tree structure.

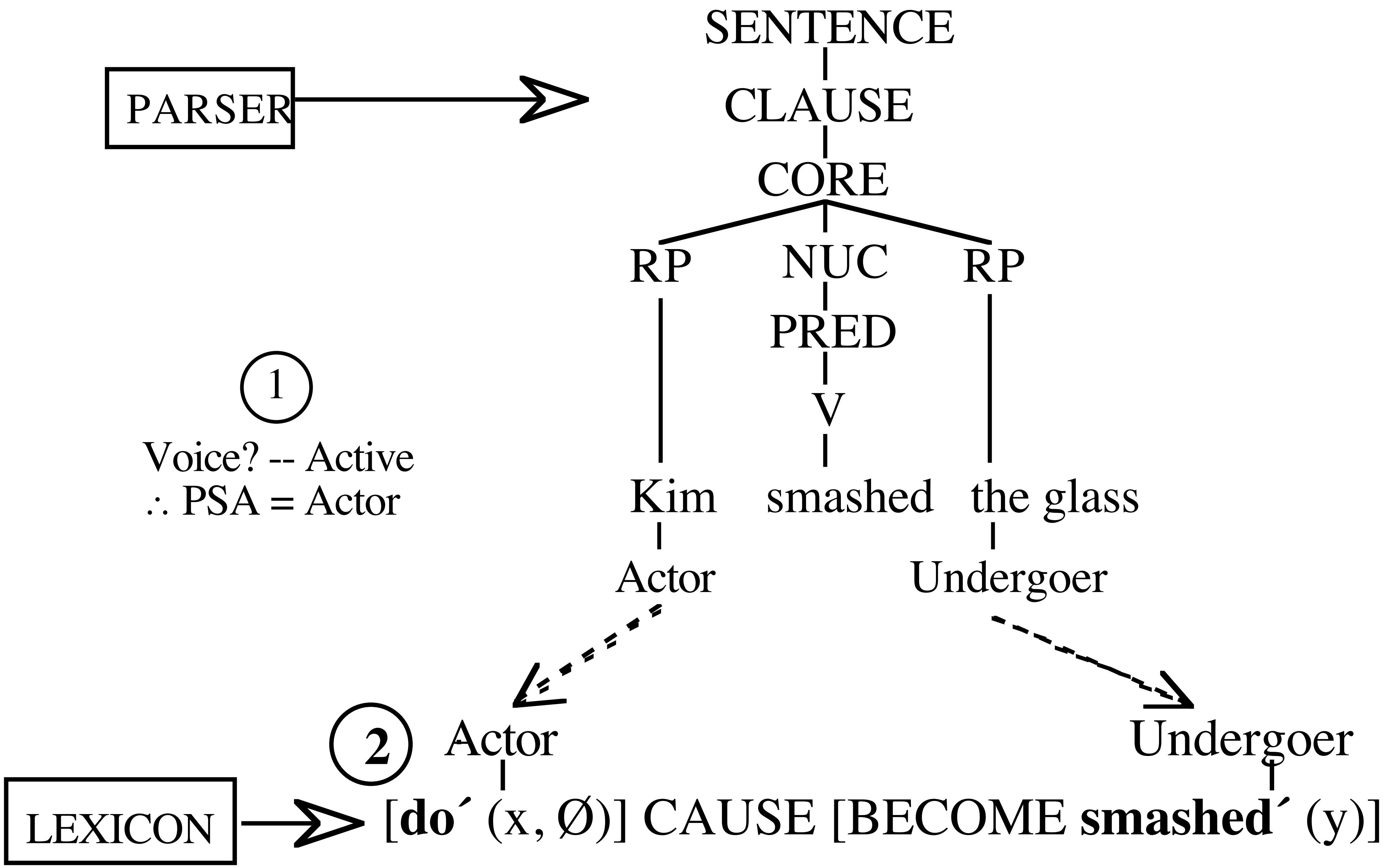
Step 1. Derive as much information from the overt morphosyntactic features of the clause: case marking/word order, the voice of the verb, adpositions.

Step 2. Retrieve the LS of the verb from the lexicon and assign macroroles where possible.

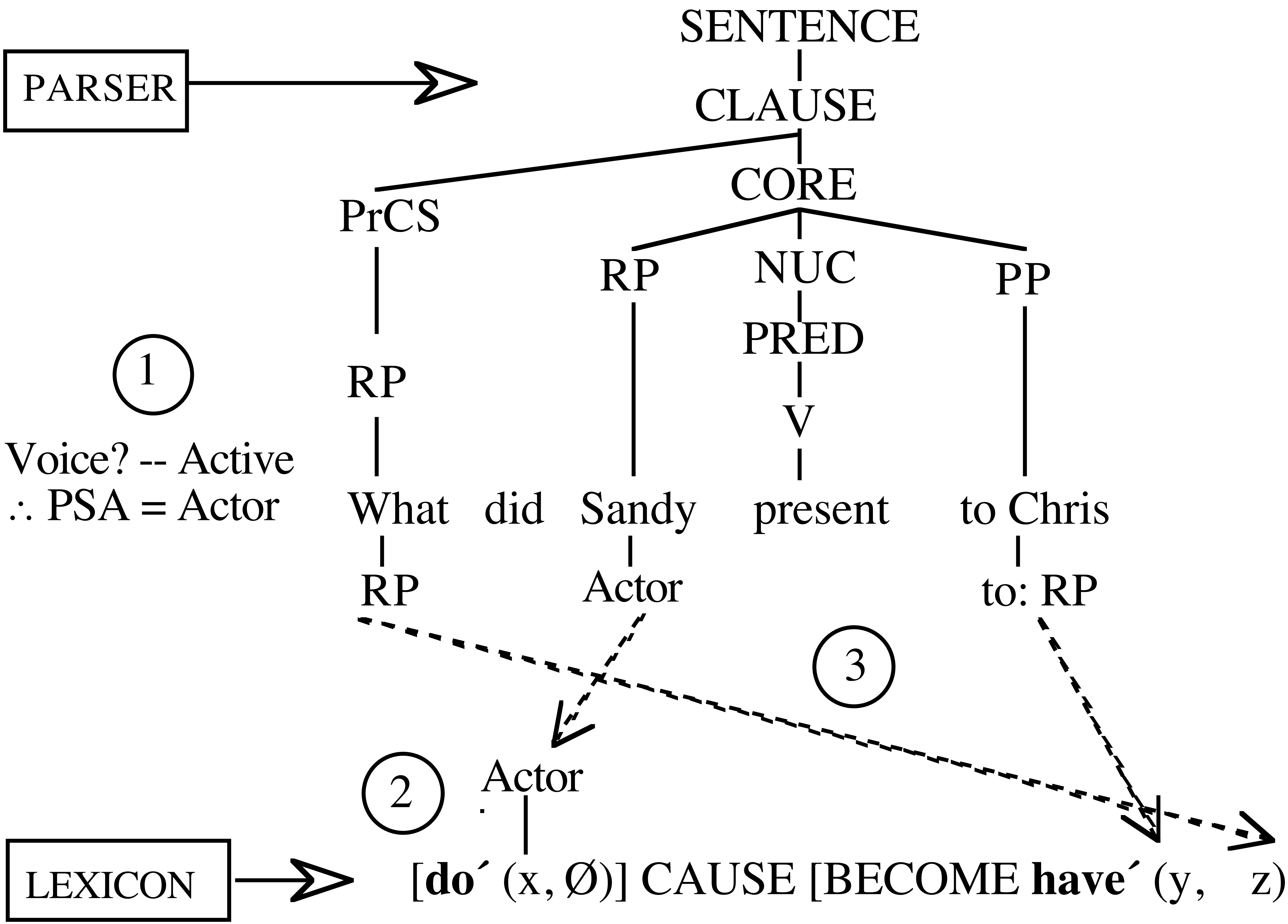
Step 3. Link everything in the core to the argument positions in the LS; if there is an element in the PrCS, link it last to the remaining unlinked argument position in the LS.

—Linking between syntax and semantics is subject to the COMPLETENESS CONSTRAINT, which states, roughly, that all referring expressions in the syntax have to be linked to a LS position in the semantic representation, and all specified argument positions in the semantic representation have to be linked to an element in the syntactic representation.

1. The RRG linking algorithm: a review

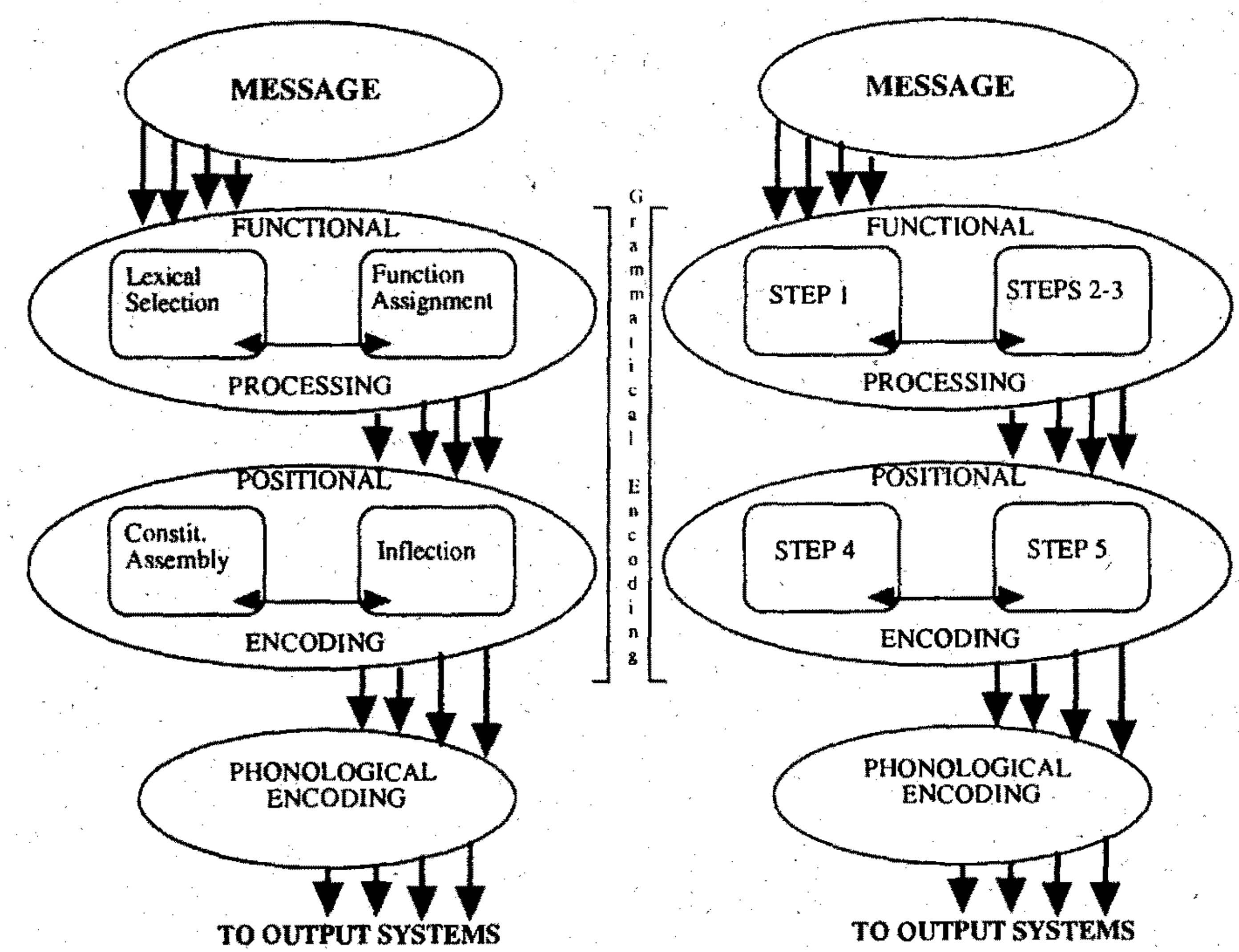


1. The RRG linking algorithm: a review



2. RRG and sentence processing: production

—The discussion of production was based on the widely accepted model of the speaker proposed in Levelt (1989). Bock & Levelt (1994) elaborated on the grammatical encoding aspect of production, and what they proposed matches the RRG semantics-to-syntax linking algorithm to a striking degree.



From Bock and Levelt (1994)

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

2. RRG and sentence processing: comprehension

—There are a couple of glaring examples of where the idealizations of the linking algorithm are not compatible with well-established results from psycholinguistic investigations of sentence comprehension.

—First, it is not the case that a hearer waits until the entire sentence is parsed before starting to interpret it (e.g. Schlesewsky & Bornkessel 2004). In other words, interpretation is incremental.

—Second, it assumes that displaced WH-expressions are linked last after all of the other arguments have been linked, whereas studies show that speakers try to resolve the long-distance dependency as soon as possible (e.g. Stowe 1985; Clifton and Frazier 1989; Traxler and Pickering 1996; Koenig, et al. 2003).

—These abstractions, while appropriate for a model of grammar, must be abandoned in a processing model.

—There is a further factor to be taken into consideration, namely, the speed of processing. The subjective impression that speakers have is that interpretation is normally instantaneous. In other words, it seems to language users that they access the meaning directly.

2. RRG and sentence processing: comprehension

— Because interpretation occurs simultaneously with parsing, the RRG linking system must be integrated into the parser. How can this be accomplished?

—One way this could be accomplished is suggested by the approach to sentence comprehension proposed in Townsend & Bever (2001).

—They propose what they call ‘pseudosyntax’, which combines parsing and determining the initial interpretation of a 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… 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 & Bever 2001: 187)[emphasis added]

2. RRG and sentence processing: comprehension

— The ‘frequent sentence patterns’ referred to above are labeled ‘canonical sentence templates’, with the most frequent one being ‘NVN actor-action-patient’.

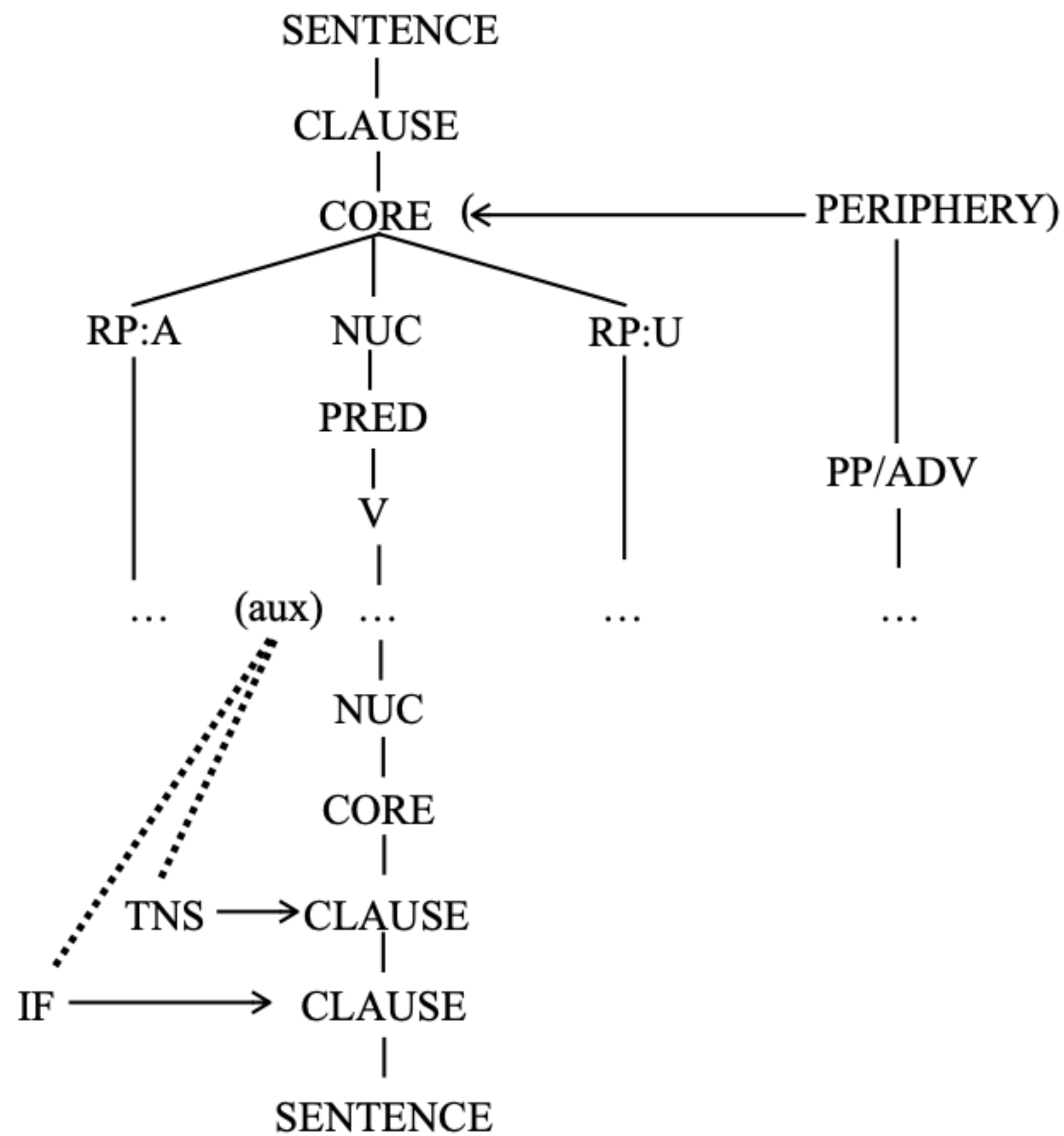
— Hence, ‘pseudosyntax’ is in essence statistically-driven templatic parsing, in which the templates contain information about the thematic relations of the XPs. It results in what is called ‘good enough’ comprehension (Ferreira & Patson 2007).

—RRG uses bare syntactic templates to represent syntactic structure, and so the idea of parsing with templates is very easy to implement.

—The first step in transforming bare syntactic templates into ‘pseudosyntax’ parsing templates (or, more accurately, ‘linking templates’) is to augment them with phrasal category information, and accordingly Townsend & Bever’s default NVN canonical sentence template for English would be RP-NUC-RP.

—The RRG templates would have the semantic macroroles actor and undergoer instead of thematic relations. Hence the default canonical sentence template for English would be RP:A-NUC-RP:U and look like this:

2. RRG and sentence processing: comprehension



—Hence from an RRG perspective, there is nothing ‘pseudo’ about ‘pseudosyntax’.

2. RRG and sentence processing: comprehension

— These templates are the first part of the solution to the problems outlined at the beginning of the section; they identify the phrases and their functions and assign macroroles to the two primary arguments in a transitive or ditransitive clause.

— The second part is arriving at the correct interpretation of the sentence, and for this we have to take a look at the lexicon and the nature of lexical entries.

— In the RRG theory of grammar, it is claimed that all of the morphosyntactic properties of a completely regular verb can be derived from its semantic representation together with the linking algorithm.

—However, this involves applying rules, principles and constraints, all of which would slow down a processing system. Hence in a processing model it is better to pre-compile the information in the lexical entries for verbs, so that when the verb is recognized all of this information becomes available immediately.

—The two things that are most important for the rapid (‘good enough’) interpretation of a template are the assignment of macroroles and non-predicative prepositions.

2. RRG and sentence processing: comprehension

— For a simple transitive verb like *kill* or *smash*, the LSs would be as in (1).

(1) a. General: [**do´** (A: x, Ø)] CAUSE [INGR **pred´** (U: y)]
b. *kill*: [**do´** (A: x, Ø)] CAUSE [INGR **dead´** (U: y)]
c. *smash*: [**do´** (A: x, Ø)] CAUSE [INGR **smashed´** (U: y)]

— Once the basic transitive template given above has been matched and the verb recognized, the basic 'who did what to whom' meaning is available by integrating the arguments from the template with the LS. This can be illustrated with *The burglar smashed the window*.

1. The matching mechanism selects the basic transitive template, yielding
   [$_{\text{CORE}}$ [$_{\text{RP}}$ A: *the burglar*] [$_{\text{NUC}}$ *smashed*][$_{\text{RP}}$ U: *the window*]] (simplified)

2. The lexical entry for the predicate in the nucleus is activated, and the annotations on the arguments in the template and the LS guide the integration (i.e RP: A *the burglar* = A: x, ∴ *the burglar* = x, RP: U *the window* = U: y, ∴ *the window* = y), yielding

[**do´** (A: *the burglar*, Ø)] CAUSE [INGR **smashed´** (U: *the window*)]

— The assignment of syntactic structure and the semantic interpretation are accomplished rapidly thanks to the annotations shared by the templates and the lexical representations.

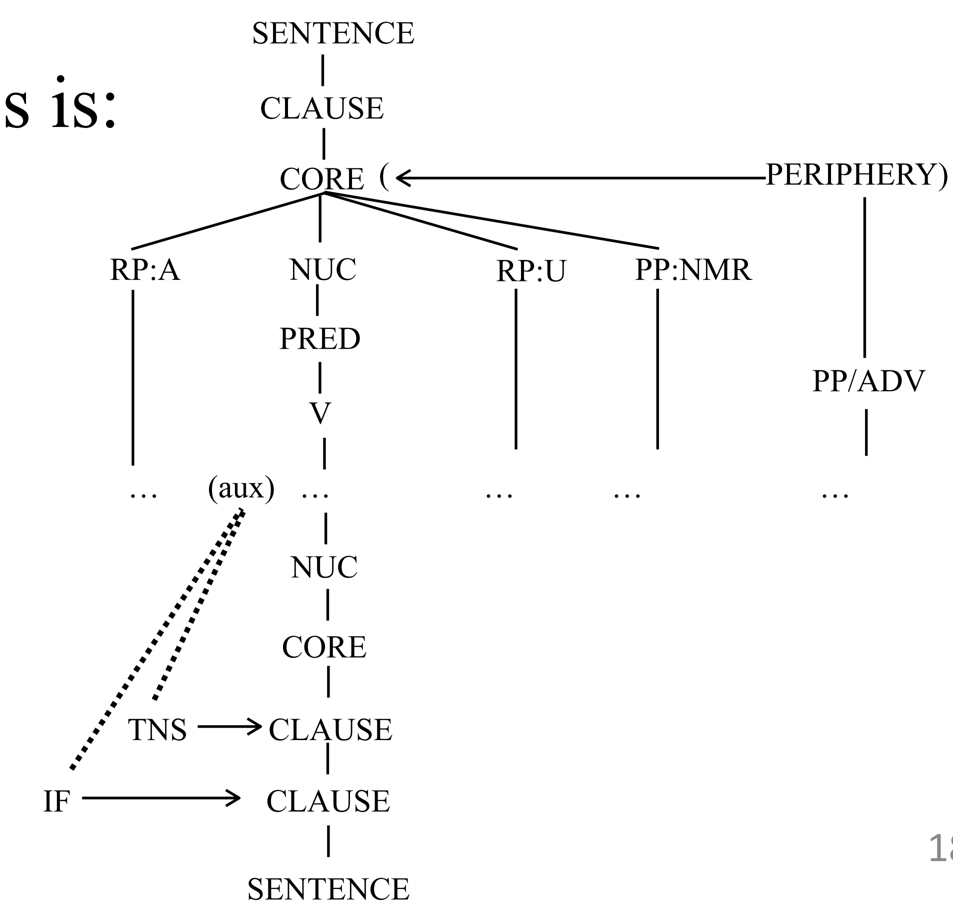
—The generalizations about PSA selection and the assignment of macroroles, case and non-predicative prepositions are now **meta-generalizations** across the linking templates and enriched LSs, rather than separate hierarchies, rules, etc.

2. RRG and sentence processing: comprehension

— Things are a bit more interesting when there are more than two arguments. A good example of a three-place verb is the transfer predicate *present*; like most three-place verbs in English, it permits more than one possible choice of the undergoer macrorole, and this choice is signaled by the preposition assigned to the non-macrorole oblique core argument. Rather than invoking macrorole assignment rules and preposition assignment rules as in an RRG grammar, the lexical entry for *present* specifies both possibilities, as in (2).

(2) a. [**do´** (A: x, Ø)] CAUSE [INGR **have´** (NMR: *to* y, U: z)]
b. [**do´** (A: x, Ø)] CAUSE [INGR **have´** (U: y, NMR: *with* z)]

— The linking template for three-place predicates is:



2. RRG and sentence processing: comprehension

— The two active voice possibilities with *present* are sketched below.

1. The matching mechanism selects the three-place predicate template given above, yielding

[$_{\text{CORE}}$ [$_{\text{RP}}$ A: *Mary*] [$_{\text{NUC}}$ *presented*][$_{\text{RP}}$ U: *the trophy*][$_{\text{PP}}$ NMR: *to Sam*]]

2. The lexical entry for the predicate in the nucleus is activated, and the annotations on the arguments in the template and the appropriate LS, (2a) guide the integration (i.e RP: A *Mary* = A: x, ∴ *Mary* = x, RP: U *the trophy* = U: z ∴ *the trophy* = z, NMR *to Sam* = y ∴ *Sam* = y, yielding

[**do´** (A: *Mary*, Ø)] CAUSE [INGR **have´** (NMR: Sam, U: *the trophy*)]

— The other possibility with *present*:

1. [$_{\text{CORE}}$ [$_{\text{RP}}$ A: *Mary*] [$_{\text{NUC}}$ *presented*][$_{\text{RP}}$ U: *Sam*][$_{\text{PP}}$ NMR: *with the trophy*]]

2.Integration with the LS in (2b) yields: A: *Mary* = x, U: *Sam* = y, NMR: *the trophy*

[**do´** (A: *Mary*, Ø)] CAUSE [INGR **have´** (U: *Sam*, NMR: *the trophy*)]

2. RRG and sentence processing: comprehension

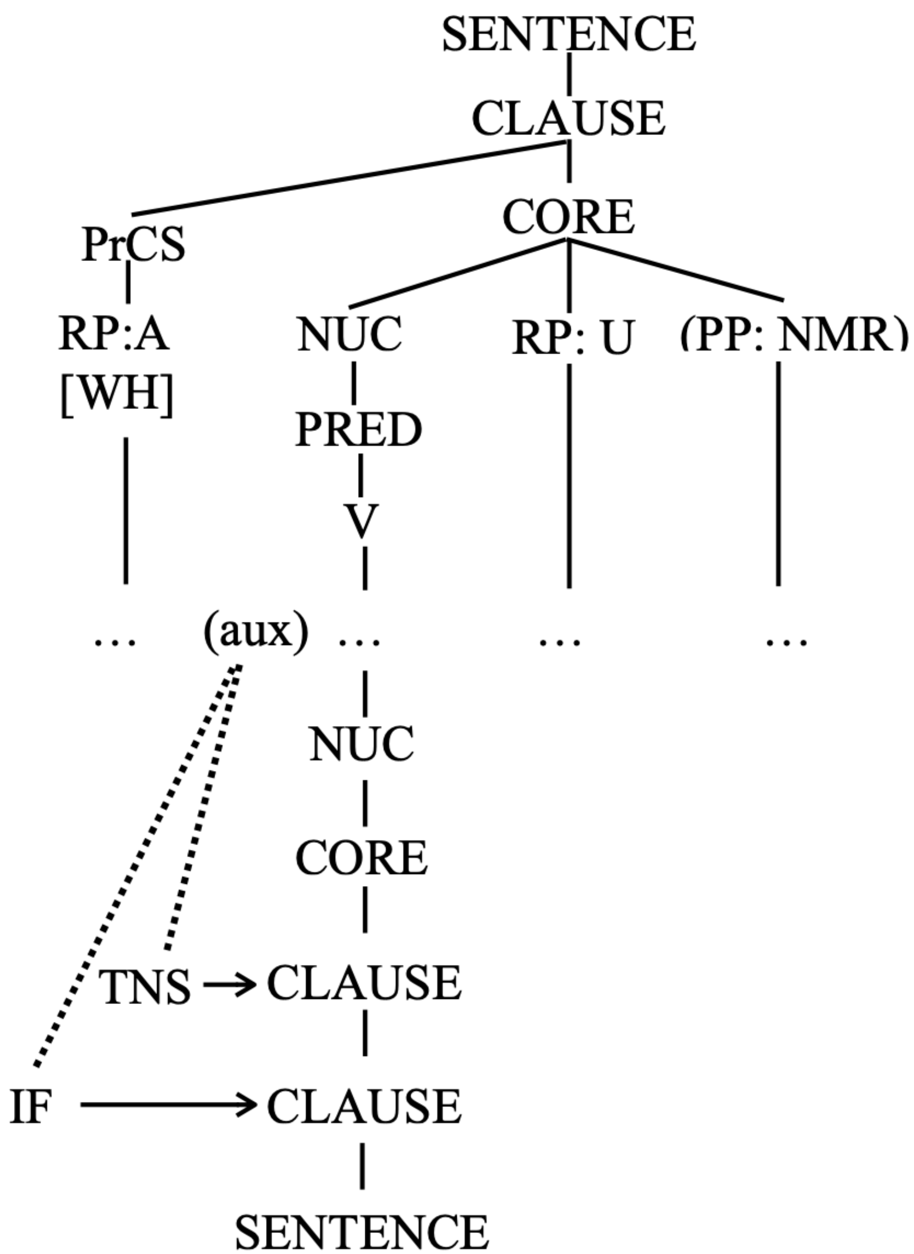
— These examples illustrate how the combination of semantic-macrorole-augmented syntactic templates and annotated lexical entries for verbs can rapidly yield the basic interpretation of a sentence (i.e. ‘who did what to whom’).

— There were two issues mentioned at the beginning of this section that RRG as a processing model must address, namely incremental interpretation and displaced WH-questions.

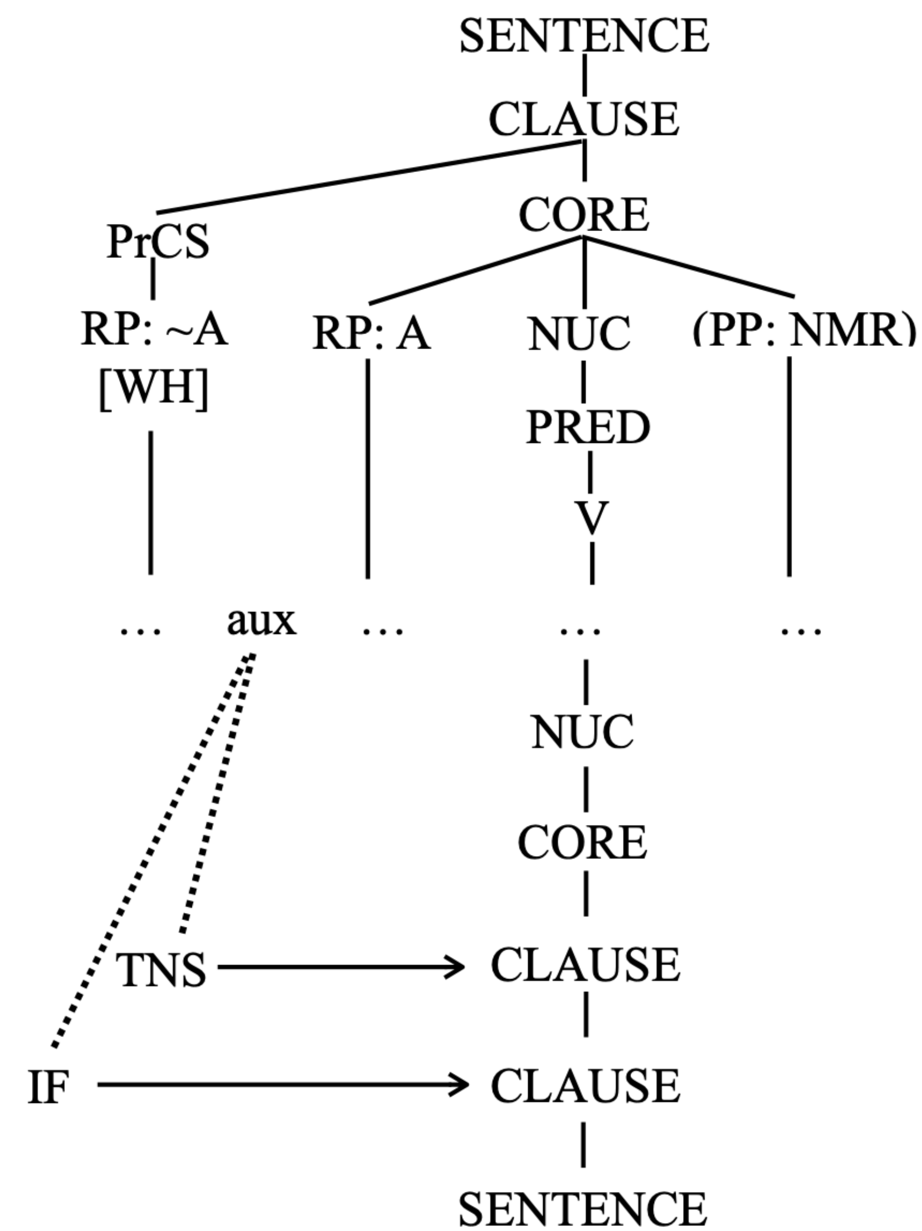
—Incremental interpretation can be accounted for in terms of parallel processing of statistically-weighted templates in conjunction with a beam-search algorithm of the type presented in Jurafsky (1996), which ranks candidate structures and lexical items within a specific range of probability, dropping candidates that fall outside that range as the process moves forward. At the first word in a sentence there are many possible candidate templates, and as each new word is encountered, the number of candidates is reduced until the correct combination of templates is chosen.

2. RRG and sentence processing: comprehension

— As for displaced WH-questions, they are handled by the templates below.



English PSA WH-Q template



English non-PSA WH-Q template

2. RRG and sentence processing: comprehension

— An example of a simple WH-question and its analysis is given below. ('~A' means 'not the A argument of the active voice transitive or three-place verb in the main clause'.)

— *What did Mary present to Sam?*

1. The matching mechanism selects the non-PSA WH-Q template, yielding
   [$_{\text{PrCS}}$ [$_{\text{RP}}$ ~A: *what*]][$_{\text{CORE}}$ {*did*} [$_{\text{RP}}$ A: *Mary*] [$_{\text{NUC}}$ *present*] [$_{\text{PP}}$ NMR: *to Sam*]]

2. The lexical entry for the predicate in the nucleus in (2a) is selected because of the NMR: *to* specification and is activated, and the annotations on the arguments in the template and the LS guide the integration (i.e RP: A: *Mary* = A: x, ∴ *Mary* = x, etc.), yielding the interpretation

   [**do´** (A: *Mary*, Ø)] CAUSE [INGR **have´** (NMR: *Sam*, U: *what*)]

The ~A WH-expression *what* is integrated into the LS as the U, since undergoer is a kind of non-actor.

— These templates directly address the interpretation of the WH-expression and do not put it off until the rest of the sentence has been processed, as the linking algorithm does.

3. Unresolved issues

— In order to create a plausible comprehension system, two changes were proposed.

— First, the bare syntactic templates of the grammar were augmented with syntactic category information (RP, PP) and semantic macroroles, yielding linking templates.

— Second, the LSs of verbs and other predicators were augmented with semantic macroroles and the adposition or case carried by oblique core arguments.

— The result of this is that parsing and syntax-to-semantics linking are collapsed into two steps, as illustrated above.

— What implications do these changes have for the linking algorithm for mapping semantics into syntax, which underlies possible models of language production? This question was left open at the end of Van Valin (2006).

—It was noted there that there were now two sets of syntactic templates in the theory, the bare templates used in linking from semantics to syntax, and the semantically augmented linking templates used in linking from syntax to semantics. There are two sets of LSs as well: the 'pristine' LSs used in semantics-to-syntax linking, and the morphosyntactically and macrorole enhanced LSs used with the linking templates in syntax-to-semantics mapping.

— There is clearly a great deal of redundancy here that needs to be resolved.

4. Production revisited

— In the first section the semantics-to-syntax linking algorithm was illustrated with the sentence *Max was interviewed by CNN during the insurrection*.

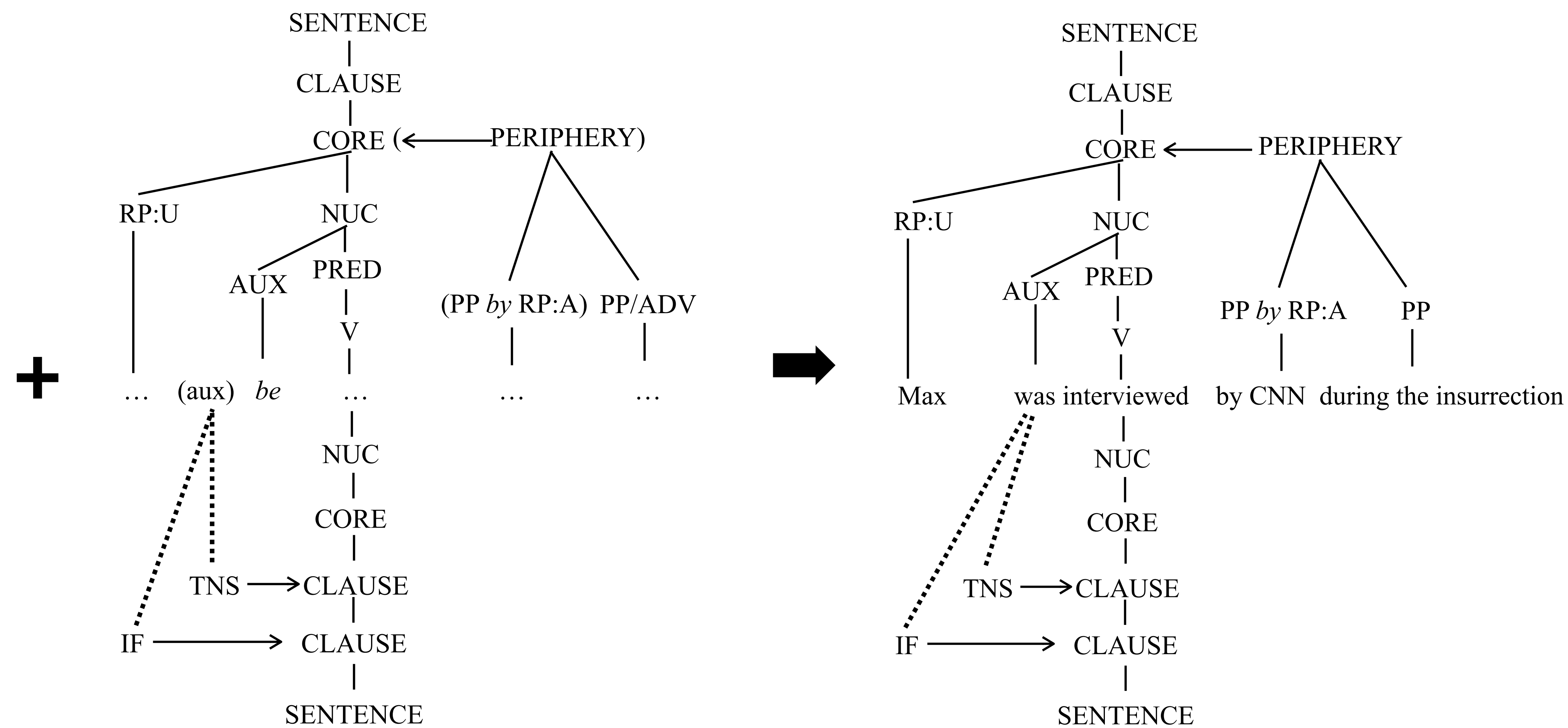
— It involves applying rules (‘assign macroroles’, ‘select the PSA’, ‘assign case’, etc.), selecting a bare syntactic template, and inserting lexical items into the template. The content of these rules, etc., is the same information contained in the linking templates and morphosyntactically augmented LSs in the comprehension system.

— As an alternative to applying these linking steps sequentially, it is possible to condense the linking into constructing the semantic representation using the augmented LSs with lexical choices for the argument positions in them and operators, selecting the appropriate linking template, and integrating the two.

— This is illustrated for *Max was interviewed by CNN during the insurrection*.

4. Production revisited

⟨$_{IF}$ *DEC*⟨$_{TNS}$ *PAST* [**be-during′** (insurrection, [**do′** (A: CNN, [**interview′** (CNN, U: Max)])])]⟩⟩



— Thus, the five steps in the linking algorithm have been reduced substantially into a fast production process, analogous to the reduced comprehension process.

— The semantics-to-syntax algorithm assumes an idealization that the entire utterance is planned out in advance. In reality, speakers can start an utterance without having planned it to the end (Bock 1995, Sauppe 2017). Hence, production is incremental, too.

4. Production revisited

— In reality, the semantic representation on the previous slide is compatible with the following possibilities, among others.

(3) a. CNN interviewed Max during the insurrection
b. During the insurrection, CNN interviewed Max.
c. During the insurrection CNN interviewed Max.
d. Max was interviewed by CNN during the insurrection.
e. During the insurrection, Max was interviewed by CNN.
f. During the insurrection Max was interviewed by CNN.

— The speaker has to decide whether the main clause is to be active or passive voice, a decision influenced by the relative topicality of the referents of the RPs *CNN* and *Max*, and whether the temporal PP is to occur in its default position in the core-level periphery or in initial position, and if initial, whether it is a frame-setting topic in the pre-detached position or part of the assertion in the pre-core slot.

— If the speaker begins with *during*, then (3a, d) are eliminated, but the remaining four are still possible. If they begin with *CNN*, then only (3a) is possible, and likewise if the utterance starts with *Max*, only (3d) is possible. There are different commitment points in the sentence; if it starts with the PP, the speaker is not yet committed to the voice of the main clause, whereas if it starts with an RP, the speaker is committed to the form of the main clause and the placement of the PP.

4. Production revisited

— This example has assumed that the speaker had decided on the predicator, but it is not unusual for there to be competing predicators with different implications in play. An alternative way of describing Max's encounter with CNN would be with the verb *talk (to)* as in (4).

(4) a. Max was talking to CNN during the insurrection.
b. ⟨IF *DEC* ⟨TNS *PAST* ⟨ASP *PROG* [**be-during′** (insurrection, [**do′** (A: Max, [**talk′** (Max, NMR *to*: CNN)])])]⟩⟩⟩

— A main clause beginning with *Max was*… can be continued with either *interviewed by CNN* or *talking to CNN*, reflecting two very different syntactic patterns. The speaker can begin a sentence before deciding on a final structure for the utterance.

— Because structural templates play a crucial role in the processing system, the incremental nature of processing is captured by competition among possible templates which is resolved at critical points during the sentence. For comprehension, the number of potentially relevant templates is reduced word by word as the receiver processes the sentence linearly. The result of this winnowing should ideally be a single structure associated with a single meaning, and multiple structures and meanings create ambiguity . For production, the speaker can begin uttering a sentence without having decided the final form and meaning of it. Here again there are semantic representations and structural patterns competing, and the choices made at critical points are a function of the speaker's intention to communicate a particular message.

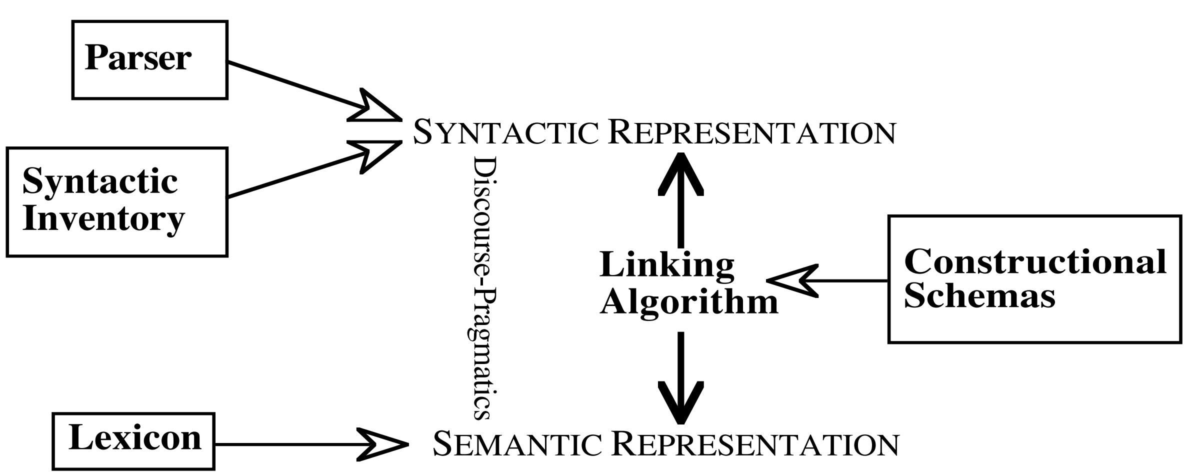
5. Conclusions

— In order to use an abstract competence grammar for language processing, both production and comprehension, it is necessary to make changes to the system.

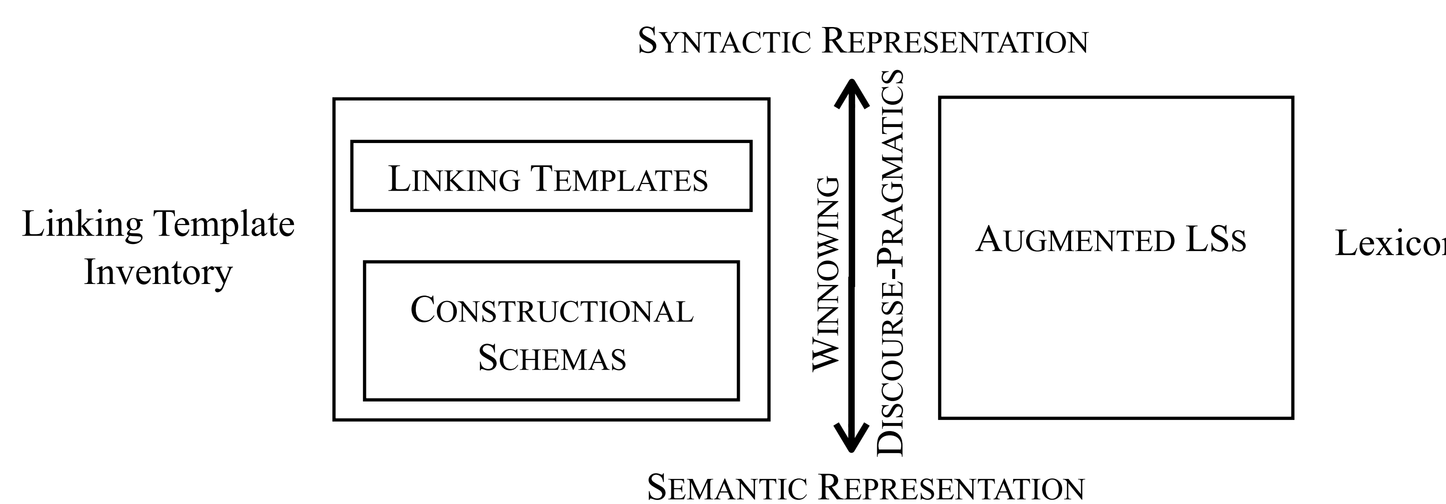
—In particular, the rules and constraints that the abstract grammar employs in the mapping between meaning and form and between form and meaning are precompiled in the syntactic templates and LSs for verbs and other predicators.

—These linking templates and augmented LSs play a central role in both production and comprehension, affording rapid and direct coding in the case of production and what native speakers perceive as nearly instantaneous interpretation with respect to comprehension.

—There are, accordingly, two versions of RRG: the familiar abstract grammar and the processing system.



RRG as an abstract model of grammar



RRG as a processing system

5. Conclusions

— The same rules, principles, constraints, etc. are captured in both versions, albeit differently.

—In the abstract grammar, they are stated explicitly as part of the linking algorithm, whereas in the processing system they are meta-generalizations over the linking templates and augmented LSs.

—Each version has an important role to play in the characterization of the communicative competence of native speakers of human languages.

THANK YOU FOR YOUR ATTENTION!

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