An Adjacency Constraint on Argument Selection *

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1 Introduction

As Chomsky (1957) made clear, natural language syntax cannot be described *solely* in terms of finite-state grammar. Unfortunately, that argumentation has resulted in frequent lack of realization of the importance of word order in the syntactic literature; the inadequacy of such a purely word-order-based model as finite-state grammar does not mean that word order has no role to play.

To say the least, given that native judgments are results of real-time processing, it would rather be surprising that (un)acceptability judgments had nothing to do with word order. Hence, recently, attempts to explain seemingly syntactic phenomena in terms of real-time processing (e.g. Hawkins 1994).

In this paper we join such a recent trend by making a specific proposal about word order effects and model the proposal in terms of working memory. The structure of the paper is as follows. In Section 2, we illustrate the (un)acceptability judgments we intend to account for; we point out that the existing accounts fail to capture the observational generalization behind the constructions. In Section 3, we propose a specific word order account, modeled in terms of working memory. In Section 4, we demonstrate that our proposal nicely accounts for the phenomena in question. In Section 5, we further examine the nature of our proposal, firstly by dealing with a potential problem, and secondly by illustrating its further predictions. Section 6 concludes the paper.

2 Data and Problems

Kaplan and Bresnan (1982) pointed out the following examples, which pose a problem (at least) for a movement-based analysis of topicalization. An obvious explanation for the ungrammaticality of (1a) would be to assume that *of* cannot take a *that*-clause as its complement. However, (1b) betrays this, since the *that*-clause can serve as the (dislocated) complement of *of* without causing ungramamticality.

(1) a.*John was thinking of that he was stupid.

b. That he was stupid, John was thinking of.

The solution proposed in the LFG literature (Kaplan and Zaenen 1989; Bresnan 2000) is to state complement selection in terms of grammatical function (GF), instead of syntactic category; the linking of GF and syntactic category is stated by a separate constraint. For example, in Bresnan (2000) and Falk (2001), (i) *of* selects OBJ, (ii) Lexical-Mapping Theory (LMT) links OBJ and NP, and TOP and CP, and (iii) Functional Uncertainty (Kaplan and Zaenen 1989) ensures that the TOP value and the OBJ value are identical.[1]

Thus, the f-structure of (1a), depicted in Figure 1, violates (i), while the f-structure of (1b), depicted in Figure 2, causes no violation.

*A very earlier version of the intuition underlying the theory described here was presented at the Japan Cognitive Science Society (JCSS) annual meeting in 2003. We thank the JCSS audience as well as Shûichi Yatabe (the University of Tokyo) for helpful comments, Mafuyu Kitahara (Waseda University) for an informal discussion, and Campbell Hore (Nara Institute of Science and Technology) for native judgments.

[1]Note that in Kaplan and Bresnan (1982), a *that*-clause is not allowed to serve as a complement of preposition by PS-rule.

$$\left[\begin{array}{ll}
\text{TOP} & \left[\begin{array}{ll} \text{PRED} & \text{`be}\langle(\uparrow \text{SUBJ})(\uparrow \text{OBJ})\rangle\text{'} \\ \text{SUBJ} & [\text{PRED}\ \ \text{`he'}] \\ \text{OBJ} & [\text{PRED}\ \ \text{`stupid'}] \\ \text{TENSE} & \text{PAST}\end{array}\right] \\
\text{PRED} & \text{`think of}\langle(\uparrow \text{SUBJ})(\uparrow \text{OBJ}_{of}\text{OBJ})\rangle\text{'} \\
\text{SUBJ} & [\text{PRED}\ \ \text{`John'}] \\
\text{TENSE} & \text{PAST} \\
\text{OBL}_{of} & \left[\begin{array}{ll}\text{PCASE} & \text{OBL}_{of} \\ \text{OBJ} & \end{array}\right]
\end{array}\right] \quad ?$$

Figure 1: The f-structure of (1a)

$$\left[\begin{array}{ll}
\text{TOP} & \left[\begin{array}{ll} \text{PRED} & \text{`be}\langle(\uparrow \text{SUBJ})(\uparrow \text{OBJ})\rangle\text{'} \\ \text{SUBJ} & [\text{PRED}\ \ \text{`he'}] \\ \text{OBJ} & [\text{PRED}\ \ \text{`stupid'}] \\ \text{TENSE} & \text{PAST}\end{array}\right] \\
\text{PRED} & \text{`think of}\langle(\uparrow \text{SUBJ})(\uparrow \text{OBJ}_{of}\text{OBJ})\rangle\text{'} \\
\text{SUBJ} & [\text{PRED}\ \ \text{`John'}] \\
\text{TENSE} & \text{PAST} \\
\text{OBL}_{of} & \left[\begin{array}{ll}\text{PCASE} & \text{OBL}_{of} \\ \text{OBJ} & \end{array}\right]
\end{array}\right]$$

Figure 2: The f-structure of (1b)

However, such LFG analyses fail to predict the grammaticality differences in the following examples, which intuitively seem to be related to the pattern observed in (1). (4c–d is from Quirk et al. (1995, §10.41), cited from Yatabe(2004).)[2]

(2) a. John was thinking of Mary.

b.*John was thinking of that he was stupid. (=(1a))

c. John was thinking of Mary and that he was stupid.

d.*John was thinking of that he was stupid and Mary.

(3) a. Ken agreed with, but John denied that Mike was wrong.

b.*John denied, but Ken agreed with that Mike was wrong.

(4) a. Either she or you are/*is wrong.

b. Either your brakes or your eyesight is/?are at fault.

c. Either your eyesight or your brakes are/?is at fault.

(4a–b) should have the same f-structure Figure 3:

Crucially, the f-structure of a coodinated phrase (SUBJ in this case) is assumed to be a set, and hence the word order difference is lost in the f-structure representation.

What is common in the above examples, it seems to us, is the following generalization: the head imposes its restriction (agreement in this case) on an argument near enough to the head but not necessarily on

[2](2c) is subsumed under this explanation only when (α) *Mary and that he was stupid* is analyzed as a constituent; if (β) *of Mary* is a constituent coordinated with the *that*-clause, (2c) would simply be an ordinary constituent coordination which poses no interesting problem. (We thank Shûichi Yatabe for pointing this out.)

However, consider (i) and (ii).

i Sally missed Japan so much she was thinking nostaligically of even election-vans and that rush-hour on the Yamanote-line was not so bad as people make out.

ii *? Sally missed Japan so much she was thinking nostalgically even that rush-hour on the Yamanote-line was not so bad as people make out and election-vans.

In (i), *even* modifies the NP and the *that*-clause, which indicates that the NP and the *that*-clause form a constituent, which functions as the complement of *of*, thereby demonstrating that (α) is a possible analysis. Further, the contrast between (i)–(ii) suggests that, even when the (β) analysis is forced, the linear order generalization is observed; the inversion of the conjuncts in (iii) degrades the grammaticality.

Of course, the badness of (ii) could be a result of the mere fact that the left conjunct is too long and hence places too much burden on working memory, independently of our specific working memory model to be developed below. However, even if we granted such an argument and assumed that (2c) is accepted only on the (β) parse, (2a–d) would then only fail to support our proposal; they would not refute it anyway.

$$\begin{bmatrix} \text{PRED} & \text{`be}\langle(\uparrow\text{SUBJ}),(\uparrow\text{OBJ})\rangle\text{'} \\ \text{SUBJ} & \left\{ \begin{matrix} \begin{bmatrix} \text{PRED} & \text{`she'} \\ \text{PERS} & \text{3RD} \\ \text{NUM} & \text{SG}\end{bmatrix} \\ \begin{bmatrix}\text{PRED} & \text{`you'} \\ \text{PERS} & \text{2ND}\end{bmatrix}\end{matrix}\right\} \\ \text{TENSE} & \text{PRES} \\ \text{OBJ} & \begin{bmatrix}\text{PRED `wrong'}\end{bmatrix}\end{bmatrix}$$

Figure 3: The f–structure of *Either she or you are/*is wrong*

an argument far enough from the head. In other words, only those arguments near enough to the head in linear order have to satisfy the requirements imposed by the head.

Such an intuition itself is not necessarily new. For example, the agreement asymmetry in coordinate structure as seen in sentences such as (4) is a rather old observation, and it is already assumed in the literature (Sadock 1998; Moosally 1998; Yatabe 2004) that the head agree only with nearer conjuncts.An exception is Johannessen (1998), who analyzes a coordinate structure as the maximal projection of the conjunction, in which the specifier and the head agree (the Spec-Head agreement assumed in GB). In a language like English in which the specifier always precedes the head, the first conjunct agrees with the head, which obeys the syntactic requirements imposed by the head selecting the coordinate structure. This predicts that, if there is an asymmetry, it is the first conjucts (but not the other conjuncts) that obey the syntactic requirements imposed by the head on the coordinate structure argument, *irrespective of word order*. For example, it predicts the opposite pattern for (4). As far as we are aware, every published work on coordinate structure asymmetries as well as our own informant judgments are in conflict with his prediction. However, they have failed to state this observational generalization in their theory; Sadock only mentions the observation. Moosally and Yatabe only stipulate agreement patterns on a case-by-case basis. And their accounts per se are not meant to, and cannot, cover sentences such as (1), on the other, thereby failing to capture the similarity between (1) and (2)–(4). It is not that they merely failed to notice the similarity and to point out that their generalization also covers (1). Any existing non-LFG account of unbounded dependencies (either in HPSG assumed by Moosally or Yatabe, or any other framework we are aware of) requires the syntactic category of the filler to match the requirement imposed on the complement by the selecting head (P in this case). Thus, unless one revises either one's treatment of unbounded dependency constructions (the syntactic approach) or one's assumption of the role played by syntax in native speaker judgments (the non-syntactic approach), their accounts cannot be extended to cover (1).

The syntactic approach would be an obvious course to take, but we dare take the non-syntactic approch. For one thing, manipulating syntactic mechanisms for unbounded dependency constructions in non-linear order terms, as in LFG, would fail to capture the observational generalization of linear order effects, and hence does not seem likely to succeed in giving a uniform treatment of (1) and (2)–(4). For another, the following examples lead us to suspect that the nature of the linear order effects is rather not syntactic:

(5) a.?Ken was thinking of, (pause) that he was stupid

b. Ken was thinking of, by the way, that he was stupid.

The observation is that the insertion of a pause improves the acceptability (10a), and the additional insertion of *by the way* makes the sentence fully acceptable (10b). On the standard assumption, a pause and *by the way* only affect real-time linear order, not syntax. Thus, any syntactic attempt not based on linear order to account for sentences such as (1) cannot cover sentences such as (10), in principle.

Let us restate our informal generalization as in (6).

(6) The Linear Order Effects (observation):
The syntactic requirement the head imposes on an argument is effective only when the argument is "near enough" to the head in linear order.

Our task then is to clarify the notion of "near enough."

3 The Working Memory Model

3.1 The General Idea

The intuition underlying our overall approach is that the Linear Order Effects (6) is a result of the need for real-time processing (parsing or generation by a human agent).

Firstly, it is already observed that, after reading or hearing a sentence, a human reader only remembers its semantics (in the sense of the predicate-argument structure), not the syntactic form in which it was expressed; thus, in a recognition test, the subjects fail to correctly recognize the voice forms of the sentences they have encountered in the memorization phase.

Secondly, real-time processing proceeds "from left to right." Given that syntactic constituency is rather orthogonal to the left-to-right linear arrangement, real-time sentence processing crucially relies on short-term memory, or working memory, an assumption already assumed widely in the psycholinguistic literature.

The former observation suggests that the goal of parsing is to construct the semantic representation of the sentence; the detailed syntactic information of the sentence is only a means for that goal and hence get lost from memory once the goal is achieved. Given that the capacity of working memory is severely limited, then, it would be rather natural, and at least theoretically possible, that syntactic information of a sub-sentential expression is "expelled" from working memory even before the end of the sentence, as soon as it has played its own role for the goal of constructing the semantic content of the sentence. At the point when a given piece of syntactic information is "expelled" from working memory, that piece fails to exerts its influence on the processing the remaining parts of the sentence, which amounts to saying that any syntactic constraint loses its force at that point. Our idea is that this possibility is indeed real, and this is exactly what is behind the (un)acceptability judgments of the above sentences.

Although this is not the right place to discuss various models of working memory (or short term memory), we assume that some sort of activation model is correct. That is, to say that an item is in working memory is to say that that item is activated in a specific way. (That item might be an item previously stored in long term memory before processing the sentence in question or an item constructed on-line.) This assumption means that whether an item is in working memory or not is not a yes-no matter but rather a matter of degree; comletely "expelled" items (or those items not put in working memory in the first place) have the activation value of zero, completely active items have the full activation value, and there are also those items whose activation values are somewhere in between.

3.2 The Specific Details

Having illustrated the overall general idea, we now specify the details of our model, gradually.

3.2.1 Adjacency

Assume that a pharse (maximal projection) P_1 (here, conceived as a node) is selected by a phrasal head P_2, which should come after P_1. Once the processor has succeeded in constructing P_1, P_2 can be immediately constructed, on a "look ahead" basis, before actually encountering those words that are (or turn out to be) parts of P_2. At this point, P_2 is constructed in working memory, with syntactic information fully consistent with the requirements imposed by P_1.

Next, assume that a lexical head L selects, and hence imposes some syntactic information on, a phrase P_2 that should come after L. In such a case, too, once the processor has processed L it can immediately construct P_2 on a "look ahead" basis, which we assume the processor does. Thus, at this point, P_2 is put in working memory, with syntactic information fully consistent with the requirements imposed by L.

Whichever is the case, the next incoming words should ideally be those which are parts of P_2; otherwise, the processor's expectation is betrayed, the attention is detracted from P_2, and hence, the syntactic information on P_2 is deactivated, given the limited capacity of working memory.

Thus, in both cases, P_2 should ideally be adjacent to P_1 or L; otherwise, the syntactic constraint C dictated by the grammar on P_2 can fail to exert its effect on the processing of the sentence, a result of which is the acceptability judgment. In other words, the "degree of adjacency" influences acceptability judgments (given that it makes sense of the "degree of adjacency"): the further P_2 is from P_1 or L, the less severe the violations of C.

3.2.2 Syntax vs. Semantics

Our general idea is that contents in working memory is activated only to the degree they are useful for the construction of the semantic content, here understood as the predicate-argument structure. Thus, what we mean by the term "syntactic" above should be understood as "whatever information is not part of the predicate-argument structure." For example, the phonological content is clearly not part of the predicate-argument structure and hence is "syntactic" in the sense used here. Similarly for the information concerning number and person agreement, even if one assumes that agreement information is part of semantics, not syntax.[3]

3.2.3 The Deactivation Degrees

We have thus far proposed that the "degree of adjacency" determines the degree of deactivation. Usually, the term "adjacency" is understood as a yes-no matter, with no gray zone. However, given that the observed adjacency effects are a result of the deactivation in working memory, it will be natural to talk about the "degree of adjacency."

Now, what does it mean for two items I_1 and I_2 not to be adjacent? It means that some other item I_3 intervenes between I_1 and I_2. Thus, our thinking leads to the conclusion that the degree of non-adjacency is just the degree to which the intervening item I_3 deactivates the syntactic information on I_2.

With all those backgrounds, the observed (un)acceptability judgments can be explained in a uniform manner if something like the following deactivation rates, where 1.0 is the "fully activated" level, 0.0 is the fully deactivated (or "expelled") level, and the effects of the presence of intervening elements are additive:

- While processing I_3, where I_3 is an argument I_3, 1.0 is subtracted from the activation level of the syntactic information on I_1 and I_2.
- While processing I_3, where I_3 is an adjunct, .3 is subtracted.
- While processing I_3, where I_3 is a pause, .3 is subtracted.

In the next section we demonstrate that this model successfully acounts for the observed (un)acceptability judgments in a uniform manner.

4 Demonstrations

In this section we demonstrate that the above model successfully accounts for the judgments in question in a uniform manner, but before proceeding, a word about the theory of grammar is in order.

A processor is a device that constructs linguistic representations using the knowledge of grammar. Thus, the precise behavior of a processor depends on the theory of grammar. In our demonstration, we have HPSG in mind as the theory of grammar. However, our reliance on the specific architecture of HPSG is minimal, and we believe that our model can be implemented on other grammatical frameworks alike.[4]

4.1 Coordination

The observed generalization is that the head agrees with the closest conjunct, where the term "agree" is meant to cover both number/person agreement and syntactic part-of-speech requirements. We examine the part-of-speech requirements on complements and the number/person agreement on subjects, in that order.

4.1.1 Compelement Coordination

The relevant examples (2a–d) are repeated here as (7):

(7) a. John was thinking of Mary.

b.*John was thinking of that he was stupid.

c. John was thinking of Mary and that he was stupid.

[3]There is good evidence that number agreement sometimes affects the propositional content of the sentence, a favorite topic for one of us (for example, see Ishikawa 1998). However, the question of whether number agreement is semantic or syntactic (in the usual sense of the term) is a thorny and complicated question. We avoid a discussion of it and simply assume that it is not part of the semantic content (the predicate-argument structure), an assumption widely held in the GB/MP literature.

[4]The crucial features of HPSG we reply upon will be noted in footnotes.

d.*John was thinking of that he was stupid and Mary.

We assume that *of* in these examples requires an NP complement, as indicated by (7b). The generalization is that, given a configuration of the form:

V $[_X$ Y and Z]

only P_1, the first or closest conjunct, is required to obey the syntactic requirement imposed by V.[5]

Immediately encountering V, the processor constructs Y. At this point, the processor does not know yet[6] that the complement of V is a coordinated phrase, and hence, there is no point in positing Y. The incoming words are analyzed as parts of Y (Figure 4):

The syntactic requirements imposed by V on Y are fully active, and the part-of-speech of the first conjunct Y has to match the requirement by V; hence the unacceptability of Figure 5.

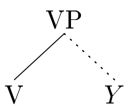

Figure 4: structure constructed by processor (doesn't encounter Y yet)

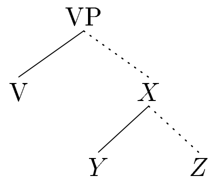

Figure 5: structure modified from already constructed structure

In contrast, upon encountering the conjunction (in this case, *and*), the processor has to modify the already constructed structure to something like the following:

X here is a newly constructed node here. However, at this point, 1.0 is subtracted from the activation level of the subcategorization information of V ($=I_1$), while processing the argument phrase Y ($=I_3$).[7] This means that the subcategorization requirement fails to be imposed on X and hence Z; hence the acceptability of (7b).

4.1.2 Subject Coordination

The relevant examples (4) are repeated here as (8):

(8) a. Either she or you are/*is wrong.

b. Either your brakes or your eyesight is/?are at fault.

c. Either your eyesight or your brakes are/?is at fault.

Here we ignore the presence of the expressions *either* and *or*.[8]

In (8a), I_2 is the VP node. First, assume that I_1 is the first conjunct, *she*. Immediately after processing *she*, the processor does not know yet that it gets coordinated with another NP. Thus, it constructs a VP node, with the third person singular agreement information. However, while processing the second conjunct *you* ($=I_3$), which is an argument, 1.0 is subtracted from the activation level of this agreement information on the VP node. Thus, third person singular agreement is not imposed on the VP node anymore. Also note that the agreement information on the first conjunct ($=I_1$) has also decayed at this point. On the other hand, at this point the mother node has to be constructed for the coordinate subject. The second conjunct has just been constructed, and hence, its second person agreement information is still active in working memory. Hence, the mother node for the coordinate subject bears the second person agreement information, hence the second person agreement on the VP and hence the head V.

Roughly speaking, a similar account applies to (8b–c).[9]

[5]Here we follow HPSG and most other syntactic frameworks (but not LFG) in assuming that a lexical head imposes part-of-speech requirements on its complements.

[6]Here the processor is assumed to be a parser.

[7]Here we are using the term "argument" in the sense that it is a semantic argument. It may or may not be an argument in the syntactic sense, depending on one's precise analysis of the syntax of coordination, which is beyond the scope of this paper.

[8]We discuss these expressions in a footnote, after giving the general idea of how our model works.

[9]Speaking precisely, this is not the case, since in (8b–c), we observe that agreement with the first conjuncts does not produce full unacceptability, which the above accounts predict.

4.2 Topicalization

The relevant examples (1a–b) are repeated here as (9a–b):

(9) a.*John was thinking of that he was stupid.

b. That he was stupid, John was thinking of.

In (9a), *of* is I_1, which constructs an NP node by "look ahead"; the subcategorization requirement of the P imposed on its complement is fully active. Thus, the processor expects an NP, an expectation betrayed here; hence the unacceptability.

In contrast, in (9b), things are radically different. Immediately after constructing the topic phrase node ($=I_1$), the processor constructs an S node by "look ahead." However, the processor next has to construct the subject NP, and then the VP node, and then the PP node, before reaching the P *of*. At least the NP and the PP are arguments. Thus, while constucting these nodes, the activation level of the topic phrase is fully deactivated and hence the part-of-speech information is no longer accessible. Hence the full acceptability of (9b).

4.3 Insertion

The relevant examples are repeated here:

(10) a.?Ken was thinking of, (pause) that he was stupid

b. Ken was thinking of, by the way, that he was stupid.

In (10a), a pause ($=I_3$) in inserted between *of* ($=I_1$) and the node for the *that*-phrase ($=I_2$). According to our mode, when actually encountering the words comprising the *that*-clause, the syntactic information on I_1 and I_3 have changed from 1.0 to 0.7 (=1.0-0.3), hence the degraded status of (10a).

In (10b), there are three intervening elements, the inserted phrase *by the way* (which is an adjunct) and the two pauses surrounding it. Each element substract .3 from the activation level of I_1 and I_3, the additive result is .9 subtraction ($.9 = .3 times 3$), which we assume is large enough and can be equated with 1.0 subtraction.[10] This means that the syntactic requirement imposed by *of* is effectively erased from working memeory, and (10b) is correctly predicted to be fully acceptable.

5 Semantic Constraints

One interesting observation is provided by Bayer (1996), who observes that *despite* rejects a *that*-clause complement, even when the clause is a non-first conjunct seperated from it by some other conjunct(s).

(11) a. Despite [LaToya's intransigence], Michel signed the contract. (NP)

b. Despite [the fact [that all the musicians quit]], Michel signed the contract. (NP)

c.*Despite [that all the musician quit], Michel signed the contracs. (*that*-clause)

d.*Despite [LaToya's intransigence] and [that all the musician quit], Michel signed the contract. (NP conjoined with *that*-clause)

We suspect that this complication is related to the presence of the expressions *either* and *or*. While the proper syntactic analysis of the *either ... or* construction is not at yet clear, one possible line of analysis would be one in terms of Construction Grammar, of which HPSG can be seen as an instance. If the general idea of Construction Grammar is assumed, it is plausible that the pharase *either X or Y* is stored in long term memory as an underspecified phrase, which is put in working memory as it is. This would significantly complicate the story, depending on whether such a construction counts as an argument or an adjunct. We suspect that the mild unacceptability in question is due to such complication, but we have to leave this issue to future research.

[10] We could alter the degree of subtraction in the previous section from .3 to $\frac{1}{3}$ without affecting the story at all, in which case the prediction is 1.0 subtraction.

This suggests that the constraint that *despite* imposes on its complement does not follow the pattern dictated by our model.[11] We mention this seeming counterexample in order to illustrate more precisely the nature of our model.

5.1 Contentfull and Contentless Prepositions

It is rather an old observation in the HPSG literature that English Prepositions have two kinds: those predicative Preposition with semantic content (P[+PRD] in the usual HPSG treatment), and those which only serve as a sort of case marker and hence are without semantic content (P[-PRD]). For example, in (12), the first *for* is a mere "case marker" with no semantic content, whereas the second *for* does have semantic content and says that the complement's referent is the person who benefits:

(12) Ken is waiting for Naomi for me.

The observation that *despite* does not follow the pattern dictated by our model and exhibited by *of* in (1) and (2) is, we assume, due to the fact that the former is a contentful P[+PRD] while the latter is a contentless P[-PRD].

Let us assume that only contentful heads can (but do not necessarily have to) impose semantic restrictions on their complements. Thus, *despite* imposes semantic restrictions on its complement, while *of* in question does not. But what kinds of semantic restrictions are imposed by *despite* ?

5.2 Selection Restrictions and the Classifications of Events

A classical argument against the possibility of giving a semantic account of the so-called Complex NP Constraint is that, while a mere *that*-clause allows extration from an element inside it, a supposedly synonymous complex NP *the fact that ...* does not. Putting aside the issue of how observations that motivate the Complex NP Constraint should be accounted for, this argument is clearly invalid. Various nouns other than *fact* can take a *that*-clause complement, as in:

(13) the fact/rumour/claim/... that ...

Thus, the natural assumption is that a bare *that*-clause is neutral as to whether it expresses a fact, a rumour, or a claim, etc. (cf. Asher 1993). Let us call the distinction between a fact, a rumour, a claim, etc, **P-SORT** (short for "proposition sort"). Hence, a bare *that*-clause is not synonymous, for they differ with respect to P-SORT.

The above observation can be expressed in at least the following two ways:

- The P-SORT of a bare *that*-clause is underspecified.
- The P-SORT of a bare *that*-clause is *nil*, a special sort that is distinct from those sorts such as *fact*, *rumour*, *claim*, etc.

If things are formulated in HPSG, in which case P-SORT will be adopted as a semantic feature whose value is the actual sort, the former analysis means that the value can unify with any sort (it only says that there is no constraint by the grammar on the sort):

(14) $\left[\text{SYNSEM}\,|\,\text{CONT}\,|\,\text{P-SORT} \quad [\;]\right]$

while the latter means that "I'm not anybody" is the sort and hence cannot unify with *fact*, *rumour*, *claim*, etc.:

(15) $\left[\text{SYNSEM}\,|\,\text{CONT}\,|\,\text{P-SORT} \quad \text{nil}\right]$

Both analyses can be formulated in HPSG, but if we choose the latter (i.e. the relevant portion of the feature structure of a *that*-clause is as described in (15) and assume that the lexical entry for *despite* is something partially described in Figure 6), our model makes the correct predictions where we assume that the lexical entry for *fact* is partially described in Figure 7:

[11] This leads one to wonder how the requirements imposed by *despite* manifest in such extraction constructions as topicalization. However, as Huddlston, Pullum and Peterson (2002) point out, *despite* does not allow extraction of its complement in the first place:

i *Here is a list of the objectors, [that they went ahead [despite __]].

and thus we cannot examine whether it follows the patter or not in extraction constructions.

$$\begin{bmatrix} \text{SYNSEM}\,|\,\text{LOC} \begin{bmatrix}\text{CAT}\begin{bmatrix}\text{HEAD} & \text{P}\\ \text{COMPS} & \langle \boxed{1} \rangle\end{bmatrix}\end{bmatrix} \\ \text{ARG-ST}\ \boxed{1}\begin{bmatrix}\text{SYNSEM}\,|\,\text{LOC}\,|\,\text{CONT}\begin{bmatrix}\text{P-SORT} & \neg\, nil\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

Figure 6: A partial description of the lexical entry of *despite*

$$\begin{bmatrix} \text{SYNSEM}\,|\,\text{LOC} \begin{bmatrix} \text{CAT}\begin{bmatrix}\text{HEAD} & \text{N}\\ \text{COMPS} & \langle \boxed{2} \rangle\end{bmatrix} \\ \text{CONT}\begin{bmatrix}\text{P-SORT} & fact\\ \text{P-SOA} & \boxed{3}\end{bmatrix} \\ \text{ARG-ST}\ \langle \boxed{1}, \boxed{2}\begin{bmatrix}\text{SYNSEM}\,|\,\text{LOC}\,|\,\text{CONT}\begin{bmatrix}\text{P-SORT} & \neg\, nil\\ \text{P-SOA} & \boxed{3}\end{bmatrix}\end{bmatrix}\rangle \end{bmatrix}\end{bmatrix}$$

Figure 7: A partial description of the lexical entry of *fact*

When it takes a *that*-clause complement, the clause unifies with $\boxed{2}$, which structure-shares the P-SOA value $\boxed{3}$ with the head noun *fact*. In other words, the propositional content is "inherited" from the *that*-clause complement to the head noun *fact*, and hence to the whole NP *the fact that ....* On the other hand, the *that*-clause complement and the head noun *fact* have distinct P-SORT values: *fact* and *nil*. That is, the propositional sort is not inherited. Thus, while a bare *that*-clause bears the [P-SORT nil] specification and hence rejected by *despite*, such an NP as *the fact that ...* bears the [P-SORT fact] specification, which successfully unifies with the [P-SORT ¬nil] requirement imposed by *despite*, and hence can successfully combines with it.

The assumption that *despite* requires a non-nil complement is a reflection of the intuition that the complement of *despite* has to denote something which is already established and somehow presupposed. For example, in (16a), the fact that the content of the *that*-clause is a rumour/claim etc. is already established and presupposed:

(16)

despite the rumour/claim that ...

*despite that ...

In contrast, in (16b), only the P-SOA (the propositional content) is stated. The propositional content is expressed even by an imperative, and hence, by itself does not establish anything. This is the cause of the unacceptability.

In short, we suggest that the real generalization is not that *despite* rejects a non-NP complement but rather that it rejects a complement which resists a factive (or presuppositional) reading. Indeed, many NPs allow a factive interpretation in this context, and hence, the inherent factivitity is not in question. Our choice of assigning the *nil* as the P-SORT value to a bare *that*-clause, instead of simply underspecifying it, reflects this observation: it claims that it is *not* anything that can be understood as a factive.

5.3 The Survival of Semantic Constraints

Remember the intuitive idea behind our model: the requirement imposed by a linguistic item on another item decays in working memory to the extent that it has finished playing its role for the constrution of the semantic content. This means that semantic constraints should survive, irrespective of word order; they survive even after the processing of the whole sentence is well finished.

This in turn means that the semantic constraint imposed by *despite* survives, no matter what the word order is. That is, it requires a complement whose P-SORT value is not *nil*. This is why a bare *that*-clause is not allowed even as a second conjunct.[12]

[12] Shûichi Yatabe (p.c.) points out that a bare *that*-clause is sometimes interpreted as a fact:

6 Discussion

Our model successfully gives a uniform account of the observed (un)acceptability judgments, but the success partially owes to the price we have paid: the stipulation of numerical degrees of deactivation. Indeed, it makes a good sense that this is a stipulation; we have decided the numerical degrees so that our model would give the correct predictions for (10a–b). To the extent that the numerical specifications have no independent evidence, our account of (10a–b) could be called a mere paraphrase of the observed degrees of unacceptability, or a translation of the observation to a description in terms of working memory.

However, while a mere observation makes no further empirical predications, our "paraphrase" or "translation" definitely does. Although we have not confirmed the predictions at this point, a model or theory which makes unexpected empirical predictions indicates a future research agenda and hence is fruitful, we assume.

In this section, we first point out that our account makes at least one further, independent predication. And then we conclude this section with a somewhat speculative remark.

6.1 Phonological Priming

The conceptual justification for our assumption that "syntactic" information decays in working memory is that the goal of processing a sentence is to produce a semantic representation, and hence, it is costly to keep an item active in working memory even after it has become useless and is something that a human processor is likely to avoid. This predicts that phonological information becomes deactivated too (possibly even before purely syntactic information becomes deactivated).

This prediction could be empirically tested. A word is known to cause various priming effects. For example, assume you assign a lexical decision task to the subjects in a controlled experimental setting[13] and measured the response time (RT). The RT for the test word becomes faster if you had presented another word that has a close semantic relation with the test word beforehand, than if you hadn't, in which case psychologists say that you have observed a(n) (indirect) semantic priming effect. Similarly, a similiar priming effect is observed if you had presented another word that resembles the test word phonologically beforehand, in which case you have observed a(n) (indirect) phonological priming effect. The usual assumption is that such a priming effect is observed only when the relevant semantic or phonological information is active in working memory. Thus, if our model is correct, we naturally expect not only that phonological priming effects disappear more rapidly than semantic priming effects but also that the disappearance rates of phonological priming effects correlate with the degree of the failure for the relevant syntactic constraints to manifest their effects.

Although we have not actually confirmed or disconfirmed these predictions, the numerical assignments in our model are not mere paraphrases of the observations to the exent that they make such independent predictions.

6.2 Timing vs. Overt Lingusitic Materials

In visual and auditory perceptions, the stimulus is often occluded by irrelevant noise, in which case the ability to restore those parts missing from the stimulus (or to reconstruct the whole shape of the original

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(i) a. [That John was drunk at that time] caused traffic accident.

b. [The fact [that John was drunk at that time]] caused traffic accident.

c. [That John won the lotto] surprised his girlfriend.

d. [The rumor [that John won the lotto]] surprised his girlfriend.

In (ia) and (ic), it does make sense that the subject is interpreted as a fact. We can point out that the verbs require the subjects to be interpreted as facts. On the other hand, the subjects in (ib) and (id) presuppose that the content of the *that*-clause is a fact or rumor. That such a factivitity presupposition is operative is suggested by the degraded status of (ii):

ii ?[That John might won the lotto] surprised his girlfriend.

However, this suggests that a bare *that*-clause sometimes does allow a "fact" interpretation, i.e. as a [P-SORT fact] phrase, an observation rather in conflict with the account illustrated in the main text. A discussion of this conflict is left for future research.

[13] A lexical decision task is a task to decide whether the presented stimulus "word" is a real word in your native language or a fake word that in fact is not a word in your language.

stimulus based on the observed parts) is crucial for the survival of the agent. However, two cases should be distinguished: those cases in which some parts are simply missing, and those cases which the missing parts are replaced with some "noise." Automatic perceptual restoration occurs only in the latter case. For example, a sequence of discrete pure tones seperated by silent intervals is perceived as just that, a series of pure tones and silent intervals (no restoration). However, if an appropriate white noise inserted into each silent interval, suddenly it is perceived as one continuous pure tone with white noises imposed on it (restoration).[14]

Those two cases can be conceptualized as those cases in which the expected material (a pure tone) is simply missing and those cases in which something unexpected (a white noise) is present. Thus conceptualized, the distinction begins to sound relevant to our discussion of the linear order effects. In sentence processing, the distinction corresponds to the distinction between (A) those cases in which the expected expression is simply missing and (B) those cases in which an unexpected expression appears. But what counts as an "(un)expected" expression?

In our present model, the presence of a pause and the presence of an adjunct are assumed to have the same numerical effect, as opposed to the presence of an argument. If a pause does not count as an "unexpected expression," no parallelism could be pointed out between our present model and the above observation in visual and auditory perception. However, what if a pause does count as an "unexpected expression" ? In other words, if we want to seek for some non-trivial parallelism, we would have to assume that a pause does count as an "unexpted expression."

Of course, we are not saying that the results of an unexpected shape of the stimuli are the same in the linear order effects dealt with in this paper and the observation in perceptual psychology. (Definitely we are not dealing with "restoration.") However, if our present model is on the right track, it suggests that a pause has a similar status as an overt linguistic expression such as an argument or an adjunct.

Note that we are not advocating that a pause should be conceived as a linguistic expression in the narrow sense (an empty category); a pause is only a silent time interval. Rather, the suggestion is that a time interval does make a difference, which is known to be the case in phonetic peception.

For example, suppose that *can* in (17b) is pronounced with a stress on it, in which case the vowel becomes indistinguishable from that in *can* in (17a) ([æ] in American English).

(17) a. I can do it.

b. I cán do it.

Crucially, [t] in (17b) is not released and hence fails to exhibit a burst, and because of the presence of [d] immediately following it, its presence or absence cannot be distinguished on the basis of the formant transition of the following vowel. Thus, in such a case, (17a–b) cannot be distinguished on the basis of overt sounds. Then, how are they distinguished in phonetic perception? They are distinguished on the basis of the presence of a silent interval between [n] and [d] in (17b) that is not found in (17a).[15]

If our model is on the right track, it suggests that the presence of a mere time interval exhibits an effect not only in phonetic perception but also in (un)acceptability judgments. If our reasoning is correct, the reason is obvious: both are something done in real-time. Real-time processing is, by definition, crucially time-dependent, and it would be rather surprising that information concerning time would exhibit no effect in human speech behavior in real time, subspecies of which are phonetic perception and (un)acceptability judgments. This suggests that lingusits should pay more attention to real-time processing than they have done.

7 Conclusion

In this paper we have proposed a specific working memory model to account for the (un)acceptablity judgments. The merit of our proposal argued for in this paper is that it gives a *uniform* account of the observed judgements, instead of formulating a seperate (syntactic) mechanism to account for each observation. Indeed, its further prediction is yet to be (dis)confirmed, and various technical details are yet to be refined. However, if on the right track, our approach suggests that linguists should pay more

[14] See (and hear) Bregman (1990) and Bregman and Ahad (1996) for a demonstration of this auditory restoration, as well as a demonstration of a similar restoration effects in visual perception and a discussion thereof. The well-known Phoneme Restoration Effect can be seen as a subspecies of this.

[15] We regret that we cannot point to the original literature; we owe this story to an informal introductory lecture on phonetics by Takehiko Makino (p.c.).

attention to the fact that (un)acceptability judgments are a result of real-time processing and hence is not immune to the working of the human processor. A seemingly grammatical phenomena is not necessarily grammatical.

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