

# LOWERING ACROSS LANGUAGES\*

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The contrast in processing difficulty among different cases of local ambiguity has often been captured in terms of the type of reanalysis that is required. Of particular importance has been the distinction between lowering and raising of a constituent from the position in which it is attached originally, raising being the more costly operation and therefore producing conscious garden path effects. Unfortunately, this simple dichotomy has proven insufficient to capture the ease of resolving a range of cases of local ambiguity: many cases which ought to be resolvable by lowering yield garden path effects. In this paper, we focus on an apparent contrast in lowering possibilities between English and Japanese. We show how by adopting the structural relation of *c-command* as the primitive used by the parser to characterize structural relations, we can account for these contrasts without resorting to positing distinct parsing strategies in the two languages. Instead, the use of *c-command* enables us to derive the apparent parsing differences from independently necessary grammatical differences. Finally, using *c-command* as a parsing primitive provides, we believe, a way to bring together two strands of work on parsing models, those rooted in structure and those rooted in lexical and thematic relations.

## 1 Local Ambiguity and Lowering

It is well-known that local syntactic ambiguities are rampant in natural language. In processing a sentence, there are likely to be multiple analyses compatible with the prefix seen or heard, although only one of these might turn out to be consistent with the rest of the sentence. In general, however, processing seems effortless, and the presence of such ambiguity apparently does not give rise to difficulties in processing. This might be attributed to the fact that we do not necessarily pursue all analyses. As long as the appropriate analysis is not discarded, processing could be continued without difficulty. There is, however, a contrast in processing difficulty among different types of local syntactic ambiguities. In some cases, we seem compelled to select one of the possible analyses, prior to hearing the disambiguating context, which turns out to be incompatible with subsequent input. When this is discovered, we experience some confusion or difficulty, an effect that has been called a “garden path” effect. A well-known example of such a case is

- (1) While she was mending the sock fell off her lap.

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Prior to hearing the word *fell*, the sequence *she was mending the sock* could be treated as a single sentence. Such an analysis of this sequence is in fact appropriate for completions like that in (2).

- (2) While she was mending the sock the phone rang.

Alternatively, the noun phrase *the sock* can be taken to be the subject of the matrix sentence to which the *while* adverbial clause is adjoined. This is the analysis that is necessary for (1). To explain the anomaly of (1) and acceptability of (2), it has been proposed that the parser pursues only the single sentence analysis immediately upon hearing *the sock*, without waiting for disambiguating context. If we assume that revising this analysis is difficult for the parser, this explains why cases like (1) that are incompatible with the selected analysis pose difficulty, while those like (2) which are compatible do not.

Many cases of local ambiguity do not, however, seem to trigger this kind of premature decision that leads to subsequent difficulty. For such cases, any number of possible completions are parseable by the listener without significant difficulty. For example, the initial sequence of words in (3) can be grammatically followed by any of the completions in (4).

- (3) I saw the student ...  
(4) a. ... yesterday.  
b. ... leave the room yesterday.  
c. ... from Turkey's mother yesterday.  
d. ... from Turkey's mother leave the room yesterday.

In each of these completions, the structural position of the noun phrase *the student* differs. In the first completion, this noun phrase is to be attached as the object, whereas in the third completion, the object NP is *the student from Turkey's mother* (headed by *mother*) and not *the student*. In the second and final completions, the right analysis requires the verb *see* to take a sentential complement. Nonetheless, speakers do not appear to experience significant difficulty in any of these cases. The ease in processing these different completions seems to suggest that the initial sequence does not trigger a premature commitment to view the noun phrase *the student* as the object or even to a specific sense for the verb *see* (corresponding to its different subcategorizations); decisions that would need to be retracted for the different completions. This is in apparent contradiction with what we hypothesized above concerning examples (1) and (2) above, namely that we did in fact make an immediate commitment to one analysis over the other.

There is however a way to reconcile these cases. Suppose that in both sets of examples we do make an immediate commitment that the NP-V-NP sequence corresponds to a simple SVO sentence. This will necessitate reanalysis both in completions that cause difficulty and some that do not. However, there is a significant difference between these classes of cases. In the situations in (4), the NP *the student* is consistently reanalyzed to a position which is "lower" in the tree than that in which is originally resides (see Figure 1). That is, in every case of "easy" reanalysis, the NP continues to be a member of every constituent that it was originally hypothesized to be a member of. In contrast, the reanalysis that is necessary for an example like (1) involves raising of the NP out of the constituent (object of the verb *mending*) into which it is originally attached (see Figure 2).

Thus, we might hypothesize that reanalyses which require the use of lowering are less costly than those requiring raising (Abney 1989, Pritchett 1987). This difference in types of reanalysis turns out not to be an idiosyncratic property of the English parsing mechanism, but applies to languages that are rather structurally distinct, such as Japanese, as we shall soon see.

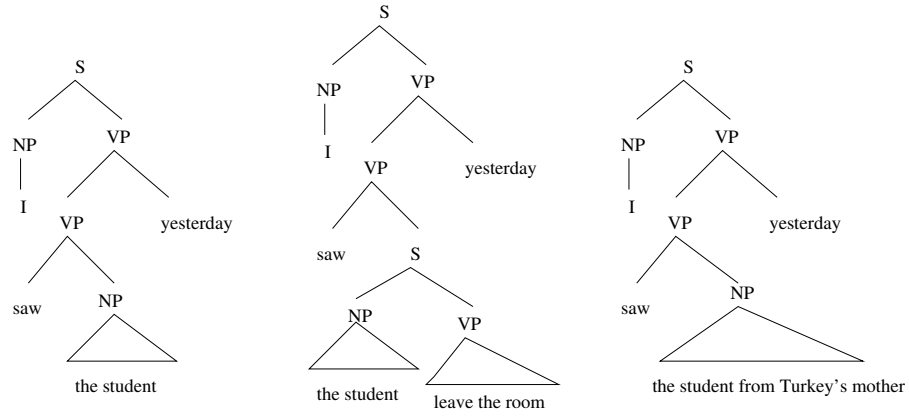


Figure 1: Analyses for (4)a-c

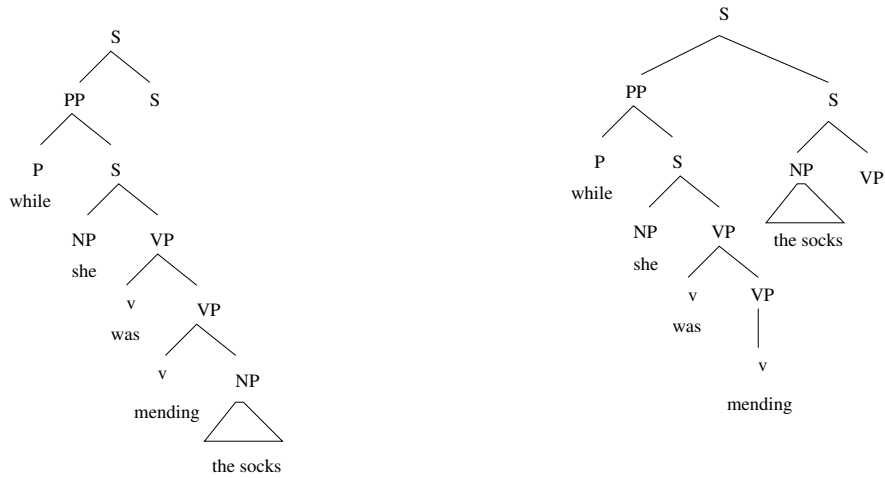


Figure 2: Possible analyses for initial sequence in (1) and (2)

## 2 D-Theory Parsing

Since the work of Marcus, Hindle and Fleck (1983), there have been a number of proposed parsing models that manipulate descriptions of trees rather than trees themselves (Weinberg 1993, Gorrell 1995, Sturt and Crocker 1996). The main benefit of such *D-Theory* models is that they provide a simple characterization of those cases of local ambiguity that give rise to conscious processing difficulty and those that do not. When more than one analysis is possible, such parsers produce make assertions about phrase structure that are common to these analyses. Such underspecification are made so that no commitment is made to any one particular analysis, but rather to a set of analyses assumed to be appropriate for the prefix of the input uttered. As processing proceeds and more input words are encountered, additional assertions would reduce this set of possible analyses. However, for some completions, it is possible that some property of an initial description must be withdrawn; that is, the parser does not behave monotonically. If we take retraction of assertions to be difficult for the parser, this allows us to characterize those cases of local ambiguity that give rise to conscious processing difficulty as those whose parsing descriptions grow non-monotonically during the course of the sentence. Though these models differ from one another in precisely how and when they make use of underspecification, they all exploit *dominance* (as opposed to immediate dominance) as a primitive in (under)specifying structures.

Given our previous discussion on lowering versus raising, one can understand why D-Theory parsers make assertions of dominance. The use of domination instead of immediate domination allows the model to represent “easy” cases of local ambiguity because this representation is compatible with more than one phrase structure tree whose nodes are connected by immediate domination links: any domination link can be “stretched” to an unbounded length to accommodate additional as yet unspecified structure. That is, when a parser asserts that a node  $X$  dominates a node  $Y$ , additional statements (say based upon the words in remainder of the sentence) affecting the relation between these two nodes can only serve to “lower”  $Y$  to any position within the tree rooted by  $X$ . Thus, for instance, when the prefix *I saw the student* is encountered, rather than attaching the phrase *the student* as being immediately dominated by the verb phrase headed by *saw* (which roughly states that this noun phrase is to be considered as the object of the verb), the assertion of the verb phrase dominating the noun phrase could be made by the parser. For any of the completions given in (4) above, this domination assertion would hold in the final analysis.

While the assertion that  $X$  dominates  $Y$  enables us to predict ease in processing in cases where  $Y$  has to be “lowered” within the constituent given by  $X$ , this domination assertion also predicts difficulty in processing a completion for which the appropriate analysis would have node  $Y$  raised out of the constituent  $X$ , as this calls for retraction of the domination assertion. Thus, for an example like (1), if we assume that the parser initially asserts that the VP headed by *mend* dominates the NP *the sock*, parsing the remainder of the sentence will necessitate retraction of this dominance link and therefore will cause difficulty.

## 3 Lowering in Japanese

There have been a number of attempts to apply the distinction between local ambiguities whose resolution requires lowering and those that demand raising to examples from Japanese. Consider, for example, the following easily processed sentences (from Inoue 1991 and Mazuka and Itoh 1995):

- (5) a. [<sub>Rel</sub> Mary-ga    sinseihin-wo     $t_i$  kaihatu-sita ] kaisy-a-ga<sub>i</sub>    tubureta  
Mary-nom new product-acc    developed    company-nom went bankrupt

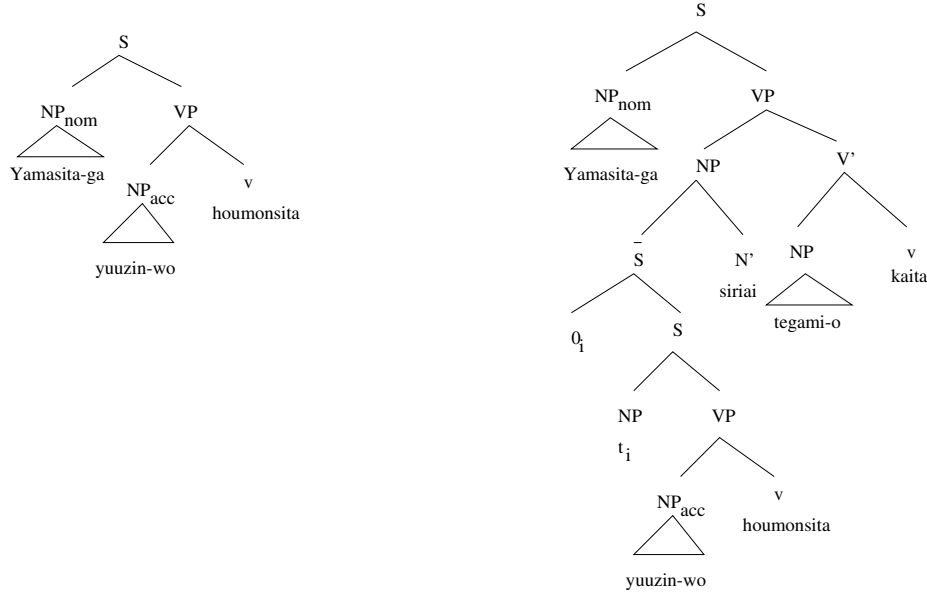


Figure 3: Initial and subsequent analyses for (5)b

- “The company where Mary developed the new product went bankrupt.”
- b. Yamasita-ga [Rel  $t_i$  yuuzin-wo houmonsita ] siriai-ni tegami-o kaita  
 Yamasita-nom friend-acc visited acquaintance-dat letter-acc wrote  
 “Yamasita wrote a letter to an acquaintance who visited his friend.”

In each of these sentences, the initial sequence consists of a nominative NP followed by an accusative NP in turn followed by a transitive verb. Since Japanese is a verb-final language, let us assume that the parser asserts that these comprise a simple matrix sentence. In both cases, the verb is followed by an NP, a sign that the previously encountered material cannot be the matrix clause, but instead must, at least in part, make up a relative clause modifier to the following NP. In example (5)a, it is the entire NP-NP-V sequence that comprises the relative clause. In the second case, only the second, accusative NP *yuuzin-wo* and the verb reside within the relative. In both cases, the reanalysis required by the completions can be accomplished by lowering, or its D-theory analog. In (5)a, no domination link needs to be retracted and we need only to add further domination links to embed the previously constructed sentence within the NP. In (5)b, again without retracting any domination links, we can assert a domination link between the NP *siriiai-ni* and the previously constructed VP, so as to embed it within the relative clause modifier, while leaving the subject NP and this new NP dominated by the originally constructed matrix S (see Figure 3).

The previous examples contrast in ease of processing with the following garden path sentence (from Mazuka and Itoh 1995):

- (6) Yamasita-ga yuuzin-wo [Rel PRO  $t_i$  houmonsita ] kaisya-de mikaketa  
 Yamasita-nom friend-acc visited company-loc saw  
 “Yamasita saw his friend at the company he visited.”

This example begins with precisely the same NP-NP-V sequence as (5)b. Note that in Japanese, subject and object noun phrases need not be overt. Thus, one possible resolution of the relative clause structure, and the one which is necessary here, retains neither of the first two NPs as arguments of the verb *houmonsita* within the relative modifier of *kaisya-de*. Instead, the subject NP of the relative clause is filled by a null pronoun (represented as PRO in (6)), and the head

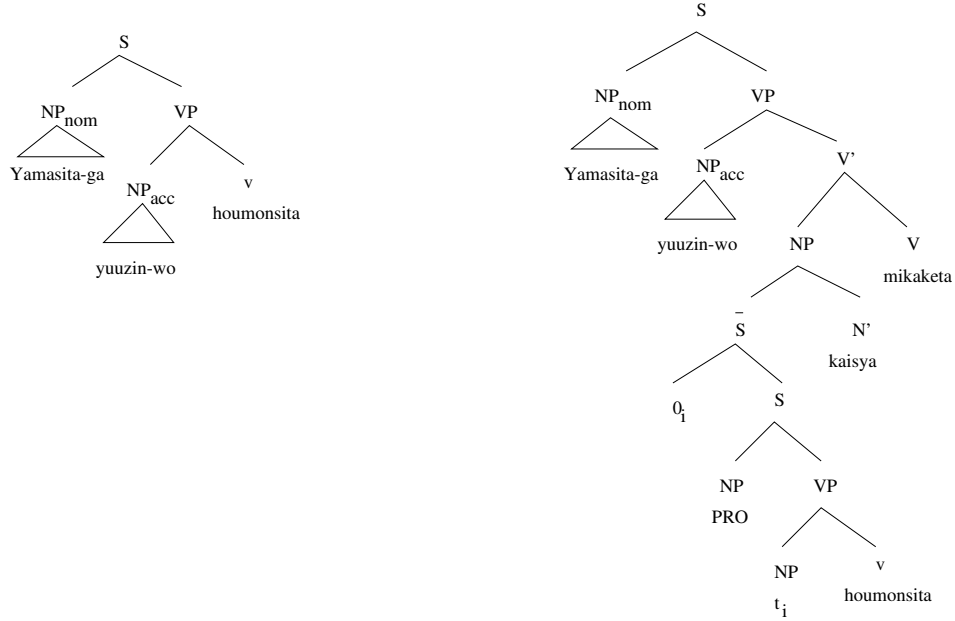


Figure 4: Initial and subsequent analyses for (6)

NP *kaisya-de* is interpreted as the object (see Figure 4). Note that if we allow cost-free lowering, this reanalysis should be possible (contra Gorrell 1995): we need only lower the verb *houmonsita* inside the relative clause, in D-theory terms stretching the previously asserted dominance relation between VP and V (cf. also Sturt and Crocker 1996). This case therefore poses a serious puzzle for the D-theory/lowering account of “easy” local ambiguities.

A number of proposals have been made to reconcile the difficulty of examples like (6) with the D-theory view of parsing. Weinberg (1993) suggests that a link between a VP and the verb must be understood as one of direct domination rather than simple domination. Her justification for this derives from the need for nodes in a structure to be licensed, and it is only in virtue of the VP immediately dominating the V from which it projects (and with which it shares features) that it is (internally) licensed. While sufficient to distinguish (6) from (5)a and (5)b, this proposal suffers from the need to introduce a new structural relation, immediate domination, into the vocabulary of the parser. Furthermore, it is unclear why, in contrast to V and VP, VP must not be directly dominated by S (or *I'* and VP under Weinberg’s structural assumptions), given that S is typically taken in some sense to be a projection of the verb and hence should share many of its features (Grimshaw 1991).

Sturt and Crocker (1996) suggest an alternative which does not necessitate the introduction of new descriptive vocabulary. They note that under the D-theory view of parsing, there are no restrictions whatsoever on the set of dominance relations that can be added at each point during the parse, i.e., the set of constituents that can be lowered. What is crucial is that none are retracted. Sturt and Crocker suggest that in order to produce a feasible parsing model a particular set of parsing operations (each of which adds a particular set of dominance relations) must be specified along with a control structure to determine which operation should be applied when. Though we will not need to elaborate in detail the parsing operations they propose (see their paper for description), the essential insight behind their choice of operations is that additional dominance relations may only be asserted (or alternatively “attachments” made) between nodes on the right edge of the previously built structure and the left edge of the projection of the most

recently encountered word or vice versa. Crucially, this prevents reanalyses internal to constituents that have already been established. Sturt and Crocker also specify an ordering in which the parser searches for possible “attachments” from among this restricted set of loci for new dominance statements until an attachment is found that is both grammatical and semantically plausible. In the case of English, Sturt and Crocker suggest that the parser considers the possibilities in a bottom-up fashion. This proposal mirrors a wealth of proposals in the psycholinguistics literature about preference for low over high attachment (Kimball 1973, Frazier 1979). For Japanese, however, Sturt and Crocker propose that attachment sites are considered in a top-down fashion. Examples like (5)a are rendered unproblematic since the assertion of dominance between the NP *kaisya* ‘company’ heading the relative clause and the previously constructed S is a grammatically and semantically possible attachment, as ‘company’ can be interpreted as a locative modifier of the transitive clause. In example (5)b, such an adverbial construal of the head NP *siriai* ‘acquaintance’ is impossible, blocking the assertion of a statement of dominance of S by NP. Next, attachment at the VP level is attempted, and is successful, as *siriai* is a possible subject of the clause *yuuzin-wo houmonsita* ‘visited his friend’. Thus, the parser asserts that the NP headed by *siriai* dominates this VP, thereby lowering the VP within the relative clause. For the problematic example (6), the same sequence of attachments is attempted. Because the NP *kaisya* ‘company’ can be construed as a locative modifier, the parser posits that this NP dominates the previously constructed S (with an interpretation *the company where Yamasita visited his friend*), ignoring the possibility of lowering only the verb *houmonsita* ‘saw’. This will have the effect that the two initial NPs will not be able to escape from the relative clause to serve as arguments to the main verb, blocking the necessary analysis.

This proposal is intriguing in that it avoids the need to resort to additional vocabulary in the parser’s structural description. The parser posits only relations of dominance. As dominance relations alone are insufficient to block lowering of the verb alone, Sturt and Crocker exploit a specific ordering among reanalysis possibilities to prevent this case of reanalysis from occurring. Though Sturt and Crocker provide a potential explanation for why English and Japanese should differ in the orderings in which they consider reanalyse, stated in terms of Frazier’s (1994) Minimal Revisions Principle, there is little independent empirical support for the proposal that the Japanese parser searches in a top-down fashion.<sup>1</sup> This is in contrast to the wealth of parsing evidence for low attachment preferences. Further, to the degree that it can account for the same range of data, a proposal which unifies the actions of the parser across languages is clearly to be preferred to one which posits divergent parsing behavior, as it avoids a potential learning problem. In the next section, we will make just such a proposal, one that maintains the advantage of Sturt and Crocker’s approach in using a single structural relation in the parser’s representation, while avoiding the need

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<sup>1</sup>Indeed, one of the two cases that Sturt and Crocker bring up in support of their proposal does not seem to follow (about the other case, see below). The relevant example is the following (their example 23):

Yamasita-wa yuuzin-wo [<sub>Rel</sub> PRO *t<sub>i</sub>* houmonsita ] kaisya-de mikaketa  
 Yamasita-top friend-acc visited company-loc saw

“As for Yamasita, he saw his friend at the company he visited.”

This sentence is identical to the garden path example (6) with the single difference that the initial NP is morphologically marked as topic rather than as nominative case. They observe that speakers find this sentence considerably easier to process than (6). Since topic marked NPs must not appear within an embedded clause, the possibility of lowering the entire S within the relative clause is ruled out. They conclude, therefore, that nothing blocks the possibility of the V lowering analysis, hence its relative acceptability. However, they neglect to consider the possibility of the VP lowering analysis in which *kaisya* ‘company’ is construed as a locative adverbial for a null-subject relative, i.e., the company where (he) visited his friend. Following a top-down strategy, this ought to be considered prior to V-lowering, and hence should block it, yielding a garden path.

to parameterize the behavior of the parser across languages.

## 4 A New Parsing Primitive: C-Command

All of the parsing models we have discussed in the D-theory line of research have shared the property of using assertions of dominance to (under)specify hypothesized structure. It is worth noting, however, that the dominance relation, while almost universally adopted for describing trees, is rarely used directly in stating linguistic principles and characterizing the relations that underlie structure-building. Consider, for example, the relation of selection of a complement by a head. Stated in terms of dominance, a head  $H$  selects the phrase which is dominated by the node which (directly) dominates  $H$ . This rather indirect characterization is rarely used, however. Instead, alternative structural relations are typically exploited. Thus, we often say that a head selects a phrase under the configuration of *c-command*. Roughly speaking, a node  $X$  c-commands another node  $Y$  if it is the case that  $X$  precedes  $Y$  or vice-versa and the parent of  $X$ , say  $Z$ , dominates  $Y$ . Thus, while  $Z$  dominates both  $X$  and  $Y$ , the precedence requirement ensures that  $X$  can not dominate  $Y$  (or vice-versa). In contrast to dominance, the use of the c-command relation in linguistic theory is ubiquitous. It is this structural relation that has been implicated in phenomena such as binding, negative polarity item licensing, quantifier scope, movement, among others. With this conceptual motivation, we suggest that the parser builds representations using the relation of c-command rather than dominance. We will see that the use of c-command by a D-theory style parser enables it to mimic much of the behavior of dominance-based parsers, particularly in the range of examples that have motivated the use of dominance. Further, two simple strategies to determine when a parser asserts c-command explains not only the lowering possibilities seen in domination-based parsers but also explain why the range of phrases that can be lowered can be constrained.

To illustrate the use of c-command, consider the situation where the parser encounters the initial sequence in (3), focusing especially on the the relation between the verb *saw* and the NP *the student*. If we were to assume that the NP was the object of the verb, it would follow these two should c-command one another. Furthermore, the verb would c-command any word or phrase that appears with the NP, but any proper subphrase within NP would not c-command the verb. The verb *saw* allows for two distinct types of complements, however: a noun phrase or a sentence. Since *the student* would fit as an initial sequence for either of these, the parser can safely assert that the verb c-commands the NP. This assertion can be seen, in terms of dominance, as the assertion that the verb phrase headed by this verb dominates the NP. Thus, any lowering of the NP will not force a retraction of the assertion of c-command. Once there is evidence that the subcategorized complement is finished, then can we assert that the NP c-commands the verb, thereby “closing” the VP constituent. It is only the assertion of the second c-command relation that effectively completes the combination of a head and a complement it subcategorizes.<sup>2</sup>

It is not difficult to see that a parser using c-command can mimic the behavior of dominance based parsers. For those examples where a constituent was attached to the right of some selecting

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<sup>2</sup>This is not to say that interpretation of the structure will be impossible until the assertion of this final relation. Rather, during the course of the parse, an interpretation can be derived by extracting the so-called “standard referent” of the description (Marcus, Hindle and Fleck 1983, Rogers and Vijay-Shanker 1996). If the verb is asserted to c-command an NP and further assertions are made, the standard referent of this set of assertions will have the NP c-commanding the verb as well, as this corresponds to the minimal well-formed tree structure satisfying all of the assertions. Of course, the parser’s behavior will not be monotonic over the representations that are extracted as standard referents at each point during the parse.

lexical head as an argument (cf. (4)), lowering is compatible with assertions of a (unidirectional) c-command relation from the attachment site to the attached element. Raising of elements attached in the same fashion, as in (1) vs. (2), will similarly be blocked: in a higher position, it will no longer be c-commanded by the selecting head, the verb *mending* in these cases.

## 5 Explaining the Cross-Linguistic Contrast

The important point in our proposed use of c-command in parsing is that it is more than a simple notational variant on dominance. In particular, when we state that a verb c-commands an NP, the structural relation between the verb and its parent is not underspecified. Thus, a c-command based parser posits that while the noun phrase can be lowered, the verb alone can not. In this respect, the structure a c-command-based parser posits is less flexible than that of a dominance-based parser. In fact, we believe that there is empirical support for precisely this restriction, support which stems from the Japanese cases discussed above.

Consider the behavior of the c-command-based parser on an NP-NP-V sequence such as that which begins examples (5)a, (5)b, and (6). Let us assume as before that the parser initially hypothesizes that this sequence constitutes a simple SOV clause. In c-command terms, this will mean (at least) that the first (nominative) NP c-commands the second (accusative) NP as well as the verb, and also that the verb c-commands the accusative NP, as a result of the hypothesized thematic dependency (more on this below). This allows us to explain why lowering of the entire S is possible in (5)a, as no c-command relations are disturbed, and also why the VP can be lowered in (5)b, as the c-command relations between the nominative NP and elements of the VP are preserved under lowering. In contrast, the lowering of the verb alone (without the lowering of the initial NPs) that would be necessary to reanalyze the initial sequence in (6) to produce a globally well-formed analysis would violate the c-command relation of the accusative NP by the verb. Thus, the use of c-command allow us to directly capture the difference among the different types of lowering, indicating why reanalyses that require lowering of the verb alone give rise to garden paths.

Recall that the definition of c-command requires that the parent of the c-commander must dominate the c-commandee. Thus if a verb c-commands an NP, it has as an immediate consequence that the verb must remain immediately dominated by its VP (which must also dominate the NP): lowering of the verb would mean that the parent of the verb no longer dominated the NP. This use of immediate domination is extremely reminiscent of Weinberg's proposal discussed above. What is novel here, though, is that the requirement of direct domination follows in our case directly from the use of c-command, and does not require any further stipulations.

In the cases we have discussed thus far, we have been implicitly assuming the parser uses some sort of strategy to posit c-command on the basis of identified thematic relations to structural relations. Let us now make this explicit. For the purposes of this paper, we focus on the head-complement relation:

- (7) Head-Complement Strategy: when an element  $Y$  is recognized as the complement of a head  $X$ , assert that  $X$  c-commands  $Y$ .

As noted above, when  $Y$  remains the complement in the final structure, it will also c-command  $X$ , the head. We assume that this is filled in by some other process, perhaps waiting until the delivery of the syntactic structure to a interpretive level of processing (see note 2).

The Head-Complement Strategy allows us to account for the apparent counter-examples to the distinction between the types of Japanese examples we have discussed above. Mazuka and Itoh

(1995) point out the following example whose structure is identical to that in (6), but which they report is considerably easier to process:

- (8) Hiroshi-ga aidoru kasyu-wo [Rel PRO  $t_i$  kakusita ] kamera-de totta  
 Hiroshi-nom popular singer-acc hid camera-with photographed  
 “Hiroshi photographed the popular singer with the camera he was hiding.”

Mazuka and Itoh observe that the difference between this example and structurally similar garden paths “can probably be accounted for by factors including the meaning of the individual verb, the strength of the relation between the NP and the verb, and other pragmatic knowledge. For example, hiding a popular singer . . . is probably not as likely an event as . . . visiting a friend . . .” (p. 308). We can make use of these observations directly in our explanation of the ease of processing this case: the parser does not recognize a head-complement relation between the verb *kakusita* ‘hid’ and the preceding NP *aidoru kasyu-wo* ‘popular singer’. Thus the Head-Complement Strategy does not apply, and consequently there is no assertion of c-command of the NP by the verb which blocks lowering of the verb alone.

There will be situations in which we will want to integrate structural elements in the absence of any hypothesized thematic dependencies. To do this, we assume the existence of a default mapping between ordering and c-command (Kayne 1994, Weinberg 1997, Phillips 1996, Phillips and Gibson to appear).

- (9) Default Order Mapping Strategy: In the absence of conflicting evidence, assert that  $X$  c-commands  $Y$  for successive words in the input  $X$  and  $Y$ .<sup>3</sup>

Of course, such a strategy cannot apply generally, as grammars allow structures that are not strictly right branching. We envision sources of information such as prosodic (or punctuation) boundaries, thematic completeness of a constituent, and certain aspects of discourse context to constitute the type of evidence the parser might consult to block application of this strategy.

The combination of the Head-Complement and Default Order Mapping strategies has interestingly divergent implications for SVO and SOV languages.<sup>4</sup> For an SVO language, the two strategies will result in the assertion of an identical c-command relation in the case of identified V-O sequences, i.e., the verb will c-command the object NP. As discussed above, this relation gives the familiar pattern of cost-free reanalysis via lowering of the hypothesized object. However, for an SOV language, the application of the two strategies will yield a relation of mutual c-command between the verb and object: the object c-commands the verb because of the precedence relation between them, while the verb c-commands the object because of the hypothesized head-complement relation. Consequently, no lowering of the either the object or verb alone is possible, explaining the Japanese behavior. The difference in lowering possibilities between Japanese and English thus follows from the independently necessary word order difference between the two languages, and we do not need to posit distinct parsing strategies for the two languages.

## 6 Further Implications

The use of c-command as a primitive for the parser has a number of other beneficial effects on explaining cases where lowering appears to be blocked. Consider the following classic garden path

<sup>3</sup>If  $X$  is the rightmost (overt) element in a recently closed constituent, a natural generalization of this strategy will assert that this closed constituent containing  $X$  c-commands  $Y$ .

<sup>4</sup>Note that so long as specifiers occur to the left of the head, the existence of this default strategy obviates the need for a mapping between the spec-head relation and c-command. The default mapping will always give the desired result: that the specifier c-commands the head.

sentence:

(10) The horse raced past the barn fell.

Consider the behavior of parsers that assert only domination statements. Under the standard assumption that the VP headed by *raced* is initially parsed as that of the main clause and therefore dominated by the root S, there is nothing to block lowering of this VP into the relative clause modifying the NP *the horse*. Unfortunately, this would predict that (10) is as easily processed as (11).

(11) The horse raced past the barn a few minutes ago.

Gorrell (1995) argues that such an example motivates the need to add the relation of precedence to the parser’s vocabulary. By saying that the subject NP precedes the VP headed by *raced*, the reanalysis required for (10) is blocked since this precedence relation could no longer hold if the VP were within the NP, as precedence and dominance are mutually exclusive. C-command allows us to avoid this use precedence entirely. By the Default Order Mapping Strategy, the NP *the horse* will be taken to c-command the verb *raced*. Since a node cannot c-command something that it contains, the verb cannot be lowered within this NP. In contrast, (11) can be processed without the retraction of this c-command relation.

An additional example that Gorrell uses to motivate the need for precedence to block cases of lowering is:

(12) I gave the man the report criticized a demotion.

If the parser asserts only that the VP headed by *gave* dominates the two NPs *the man* and *the report*, there is nothing to prevent the noun phrase *the report* from being lowered into a relative clause modifying *man*. To render such lowering non-monotonic, Gorrell proposes the parser should additionally assert a statement of precedence between the two NPs. The explanation for the impossibility of lowering goes through just as in the previous. Suppose, though, the parser posits a c-command relation between the two NPs, i.e., the first one c-commands the second (Larson 1988). This will have a similar effect of blocking the possibility of lowering without resorting to precedence.

## 7 Conclusion

In this paper, we have investigated the processing of locally ambiguous sentences whose non-preferred analyses differ from the preferred one in terms that can be characterized as lowering. We have found that not all instances of lowering are equally easy for the human sentence processor, in contrast to what would be expected under the D-theory proposal of Marcus, Hindle and Fleck (1983), where structures are (under)specified through the use of a dominance, rather than immediate dominance, relation. We have attempted to show how the use of c-command as the primitive relation for specifying the parser’s hypothesized structure enables us to distinguish between those cases of lowering that are unproblematic and those that give rise to conscious garden path effects. In particular, we have seen how differences between the word order of Japanese and English explains why lowering along the right frontier is possible in English, though not in Japanese.

We believe that c-command is a far more natural choice than dominance as the primitive for the parser’s description as it allows us to link the parser’s operations more directly to the selectional relations that are presumably driving much of its action.<sup>5</sup> The use of a relation between the verb and

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<sup>5</sup>From the perspective of the text, where c-command is defined in terms of domination, it is somewhat surprising

the NP is reminiscent of the use of thematic selection as a parsing primitive (Pritchett 1987, etc.), unsurprisingly as (local) c-command is the structural analog of selection. Yet, since c-command is a structural relation, it need not be retracted in many situations that would necessitate thematic reanalysis. We believe that the use of c-command as a primitive in description-based parsing provides a way of bringing together two divergent strands of work on parsing models, those rooted in structure and those rooted in lexical and thematic relations.

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that the parser should choose to manipulate this more abstract relation. In other work (Frank and Vijay-Shanker 1995), we have argued that c-command should not be viewed as a relation derivative from dominance, but rather that it should be taken to be the primitive relation in terms of which phrase structures are defined. From this perspective, it is of course natural, and indeed virtually necessary, to take c-command to be the basic relation that the parser manipulates. For the purposes of this paper, we leave open the issue of whether c-command is a primitive or derivative relation, keeping in mind that the former is the more attractive possibility.

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