A Lexical Semantic Approach to the Garden-path Effect and the Temporal Ambiguity

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1. Introduction

This paper investigates what causes the garden-path (GP) effect, the difficulty in interpreting so-called 'garden-path (GP) sentences,' exemplified as in (1):

(1) GP: The horse raced past the barn fell.[1]

(Pinker (1994: 211))

Most readers/listeners are 'led "up the garden path" to an incorrect analysis' (Pinker (1994: 211)) and fail to parse (1) correctly.

For the purpose of examining the factors that trigger the GP effect, it is helpful to compare GP sentences with temporarily ambiguous (TA) sentences, as in (2):

(2) TA: I knew the man hated me passionately.

(Pritchett (1988: 541))

The significant difference between GPs and TAs is that TAs can be correctly analysed, despite their potential for an incorrect parse during processing, while GPs can hardly be analysed correctly.

In this paper, I will propose the following hypothesis:

(3) a. When people process sentences, they deduce the

lexical conceptual structure (LCS) of the predicate verb (or of what they *believe* to be the predicate verb). Each constituent that appears in the LCS is co-indexed with the actual lexical input, with consideration given to syntactic/semantic adequacy.

b. A parsing reanalysis which discards an already co-indexed relationship is costly and causes the GP effect.

This paper is organized as follows: In section 2, I briefly review Pritchett's (1988) 'theta reanalysis constraint' approach and MacDonald, Pearlmutter, & Seidenberg's (1994) 'frequency-based' account, and point out some examples which they cannot explain. Section 3 illustrates how LCS determines the argument structure of sentences during processing. Also investigated here is how this lexical-semantic approach predicts parsing difficulties. In section 4, I will refer to some matters which require more detailed concern. Section 5 summarizes this paper.

2. Previous Studies

In this section, in order to show how the system of language processing is treated in previous studies, I review Pritchett (1988) and MacDonald et al. (1994). Hawkins (1994), who also suggests a significant approach to language processing, will

be referred to in discussion which is related to Pritchett (1988).

2.1. Pritchett (1988)

Pritchett (1988) provides a constraint on the process of syntactic parsing, which prohibits a certain reanalysis of θ-role assignments. It is called 'Theta Reanalysis Constraint,' described as follows:

(4) Theta Reanalysis Constraint (TRC):

Syntactic reanalysis which interprets a θ-marked constituent as outside of its current θ-domain is costly.

(Pritchett (1988: 545))

A simple definition of θ-domain is:

(5) θ-domain:

α is in the α θ-domain of β iff α receives the γ θ-role from β or α is dominated by a constituent that receives the γ θ-role from β.

(ibid)

Let us examine the GP-effect of (6), following Pritchett (1988).

(6) GP: I gave the boy the dog bit the bandage.

(Pritchett (1988: 566))

First of all, readers/listeners identify *I* as an NP. Then, g*ive* is identified as V and its maximal θ-grid is recovered:

(7) the maximal θ-grid of *give*

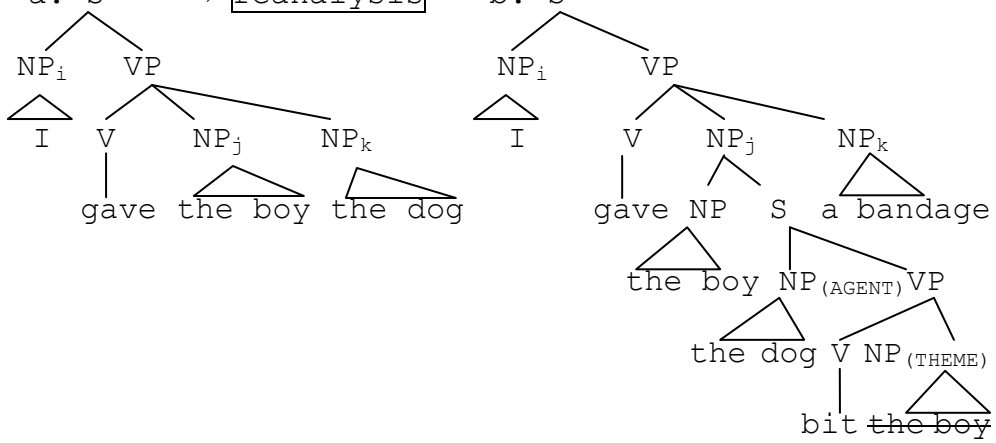
Source/Agent[2]	Goal	Theme
i	j	k

(Cf. Carnie (2002: 170))

As reading/listening proceeds, *the boy* and *the dog* are identified as NPs and assigned Goal/Theme respectively. At this point, a syntactic structure (8a) is constructed and the parsing is assumed to be 'finished,' since the maximal θ-grid of *give* is 'satisfied.'

However, when readers/listeners encounter another verb, *bite*, they need to reanalyse (8a) to (8b) in order to satisfy the θ-role assignment of *bite:* (Agent, Theme).[3]

(8) a. S → reanalysis b. S



This reanalysis removes *the dog* from the theme domain of *give* (indicated by the subscription 'k') and reinterprets it as the agent of *bite* within the relative clause construction, which results in a violation of the TRC. Pritchett (1988) claims that the GP effect of (6) is consequently predicted.

2.2. MacDonald, Pearlmutter, & Seidenberg (1994)

MacDonald et al. (1994) attributes the syntactic

ambiguities to the frequencies of (co-)occurrence of each lexical entity, and the weighing of probabilistic/grammatical constraints. They claim that the readers/listeners tend to be 'garden-pathed' when a certain lexical entity of the sentence is morphologically ambiguous and requires a relatively less frequent interpretation.

They illustrate the adequacy of this theory citing MacDonald's (1994) psycholinguistic experiment. Compare (9a-c):

(9) a. TA: The rancher knew that the nervous cattle *pushed* into the crowded pen were afraid of cowboys.

b. TA: The rancher knew that the nervous cattle *moved* into the crowded pen were afraid of cowboys.

c. The rancher knew that the nervous cattle *driven* into the crowded pen were afraid of cowboys.

(cf. MacDonald et al. (1994: 690))

In (9a, b), the italicized verbs (*pushed/moved*) show the main verb/reduced relative ambiguity. Sentences like (9a) are used as 'the biased transitive condition', for the ambiguous verbs (e.g., *pushed*) appear more frequently in transitive structures than intransitive ones; (9b) is an example of 'the biased intransitive condition,' since the verbs in this condition (e.g., *moved*) have higher frequency as intransitives than as transitives. (9c), in contrast, shows no ambiguity and hence is treated as a control condition: *driven* is unambiguously

analysed as a past participle because of its morphological form. As illustrated in (10), unergative verbs (e.g., *sleep*), which are purely intransitive, cannot appear in reduced relative construction.

(10) *The rancher knew that the nervous cattle *slept* into the crowded pen were afraid of cowboys.

(ibid)

(10) suggests that readers/listeners analyse less accurately the biased intransitive conditions with the reduced relative interpretation, because they assume the ambiguous verbs to be more frequent intransitives, which results in the GP-effect in the disambiguation region. The result of this experiment matches this prediction: Self-paced reading times (RTs) in the disambiguation region (i.e. *were afraid*) for the biased intransitives were reliably (33 milliseconds per word) longer than controls, while RTs for the biased transitives in the same region did not differ from unambiguous conditions.

Given the argument above, MacDonald et al. (1994) insist that computing the probabilistic relationship between lexical entities of the ongoing sentence plays a crucial role in syntactic processing.

2.3. Some problems with the previous studies

I now turn to some problematic evidence in approaches taken by Pritchett (1988) and MacDonald et al. (1994). Firstly, let us consider two problems with Pritchett's (1988) approach.

Pritchett (1988) bypasses a distinction between the GPs and the TAs. This lack results in the TRC's inability to capture the idiosyncratic status of the TAs: they are more difficult to parse than unambiguous sentences, but are nevertheless well understood, unlike GPs. To take a concrete instance, let us compare (11a) with (11b).

(11) a. TA: The student forgot the solution was in the back of the book.

b. The student hoped the solution was in the back of the book.

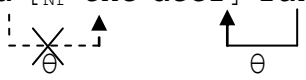
(Pinker (1994: 214))

In (11a), [$_{NP}$ the solution] is temporarily ambiguous (object NP/subject of the subordinate clause), because the predicate verb *forget* licenses both an NP and a clause as its object. Here, the reanalysis process that removes *the solution* from the object position of *forget* and attaches it to the TP,spec of the subordinate clause does not cause the violation of TRC, since [$_{NP}$ the solution] is dominated by the constituent which is assigned a θ-role by *forget*. In contrast, (11b) is unambiguous and has nothing to do with the TRC. Since *hope* takes only a clausal complement,[4] [$_{NP}$ the solution] should essentially be attached to its subject position. Therefore, the TRC account cannot explain the difference in processing difficulty between (11a, b).

More interestingly, Christianson, Hollingworth,

Halliwell, & Ferreira (2001) suggest that some TA sentences seem to be free from the reanalysis cost predicted by TRC violation. Their psycholinguistic experiment [5] reveals that many participants interpret [$_{NP}$ the deer] in (12) not only as the object of *hunt*, but also as the subject of *ran* (see (13a, b)).[6]

(12) TA: While Bill hunted [$_{NP}$ the deer] ran into the wood.



(Christianson et al. (2001: 373))

(13) a. Bill hunted [$_{NP=THEME}$ the deer]

b. [$_{NP=AGENT}$ The deer] ran into the wood.

Christianson et al. (2001) call this tricky interpretation 'Limited Repair' parsing, in the sense that the repair is 'limited' because the reanalysis that assumed to be conducted is not *complete* but merely *good enough*.

The process that removes [$_{NP}$ the deer] from the object of *hunted* and reattaches it to the subject of *ran* is a violation of TRC. Hence, the GP-effect is expected in the stimuli like (12). However, the result suggests that participants are not garden-pathed in spite of the TRC violation. Instead, they do not actually *remove* the already (incorrectly) parsed element unless some contextual information imposes.[7]

Next, I will consider counterexamples against MacDonald et al's (1994) approach. Here again, 'Limited Repair' parsing poses a question. Christianson et al. (2001) conduct another experiment whose procedure is the same as the one illustrated

above (see also fn. 5), but a unique class of verbs, namely semireflexive verbs are used. Let us look at this (14):

(14) TA: While Anna dressed the baby that was small and cute spit on the bed.

(Christianson et al. (2001: 389))

Unlike optionally intransitive verbs[8] like *hunt*, semireflexive verbs like *dress* are obligatorily understood as reflexive without a direct object. See (15):

(15) a. Bill dressed. = Bill dressed himself.

b. Bill hunted. ≠ Bill hunted himself.

The result shows that participants incorrectly responded 'yes' to the question '*Did Anna dress the baby?*' approximately 60% of the time in reading TAs containing semireflexive verbs, suggesting again that the first established syntactic relationships are not fully revised upon reanalysis. Since MacDonald et al. (1994) rely on the 'frequency' of each lexical item, this result is opposed to their prediction: because reflexive uses appear to have high frequency, (14) could be correctly (re-)analysed; there is no reason to persist in the first established syntactic relationships which turn out to be incorrect. Nevertheless, the result conflicts with MacDonald et al's (1994) prediction.

Pickering, Traxlar, & Crocker's (2000) eye-tracking experiment also raises a question in the frequency-based account. Their experiment employs sentences like (16a, b).

(16) a. TA: The young athlete realized her potential one day might make her a world-class sprinter.

b. The young athlete realized her exercises one day might make her a world-class sprinter.

(Pickering et al. (2000: 452))

(16a) is temporarily ambiguous because [$_{NP}$ her potential] could be the direct object of *realized*, as in (17a), as well as the subject of its clausal complement. In contrast, (16b) shows less (or no)[9] ambiguity since it is less plausible if the direct object analysis is adopted. Compare (17a, b):

(17) a. The young athlete realized her potential.

b. ?The young athlete realized her exercises.

According to Pickering et al. (2000), the verbs used in this experiment were chosen so as for the clausal complement analysis to be two times or more common than the object analysis for them.[10] Hence, if syntactic parsing was 'frequency-based,' then no reliable difference in eye-movement between (16a, b) would be observed. The result suggests that this was not the case: In the regions *before* the point of disambiguation (e.g., *might*), mean total time on the noun region (*her potential/her exercises*) was longer for (16b) than for (16a) and the postnoun region (*one day*) produces reliable differences in the right-bounded, regression-path, and total-time measures ((16b)>(16a)), which reflects the difference in adequacy between (17a, b); *after* the point of disambiguation, (16a) produces the reliably longer

right-bounded time than (16b) at the point where participants encounters the subordinate auxiliaries or verbs.[11] These results allude to participants' consideration to adequacy of the direct object analysis. Consequently, Pickering et al.'s (2000) experiment conflicts with the 'frequency-based' prediction, given that *realize* most frequently takes clausal complements.

3. A Lexical Semantic Approach

In this section I will propose an alternative model of language processing based on lexical semantic information of the predicate verb, which covers cases that are problematic for Theta Reanalysis Constraint and/or the frequency-based framework.

3.1. Lexical Conceptual Structure (LCS) of the predicate verb

In my proposal, Jackendoff's (1990) 'Lexical Conceptual Structure' (henceforth, LCS) plays an important role in determining the syntactic structure, especially the argument structure of the sentence that readers/listeners are processing. So, before applying it to GPs/TAs, it is helpful to review how sentences are analysed following the LCS approach. Let us consider this (18):

(18) $[\text{John}]_i$ entered $[\text{the room}]_j$

(cf. Jackendoff (1990: 46))

The LCS of the predicate verb, *enter* is given in (19):[12]

(19) enter

____ <NP_j>

[$_{Event}$ GO ([$_{Thing}$ JOHN]$_i$, [$_{Path}$ TO ([$_{Places}$ IN ([$_{Thing}$ ROOM]$_j$)])])]

(ibid)

As (18) and (19) illustrate, the conceptual structure corresponds to the syntactic one: The sentence corresponds to the entire event in conceptual structure, and the verb to the event-function GO. The subject is incorporated into the first argument of GO, and the object into the second argument.

With regard to language processing, it is necessary to make clear *when* the matching between arguments and actual inputs takes place. Although Jackendoff (1990) does not explicitly refer to this matter, the GP-effect provides strong support that readers/listeners try to identify possible constituents with arguments in LCS at every point during processing. Also importantly, semantic/pragmatic adequacy of the outcomes must be considered at the same time. For example, it is easy to predict the inadequacy of (20), even before the whole input:

(20) a. [?]Sincerity entered the room.

b. [$_{Event}$ GO ([$_{Property}$ SINCERITY]$_i$, [$_{Path}$ TO ([$_{Place}$ IN ([$_{Thing}$ ROOM]$_j$)])])]

(Jackendoff (1990:51))

In (20), [$_{NP}$ sincerity] can never function as the subject of *enter*, since its feature [Property] mismatches the conceptual

category which is licensed: the position indexed *i* is specified as a Thing. Consequently, readers/listeners notice that the derivation will collapse.

3.2. Relationships between LCS and GP/TA

This subsection investigates how the GP-effect and temporal ambiguity are predicted with LCS regarded as a key factor. To begin with, recall (11), presented here as (21):

(21) a. TA: The student forgot $[[_{NP}$ the solution$]_{j?}$ was in the back of the book$]_j$

b. The student hoped $[[_{NP}$ the solution$]_{*j}$ was in the back of the book$]_j$

As noted in 2.3., (21a) is temporarily ambiguous because *forget* can take either an NP or a sentential complement. *Hope*, in contrast, takes only a sentence as its complement. The partial LCSs for *forget* and *hope* are illustrated in(22a, b):

(22) a. $\begin{bmatrix} \text{forget} \\ V \quad \begin{Bmatrix} NP_j \\ S_j \end{Bmatrix} \\ \_\_\_\_ \end{bmatrix}$ b. $\begin{bmatrix} \text{hope} \\ V \\ \_\_\_\_ \quad S_j \end{bmatrix}$

Based on the difference in LCSs between (22a, b), we can readily account for the fact that (21a) is more difficult to parse compared to (21b), in spite of the superficial similarity: On one hand, in parsing (21b), readers/listeners univocally interpret $[_{NP}$ the solution] as an element of the subordinate clause (S_j) [13] because of the lack of any alternative possibility; in parsing (21a), on the other hand, they should

waver in parsing [$_{NP}$ the solution] because of its multiple possibility of interpretation. In other words, not only can this NP be interpreted as an element that appears in S_j, but also as NP_j, at the point of parsing [$_{NP}$ the solution], i.e. before the encounter with the disambiguating *was*.

I now turn to another example of TA/unambiguous contrast (16a, b), repeated here as (23a, b):

(23) a. TA: The young athlete realized her potential one day might make her a world-class sprinter.

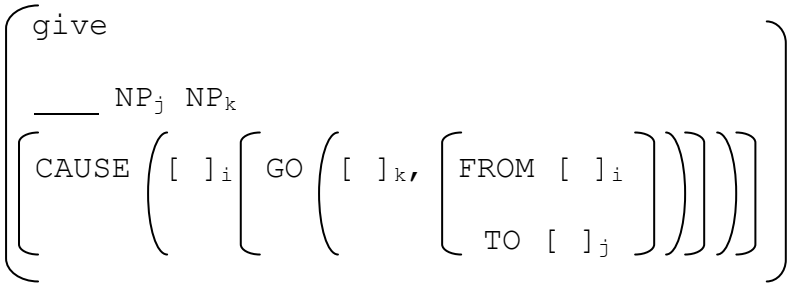
b. The young athlete realized her exercises one day might make her a world-class sprinter.

Unlike (21), it is not the selectional features of the predicate verb but the collocational adequacy between the predicate and its argument that alters the temporal ambiguity. As shown in (20), a semantically inadequate analysis is excluded during processing. Thus, the contrast between (23a, b) can be illustrated as follows: in (23b), readers/listeners avoid semantically peculiar interpretation [$_{VP}$ realized [$_{NP}$ her exercises]] and adopt the alternative option, [$_{VP}$ realized [$_{S}$ [$_{NP}$ her exercises]…]]. In (23a), the interpretation [$_{VP}$ realized [$_{NP}$ her potential]], which later turns out to be incorrect, is highly probable and hence displays a temporal ambiguity.[14]

Finally, I will propose an explanation to predict the GP-effect in LCS framework. Recall an example of GP (6), repeated here as (24):

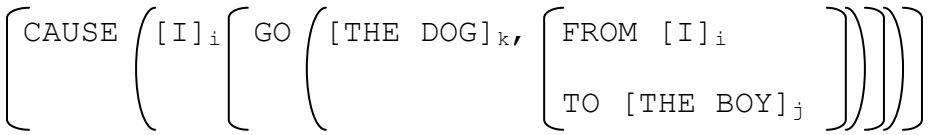
(24) GP: I gave the boy the dog bit the bandage.

LCS for *give* is sketched in (25):

(25)


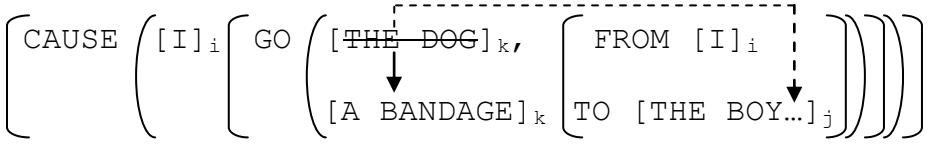
In processing (24), at the point of *I gave the boy the dog*, each NP (*I*, *the boy*, *the dog*) is co-indexed with the arguments indexed *i*, *j*, *k*, respectively, and the outcome is semantically adequate. See (26):

(26) $[I]_i$ gave $[\text{the boy}]_j$ $[\text{the dog}]_k$



However, the input of *bit* reveals that (26) is incorrect and makes a certain NP detach from this argument structure: *the dog* cannot anymore be indexed *k*. See (27):

(27) $[I]_i$ gave $[\text{the boy the dog bit}]_j$ $[\text{a bandage}]_k$



The significant difference between GPs (e.g. (24)) and TAs (e.g. (21a)/(23a)) is that GPs involve reconstruction of the ongoing relationship between the argument structure of the predicate verb and actual arguments, while TAs merely have more than one possible argument structure and no detachment process is required.

To conclude thus far, I have shown that the LCS approach provides a systematic explanation of certain difficulties that readers/listeners may face during language processing —— the GP-effect and temporal ambiguity. I propose the following principles in syntactic parsing stated as (28a, b):

(28) a. When people process sentences, they assume the lexical conceptual structure (LCS) of the predicate verb (or of what they *believe* to be the predicate verb). Each constituent which appears in the LCS is co-indexed to the actual lexical input, considering the syntactic/semantic adequacy.

b. A parsing reanalysis which discards an already co-indexed relationship is costly and causes the GP effect.

(= (3))

The GP-effect is predicted by (28b), and the temporal ambiguity is predicted by predicate verbs' LCS as well as syntactic/semantic adequacy of the resultant structure.

3.3. Multiple argument structures and unexpressed arguments

Obviously, a single lexical item often has multiple argument structures. For example, *dress* functions either as a transitive verb (*Anna dressed the baby.*) or a semireflexive verb (*Anna dressed in a new suit.*), and an unaccusative verb *break* displays the well-known 'causative alternation.' See (29) for

a concrete example:

(29) a. Pat broke the window.

b. The window broke.

(Levin & Rappaport Hovav (1995: 79))

In this subsection, I will address how sentences which contain these verbs are processed, considering the relationship between the underlying LCS of the predicate verb and unspecified arguments. This investigation is intended to provide some suggestion for 'Limited Repair Parsing.'

For the purpose of detailed examination, first I investigate a relationship between multiple argument structures and sentence interpretation. Levin & Rappaport Hovav (1995) claim that unaccusative verbs that display causative-alternation (e.g. *break)* are underlyingly causative and dyadic, even in the intransitive form. A rough LCS of *break* is sketched as (30):

(30) *break*: [[<NP_i> DO-SOMETHING] CAUSE [NP_j BECOME BROKEN]]

(cf. Levin & Rappaport Hovav (1995: 83))

The two subevents are characterized as the *causing* subevent: [<NP_i> DO-SOMETHING] and the *central* subevent: [NP_j BECOME BROKEN]. The causing subevent ensures that this verb is basically transitive. Causative alternation (in Levin & Rappaport Hovav's (1995) term, 'detransitivization') is possible precisely where the central subevent can occur without an explicit causing event. The derivation of (29a, b) is shown in (31a, b) respectively:

(31) a. [[NP_i DO-SOMETHING] CAUSE [NP_j BECOME BROKEN]]
[Pat]$_i$ [the window]$_j$

b. [[NP_i DO-SOMETHING] CAUSE [NP_j BECOME BROKEN]]
[Ø] [the window]$_j$

Consequently, (29b) is interpreted to mean that the window became broken without the intervention of an agent, although some unspecified external force definitely caused the event of breaking, since the window is unlikely to become broken spontaneously. Interestingly, when a described eventuality obligatorily involves the intervention of an agent, the agent can never be omitted:

(32) a. He broke his promise/the contract/the world record.

b. *His promise/The contract/The world record broke.

(Levin & Rappaport Hovav (1995: 85))

Notice that the above discussion provides some insights into language processing. Especially, 'Limited Repair Parsing' is well explained with the underlying LCS of the predicate verbs taken into account. (12) and (14), repeated below as (33a, b) are of typical examples for which 'Limited Repair Parsing' is adopted, according to Christianson et al. (2001):

(33) a. TA: While Bill hunted the deer ran into the wood.

b. TA: While Anna dressed the baby that was small and cute spit on the bed.

The ambiguities in (33) result from the multiple options of the subordinate verbs' argument structures: in (33a), transitive vs. intransitive; in (33b), transitive vs. semireflexive. A crucial fact for explaining why reanalysis in (33) is 'limited' while other TAs can be fully analysed is that the 'multiple' options are not in equal status but rather hierarchical. *Hunt*, for example, is basically transitive and takes a [+animal] direct object. It can *optionally* be intransitive where the direct object does not have to be specified, because of factors such as contextual information. In other words, when intransitive *hunt* is used, the [+animal] direct object is implicitly understood. However, (33a) has no such contextual factor, and the adjacent NP *the deer* is of the typical game of hunting. As a result, even when readers/listeners analyse again its relationship with the main clause, they tend to decide that it was the deer that Bill was hunting.[15]

Dress, in turn, is also basically transitive, requiring a direct object NP and a PP. According to Jackendoff (1990), the multiple argument structures of *dress* are unified like (34):

(34)
dress
V
____ <NP$_j$> <PP$_k$>
[CAUSE ([ ]$^{\alpha}_{i}$, [GO ([**{**α**}**]$_{\{j\}}$, [TO [IN [CLOTHING]]$_k$])])]

(Jackendoff (1990: 81))

In this notation, curly brackets mark the possible alternation

of LCS as mutually exclusive. Following Jackendoff (1990), the crucial constituent here is Theme, which has two *mutually exclusive* possibilities. It is either co-indexed to the direct object (NP_j) or else bound to the Agent (semireflexive use). In (33b), what appears right after this verb is [$_{NP}$ the baby]. Here, there could be two possible choices: either it is marked *j*, or it is interpreted as an element of another clause, with the Theme bound to the subject *Anna*. However, our knowledge of the world tells us that *the baby* is the typical Theme of *dress*, since babies cannot dress themselves without other people's help.[16] Rather, it is quite adequate to assume that they are dressed by someone (especially by their parents).

To conclude, 'Limited Repair Parsing' is captured as follows: The underlying LCS of the ambiguous verb has an optional slot to which the constituent that is *imperfectly* reanalysed can remain attached. The incorrectly parsed constituent is of a typical argument of the ambiguous verb and the whole sentence that results from the 'Limited Repair Parsing' is also semantically understandable.

3.4. Conclusion

To sum up section 3, (36a-c) illustrate how the GP-effect, temporal ambiguity, and 'Limited Repair Parsing' have been treated in this paper.

(36) a. GP-effect:

During processing, readers/listeners are to give

up the first-established relationship between the arguments that appear in LCS and the actual input and to detach a constituent from the already co-indexed argument position. This reconstruction process of the argument structure results in a strong difficulty in interpreting the sentence.

b. Temporal ambiguity:

There is more than one possible argument structure in LCS of the verb in question. If the resultant argument structure is semantically plausible in both cases, readers/listeners cannot determine the correct one until the disambiguation.

c. Limited Repair Parsing:

A constituent remains within the LCS of the former verb even though it is reanalysed as an argument of the latter verb. This is because the former verb basically licenses the argument and forms a typical collocation with it.

As such, this paper has presented a consistent analysis of language processing, which accommodates the unsolved cases in Pritchett's (1988) and/or MacDonald et al. (1994). In the next section, I will present some further issues that should be accounted for in future studies.

4. Residual Issues

One disadvantage of applying Jackendoff's (1990) LCS notation into language processing is that it abstracts away from aspectual information of sentences.[17] For instance, the LCS of *hunt* only tells that an [+animate] Agent hunts an [+animal] Theme, regardless of such properties as telicity, habituality, genericity, etc. However, in fact, aspectual information undoubtedly affects sentence interpretation. Compare (37a, b):

(37) a. Bill hunts (in the wood).

b. Bill is hunting (in the wood).

(37a) usually receives a habitual interpretation, which can be paraphrased as 'Bill habitually hunts (in the wood)' or 'Bill's hobby is hunting (in the wood).' It is only in a special case such as an 'instantaneous' present that it can describe an ongoing event. (See also Binnick (2005: 352)). In contrast, (37b) tells us that Bill is actually engaged in hunting at the speech time and hence there must be a certain animal that Bill is chasing. Therefore, the unexpressed Theme in the LCS of *hunt* should be highly activated in (37b), compared with (37a).[18] This gives rise to a reasonable prospect that with a progressive use, in (38b), [$_{NP}$ the deer] may have a strong tendency for the (incorrect) direct object interpretation, while (38a) may be open to an interpretation such as 'When Bill (*habitually*) hunts, the deer *often* runs into the wood:'

(38) a. When Bill hunts the deer runs into the wood.

b. When Bill was hunting the deer ran into the wood.

Discourse Representation Structure (DRS), proposed by Smith (2003), provides a possible solution to this issue. DRS enables us to include an 'aspectual viewpoint' into a description of the analysis of the sentence in question, which is interpreted from the form of the verb, its arguments, and adverbials – the latter sometimes in another sentence. Partial DRSs for (37a, b) are presented in (39a, b):

(39) a. 'Bill hunts.'

x y e
1. x = Bill
2. y = Ø
3. e: hunt (x,y)
4. e = Event
5. {Viewpoint (e) = habitual}

b. 'Bill is hunting'

x y e
1. x = Bill
2. y = Ø
3. e: hunt (x,y)
4. e = Event
5. {Viewpoint (e) = imperfective}

Indices *x* and *y* indicate each arguments, and *e* introduces the event of Bill's hunting. Line 3 is equivalent to the argument structure and line 4 specifies that the situation entity is an event. What is of the most remarkable is line 5: with DRS, aspectual information can also be systematically captured as one of the factors that determine sentence interpretation.[19] This fact suggests that DRS may provide more profound insights into language processing.

5. Conclusion

In this paper, I have argued that potential obstacles to sentence interpretation are coherently predicted by lexical-semantic properties of verbs and their arguments. Previous models of language processing have commonly been based on meagre and somewhat only 'superficially visible' factors such as a surface syntactic structure or a probable collocation. In fact, various features can simultaneously influence a sentence's possible interpretation. The proposed analysis can capture readers/listeners' computations of the *underlying* properties of elements in the unfolded sentence with LCS, and is available to describe not only factors in relation to traditional *competence* but for factors related to *performance* (e.g., our knowledge of the world). Therefore, I believe, this approach provides a more reliable explanation for language processing.

NOTES

[1] For convenience, garden-path sentences are labelled 'GP,' and temporally ambiguous sentences 'TA.'

[2] External theta roles, which are assigned to NPs appearing at the spec,VP position, are indicated by underlining the name of the θ-role in the grid.

[3] In relation to this point, Hawkins (1994) suggests an account on the basis of 'Early Immediate Constituents' (EIC). According to EIC, the human parser prefers (i) to (ii) (= (8b)), because larger number of words that intervene between the predicate verb (*give*) and the leftmost word of the last immediate constitute (IC) of VP (i.e. PP in (i) and NP_k in (ii)) makes it more costly to parse the sentence.

(i) I [$_{VP}$ [$_{V}$ gave] [$_{NP}$ a bandage] [$_{PP}$ [$_{P}$ to] the boy the dog bit]]
1 2 3 4

(ii) I [$_{VP}$ [$_{V}$ gave] [$_{NPj}$ the boy the dog bit] [$_{NPk}$ [$_{Det}$ a] bandage]]
1 2 3 4 5 6 7

EIC also explains the GP-effect on (ii); the structure which interprets [$_{NP}$ the dog] as an IC of VP is more preferable. However, this purely syntactic account is not sufficient to explain the whole case of language processing, as I discuss in 2.3 and the following.

[4] Precisely, of course, *hope* can also take an infinitival complement. This fact will not cause a temporal ambiguity, since the subsequent NP serves as a subject of the 'subordinate clause,' regardless of its finiteness.

[5] In this experiment, participants are asked to read target sentences like (12), as well as control conditions (see fn. 7) and irrelevant fillers. They are subsequently asked to answer the questions like '*Did Bill hunt the deer?*' The result is that the percentage of incorrect 'yes' responses in the target sentences is reliably higher. For details, see Christianson et al. (2001).

[6] This interpretation, inevitably, results in a violation of the theta-criterion, as stated in (i):

(i) Theta Criterion:
Each argument bears one and only one theta-role, and each theta-role is assigned to one and only one argument.
(Chomsky (1981: 36)

[7] The result of Christianson et al.'s (2001) experiment shows that in conditions where incorrect interpretations become semantically inadequate (e.g., *While Bill hunted the deer paced in the zoo.*), participants are less likely to leave the inadequate NPs in the object position of the subordinate clause. Compare (ia, b):

(i) a. Bill hunted the deer that ran into the wood.
b. ?Bill hunted the deer that paced in the zoo.

[8] Actually, Christianson et al. (2001) define them as 'optionally transitive'. However, verbs such as *hunt* or *eat* are underlyingly transitive, and can *optionally* omit its direct objects when they are already known or inferable from the context, meaning 'hunt something' or 'eat something'. Hence, I regard them as 'optionally intransitive.'

[9] Some might treat (16b) as a TA, but in fact, (16b) is not 'temporarily ambiguous' because, as shown in (17b), [$_{NP}$ her exercises] has little potential to be interpreted as the direct object of *realized*.

[10] This frequency bias is modulated in accordance with three pretests. See Pickering et al. (2000) for the precise data.

[11] The meaning of measures reported in this experiment (and relevant to my concern) is shown as follows:

(i) Total time: all fixation times within the region in question.
(ii) Right-bounded time: all fixations within a region before the eye fixates any region to the right of it.
(iii) Regression-path time: all fixations within a region and on prior regions, until the eye crosses the right boundary of the region.

[12] The broken brackets mean that the constituent is optional. Compare:
(i) a. John entered the room.
b. John entered.

[13] So, a conceptual structure can be embedded in another (superordinate) LCS. In (21), the LCS of the subordinate clause should be embedded at the point of S_j. Then [$_{NP}$ the solution] will serve as the external argument of the embedded LCS.

[14] This hypothesis is consistent with the result of Pickering et al.'s (2000) eye-tracking experiment; participants find more difficulty *after* disambiguation for (23a) but *before* disambiguation for (23b).

[15] In this connection, 'typicality' must have an important effect on *limited* or *full* repair on parsing TAs. Compare:
(i) a. While the boy was walking the dog barked loudly.
b. While the boy was walking the frog jumped into the pond.
Here, *dog* is a typical animal that is walked by its owner, but *frog*, in contrast, can hardly be walked (by its owner). Consequently, it seems that (ia) undergoes *limited* repair parsing, while (ib) is *fully* analysed.

[16] Also, the definiteness of the NP (*the* baby) seems important: other things being equal, [$_{NP}$ the baby] in (33b) is adequately interpreted to mean *Anna's baby* because '[*t*]*he* indicates that the head of the NP is considered [sufficient in the context to identify the referent].' (Huddleston & Pullum (2005: 91)).

[17] In Jackendoff (1991), he suggests a way to include aspectual information, features of which he assumes to be parallel to those on nouns and NPs, in his LCS approach. With this revised version of LCS, it seems possible to capture the contrast between (37a, b). Here, however, I use the DRS representation presented in Smith (2003) because of its advantage that it can also account for contextual factors on interpretation. Jackendoff's (1991) approach still abstracts away from them.

[18] A reviewer points out that objects are omissible not only in simple present structures but also in progressive structures:
(i) As she chops the lettuce for salad accomplishment, we talk and laugh. …. I notice a sense of urgency in the way she is chopping, and I ask if I can take over for her.
However, it is undoubtedly normal to interpret that the person who is denoted by 'she' is chopping *lettuce*, given the context in (i). Here again, like (37b), the unexpressed theme/patient must be compensated conceptually, with such aid as contextual information or common sense. Accordingly, I think that in dynamic interpretation, the omitted objects of the predicate verb should be accessed mentally, even though they are not explicitly present.

[19] As we have seen in section 4, DRS may be more informative than LCS. This paper nevertheless focuses on LCS, for the aim of proposing a *basic* principle of language processing; aspectual (and contextual) information is rather peripheral in the sense that it functions as an

aid to interpretation *only when available*.

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