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Subject: Parsing Optional Garden Path Sentences in Hebrew

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CONTENTS

ABSTRACT

The grammatical theory of parsing performance (Pritchett 1992) assumes a head-driven parser that bases its syntactic attachment decisions predominately through the use of theta grids of predicates. Under this assumption, the theory defines optional garden path (GP) sentences, e.g. *Katrina gave the man who was eating the fudge. The fudge* can be licensed by the third theta role of *give* or the second theta role of *eat*. If the latter occurs, a garden path effect will be experienced, since reanalysis will be required: The third role of *give* was not awarded in violation of the theta criterion. If the former occurs, then no garden path effect will be invoked, since it is the correct analysis of the sentence. The prediction is that optional GPs will manifest chance distribution of the occurrence of the GP effect, depending on the arbitrary decision of the parser.

Optionality does not exist within the garden path model (Frazier 1987), since the parser is not driven by theta grids. The model relies on two principles, Minimal Attachment and Late Closure. According to these principles, the human sentence processor favors attachments that introduce the least number of nodes to the syntactic tree (Minimal Attachment) but only in the window where processing is currently being carried out (Late Closure). In this study, the predictions made by Late Closure were empirically tested. In other words, the parser will always prefer to attach the second theta role of *eat* in the example above, in agreement with Late Closure. Thus the model predicts that optional GPs will demonstrate to have the same distribution of the occurrence of the GP effect as canonical GPs, for example in sentences such as: *After Dana drank water flowed from the tap*, that always invoke a garden path effect.

The obligatoriness of a theta role was also considered a factor that might influence the parsing of optional garden path sentences. In general, it was predicted that if the parser considers obligatoriness during on-line processing, then the third theta role of *give* would always be awarded first, since it is obligatory. Optional garden path would then be shown to be free from the garden path effect.

The study was designed to test which theoretical predictions were borne out by empirical results. Two experiments were conducted on native speakers of Hebrew. These were first given a canonical GP and an unproblematic sentence and were asked to specify which was the more difficult of the two. Then they were given stimuli sentences and

were asked to specify whether stimuli sentences were as difficult as the canonical GP or as the unproblematic sentence. The percentage of people that indicated a certain sentence type to be difficult was calculated, including contrasts between sentence types and the correlation between the distribution of the results and the distribution of chance for the relevant sentences.

The results obtained do not indicate that obligatoriness of theta roles plays a part in parsing, since the results show that optional garden paths were not entirely garden-path free. Neither do they support the predictions of Late Closure, since the percentages of optional GPs were significantly different from canonical GPs. Rather, the predictions made by the grammatical theory are valid since the results indicate more sporadic occurrence of the GP effect in optional GPs compared to canonical GPs. Nonetheless, it appears that the proximity to the theta-assigner (Late Closure) does play some role during processing. This perhaps led Frazier to conclude that Late Closure is a parsing principle that reflects the mechanism of the human sentence processor. Importantly, however, the results clearly indicate that proximity is not the underlying mechanism guiding the parser, but rather an additional factor. On the same note, Late Closure obscured the underlying mechanism of the human sentence parser.

The conclusion of the experiments have a profound impact on how human natural language processing is explained, since it weakens the status of the garden path model as one that accurately predicts the occurrence of the garden path effect. In fact, it has been demonstrated that in order to explain parsing performance one must rely on linguistic knowledge rather than observations on human performance alone. Furthermore, and most importantly, the success in accounting for processing phenomena in a simple and unified fashion as suggested in Pritchett's theory, both in English and in Hebrew, provides strong evidence that the heart of parsing theory, i.e. the mechanism of the human sentence processor, is derived from the theory of grammar.

CHAPTER ONE

Between Theories

1.0   Introduction

For many years, theoretical linguists were not engaged in the research of processing breakdown of sentences, a subject that belonged to the realm of psycholinguists. Indeed, long has been the discussion whether, and if yes, how parsing performance and grammatical competence are associated. Along the years, the questions whether grammar was psychologically realized and whether grammatical competence and parsing performance were related received several different answers. In the early 1960's the answer to this question was 'yes', in the late 1960's 'no', during the 1970's the answer was 'not really', and in the 1980's it was 'yes' (Frazier 1988). In the 1990's the relationship between grammatical competence and parsing performance was demonstrated in practice through several works of linguists (Pritchett 1992, Gorrell 1995, Weinberg 2001).

Bever (1970) was the first one who had supplied sentences that seemed to have a different psychological effect than any other sentences (examples will follow), making those potential candidates for the study of human performance. The so-called garden path sentences became the object of many psycholinguistic researchers. It was Kimball in his article from 1973 that postulated seven principles of parsing performance in natural language, relying on garden path sentences, among others. At the time, it seemed that the seven principles Kimball (1973) had postulated were observations on parsing performance, and had nothing to do with grammatical competence. Research was continued mainly by Frazier & Fodor (1978) and Frazier (1978). What came to be later known as "the garden path model" was an attempt to construct a model, which was less descriptive of the phenomena Kimball had previously pointed out, but rather had a more predictive nature. His seven principles were reduced to a theory of two, and it became the most influential and prominent theory of human sentence parsing among psycholinguists to this day. In practice, "the garden path model" deemphasized grammatical theory in natural language processing. On the other side of the spectrum, other researchers (Marcus 1980; Berwick & Weinberg 1984, 1985) held the opinion that grammar rather than the parser had a role in parsing performance and that one cannot

simply rely on observations on performance. It was Pritchett (1988, 1991, 1992), who delineated in practice and with much detail the relationship between parsing performance and grammatical competence through garden path sentences. In this, he challenged Frazier's theory especially with regard to the descriptive and predictive argumentations in her theory. Pritchett's theory is still being disregarded by psycholinguists in the claim that parsing performance is not a branch of theoretical grammar. Additionally, theoretical linguists are not occupied by performance issues, as their main concern is grammatical competence. This is the reason why Pritchett's theory remains a relatively unknown theory. The main purpose of this thesis is to distinguish between Frazier's and Pritchett's theories and to see which of their respective theoretical predictions are born out by actual parsing performance.

The first chapter of this thesis is dedicated to the definition of the garden path phenomenon and to the description of the relevant theories about garden path sentences. The second chapter will be concerned with the relevant theoretical predictions of each theory with regard to a special type of garden path sentences that might help decide which of the theoretical predictions are born out by parsing performance. The third chapter will present the first experiment that was conducted, and the fourth chapter shall delineate the second one. In the final chapter, a general discussion will be presented and possible directions for further research.

1.1   The garden path phenomenon according to Pritchett

It is a well-known fact that certain sentences prove to be extremely difficult for humans to process. Unlike unproblematic ambiguous sentences, garden path sentences invoke an effect, which originates in processing breakdown. In a garden path sentence, one is lead down a garden path, which ultimately causes this processing breakdown, whereas in ambiguous sentences, this is not the case. For instance, consider the following ambiguous sentence in Hebrew:

(1)   Ha-ba'al ha-zo'em hika et ha-iša im ha-garzen.

The husband angry hit ACC the woman with the axe.

The angry husband hit the woman with the axe.

a. The angry man hit [the woman with the axe]$_{NP}$.

b. The angry man hit [the woman]$_{NP}$ [with the axe]$_{PP}$.

The sentence does not appear to induce any conscious difficulty and it is unproblematic. This is because ambiguous sentences do not satisfy the basic notion of garden path sentences: that one must be led down an erroneous path to induce the effect: Both representations of the sentence are grammatical. In a garden path sentence, one path, the first one to be processed, leads to a violation of a global grammatical principle. Ambiguous sentences that occur in natural language do not mislead one into making a local parsing decision, which stands in contradiction to a global grammatical principle. Both syntactical analyses (1a) and (1b) are perfectly grammatical, whereas in a garden path sentence the first reading encounters a local failure in satisfying a global grammatical principle. There is another condition for the occurrence of the garden path effect according to Pritchett, which is the parser's inability to subconsciously reanalyze the sentence in order to obtain a grammatical representation. This is not the case in example (1) given here, as the parser obtains both syntactical representations without difficulty. In order to explain what the garden path phenomenon is, let us examine the following Hebrew sentence:

(2)   ¿axarey še-dana šateta ma'im zarmu ba-xacer.[1,2]

           After that Dana drank water flowed in the yard.

           After Dana drank water flowed in the yard.

The human sentence processor begins parsing the sentence. Upon arrival at the sixth word *flowed*, so it seems, the processor discovers something is missing, namely a subject

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[1] The reversed question mark indicates a garden path sentence.

[2] Garden path sentences are absent of punctuation or intonation in speech, and their acceptability in either modalities relies on the absence of this type of information. In a pilot experiment that was held within this work, most people naively asked whether garden path sentences of the type that contained object-subject ambiguity were lacking a comma, thus suggesting that the sentences lacked intonational cues and therefore were ungrammatical (essentially they meant that the GP effect would not occur in speech). As Pritchett (1992) points out in note 9, preposed adverbial clauses are not ungrammatical in the absence of punctuation:

(i)   After Mary drank she fell off the stool.

If prosodic cues or punctuation are intended to circumvent ambiguity in speech, it is not clear why they are not required (ii):

(ii)   Mary discovered the water had evaporated.

The conclusion is that prosodic cues help to circumvent garden path effects. Note that they cannot themselves force them. For instance, if one uses strong relative clause intonation, (iii) can be disambiguated:

(iii)   ¿The mortician told the mourners he was having trouble with to get out.

However if the same intonation is applied to (iv),

(iv)   The mortician told the mourners he was having trouble with the graves.

there is still no garden path effect. No intonational cues are required to interpret (iv), which is easily processed even in neutral speech, while intonational cues are required to prevent the GP effect in (iii). Thus, to claim that a sentence is ungrammatical because it lacks intonational cues is merely rephrasing the question of the occurrence of the garden path effect, but it does not provide an answer to the question.

for *flowed*. The processing of the sentence has failed and reanalysis is called for. One was lead down a certain "garden path" and found it to be grammatically defective. Specifically, the sentence contains object-subject ambiguity. Initially, the NP *water* is attached as an argument of the matrix verb *drank*, but as analysis continues, the parser notes that *flowed* misses a subject. The parser, being unable to correct this error, transfers the processing of the sentence to the conscious mind, an operation that invokes a severe garden path effect. The conclusion that should be drawn here is that ambiguity in itself cannot be the source of the garden path effect, but rather a failure in creating an appropriate syntactical representation that satisfies grammatical principles and the inability of the parser to correct it. Local ambiguity is a necessary condition but not satisfactory for the invocation of the garden path effect.

There are additional types of local ambiguities that are found in English and lead to the garden path effect, for example (a) main clause-relative NP ambiguity: *¿The horse raced past the barn fell*; (b) complement clause-relative clause ambiguity: *¿The doctor told the patient he was having trouble with to leave*; (c) lexical ambiguity: *¿The old train the children* or in Hebrew: *xulca tova'at ba nahar* (A drowning woman was saved in the river/A shirt was drowning in the river), where there is lexical ambiguity between an NP and a VP. Note that this type of sentence, incorporating lexical ambiguity, results in syntactic ambiguity. However, this work will focus on constituents whose lexical entry is clear, and not on problems that might arise because of an erroneous identification of a lexical category. The types of sentences in (a) and (b) will also not be the concern of this work, as Hebrew does not permit the omission of a relative complementizer as English does. Hebrew entertains other garden path sentences that incorporate (d) object-subject ambiguity; as demonstrated in (2); in English: *¿After Susan drank the water evaporated;* and (e) double object ambiguity (or ditransitive ambiguity): *¿Katrina gave the man who was eating [the fudge] [the wine];* in Hebrew: *¿ha anašim he-ifu la gorilla še ohevet le exol [botnim meluxim] [et hagar-inim]* (The people threw the seeds to the gorilla that liked eating salted peanuts). The Hebrew versions of types (d), (e) will be discussed at length later on.

1.1.0   The grammatical theory of processing[3]

In his book, Pritchett (1992) laid the grounds for a grammar-based theory, which contained a parsing algorithm. The main assumption in his theory is that the core of syntactic parsing consists of the local application of global grammatical principles, the first and foremost principle is the theta criterion (A definition follows). The parsing algorithm is able to predict the performance of human sentence processors and the occurrence of the severe effect associated with garden path sentences in various languages, thus gaining insight into the workings of human cognition. The algorithm is (definitions follow):

(3)   a. Input a word.

b. Recover lexical information, including category and theta grid, and project the appropriate XP(s).

c. Maximally satisfy the theta criterion via Theta Attachment (TA) as constrained by the Theta Reanalysis Constraint[4] (TRC).

d. If input 'ceases' affirm that the resulting structure satisfies all relevant grammatical principles (success); and if not (failure) invoke *conscious* reanalysis, by definition yielding the GP effect; otherwise continue to the next word.

(Pritchett 1992, p. 96).[5]

The definitions of the theta criterion and of Theta Attachment are **Theta Criterion**: Each argument *a* appears in a chain containing a unique visible theta position P, and each theta position P is visible in a chain containing a unique argument *a* (Chomsky 1986b). **Theta Attachment**: The theta criterion attempts to be satisfied at every point during processing given the *maximal* theta grid.

Now, let us demonstrate how the parse algorithm is carried out on the afore-mentioned Hebrew garden path sentence, repeated here:

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[3] The models that will be described in the following sections will deal with the attachment of arguments, i.e. constituents that assume structural positions that are accessible to theta role assignment. The attachment of adjuncts and quasi-arguments will be shortly discussed in the last chapter. .

[4] **Theta Reanalysis Constraint**: Syntactic reanalysis which reinterprets a theta marked constituent as outside of a current theta domain and as within a distinct theta domain is impossible for the Human Automatic Processor; where **Theta domain** is defined as: *a* is in the γ domain of β iff *a* receives the γ theta role from β or *a* is dominated by a constituent that receives the γ theta role from β.

[5] Pritchett (1992) further demonstrated quite convincingly that the Theta Reanalysis Constraint could be replaced by a purely structural constraint, which makes the need for the definition of the theta domain and the labeling of theta roles superfluous. The constraint, entitled the OLLC (On Line Locality Constraint) by Pritchett shall be discussed in the continuation.

(4)　　¿axarey še-dana šateta ma'im zarmu ba-xacer.

　　　　After that Dana drank water flowed in the yard.

　　　　After Dana drank water flowed in the yard.

Taking Prichett's theory seriously, it is assumed here, following Reinhart & Siloni (2001; also Altmann 1999; Boland, Tanenhaus, Garnsey, & Carlson 1995), that all constituents are stored in a buffer until attachment can be executed, namely once a theta assigner (a V or a P) is encountered. Abiding to this assumption, non-theta assigners are admitted to the buffer[6] with their lexical information. Once *drank* is encountered, which is a theta role assigner, it must satisfy Theta Attachment. Given its *maximal* theta grid, $<\theta_1,\theta_2>$, the assigner can license the NP *dana* with θ_1 and thus an attachment is generated:[7]
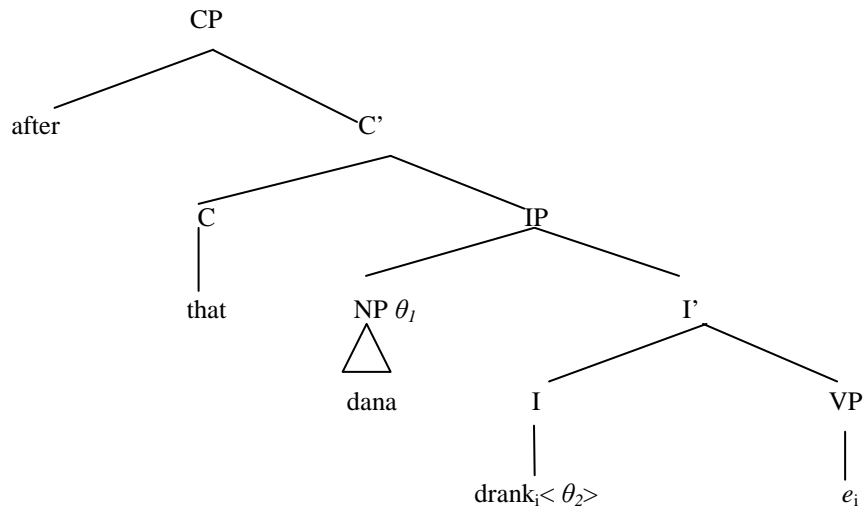
At this stage, TA might be considered to be *temporarily* violated since the second theta role cannot be assigned. However, this is not a violation of the principle of parsing (TA). As postulated, the parser *attempts* to satisfy the theta grid, but clearly, there is no NP to assume a theta role. Now *water* is admitted to the tree and assigned the second theta role. Consequently, TA is satisfied along with the theta criterion:

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[6] *After* is a theta assigner. However since it is irrelevant to the explanation, it shall be disregard.

[7] In Hebrew, there is evidence that the verb is raised from V^0 to I^0, and I shall assume the verb is raised at this stage.
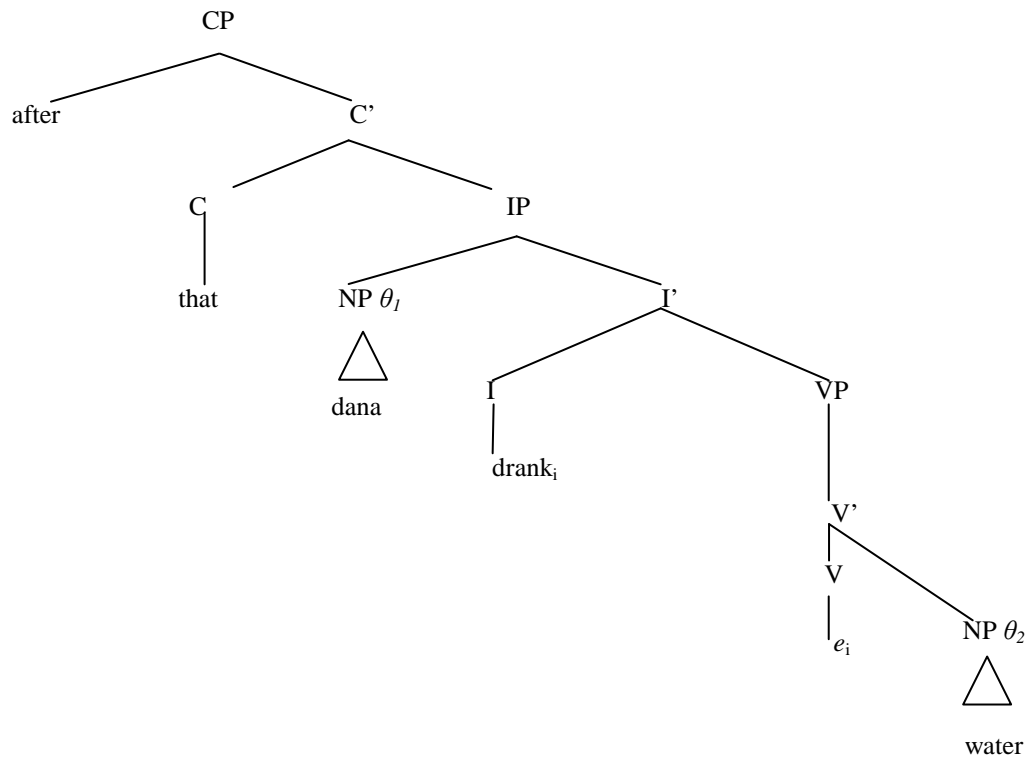
In the next step, *flowed* is admitted to the parse with its own maximal theta grid, $\langle\theta_1\rangle$, and it must satisfy the theta criterion through TA. Since the human sentence parser recognizes that there is no available overt NP that can receive the first theta role of *flowed*, and that satisfying the theta criterion would essentially mean directly reinterpreting the theta marked NP as outside of the current theta domain and within another, processing breakdown is experienced because the Theta Reanalysis Constraint (TRC) is violated. At this point, a short explanation is necessary about replacing the TRC with a different constraint. Pritchett introduced a purely structural constraint on reanalysis instead of the TRC, showing that grammatical configurations rather than surface word patterns determine proceessability. The large scope of predictions of the garden path effect made by the new structural constraint shows that parsing is syntactic at the core; an important distinction for other theories that rely on other non-syntactical assumptions. The new On Line Locality Constraint (OLLC), which replaces the TRC, relinquishes the definition of theta domain:

(5)   **The OLLC**: The target position (if any) assumed by a constituent must be *governed*[8] or *dominated*[9] by its source position (if any), otherwise attachment is impossible for the automatic Human Sentence Processor (Pritchett 1992, p. 101).

Returning to the parse of sentence (4), satisfying the theta criterion means directly transferring the theta marked NP from its initial position to another, an impossible move if the target position is not governed nor dominated by its source position. Consequently, the parse breaks down, producing the garden path effect. The transfer is carried out consciously; the NP *water* is removed from its source position and transferred to a new, target position. Looking at the final correct tree, it can be observed that the target position (marked by a square) of the theta marked NP is not governed by its source position (marked by an octagon), as the source position does not m-command the target position, and there are several maximal projections dominating the former but not the latter. This stands in clear violation of the OLLC:

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[8] (i) **Government**: *a* governs *β* iff *a* m-commands *β* and every *γ* dominating *β* dominates *a*, *γ* a maximal projection; (ii) **m-command**: *a* m-commands *β* iff *a* does not dominate *β* and every *γ* that dominates *a* dominates *β*, *γ* a maximal projection (Pritchett 1992, note 101).

[9] The disjunction between dominance and government seems to obscure a generalization. If the stipulation that in order for *a* to govern *β*, *a* must not dominate *β* were removed, then direct dominance would also constitute government, and the disjunction will be removed. Alternatives to these definitions can be definition of SPEC-head relations or defining government in terms of barriers (Chomsky 1986a). Note that this would be desirable, if government is indeed not a coherent and relevant notion and should be discarded (as suggested by Chomsky 1995). These possibilities require thorough investigation, but it is not directly relevant to the purposes of this work. Thus, the disjunction will be allowed to stand.

CP
C'
C IP
IP
NP θ₁
water
I'
I VP
flowed V'
V'
V
e_i
PP
at the yard
CP
after C'
C IP
that NP θ₁
dana
I'
I VP
drankᵢ
<θ₂>
V'
V NP
e_i
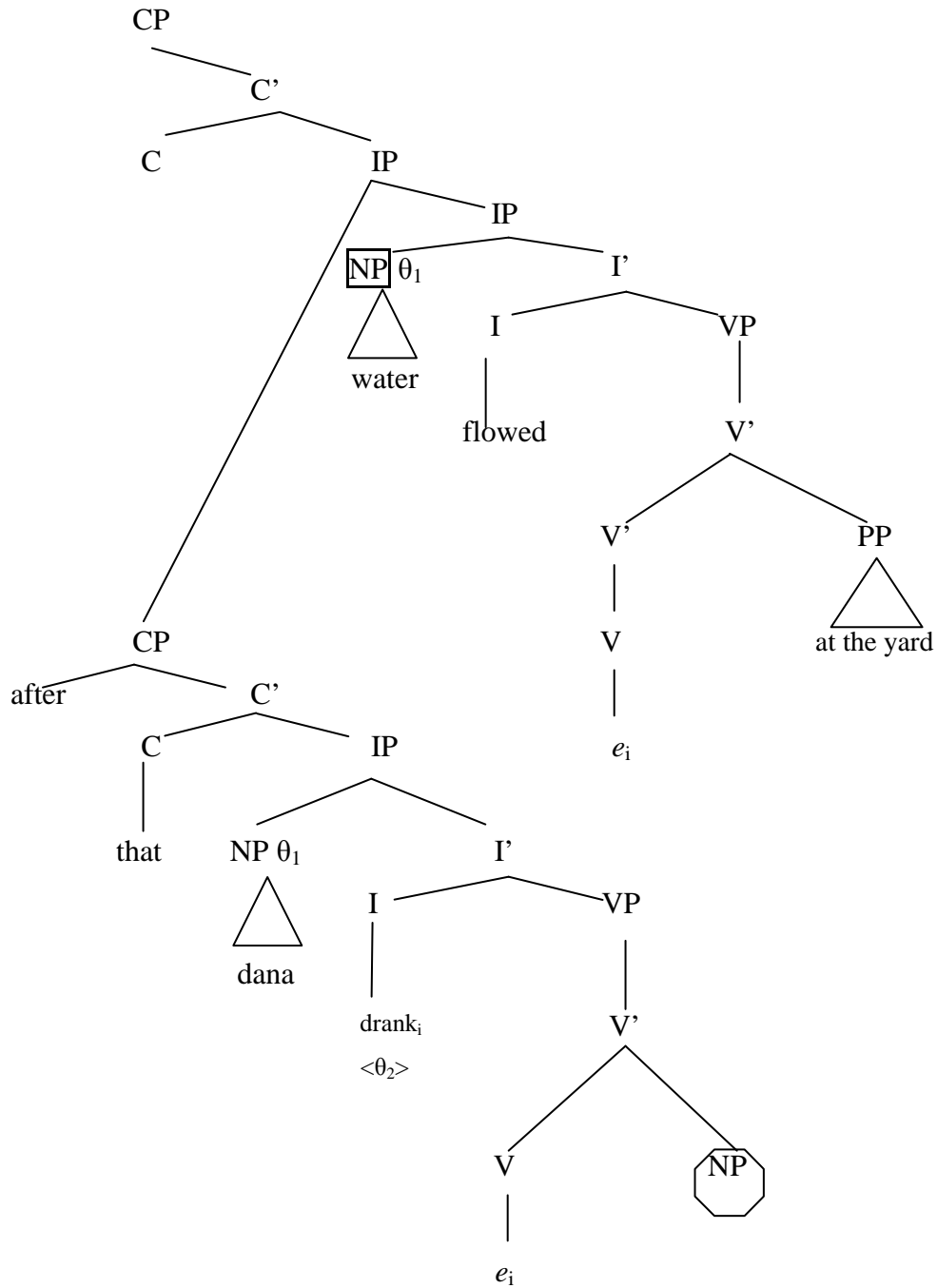
1.2 The garden path phenomenon and model according to Frazier

For expositional reasons, it would be convenient now to introduce the two principles of human sentence processing suggested by Frazier (1987), known as the garden path model:

(6)   **Minimal Attachment**: Do not postulate any potentially unnecessary nodes.

(7)   **Late Closure**: If grammatically permissible, attach new items into the clause or phrase currently being processed (i.e. the phrase or clause postulated most recently).

Returning to sentence (4), the Minimal Attachment principle predicts that *water* will be attached as the complement of *drank*, since if *water* indicated a new clause, this would essentially introduce another unnecessary node (another CP). The item is "closed" in accordance to the Late Closure principle, as attachment of *flowed* to the previous clause is not grammatically permissible. This strategy of processing the sentence is rendered incorrect and the transition from attaching *water* as the object of *drank* to attaching it as the subject of the consecutive clause is costly. This costly reanalysis is the source of the garden path effect.

In establishing her theory, Frazier relies on her many experiments that support her model of human sentence processing (Frazier 1978, 1983, 1988; Frazier & Rayner 1982, to mention but a few).   Note that Late Closure incorporates a condition that is based on grammar, only that it is not specified how grammar interacts with this principle, what is the practical implication of grammar on Late Closure, and what is the meaning of "being grammatically permissible". This fact renders the principle as descriptively adequate only. Therefore, the grammatical theory of parsing performance becomes more accurate as it defines the manner in which the parser forms structure: The parser is motivated by Theta Attachment, according to which the human sentence processor can decide which attachments it can undertake and generate structure. In that respect, the garden path model does not specify what guides structure building, only what is not structurally preferred.

Despite that, the garden path model is a prominent psycholinguistic model for explaining human sentence processing. It should be emphasized that in Frazier's model, *every* reanalysis is costly, even in ungrammatical or ambiguous sentences that might require reanalysis[10]. However, it is a well-established fact that ungrammatical sentences

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[10] Note that, as Pritchett (1992) points out in footnote 11, Frazier's definition of the garden path phenomenon is much broader than the one delineated in section 1.1. Essentially, she is satisfied with a local erroneous parsing decision that fails to produce the correct syntactic representation to define the garden path phenomenon (Frazier 1978). The terms "severe garden path" or "conscious garden path" are reserved to sentences where the parser is unable to correct the representation after making a local erroneous syntactic decision. Pritchett refers to weak GP sentences (The ones Frazier simply refers to as

do not evoke the garden path effect even if reanalysis is called for, which stands in contrast to Frazier's prediction.[11]

Until now, it has been illustrated that the theories make equal predictions with regard to the occurrence of the garden path effect. A test of their validity will be which of the success of one theory or the other in correctly predicting the occurrence of the garden path effect over a larger corpus of data. In the next section, theoretical considerations for preferring the grammatical theory of processing will be provided.

1.3   Preferring the OLLC over the garden path model

In comparing Frazier's model and Pritchett's theory, one must take preference to the theory that makes the right predictions concerning human sentence processing. Let us now consider an example where Frazier's model fails to make the right prediction:

(8)   a. ¿Ron warned Rex would die.[12]

   b. Ron knew Rex would die.

In sentence (8a) but not in sentence (8b) there is a garden path effect. Minimal Attachment and Late Closure predict the same parsing performance for both sentences. *Rex* would preferably be minimally attached as an object of the preceding V, and since the continuation is not grammatically permissible, this item will be closed. Once the human sentence processor realizes this parse is erroneous, reanalysis is required, in both sentences. Since reanalysis is costly, the garden path effect is predicted in both (8a) and (8b), thus making the wrong predictions[13]. Now let us examine the prediction the OLLC makes. Leaving out irrelevant parts of the tree, initially, this is the parsed tree:

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garden path sentences) as "unproblematic reanalyses" and (severe) garden path sentences are only the ones that satisfy both conditions depicted in 1.1. This terminology will be held here.

[11] The degree of the garden path effect might lead to confusion with regard to the predictions made here. The parsing algorithm by Pritchett predicts a severe GP effect, which causes breakdown and requires conscious reanalysis. Frazier predicts any reanalysis not to be cost-free and therefore to invoke a garden path effect. For an elaborate discussion over difficulty of processing, cf. Appendix A.

[12] Note that the dropping of *that* in (8a) cannot be the explanation for the obvious processing difficulty although *warned* seems to miss it. If *acknowledged*, which does not easily drop *that* is used in the same construction, still no processing difficulty is experienced:

(i)   Ron acknowledged Rex would die.

This is so because *knew* and *acknowledged* have the same theta grid and the same syntactic operation, occurs in both instances, which will be explained in what follows.

[13] It could be possible to claim à la Frazier that both sentences are parsed in the same way only that in (8b) reanalysis goes unnoticed. However, the mechanism, which allows it, is not clear, as shall be discussed in the continuation.

```
                    VP
         /                    \
        V                      NP
        |                      |
      knew                    Rex
```
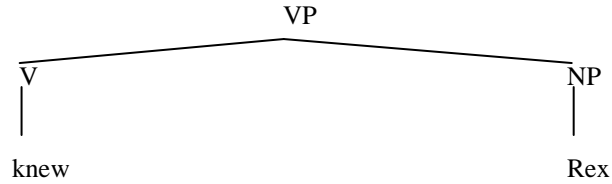
After the violation of the theta criterion has been discovered, reanalysis is required. The CP assumes the position of the NP, since the subcategorization framework of *knew* is: [_NP/CP]:

```
                    VP
         /                    \
        V                     [CP]
        |                      |
      knew                     IP
                      /                 \
                   (NP)                  I'
                    |              /           \
                   Rex            I             VP
                                  |             |
                                would          die
```
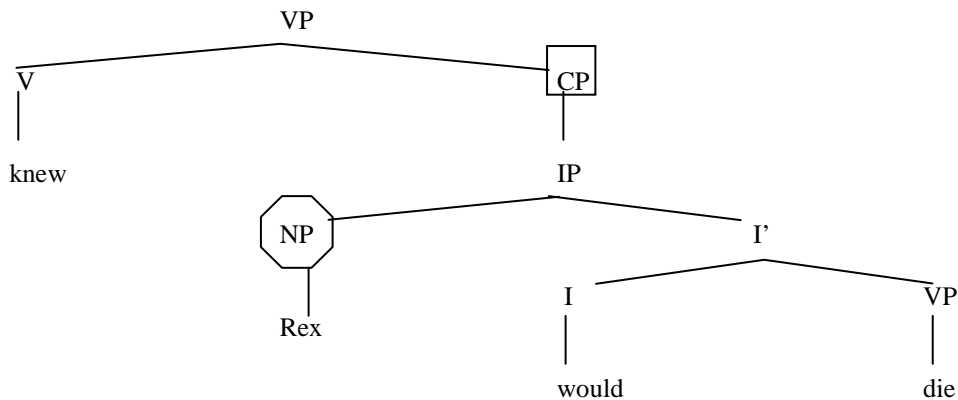
In the final tree, it can be observed that the dominance clause of the OLLC is satisfied and thus the prediction is correct: no garden path effect will occur in (8b). Now let us consider sentence (8a). At first, the sentence is parsed in the same manner as (8b):

```
                    VP
         /                    \
        V                      NP
        |                      |
     warned                   Rex
```
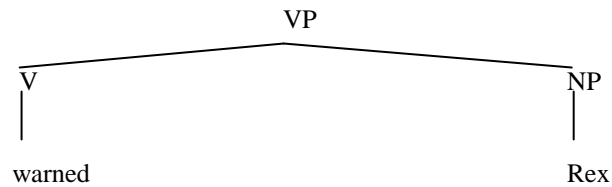
However, in the final tree, the first internal argument position does not govern the target position. This is so because the subcategorization frame of *warn* is: [_NP,CP]); and reanalysis moves *Rex* from the first internal argument position to the [Spec,IP] position of the relative clause. The source position clearly does not govern the target position, since there are several maximal projections intervening: an IP and a CP.

VP

V   NP   CP

warned

NP   IP

Rex   NP   I'

I   VP

would   Die
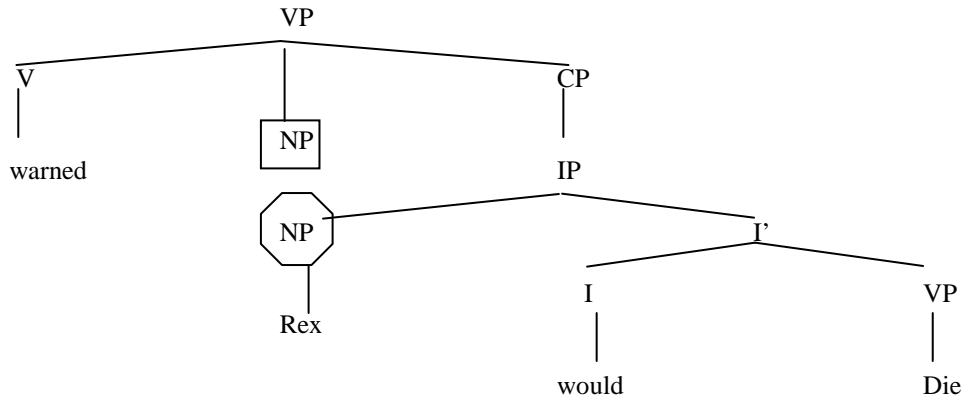
For these reasons, the OLLC correctly predicts a garden path effect in (8a) only, but not in (8b), in correspondence to actual performance.

There are additional considerations not to prefer the garden path model of sentence processing. Let us first examine Late Closure in isolation from Minimal Attachment. Late Closure is a mere stipulation from observations on human performance, and it in itself makes the wrong predictions concerning the parsing of non-garden path ambiguous sentences that are abundant in English. Consider (9):

(9)   Malcolm bought the book for Susan.

The preferred interpretation of (9) is (10a) rather than (10b):

(10)   a. [IP Malcolm [VP bought [NP the book][PP for Susan]]]

        b. [IP Malcolm [VP bought [NP [the book][PP for Susan]]]]   (Pritchett 1992)

The PP *for Susan* would be preferentially associated by Late Closure with the lowest node; the NP *the book*, thus leading to the wrong prediction that (10b) is the primary interpretation. Late Closure, as it stands in itself, is not preferred here. The interpretation of (9) could be saved by Minimal Attachment, since attaching the PP *for Susan* to the previous NP would create an additional higher NP, as in (10b), therefore preferring (10a). As can be seen, Minimal Attachment overrules Late Closure, because there is no such principle, its apparent effects are derivative. Another interesting case for not preferring Late Closure is the following sentence:

(11)   The daughter of the king's son admired himself.   (Reported in Frazier 1998)

Extreme difficulty was noted in an experiment conducted by Inoue & Fodor (1995) when *himself* was encountered. The difficulty arises since *the daughter* has been analyzed as the head of the subject NP and since it is a feminine noun, there is no appropriate antecedent for the reflexive *himself.* (The constraint being violated here is Condition A of

the Binding Theory.) Therefore, reanalysis of the internal structure of the NP is required so that *son* is analyzed as the head, giving rise to the meaning as set forth in (12):

(12)   Her (the daughter of the king) son admired himself.

Clearly, the parser's first decision as exemplified in (12) goes against Late Closure, otherwise *himself* would have been initially associated with *son*, as this is the phrase being processed. However, this goes against the first pass reading of the sentence and its apparent difficulty.

The main notion that Late Closure incorporates, namely proximity or locality effect, was further empirically tested by Konieczny (2000). In an on- and off-line experiment, the locality effect has been measured (roughly) by the number of words separating between the verb and its arguments, following Gibson (1998)[14]. The expectation was that the more words there were in between, the more time it would take to process the sentences. This, however, was not supported by the experiment, indicating that readers did not make preferences of locality. These findings shake the status of locality as a principle in on-line parsing.

As it seems, Late Closure, or the locality effect it incorporates, is not a principle in parsing. Nonetheless, it appears from psychological observations on attachment decisions that the parser makes *some* considerations of proximity (or locality), i.e. that the incoming constituent shall be attached to the previous phrase, which is the one currently being postulated. However, for reasons of clarity, the predictions relying on Late Closure shall be referred to as proximity in this work. Over a period of three years, a preliminary informal survey at the Tel Aviv University was conducted, and it seemed that proximity constituted a role in the parser's decision making-its status will be discussed late in this work.

The status of Minimal Attachment as a parsing principle is also dubious (cf. Pritchett (1992) section 5.1.1, p. 144 for a discussion; Holmes (1987); Phillips (1995); Phillips & Gibson (1996); Gorrell (1998) for experimental work on the matter). As

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[14] Gibson (1998) used the term "integration cost", i.e. that integration of constituents into the structure is costly. Integration cost monotonically increases as the function of the distance of the current item to its previous dependents. In German, the verb is final; therefore, if its dependents appear in the beginning of the sentence, the cost of integration increases. Hence, sentence (i) is expected to be more costly than sentence (ii).

(i)   *Er hat das Buch*, das Lisa gestern gekauft hatte, *hingelegt*.
        He has the book, that Lisa yesterday bought has, *laid down*.

(ii)   *Er hat das Buch hingelegt*, das Lisa gestern gekauft hatte.
        He has the book laid down, that Lisa yesterday bought has.

chapter two will reveal, the predictions of Minimal Attachment are orthogonal to this study, therefore they will not be the concern of this work.

Despite the persuasive argumentations to favor Pritchett's theory, it will be even more convincing to see which of the predictions each theory makes are borne out by experimental results. The way in which to do that will be the concern of the next chapter.

C H A P T E R   T W O

The Case of Possible Optionality

2.0   Possibly optional garden path sentences and their respective predictions

Another type of garden path sentences incorporates possible optionality in the manner with which the parse is to be carried out. This is predicted within the framework of the grammatical theory of parsing performance. An incoming NP for instance that appears after an embedded clause could have the option of receiving a theta role either from a matrix theta assigner or from an embedded theta assigner. Accordingly, a local erroneous parsing decision might lead to the invocation of the garden path effect, whereas the other one would not. The decision in which way to analyze the sentence is arbitrary, according to Pritchett, emanating in sporadic occurrence of the garden path effect, unlike sentence (4) that induces difficulty in every instance of a parse. Let us see now how the theoretical prediction is derived from Pritchett's Theory. The following sentence is predicted to be of this kind:

(13) $^{\checkmark}/_{\textrm{¿}}$ ha ima kilfa la yeled$_i$ še e_i axal tapuax.[15,16]

>   The mother peeled to child that ate apple.

>   The mother peeled for the child who was eating an apple.

The parse starts with the NP *the mother*, which is let in the buffer. The third constituent is a theta assigner that incorporates three theta roles in its theta grid. At this instance, attachment through TA can be attempted to satisfy the theta criterion. The first theta role is awarded to *the mother*. The following incoming constituent *to child* is licensed by the second theta role of *peeled* and attached as a complement. The sixth and seventh constituents *that ate* enter the buffer and are admitted to the second theta domain of *kilfa*. The parser can now create the CP, the relative clause, since a theta assigner has been

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[15] The sign "$^{\checkmark}/_{\textrm{¿}}$" indicates a possibly optional garden path sentence.

[16] As Pritchett (1992) notes, the actual *content* of theta role assignments in ditransitive constructions is often ambiguous, but this is not problematic:

(i) a. Louis gave the dog to Barbara.

   b. Louis gave the dog a treat.

In (i), the first NP may globally obtain a THEME or GOAL role. These ambiguities are not costly, and it does not appear that the semantic role involved may be a source of difficulty. Thematic role labels represent shorthand for discussing argument structure positions required by virtue of the theta criterion. Though the fact that a particular structural position is assigned a semantic role is indeed crucial, what the content of that particular role is not and therefore shall be ignored in this work.

introduced to the parse. The theta assigner *ate* has two theta roles maximum. Recall that TA requires the satisfaction of the theta criterion given the *maximal* theta grid: The first theta role of *ate* is awarded to the trace left by the operator in the relative clause. At this stage, the parser maintains two theta roles floating: the third theta role of *peeled* and the second theta role of *ate*. The last incoming NP can be licensed by the remaining third theta role of *peeled* or by the second theta role of *ate* (notice that the second theta role of *ate* is optional). So producing the correct attachment of the NP depends upon the local decision the human sentence processor makes. If the parser decides to discharge the third theta role of *peeled*, the parse would not invoke the garden path effect, as no violation of the theta criterion will come about. Alternatively, if the parser decides to issue *apple* with the second theta role of *ate*, leaving the third theta role of *peeled* in the buffer, the outcome would be a garden path effect. Since the third theta role of *peeled* must be discharged in order to yield a grammatical representation, since the role is obligatory, the NP *apple* is transferred from its current position as the complement of *ate* to the complement position of *peeled*. However, it is exactly this move that is barred by the OLLC, because the source position of *apple* does not govern its target position (the source position is within the embedded clause and the target position is within the matrix clause, so neither government nor dominance is possible). The OLLC predicts in this case that the garden path effect shall be invoked. Hence, the prediction here is that the parser makes an arbitrary decision, when faced with a surplus of theta roles to be issued onto a single constituent.

Now consider another similar case, where an NP immediately following the embedded verb must be interpreted as its complement but is locally misconstructed as a matrix object:

(14)　　✓/¿ Ha paselet natna la itonay še ohev ciyurim psalim.

　　　　The sculptress gave to journalist that liked paintings sculptures.

　　　　The sculptress gave the journalist that liked paintings sculptures.

Assume that Theta Attachment in (14) leads to making the incorrect attachment of *paintings* as the complement of *gave*, rather than *liked*. For *sculptures* to be interpreted as the complement of *gave*, reanalysis is required in which *paintings* is attached as the object of *liked*, but it violates the OLLC. The second complement of *gave* (the position originally occupied by *paintings*) does not govern its target position inside the relative clause

modifying the complement of *liked* since several maximal projections intervene, nor does it dominate it. Alternatively, had *paintings* been initially attached as the complement of *liked*, *sculptures* could have been attached as the complement of *give*. This is the correct analysis that does not lead to a local violation of the theta criterion, rendering the OLLC inapplicable. Like example (13), sentence (14) incorporates the possibility for arbitrary decision-making.

The arbitrary decision-making prediction described here à la Pritchett, viz. that individuals experience severe processing breakdown in this sentence or find it unproblematic, relies on impressions that were received from several informal experiments (cf. Pritchett (1992), notes 12, 111), although the experiments were not designed to study the question at hand. The experiments to be described in the continuation will put these predictions to test.

From now on, garden path sentences that Pritchett predicts to incorporate optionality shall be referred to as "possibly optional garden path sentences", since the tests here will attempt to examine whether these sentences indeed manifest the optional occurrence of the garden path effect. Frazier's theory has different predictions with regard to these sentences, as shall be discussed below.

2.1   The prediction of the garden path model

In sentence (13), the parse proceeds in accordance with LC and MA. Although in the previous section it was shown that Pritchett predicted an arbitrary decision-making, when considering the garden path model, no such quandary emanates. The parser attaches the NP *apple* as the argument of *ate*. If this attachment decision were not preferred, attaching *apple* as the argument of *peeled* would violate LC, as it is out of the clause currently being processed.[17] Thus, the prediction made by the garden path model is different from that of the grammatical theory. It is predicted that a garden path effect shall be invoked in all instances of parsing of this type of sentence, because reanalysis is required once it is realized by the parser that this was the incorrect attachment decision. The erroneous decision is not cost-free since it requires reanalysis and will therefore result in the invocation of the garden path effect.

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[17] Note that MA does not play a role in the attachment decision, both attachment decisions of the NP whether to the first or the second theta assigner introduce the same number of nodes.

Optionality in terms of making arbitrary decision is non-existent also in sentence (14). Although when *paintings* is entered, it can attach the NP as an argument of the embedded verb or the matrix verb. Late Closure prevents attachment of the NP to the latter, as it is out of the window currently being parsed. The second incoming NP *sculptures* must be then attached to the matrix verb. The parsing as predicted here leads directly to the correct syntactic representation of the sentence, removing the need for reanalysis. Whereas it is predicted by Pritchett that sentences such as (13) and (14) would have sporadic occurrence of the garden path, within the garden path model (13) would invoke a garden path effect at all instances of parsing and (14) would be unproblematic to process. In this sense, the two theories make distinct predictions with regard to human performance.

2.2 Another possible parsing strategy

The possible parses suggested in the previous sections however raise a question. Why would the parser not take into consideration the status of theta roles as obligatory or optional? Namely, why would it rather not discard the obligatory theta role of *peeled* first in (13), leading to a non-garden path sentence in all cases? On the face of it, it seems that the obligatoriness of theta roles could play a part in the parsing of sentences[18]. If it does, the prediction is that *an apple* in (13) will be given the third theta role of *peeled*, leaving the nonobligatory second theta role of *ate* in the buffer. This parse would essentially lead to a non-garden path sentence at all instances of the parse, as the correct parse is the first one to be produced. In sentence (14), both theta assigners have obligatory roles. As a consequence, the occurrence of the garden path effect depends on which theta role will be given first to the NP following the embedded clause. If the theta role of *gave* is

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[18] Pritchett dismissed the idea that Theta Attachment was guided by sublexical features such as role obligatoriness. Considering obligatoriness during parse of possibly optional garden path sentences would not yield the sporadic occurrence of the garden path effect in possibly optional garden path sentences (Pritchett 1992, p. 113, 114), as using this information biases the parse towards making a certain attachment. Pritchett gives three more objections to the notion of obligatoriness. First, there was no theoretical reason to assume that the parser *initially* discharges obligatory theta roles, when such an analysis creates a constituent (e.g. a relative NP) for which a role must be found, such as in the sentence:
(i) *The spaceship* destroyed in the battle disintegrated.
In (i) the first NP must await the initial discharge of the obligatory internal role after *destroyed* is encountered. Since it is true that a target for the obligatory role might appear at some later point in the input string, arguing for the primacy of role discharge over role receipt would be stipulative and unnatural. Second, the subject role is also obligatory, so that the primacy of an obligatory internal role over the external role is somewhat of a mystery. Finally, SV readings are normally primary (in (i) they are secondary); arguing against this order seems to be counter intuitive.

awarded first, then *psalim* will be left without a theta role, in violation of the theta criterion, leading to a garden path effect. If the theta role of *liked* is the one to be initially discharged, then this will lead to the correct parse of the sentence, and no garden path effect will ensue. All other things being equal, sentence (14) should demonstrate sporadic occurrence of the garden path effect, as the two relevant roles are obligatory.

People may largely differ in their sense of obligatoriness of theta roles. Notwithstanding, it is a fact of natural language that some verbs easily drop their arguments (such as *drink*, *eat*, *cook*), and others do not (*give*, *prepare*). In the sentences that were used in the experiments, the obligatoriness of theta roles was tested informally on a small group of people, using judgment tasks. Common verbs were used that were known to feature these properties: easy or difficult drop of arguments (such as in the verbs mentioned here).

2.3   The predictions according to the strategies

So far, it has been established that the possibility of optionality can occur due to surplus of theta roles emanating from two theta assigners that may be administered onto a single constituent. According to Pritchett, the distribution of the garden effect in possible optional garden path sentences (both (13) and (14)) would be chance, as the parser is guided by Theta Attachment, being oblivious to considerations such as obligatoriness or proximity, consequently making arbitrary decisions. It is then predicted that arbitrary decision-making will be exemplified by binomial chance distribution. However, in the experiment, it is not expected to obtain this pure statistical result, as there are always some unknown interfering circumstances. In order to see whether the results obtained are indeed what is expected to be, it is required to compare the results of possibly optional garden path sentences to garden path sentences that do not incorporate optionality and to sentences that pose no substantial difficulty to the human sentence processor. If the results of the optional garden path sentences fall in between the range of garden path sentences and unproblematic sentences, then this result can be considered to represent arbitrary decision making, although it might not be correlated with pure binomial chance distribution.

Structural proximity as manifested by Late Closure means that the garden effect would be invoked at all instances of reading of optional garden path sentences such as

(13). The expected distribution would assumingly be similar to that of garden path sentences. In sentences such as (14), the prediction is reverse and the distribution of the occurrence of the garden path effect should be similar to those of unproblematic sentences.

When taking into consideration a sub-lexical feature such as obligatoriness of theta roles and under the assumption that obligatory theta roles would be discarded of first, possibly optional garden path sentences of type (13) would not invoke the garden effect, as the correct parse is the first one to be generated. They would have the same status as of sentences that do not introduce any difficulty to the parser and that do not invoke the garden path effect. If a type of sentence such as (14) is considered, where both theta assigners have obligatory roles to discharge, then the distribution of results will be arbitrary, since it depends on the local decision the parser makes with regard to which obligatory role it will discard of first.

The following chapter is intended to describe the methodology that was used in this study in order to find out the distribution of the parsing decisions and thus determine the parser's mode of operation.

C H A P T E R   T H R E E

Experiment A

3.0   Methodology of experiment A

In table (3.1), examples of the types of sentences that were used in the experiment are given. In table (3.2), the predictions of the distribution of the garden path effect for each sentence type are shown with regard to each of the hypotheses discussed in the previous chapter:

Table (3.1): Examples of sentences

An example of the sentences according to type	The 3rd theta role of the matrix theta assigner is	The 2nd theta role of the embedded theta assigner is
Possibly optional garden path sentences		
Ha-davar masar la-iša še-memayenet mixtavim xavila. The postman delivered to the woman that sorted letters packet. The postman gave the woman that sorted letters a packet. These sentences will be titled **TYPE 2NP(ObOb)**: Sentences that contain two predicates ambiguity and two NPs.	Obligatory	Obligatory
Ha-melcarit natna la-baxur še-ohev lištot ma-im. The waitress gave to the guy that likes to drink water. The waitress gave the guy who likes to drink water. These sentences will be titled **TYPE 1NP**: Sentences that contain a subject relative clause with two predicates ambiguity and a single NP.	Obligatory	Nonobligatory
Canonical, non-optional garden path sentences		
Lifney še-dan hikri širim ši'amemu otanu.[19] Before that Dan read (aloud) songs bored us. Before Dan read aloud songs bored us. These sentences will be titled **TYPE GP**: Sentences that contain object-subject ambiguity.	Irrelevant	Irrelevant

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[19] This type of sentence was used for control. It is predicted that these sentences will invoke the garden path effect at all instances of parsing (above chance distribution).

<u>**Table (3.2): Predictions of distribution according to parsing strategies**</u>

Type of sentence (from Table 1)	Obligatoriness	Random	Proximity
TYPE 2NP(ObOb)	The distribution depends on which available role will be given to the first NP immediately following the embedded clause. The distribution then should be chance.	Chance distribution	No GP effect: Above chance distribution, like that of FILLER sentences (having no garden path effect); the NP following the embedded clause shall always be attached as the argument of the embedded verb.
TYPE 1NP	No GP effect: Above chance distribution, like that of FILLER sentences. The theta role of the matrix theta assigner shall always be assigned to the NP following the embedded clause.	Chance distribution	GP effect in all cases: Above chance distribution, like that of TYPE GP sentences.

3.1   The questionnaire

Seventy-two native speakers of Hebrew were given 28 sentences in random order (TYPE 2NP(ObOb), TYPE 1NP, TYPE GP and roughly equally complex FILLERS).

The questionnaire design was proposed by Iris Mulders (p.c.). First, the subjects were asked to rate two sentences with respect to one another. Sentence A was a TYPE GP sentence and sentence B was a non-garden path sentence (but roughly equally complex). The subjects were asked to circle the sentence that was more difficult[20]. Subjects, who thought sentence B was more difficult, were left out of the experiment, as their results were useless–they simply did not understand the task. Overall, 60 subjects remained in the experiment. Second, subjects were given a list of 28 sentences (All sentences were 6±1 words. The FILLER sentences were of roughly equal complexity as

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[20] The instruction 'in terms of time' was added, since in a pilot experiment, subjects had asked in what terms were the sentences difficult.

the rest of the sentences) and were asked to rate the test sentences to be "as difficult as A" or "as difficult as B". The questionnaire in Hebrew can be found in Appendix 1.

3.2   Results

The results rely on the frequency of the number of people that answered A, i.e. that a certain sentence out of a certain type was difficult, and are based on 60 Hebrew native speakers, all students of Tel Aviv University. For the frequency of A answers according to types of sentences, and for the full list of sentences in phonetic transcript and English interpretation, cf. Appendix 2.

3.2.0   Item analysis: Analysis of variance (F-test)

Every sentence received a score, which was the percentage of subjects who had chosen A, including the standard deviation from the mean value of each sentence that belonged to this category. Here are the results:

Table (3.3): Item Analysis

Type of sentence	Mean value (%)	SD
FILLER	2.86	3.29
TYPE GP	82.61	14.27
TYPE 1NP	70.00	14.75
TYPE 2NP$_{(ObOb)}$	30.95	15.33

3.2.1   Contrasts: significance of sentence groups

Here are the calculations of contrasts between the types, which enable us to see whether they are significantly different from one another, including the value of probability of each type.

Table (3.4): Contrasts

Contrast	F Value[21]	Probability (p)[22]
TYPE GP vs. TYPE 1NP	3.34	0.0800
TYPE GP vs. TYPE 2NP$_{(ObOb)}$	53.02	0.0001
TYPE 1NP vs. TYPE 2NP$_{(ObOb)}$	32.00	0.0001
FILLER vs. TYPE 1NP	94.62	0.0001
FILLER vs. TYPE 2NP$_{(ObOb)}$	16.57	0.0004

3.2.2 Correlation between distributions of results to binomial chance distribution

The correlation between the distribution of the results to the binomial chance distribution was calculated to be $\chi^2(DF=6)=114$, $p<0.01$; for TYPE 1NP. The chi square result for the correlation between the distribution of TYPE 2NP$_{(ObOb)}$ and binomial chance distribution was $\chi^2(DF=6)=57$, $p<0.01$.[23],[24]

3.2.3 Filtering the results: Item analysis

It was expected that FILLERS will be answered with zero A responses, and TYPE GP with seven (the maximal number) A responses. The subjects that answered less than or one A response to FILLERS and more than or 6 A responses to TYPE GP were extracted from the total number of subjects to form the consistent group being tested here. Table (3.5) depicts the mean percentage of their answers to the remaining types of sentences, based on 33 subjects:

Table (3.5): The filtered percentages

Type of sentence	Mean value (%)	SD
FILLER	2.01	5.2
TYPE GP	92.20	7.22
TYPE 1NP	79.22	18.59
TYPE 2NP$_{(ObOb)}$	30.30	23.62

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[21] F value is the measure of difference between two means, with relation to the variance of the data. An F value with a probability value of less than 0.05 means that the difference between two means is significant.

[22] When the probability (p) is less than 0.05, the difference between two groups of sentences is significant.

[23] The correlation was calculated according to the following example: A score of one, e.g., was given to the number of people that had said only once TYPE 1NP was difficult, (a score of two to the number of people that had said twice TYPE 1NP was difficult, etc.) and this frequency was compared to pure binomial distribution of chance.

[24] Chi square is the measure for independence between two groups of results in an experiment.

3.3   Discussion

From the item analysis results, TYPE GP sentences were the most difficult sentences, in comparison to the percentages of other sentence types. FILLER sentences were the easiest ones. These are the expected results with regard to TYPE GP and FILLER for all theories. It can be observed that the crucial majority of subjects considered TYPE 1NP to be difficult and TYPE 2NP$_{(ObOb)}$ to be easy. The contrasts indicate that all sentence types were significantly different from one another, except TYPE GP and TYPE 1NP, which were insignificantly different from one another, but the value of p was close to the criterion of significance ($p<0.05$). No correlation between pure binomial chance distribution and any other sentence type was found.

In order to reduce the possibility that other unknown factors interfered with answering the results, it was assumed that those subjects that had answered less than or one A response to type FILLER sentences and more than or 6 A responses to TYPE GP sentences were more reliable in their responses to TYPE 1NP and TYPE 2NP$_{(ObOb)}$ sentences. When their responses to TYPE 1NP and TYPE 2NP$_{(ObOb)}$ were extracted, it became clear that the majority of responses was that TYPE 1NP was difficult, and that TYPE 2NP$_{(ObOb)}$ was easy. Overall, the filtered results are similar to those obtained from the entire group of subjects.

As can be initially deduced from the predictions in Table (3.2) and relying on sentences such as TYPE 1NP, the strategies in which obligatoriness of theta roles was taken into consideration during the parse and Pritchett's own random prediction were not supported by the results. Rather, the prediction made by considerations of proximity was validated. Note however that TYPE 2NP$_{(ObOb)}$ did not reveal the low percentage that was observed with regard to FILLER sentences. Rather this type of sentence was found between the FILLER percentage results and the TYPE 1NP percentage results. Namely, TYPE 2NP$_{(ObOb)}$ was significantly different from FILLER and from TYPE 1NP. If proximity is what guides the human processor, how can the results obtained for TYPE 2NP$_{(ObOb)}$ be explained? Proximity predicts them to be insignificantly different from FILLER sentences (see table). However, the results are different. Tanya Reinhart (p.c.) points out that this can be explained if it is assumed that the results actually reflect random decision making, obscured by proximity, which is used as a parsing heuristic. This means that the subjects, facing optionality in assigning theta roles, can resort to the

implementation of a parsing heuristic, namely proximity, in order to resolve it. This can explain the higher percentage of subjects that indicated that TYPE 2NP$_{(ObOb)}$ was a difficult sentence (30.95%). What is actually seen is random decision making concealed by the parsing heuristic of proximity.

When running the experiment, subjects indicated that encountering two successive NPs caused an additional difficulty in TYPE 2NP$_{(ObOb)}$ sentences. People commented thinking that the two successive NPs were the start of a list of objects or that they did not understand how the two NPs were connected to the previous phrase, thinking this was the difficulty associated with the sentences. If this is the reason why certain subjects found such sentences difficult, it is independent of the issue at hand and cannot be taken as evidence against proximity as a principle. The problem could be solved by making the separation between the two NPs more obvious, i.e. adding an accusative case marker '*et*' between the two. This modification will be done in the following experiment in order to check whether two successive NPs introduce a processing difficulty that is not connected to the garden path effect. If the results of TYPE 2NP$_{(ObOb)}$ remain higher than FILLER sentences in the modified experiment, they can be taken as evidence against proximity

Note also that the difference in percentages between TYPE GP sentences and TYPE 1NP sentences is not unsubstantial, although they are insignificantly different from one another. Again, notice that the criterion for a significant difference is $p<0.05$, and the crude result is 0.08, which is very close: the importance of this will be revealed later on. If the human sentence processor uses proximity as a parsing principle, TYPE 1NP should yield the results identical to those of TYPE GP. Since the probability is on the borderline, it is required to test it again.

Moreover, Tali Siloni (p.c.) notes that there is an independent preference to have a light direct object close to its theta assigner. When a light NP is distant from its theta-assigner, native speakers judge the sentence as odd or marginal. Thus, they prefer (15b) over (15a), as the direct object *na'ala'im* 'shoes' is close to its theta assigner, the verb *xilka* 'gave'. This is so despite the fact that Hebrew does allow some flexibility in the placement of direct objects (note that the embedded verb is intransitive, so (15a) presents no optionality; it is clear that the NP must be attached to the matrix verb).

(15)   a. ?Ha mora xilka la-banot še-ohavot lirkod na'ala'im.

    The teacher gave the girls that liked to dance shoes.

    b. Ha mora xilka na'ala'im la-banot še-ohavot lirkod.

    The teacher gave shoes to the girls that liked to dance.

This preference is somewhat weakened when the direct object is heavier (longer):

(16)   a. Ha mora xilka la-banot še-ohavot lirkod na'alei rikud.

    The teacher gave the girls that liked to dance ballet shoes.

    b. Ha mora xilka na'alei rikud la-banot še ohavot lirkod.

    The teacher gave ballet shoes the girls that liked to dance.

The same problem is encountered in TYPE 1NP sentences, as the final NP is short (light). This could have affected the subjects' decisions to choose A, i.e. that the sentence was difficult. Therefore making the final NP in TYPE 1NP sentences heavier was also required.

An additional problem that people reported, even when they were not asked, was that they had had a feeling that the sentences consisted of a pattern. They were able to tell from the superficial reading of the sentence whether it was difficult or easy. They seemed to have been "trained" to circumvent the occurrence of a difficulty and predicted it as they proceeded with the questionnaire (a known phenomenon: people train themselves to "know" how to circumvent the garden path effect. However, this training diminishes over time). This might be due to the low number of FILLER sentences, or distracting sentences. In the following experiment, sentences for distraction were added.

Another issue that had arisen in the analysis of the results was the case of obligatoriness of theta roles. Although sentences of the TYPE 1NP did suggest that the notion of obligatoriness did not play a part in sentence processing, it was desirable to make this assumption more valid. In sentences of TYPE 2NP$_{(ObOb)}$, there is no indication as to whether the results are due to chance distribution or obligatoriness (cf. the predictions in table 2). Another type of sentence with two NPs was added in the purpose of dealing with this. Experiment B in the following chapter was designed to solve the problems that had arisen in Experiment A.

CHAPTER FOUR

Experiment B

4.0   Methodology of experiment B

The same types of sentences were used in experiment B as in experiment A. The final NP in TYPE 1NP sentences was made heavier by adding an adjunct. Another type of sentences was added. TYPE 2NP from experiment A was subdivided into TYPE $2NP_{(ObOb)}$ and TYPE $2NP_{(ObNon)}$, as is shown in table (4.1). Moreover, the first NP following the embedded clause in TYPE $2NP_{(ObOb),(ObNon)}$ was made heavier with a single adjunct (essentially via an adjective or a construct state). The particle that indicates accusative case '*et*' was inserted, preceding the final NP in TYPE $2NP_{(ObOb),(ObNon)}$ in order to make the separation between the two NPs more obvious. In addition, TYPE $2NP_{(ObNon)}$ was constructed using modal verbs such as *like*, *can*, *love*, and *able to*.[25] These verbs are known to improve the possibility of dropping an object, as it was difficult to find enough verbs that easily allowed it.

In table (4.1), an example of the additional sentence type that was used in the experiment is shown, and in table (4.2), the relevant predictions of the distribution of the garden path effect for this type are shown with regard to each hypothesis:

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[25] The modal verbs were chosen by informal judgment decisions.

Table (4.1): Types of sentences

Types of sentences	The 3rd theta role of the 1st theta assigner is	The 2nd theta role of the 2nd theta assigner is
Possibly optional garden path sentence		
Eli kana la-ozeret še-mekapelet bigdey ka-ic et ha-smartut. Eli bought to maid that folded clothes GEN summer ACC the rag. Eli bought the maid that folded summer clothes the rag. These sentences will be titled **TYPE 2NP(ObNon)**: Sentences that contain a two predicates ambiguity and two NPs, but the obligatoriness of the roles of the theta assigners differ as specified in this table.	Obligatory	Nonobligatory

Table (4.2): Predictions of distributions according to parsing strategies

The type of sentence (From Table 5)	Obligatoriness	Random	Proximity
TYPE 2NP(ObNon)	GP effect in all cases: Above chance distribution, like that of TYPE GP sentences.	Chance distribution	No GP effect: Above chance distribution, like that of FILLER sentences.

4.1   The questionnaire

The questionnaire was of the same type as in experiment A, described in section 3.1. However, this time the questionnaire included 60 sentences, 35 of which were test sentences of all types and the rest was sentences used for distracting the subjects. In this experiment, 20 subjects answered that sentence B was more difficult and were left out of the experiment. The questionnaire in Hebrew used for experiment B can be found in Appendix 3.

4.2   Results

The results rely on the frequency of the number of people that answered A, i.e. that a sentence was difficult, and are based on 106 Hebrew native speakers, all students of Tel Aviv University. For the frequency of A answers and the full list of sentences in phonetic transcript and their English interpretation, cf. Appendix 4.

4.2.0   Item analysis: Analysis of variance (F-test)

Every sentence received a score, which was the percentage of subjects who had chosen A, including the standard deviation from the mean value of each sentence that belonged to this category. Here are the results:

<u>Table (4.3): Item Analysis</u>

Type of sentence	Mean value (%)	SD
FILLER	6.09	3.23
TYPE GP	80.05	9.88
TYPE 1NP	64.31	16.16
TYPE 2NP$_{(ObOb)}$	21.31	7.11
TYPE 2NP$_{(ObNon)}$	29.09	4.23

4.2.1   Contrasts: significance of sentence groups

Here are the calculations of contrasts between the types to see whether they are significantly different from one another, including the value of probability of each type.

<u>Table (4.4): Contrasts</u>

Contrast	F Value	Probability (p)
TYPE GP vs. TYPE 1NP	9.55	0.0045
TYPE GP vs. TYPE 2NP$_{(ObOb)}$	144.03	0.0001
TYPE GP vs. TYPE 2NP$_{(ObNon)}$	100.09	0.0001
TYPE GP vs. TYPE 1NP, 2NP$_{(ObOb)}$, 2NP$_{(ObNon)}$	106.54	0.0001
TYPE 1NP vs. TYPE 2NP$_{(ObOb)}$	71.23	0.0001
TYPE 1NP vs. TYPE 2NP$_{(ObNon)}$	44.39	0.0001
TYPE 2NP$_{(ObOb)}$ vs. TYPE 2NP$_{(ObNon)}$	2.33	0.1382
FILLER vs. TYPE 1NP	130.58	0.0001
FILLER vs. TYPE 2NP$_{(ObOb)}$	9.67	0.0043
FILLER vs. TYPE 2NP$_{(ObNon)}$	20.37	0.0001

4.2.2 Correlation between distributions of results to binomial chance distribution

The correlation between the distribution of results and binomial chance distribution was calculated to be $\chi^2(DF=6)=122$, $p<0.01$. This was only calculated for TYPE 1NP as all the other types were significantly different from chance distribution as the examination of the crude results revealed.

4.2.3   Filtering the results: Item analysis

It was expected that FILLERS will be answered with zero A responses, and TYPE GPs with seven (the maximal number) A responses. The subjects that answered less than or 1 A response to FILLERS and more than or 6 A responses to TYPE GP, were extracted from the total number of subjects to form the group being tested here. Table (4.5) depicts the percentage of their answers to the other types of sentences, based on 61 subjects:

<div align="center">

Table (4.5): The filtered percentages

Type of sentence	Mean value (%)	SD
FILLER	1.91	6.16
TYPE GP	94.61	6.98
TYPE 1NP	68.30	25.40
TYPE 2NP$_{(ObOb)}$	21.98	5.24
TYPE 2NP$_{(ObNon)}$	24.6	4.49

</div>

4.2.3.0 Consistency of subjects

In order to examine the consistency of subjects, the subjects that answered between 3-4 times A responses to TYPE 1NP sentences were extracted from the group of 61 subjects mentioned in section 4.2.3. Then, for the extracted group, the frequency of the number of people that answered A responses to TYPES 2NP$_{(ObOb),(ObNon)}$ was calculated. These results are presented in tables 4.6.1-4.6.5.

Table (4.6.1): TYPE 1NP

Number of A answers	Number of people	Cumulative number of people
3	2	2
4	16	18

Table (4.6.2): TYPE 2NP(ObOb)

Number of A answers	Number of people	Cumulative number of people
0	12	12
1	3	15
2	2	17
4	1	18

Table (4.6.3): TYPE 2NP(ObNon)

Number of A answers	Number of people	Cumulative number of people
0	1	1
1	4	5
2	6	11
3	1	12
4	3	15
5	3	18

Table (4.6.4): TYPE GP

Number of A answers	Number of people	Cumulative number of people
6	6	6
7	12	18

Table (4.6.5): FILLER

Number of A answers	Number of people	Cumulative number of people
0	17	17
1	1	18

Again, in order to examine the consistency of subjects, the subjects that answered between 5-6 times A responses to TYPE 1NP sentences were extracted from the group of 61 subjects mentioned in 4.2.3. Then, for the extracted group, the frequency of the

number of people that answered A responses to TYPES 2NP$_{(ObOb),(ObNon)}$ was calculated. These results are presented in tables 4.7.1-4.7.5.

Table (4.7.1): TYPE 1NP

Number of A answers	Number of people	Cumulative number of people
5	17	17
6	11	28

Table (4.7.2): TYPE 2NP$_{(ObOb)}$

Number of A answers	Number of people	Cumulative number of people
0	12	12
1	8	20
2	4	24
3	2	26
4	1	27
5	1	28

Table (4.7.3): TYPE 2NP$_{(ObNon)}$

Number of A answers	Number of people	Cumulative number of people
0	6	6
1	6	12
2	4	16
3	3	19
4	2	21
5	3	24
6	1	25
7	1	26
8	2	28

Table (4.7.4): TYPE GP

Number of A answers	Number of people	Cumulative number of people
6	10	10
7	18	28

Table (4.7.5): FILLER

Number of A answers	Number of people	Cumulative number of people
0	25	25
1	3	28

Again, in order to be more certain about the consistency of subjects, the subjects that answered between 2-4 times A responses to TYPE 1NP sentences were extracted from the group of 61 subjects mentioned in 4.2.3. Then, for the extracted group, the frequency of the number of people that answered A responses to TYPES $2NP_{(ObOb),(ObNon)}$ was calculated. These results are presented in tables 4.8.1-4.8.5.

Table (4.8.1): TYPE 1NP

Number of A answers	Number of people	Cumulative number of people
2	10	10
3	2	12
4	16	28

Table (4.8.2): TYPE 2NP$_{(ObOb)}$

Number of A answers	Number of people	Cumulative number of people
0	19	19
1	4	23
2	2	25
3	1	26
4	2	28

Table (4.8.3): TYPE 2NP$_{(ObNon)}$

Number of A answers	Number of people	Cumulative number of people
0	2	2
1	5	7
2	9	16
3	3	19
4	5	24
5	4	28

<div align="center">Table (4.8.4): TYPE GP</div>

Number of A answers	Number of people	Cumulative number of people
6	10	10
7	18	28

<div align="center">Table (4.8.5): FILLER</div>

Number of A answers	Number of people	Cumulative number of people
0	26	26
1	2	28

4.2.5 Correlations

The correlation[26] between the different types was calculated to see whether there was a significant dependency between different types of sentences.

<div align="center">Table (4.9): Correlations between sentence types</div>

	TYPE GP	TYPE 1NP	TYPE 2NP$_{(ObOb)}$	TYPE 2NP$_{(ObNon)}$	FILLER
TYPE GP	--	0.26, p=0.01	-0.09, p=0.37	-0.08, p=0.41	-0.24, p=0.01
TYPE 1NP	--	--	0.01, p=0.87	0.09, p=0.34	-0.13, p=0.16
TYPE 2NP$_{(ObOb)}$	--	--	--	0.60, p=0.0001	0.16, p=0.0967
TYPE 2NP$_{(ObNon)}$	--	--	--	--	0.13, p=0.17
FILLER	--	--	--	--	--

4.4 Discussion

From the item analysis results, TYPE GP sentences were the most difficult sentences in terms of the largest percentage of people that had judged the sentences difficult, in comparison to the percentages of other sentence types. FILLER sentences were the easiest ones under the same comparison of percentage results. Again, these are the expected results with regard to TYPE GP and FILLER types. TYPE 1NP sentences demonstrated to have lower percentages than in experiment A and were found in

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[26] Table (4.9) contains the coefficients of correlations between two types of sentences. If the coefficient is higher than 0.5 (and the probability (p) is less than 0.05), then the correlation between the two types is significant

between TYPE GP and FILLER percentage results. The contrasts between the different sentence types indicate that all types of sentences were significantly different types, except TYPE 2NP$_{(ObOb)}$ and TYPE 2NP$_{(ObNon)}$, which were significantly not different from one another. In addition, the correlation calculations indicate a low significant dependency between TYPE 2NP$_{(ObOb)}$ and TYPE 2NP$_{(ObNon)}$. All other sentence types indicate no significant correlation with one another, i.e. one cannot predict that if a person replies more A answers to a certain type of sentence, then one will answer another type with more As, for instance. Still, no correlation between pure binomial chance distribution and any other sentence type was found. In order to reduce the possibility that other unknown factors interfered with answering, it was assumed that those subjects that had answered less than or one A response to type FILLER sentences and more than or 6 A responses to TYPE GP sentences were more reliable in their responses to TYPE 1NP, TYPE 2NP$_{(ObOb)}$ and TYPE 2NP$_{(ObNon)}$ sentences. When the consistent subjects were extracted from the total group and were checked, the relations between the types of sentences in terms of percentages under the item analysis remained the same, i.e. all remained significantly different types, except of course TYPE 2NP$_{(ObOb)}$ and TYPE 2NP$_{(ObNon)}$. These results conspire to show that the difference between the sentence types cannot be accounted for by proximity: It cannot explain the significant difference between TYPE GP and TYPE 1NP sentences, and the significant difference between FILLER and TYPE 2NP of both kinds. Had proximity been the principle that predicted the occurrence of the garden path effect, it would have been impossible to explain why differences between the types exist. Recall that it was not necessary to obtain pure chance distribution in optional garden path sentences, rather to see that the occurrence of their garden path effects was dissimilar either to TYPE GP or FILLER and that the occurrence was found somewhere in between these two extreme markers. This has been accepted in this experiment. At first sight, from the results in percentages from the item analysis, it might appear that TYPE 1NP and TYPE 2NP of both kinds do comply with the predictions of proximity, as the majority of people said TYPE 1NP was difficult, and that TYPE 2NP of both kinds were easy (note that TYPE 1NP and TYPE 2NP of both kinds are mirror images of one another in terms of their percentage results). However, as mentioned earlier, the significant difference between all of the sentence types cannot be accounted for by this theory.

In comparing experiments A and B, it can be observed that the modifications suggested in section 3.3 assisted in clarifying the results. TYPE 2NP$_{(ObNon)}$ strengthened the assumption discussed in section 3.3 that obligatoriness plays no role in parsing. The results of the item analysis of TYPE 1NP have become closer to chance distribution, once the final NP was made heavier. This reinforces the claim that the human sentence parser makes an arbitrary decision, when having two possible parsing paths, and that proximity is indeed an additional factor but not a principle in processing. With regard to TYPE 2NP of both kinds, the separation between the two NPs was improved in experiment B, as it was conceivable that the difficulty people associated with the sentences was related to the two consecutive NPs. The item analysis results in experiment B of TYPE 2NP$_{(ObOb)}$ sentences were approximately 10% lower than in experiment A, a difference that seems to be significant. Consequently, the data suggests that the sequence of two NPs did add some processing difficulty to these sentences. This, however, was not the only source of difficulty, as is clear from the fact that around 20% still found the sentences difficult. TYPE 2NP of both kinds are significantly different from FILLER sentences, in contrast with the prediction of proximity. This again gives rise to the assumption that proximity is not a processing principle. [[[[[Rather, it is an additional factor, which affects the decision of the human processor. As it happens, proximity obscures arbitrary decision making results.

Now the question becomes in what way can proximity be defined: Is it simply a general grammatical preference to locally attach light NPs to the previous phrase being constructed (note that this is not an additional strategy that is unique for sentences with theta roles surplus, but rather a preference of the computational system), or is it a heuristic that comes into play once a problem arises and requires solution, i.e. surplus of theta roles. The status of proximity will be discussed in the next chapter.

In the purpose of answering the question whether proximity was consistently used across parsers (viz. if parsers are consistent in their strategy for preferring local attachment), another analysis of the results was conducted. It was required to see whether the parsers that had answered 5-6 times that TYPE 1NP sentences were difficult (preferring local attachment), systematically answered that TYPES 2NP sentences[27] were easy, which would give rise to the speculation that certain (specific) parsers tend to use

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[27] There is no statistical difference between the two kinds of sentences: ObOb and ObNon, thus they shall be referred to as TYPES 2NP.

proximity systematically. To be sure, the parsers that had answered 3-4 times that TYPE 1NP sentences were difficult, indicating arbitrary decision-making, were extracted and their answers to TYPES 2NP were also counted. If the parsers demonstrate to have arbitrary decision-making in TYPES 2NP sentences as well, then it would give further grounds to assume that proximity was a method used by certain parsers at times of theta roles surplus. The 61 consistent subjects were the case group in relation to the assumptions made here.

When the subjects that only answered 3-4 times that TYPE 1NP sentences had been difficult were extracted under the assumption that this represents random answering pattern, the majority of those same people retrieved 0-1 A responses to TYPE 2NP$_{(ObOb)}$ and 0-3 A responses to TYPE 2NP$_{(ObNon)}$ (cf. tables 4.6.1-4.6.5). When the subjects that only answered 5-6 times that TYPE 1NP sentences were difficult were extracted, the majority of those same people retrieved 0-2 A responses to TYPE 2NP$_{(ObOb)}$ and 0-5 A responses to TYPE 2NP$_{(ObNon)}$ (cf. tables 4.7.1-4.7.5). In order to be sure that arbitrary decision-making was captured another group was looked at. When the subjects that only answered 2-4 times that TYPE 1NP sentences had been difficult were extracted, the majority of those same people retrieved 0-2 A responses to TYPE 2NP$_{(ObOb)}$ and 0-4 A responses to TYPE 2NP$_{(ObNon)}$ (cf. tables 4.8.1-4.8.5). The distribution of results in both types of 2NPs was broad. It was difficult to compare the results because the number of sentences in each type differed. In addition, once there were more sentences in each type, the distribution of the number of people was scattered to a greater degree. Hence, the afore mentioned counts indicate that one cannot predict the parsers' decisions when faced with different sentence types (in correspondence to the correlation results). The difficulty to attribute the results with an answering pattern of the subjects, despite the fact that the most consistent ones were considered, and because of the broad distribution of answers to TYPE 1NP in itself, affirm the assumption that proximity is resorted to by some parsers but not all. It also affirms the supposition that parsers are inconsistent in their attachment decisions. It is quite possible that proximity is resorted to only whenever a surplus in theta roles is generated, meaning that it is one of the many ways that a certain parser chooses to work by in an attempt to solve a certain syntactical problem. Another support to this assumption is that the correlation between TYPE 1NP and TYPES 2NP was insignificant. If there had been any relation between

the two groups, it would have been expected to have reverse correlation between the two sentence types. However, this is not the case. Ultimately, this analysis serves to show that parsers do not seem to be systematic with regard to the use of proximity.

At any rate, experiment B indicates that the human sentence parser is guided by Theta Attachment during on-line parsing, that the On Line Locality Constraint correctly predicts the occurrence of the (severe) garden path effect, and that the need for reanalysis is motivated by the violation of the theta criterion, namely a global grammatical principle. Finally, it has been shown that the algorithm suggested within the grammatical theory of parsing performance with regard to optional garden path sentences corresponds to actual performance. The distinction between the predictions of the various types of sentences discussed here with regard to the occurrence of the garden path effect has never been dealt with in psycholinguistic literature. Such sentences provide evidence in favor of the grammatical theory of parsing performance and against Late Closure as a parsing principle within the garden path model. In the final chapter, a general discussion will be provided over the question how the status of proximity can be studied along with additional possibilities for further research.

CHAPTER FIVE

General Discussion

5.0   Studying the nature of proximity

From the experiments conducted here, it has been concluded that proximity is not a processing principle. It has been suggested that proximity nonetheless plays a role in natural sentence processing, and that it can obscure the random decision that is made when the mechanisms that rely on grammatical competence allow two processing paths. This position is held to be valid here through the experimental analysis. However, the question is whether proximity is a grammatical preference independent of surplus of theta roles or a heuristic utilized when such a surplus is encountered. This query can perhaps be settled by a future experiment, which will involve TYPE 1NP sentences (for instance), where the NP following the embedded verb will be even heavier: having 3-5 constituents, for instance. If making the NP heavier still results in arbitrary decision-making, then it will be reasonable to assume that proximity is a heuristic, as making the NP heavier should not alter the results obtained in experiment B, i.e. that proximity is resorted to whenever a theta role surplus arises. If proximity is a general tendency to attach a lighter NP to the closest theta assigner, it is plausible that if the NP were made heavier, the results would be closer to Pritchett's "pure" chance predictions, yielding more lucid results than the ones here. Of course, the question how the parser "knows" and parses the heaviness of an NP requires further investigation.

In a comparison between experiment A and experiment B, it was observed that once the final NP in TYPE 1NP was made heavier, the results in percentages of the item analysis got closer to the pure chance distribution. This gives a firmer basis to the assumption that the use of proximity is not dependent on a surplus of theta roles, but rather on the heaviness of the relevant NP. However, it would be worthwhile to mention here several reservations concerning the validity of the data with regard to the heavier NPs and their implication on the status of proximity. From a theoretical standpoint, Theta Attachment in itself is a parsing heuristic that is resorted to in order to resolve local ambiguity by building a structure that maximally satisfies a particular grammatical constraint or constraints (Pritchett 1992, p. 14). In the sentences that incorporate

optionality, Theta Attachment is useless when theta role surplus is accumulated, as it cannot be used by the parser to make the right attachment decision that will lead to the maximal satisfaction of the theta criterion. It is therefore conceivable that when surplus is encountered, the parser turns to another parsing heuristic known to it. If so, then the status of proximity is that it is a heuristic used in replacement of Theta Attachment, but only once Theta Attachment does not lead to a non-ambiguous decision due to theta role surplus[28].

Moreover, it appears that over-lengthening an ambiguous phrase after the point of disambiguation facilitates the comprehension process (Frazier & Clifton 1998; Frazier & Clifton 1996). For instance, Frazier & Clifton (1996) found that a final adverbial phrase that cannot be incorporated into the current processing domain (e.g. the clause) results in ratings of lower comprehensibility with a short phrase like (17a) than with a long phrase like (17b):

(17)   a. John will explain to the kids that their father died *tomorrow*.

b. John will explain to the kids that their grandfather died *after*

the operation they need.

English also provides further evidence for the effect of heavy NPs, as it requires short accusative NPs to be adjacent to their licensing verb (cf. sentence (15)):

(18)   a. The spaceship destroyed *the planet*.

b. *The spaceship destroyed in the battle *the planet*.

However, once the NP is much heavier, the ungrammaticality judgment of (18b) disappears:

(19)   The spaceship destroyed in the battle the planet that was discovered by Hubble.

Consequently, there is a danger that if the final NP in TYPE 1NP sentences is too heavy, the sense of the garden path effect will also disappear and judgment of these sentences will be blurred, thus failing to facilitate the decision whether proximity is a tendency or a heuristic (For a discussion of the effects of length, cf. Christianson, Hollingworth, Halliwell, & Ferreira 2001). Moreover, it might lead to misinterpretations of garden path sentences (as demonstrated in Ferreira, Christianson, & Hollingworth 2001). If it turns out that the garden path effect is circumvented in TYPE 1NP sentences once a very

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[28] In Japanese, for instance, there is evidence for excessive cost-free use of PRO in the purpose of resolving syntactic structure, which is probably another parsing heuristic (cf. Mulders 2000). This however requires further linguistic study.

heavy NP is encountered, it could, then, be attributed to the fact that the parser has more time to finish the structural analysis of the NP, thus at the point of theta role surplus, it can withhold the thematic licensing of the heavy NP. This in turn facilitates making the correct licensing decision of the heavy NP in satisfaction of the theta criterion, and consequently circumvents the garden path effect.

5.1   Further research

The grammatical theory of sentence processing has many internal theoretical assumptions that need to be further studied. For instance, the parsing algorithm in (3) specifies extraction of theta grid. The content of the theta grid are controversial amongst linguists (Hale & Keyser 1993; Gruber 1976; Kratzer 1996; Dowty 1991; Jackendoff 1972; Reinhart 2000, 2001). Psycholinguistic research examining verb frame preferences also show broad distribution of different types of arguments (Connine, Ferreira, Jones, Clifton, & Frazier 1984), and there are indications that it might influence difficulty of processing (Shapiro, Nagel, & Levine 1993). Ultimately, the controversies amongst psycholinguists over the nature of the parser (e.g. is it parallel or serial, frequency based or constraint based; cf. Van Gompel, Pickering, & Traxler 2001, for a discussion against a constraint-based parser) are all-encompassing, especially with regard to experimental methodology and its interpretation, therefore they will not be discussed here (but cf. Mitchell (1994) for an overview of psycholinguistic controversies). Despite this, and given the assumptions made here (the attempt to satisfy the given maximal theta grid), the grammatical theory is adequate in terms of its prediction of the occurrence of the (severe) garden path effect. However, the theory contains implications over experimental results and vice versa, experimental results may render the need for amendments in the theory assumed. In the following sections, some of the issues to be studied are provided for future research.

5.1.0   Where does the parser check the satisfaction of grammatical constraints?

The grammatical theory of parsing performance is based upon the *immediate* satisfaction of the theta criterion during on-line processing. The parsing algorithm suggests that the checking of the satisfaction of the theta criterion is carried out once input ceases to flow in, and reanalysis is ensued if a failure to satisfy the criterion has been detected.

Nonetheless, it is plausible to assume that once the theta criterion has been checked to be unsatisfied, processing will break down at that very instance. At this point processing the remaining incoming data will not be executed and reanalysis shall immediately take place. The question is then where checking and reanalysis occur. Let us at first examine the following sentences:

(20)   a. ¿Without her contributions would be impossible.

        b. Without her contributions would it be impossible?

If we strictly follow the algorithm in (20a), checking the satisfaction of the theta criterion occurs after *impossible* is encountered, since input "ceases" to flow in. The parser then becomes aware that a failure to make a syntactical representation has come about, and correcting this is beyond its capabilities, thus resulting in the severe garden path effect. However, it seems that reanalysis (backtracking) already occurs at *would*. But since *would* does not contain any thematic information, and because it does not assign a theta role to its subject, the position of *would* in the syntactic tree seems to be an implausible position to induce processing breakdown within a theta-motivated theory. Moreover, if *would* had been the locus of reanalysis, reanalysis should have been invoked in (20b). Nonetheless, the sentence appears to be unproblematic. Pritchett noted (1992, p. 73) that reanalysis at *would*, as constrained by the OLLC, in terms of restructuring the given input, is impossible, since it is beyond the capabilities of the parser–it is an impossible reanalysis that can never occur. Rather, the parser continues and once *it* is encountered, which can serve as a subject of *would* in an inversion construction, the parse is saved.

Nonetheless, in an ERP experiment, Osterhout (1994) and Osterhout, McLaughlin, & Bersick (1997) have found that the typical ERP sign for a garden path effect was already recorded at *would*. Frazier & Rayner (1987) measured longer fixation times on *would* in an eye movement experiment, giving further support that reanalysis is executed at *would*. These findings appear to be contradictory as to the locus of reanalysis. It seems that the parser does not wait for the cessation of input to perform reanalysis. However, shorter fixation times were also measured on the words following *would* in the much quoted eye movement experiment reported in Frazier & Rayner (1987). This indicates that Pritchett might be right: checking is done during the parse, but reanalysis only at the cessation of input. Research will have to reconcile between the theoretical considerations and the experimental results. Eye movement seems to be the most

appealing method to be used to this end. (cf. how the method can be utilized in Rayner 1998, 1999, and Rayner & Sereno 1994; and for current controversies in eye movement experiments, cf. Starr & Rayner 2001).

5.1.1 Problems with coordination and reciprocity constructions

As was outlined in section 1.3, the following type of sentence that contains an object-subject ambiguity induces the severe garden path effect:

(21)   ¿Rex warned the ugly little man feared him.

However, as Pritchett indicates in note 86, the same sort of ambiguity in (22) does not produce the expected severe difficulty:

(22)   (¿)I was fixing the brake and the engine started.

This is because *the engine* should be attached as the argument of *fixing*, and reanalyzed as the subject of *started*, an operation that stands in violation of the OLLC, predicting a severe garden path effect. This sentence involves coordination, whose syntax is not well understood, and judgments seem to vary with regard to (22). The same issues arise when considering verbs that are ambiguous between reciprocal and transitive forms:

(23)   ¿After Tami and Bruce dated the agent announced the wedding.

(Ferreira & McClure 1997)

Further syntactical research within the grammatical theory of performance is required in order to correctly predict the occurrence of the garden path effect in sentences that contain either reciprocity or coordination (Also cf. Hoeks, Vonk, & Schriefers 2002 for difficulties with regard to processing coordinated structures; for adjustments in the garden path model for processing coordination structures, cf. Frazier & Clifton 2001 and Frazier, Munn, & Clifton 2000).

5.1.2 Is attachment head-triggered or limited to special lexical heads?

The status of garden path sentences that incorporate complement clause-relative clause ambiguity is predicted by the OLLC to be problematic:

(24)   ¿The patient convinced the doctor that he was having trouble with to leave.

However, difficulty is not encountered given disambiguating data:

(25)   The patient persuaded the doctor that was having trouble with him to leave.

The lack of an overt subject in the embedded clause leaves only the subject relative reading. This unproblematic status presents difficulty for the hypothesis that attachments of relative clauses are immediately head triggered, since it seems that attachment does not occur immediately given the head of CP, *that*. According to Pritchett, clauses are not licensed until the occurrence of the true head of S/IP, INFL, and not at the head of CP, C (Pritchett 1992, note 89). This distinction might be useful in deciding which of the various assumptions depicted here is indeed valid: (i) attachments are triggered by theta assigners only, V and P, as Reinhart & Siloni (2001) assume (and many others, as afore mentioned); (ii) the immediate (any) head-triggered assumption.

Further evidence demonstrates that the assumption that V- and P-heads license attachment is unsupported, especially in V2 languages such as German. Consider the following sentences and their respective reported difficulties (Bader & Lasser 1994):

(26a)   ...dass **sie**$_{NOM}$ nach dem Ergebnis zu fragen tatsächlich erlaubt HAT

That she   for the result   to ask   indeed   permitted has

"that she indeed has given permission to ask for the result"

Processing difficulty: **easy** (This is a test sentence)

(26b)   ...dass **er**$_{NOM}$ nach dem Ergebnis zu fragen tatsächlich erlaubt HAT

That he   for the result   to ask   indeed   permitted has

"that he indeed has given permission to ask for the result"

Processing difficulty: **easy** (This is a control sentence)

(27a)   ...dass **sie**$_{ACC}$ nach dem Ergebnis zu fragen tatsächlich erlaubt WORDEN IST

That her   for the result   to ask   indeed   permitted been   is

"that permission indeed has been given to ask her for the result"

Processing difficulty: **very difficult** (This is a test sentence)

(27b)   ...dass **ihn**$_{ACC}$ nach dem Ergebnis zu fragen tatsächlich erlaubt WORDEN IST

That him   for the result   to ask   indeed   permitted been   is

"that permission indeed has been given to ask him for the result"

Processing difficulty: **easy** (This is a control sentence)

The claim is that in (26a) and (27a), the ambiguous *sie* (between nominative and accusative case) is licensed by *fragen*, but it is not interpreted as its object, rather it seems that it is attached to the final verb (like in the unambiguous (26b)). If *sie* were attached as the object of *fragen*, then a garden path effect should have occurred when the active

auxiliary was processed–in sentence (26a), but the opposite results were obtained, (27a) is a garden path sentence (note that it is not the case the processing a passive sentence is difficult, because sentence (27b) was easily processed). This stands in violation of the OLLC, and indeed Theta Attachment, which requires attachment as soon as possible.

V2 languages and head-final languages such as Japanese apparently pose a problem for head-triggered theories of sentence processing. Indeed, there is evidence from Japanese that goes against this (Mazuka & Itoh 1995; Kamide & Mitchell 1999; Mulders 2002). The processing of head final languages requires much further research.

5.1.3 Contextual/Semantic effects

It is accepted by Pritchett that *right* context aids in interpreting garden path sentences, consider:

(28)   (¿)The horse raced past the barn fell over the sacks of potatoes that I had carelessly left in its way. (Pritchett (1992), note 98)

The consideration of context is probably not done by the autonomous parser, but rather in the conscious level. Therefore, the question here is: What is the context that circumvents garden path effects (cf. Sedivy & Spivey-Knowlton 1994; Spivey-Knowlton, Trueswell, & Tanenhaus 1993; and Binder, Duffy, & Rayner 2001). There are other indications that certain words with semantic implications circumvent the garden path effect altogether (Ni, Crain, & Shankweiler 1996):

(29)   Only horses raced past the barn fell.

These effects should be investigated to see whether these semantic/contextual effects have a bearing over syntactic analysis, and if yes, in what manner.

5.1.4 Relinquishing government

The OLLC incorporates the notion of government. Since a doubt has been cast over the relevance of government in current syntactic theory, i.e. within the Minimalist Program (Chomsky 1995), relinquishing government and perhaps replacing it with c-command might result in a more elegant and modern OLLC (recall that Pritchett (1992) used flat VP structures, an idea that is not prevalent anymore in modern theories). This calls for further theoretical research (similar to the one done in Siloni 2003; and Williams & Kalita 2000).

5.1.5 Parsing of adjuncts and quasi-arguments

The grammatical theory of human sentence processing does not specify how adjuncts are locally licensed. The crucial observation however is that adjunct-argument asymmetry is insufficient, as some adverbials behave as quasi-arguments. Locatives, instrumentals and temporals (more variably) pattern with subcategorized constituents, while manner and reason adverbs are prototypically adjunct-like (Rizzi 1990). Pritchett (1992) supplies an example, where a locative PP may be extracted from a *wh*-question, yielding only a mild subjacency violation whereas extraction of a manner PP produces a far stronger Empty Category Principle (ECP) effect:

(30)   ?[In what shop]$_i$ do you wonder what we bought e_i.

(31)   *[In what way]$_i$ do you wonder what we fixed e_i.

The locative trace behaves as if selected by the lower verb, whereas the manner adjunct does not. Additionally, unlike manner and reason adverbials, instrumentals and locatives often pattern with selected arguments with respect to various processes, which alter grammatical relations (Baker 1988). Within the grammatical theory of processing, and specifically within Theta Attachment, this means that if predicates select certain adjuncts, then their syntactic representation is predicted via Theta Attachment in the normal way. It remains to be investigated whether the behavior of pure verbal adjuncts (manner and reason) truly contrasts with quasi-arguments (locatives, instrumentals, and temporals). This distinction has not been yet made within psycholinguistics and the relevant data are largely lacking. Nevertheless, there is intuitive evidence:

(32)   ¿While the hunter waited in the field appeared a tiger.

Such constructions are somewhat marginal in English, but not in Hebrew, where constituent order is much more flexible, rendering Hebrew as a candidate language for this type of research. Compare:

(33)   ¿bizman še ha-cayad xika ba-sade hofi-a tigris.

    While that the hunter waited in (the) field appeared tiger.

    While the hunter waited in the field appeared a tiger.

Sentences (32) and (33) contain an ambiguous PP between a local locative attachment and the initial PP in an inversion construction. *In the field* will be first constructed as a quasi-argument of *wait* via Theta Attachment, but reanalysis will be required to interpret it as the inverted matrix PP. Since the target position of the PP is not governed by the

embedded source position, this will inevitably produce the garden path effect, as predicted by the OLLC. Unfortunately, constructing sentences where a PP is ambiguous between manner and locative reading is difficult, and the grammatical marginality of the data interferes with clear judgments. This indeed requires further linguistic investigation.

5.1.6 Initial choice

It seems as though the human sentence processor assigns constituents that appear in initial positions with default syntactical features. Consider the following sentences:

(34)   a. Have the boys devoured their dinners?

         b. Have the boys devoured by the tigers!

The initial constituent *have* is lexically ambiguous between a verb and an auxiliary. Since (34b) is not a garden path sentence, it is assumed that *have* is favored by Theta Attachment to be assigned with an auxiliary reading, which is confirmed by (34a). This is so because an auxiliary possesses no associated theta roles and places no local strain on the theta criterion (Pritchett 1992, p. 129). Moreover, it appears that initial NPs are also not assigned with theta roles, however they are assigned default case. Consider:

(35)   Dirigenten$_{ACC/DAT}$, die ein schwieriges Werk einstudiert haben, kann ein Kritiker ruhig applaudieren$_{DAT}$.

         Conductors, who a difficult opus rehearsed have, can a critic safely applaud.

         A critic can safely applaud conductors who have rehearsed a difficult opus.

                                                    (Hopf, Bayer, Bader, & Meng 1998)

Since the initial NP is morphologically ambiguous between cases, the surprise effect reported by subjects at the end of the sentence shows that it is assigned with the default accusative case[29]. Disambiguation occurs at the final verb, and a processing difficulty is experienced once the initial NPs default case must be replaced by dative case (cf. a discussion in Appendix A). Pritchett (1992) proposed the following principle:

> **Generalized Theta Attachment**: Every principle of the syntax attempts to be maximally satisfied at every point during processing. (Pritchett 1992, p. 138)

Since the initial NP should receive case in satisfaction of the Generalized Theta Attachment (in accord with the Case Filter: a phonetically realized NP requires case), it is assigned with an accusative case. However, the choice itself, why is the NP rather given

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[29] The default case is accusative when the NP is morphologically ambiguous between dative and accusative case. Normally, the default case in German is nominative.

an accusative case, has not been studied. Can this also be answered within the grammatical theory of processing, similarly to the preference in the initial choice of *have* as an AUX in (34)? Is it possible that unwarranted case assignment reduces processing cost, in the same manner that *have* is initially unlicensed by a thematic role? This requires psycholinguistic research, as the initial lexical choices of constituents are not well understood.

5.1.7   Chains

The examples in (34) contrast with the following (Marcus 1980):

(36)   a. Have the boys given gifts to their friends?

        b. ¿Have the boys given gifts by their friends!

Like (34a), (36a) is processable, but in contrast to (34b) the imperative in (36b) presents difficulty (providing additional evidence that the auxiliary reading is primary). First, both sentences in (36) are processed the same way:
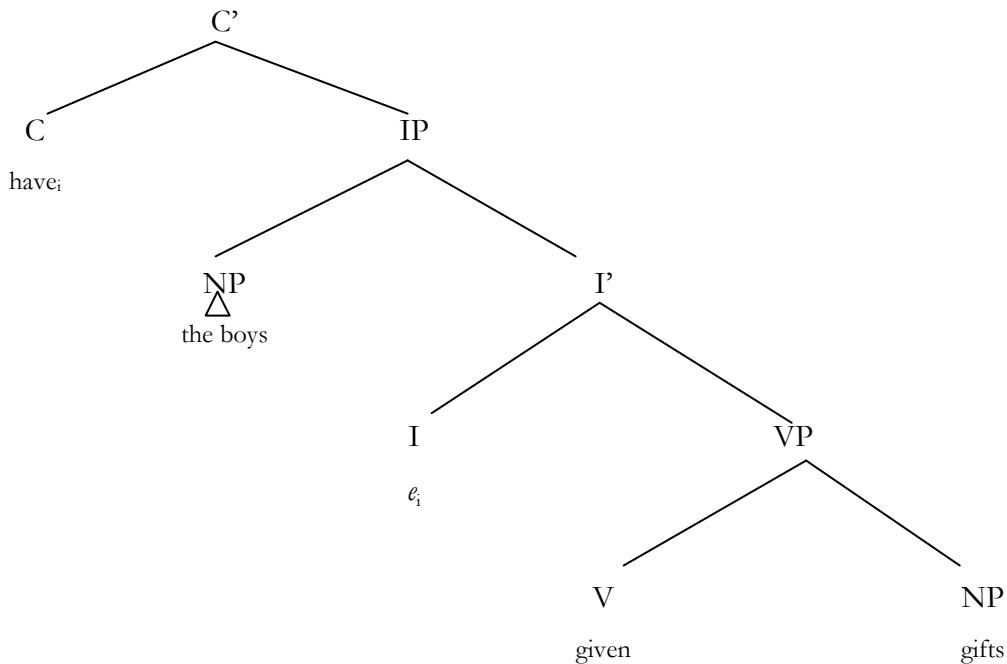
Notice that the auxiliary reading may continue through the occurrence of a post-verbal NP, here *gifts*. It is constructed as a complement through Theta Attachment, prohibiting the immediate association of *the boys* with that position. If *to their friends* next appears, no

difficulty will be sensed, as this complies with the anticipated interrogative structure. However, if *by their friends* appears, remapping must occur to this:

V'
V
have
IP
NP
the boys$_i$
I'
I
VP
VP
V
given
e_i
NP
gifts
PP
by their friends
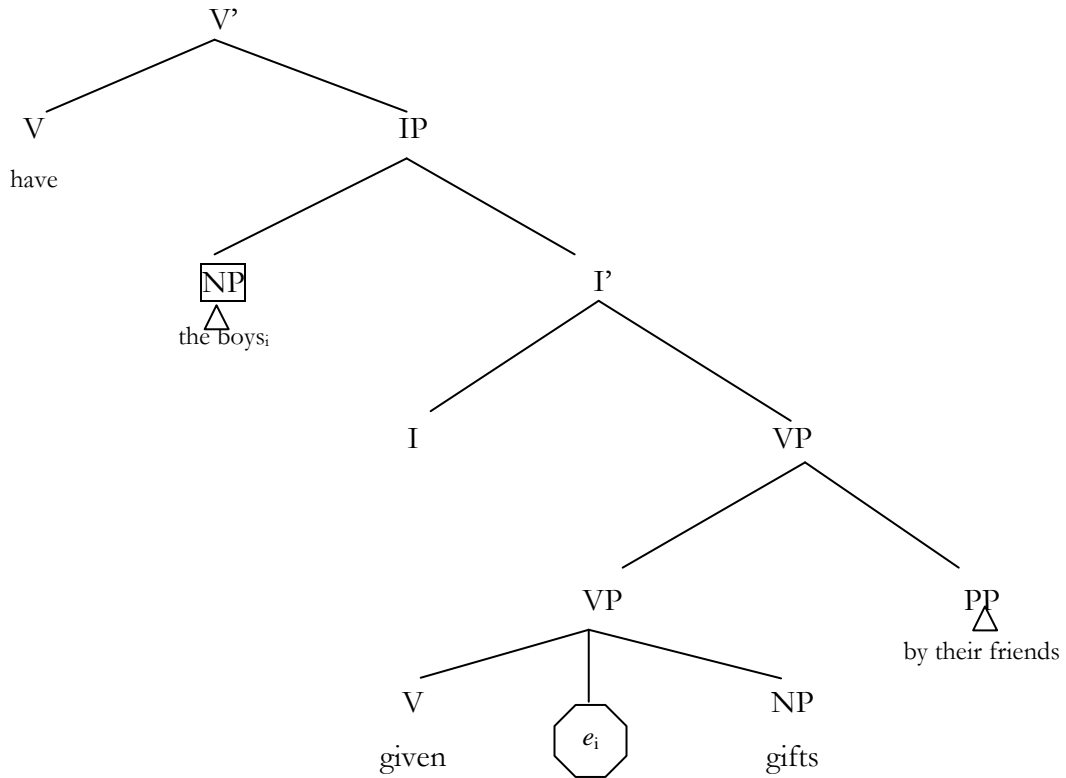
At this stage, *gifts* is reanalyzed from the first to the second object of *give*. This satisfies the government clause of the OLLC, and the sentence is rendered unproblematic. However, another reanalysis occurs. As in the first parse, the head and tail of *the boys'* chain occupy the subject position of *given*.[30] The tail must be reanalyzed as the inner object of *given*, in violation of the government and dominance clauses of the OLLC. A garden path effect is therefore invoked.

The generalization of the OLLC to chains is desirable, since it seems that initial chain construction is subject to Theta Attachment, while the OLLC constrains reanalysis. However, immediate questions are raised with regard to the status of head-movement chains and the implications of the extension of Theta Attachment to chains require further linguistic investigation.

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[30] However, if one accepts the VP-internal subject hypothesis, then the subject has a trace in [Spec,VP].

5.2   Conclusion

In the first chapter of this work, two theories, the grammatical theory and the garden path model, were introduced. In the second chapter, the optional garden path sentences were introduced and the relevant predictions of each theory were given. A question was posed: Whether the prediction of optionality in garden path sentences within one theory would be borne out by actual parsing performance; or that performance would abide to the second theory, diminishing optionality. The sentences allowed testing which of the theories made more accurate predictions with regard to the occurrence of the garden path effect. Moreover, it was enabled to test a third hypothesis, namely if obligatoriness of theta roles played a part in attachment decisions. Chapter 3 delineated the first experiment and outlined the problems that had arisen during experimentation. Chapter 4 also included an experiment, but an improved one. Ultimately, it was shown that the human sentence processor was motivated to make parsing decisions with accord to the parsing algorithm of the grammatical theory of parsing. The experiment in chapter 4 has illustrated that the parser makes attachment decisions primarily according to Theta Attachment as constrained by the OLLC, and that the optionality of attachment decisions was indeed verified by performance. The results support the predictions made by the grammatical theory of parsing performance, not by the garden path model, and show that proximity is not a principle. Rather, it has a certain role during on-line parsing, but it consequently obscures the actual mechanism of the automatic human sentence processor. Chapter 5 discussed the status of proximity. Was proximity a heuristic that the parser must resort to in the event of surplus of theta-roles or rather a preference resulting from the lightness of the relevant NP? It is suggested that it is a parsing heuristic, secondary to Theta Attachment, and that it comes into play when theta role surplus arises. In addition, the chapter delineated several research directions that need further clarifications within the grammatical theory of parsing performance. In this, the work provides cross-linguistic support for the OLLC and Theta Attachment as principles that characterize initial resolution of local ambiguity as well as a constraint on possible reanalysis.

The deepest conclusion from this work is that approaches to parsing performance that are not formulated in terms of grammatical principles are insufficient. The success of the grammatical theory of parsing in covering a wide range of data from

different languages strongly suggests that human natural language processing can be characterized in terms of Grammar, where Grammar is conditions on representation. Moreover, it indicates that the automatic parser at its core performs syntactic analysis, an indication that serves as further grounds to the assumption that the automatic mechanism of the parser abides to UG. This means that people across languages perform the same automatic processing operations, and use heuristics in order to make attachment decisions that best comply with respective syntactical constraints. As Pritchett (1992, p. 155) summarized his work:

> Success in accounting for an extremely wide range of processing phenomena in a simple and unified fashion both in English and across typologically distinct languages has provided strong evidence that the core of Parsing theory is derived from the theory of Grammar.

A P P E N D I X E S

Appendix A: Two Modes of the Parser Reflected as Different Responses to Processing Difficulty

A.0   Different types of natural responses

It is common knowledge and a fact of nature that readers report different responses to sentences of different types. Some grammatical sentences surprise the reader and do not invoke a need for severe reanalysis; others induce the severe garden path effect, which requires conscious reanalysis. Sentences that incorporate ungrammaticality of some sort (lexical, syntactical, or semantic) are also reported by readers to induce a different response in terms of difficulty of processing, but these responses are distinct from the surprise or garden path effects. Most theories that deal with parsing performance or processing show disregard to the various responses, and provide a unified explanation to the origins of the various types of processing responses and reanalysis mechanisms. It will be argued here that different responses reflect two modes of on-line operation during parsing, and that this should be taken into consideration in order to make the right predictions concerning the induced responses. Moreover, distinguishing between the different responses shall illuminate the workings of human cognition and Natural Language Processing, as shall be explained further along. Specifically, it will be claimed that the human sentence processor works in two modes of operation, one is responsible for constructing a syntactic tree and the second for the checking of the match between animacy-, Case-, and φ-features of two constituents in the parsed tree. Breakdown in operation of either mode will lead to the different responses mentioned earlier.

In the following section, examples of sentences that induce different responses will be provided. Later, current different processing theories shall be concisely reviewed and it will be demonstrated that they do not predict these different responses. Finally, an account for the variety of responses shall be supplied.

A.1 Overview of different processing difficulties

It shall be assumed here for purposes of exposition that the human sentence processor attempts to maximally satisfy every principle[31] of syntax at every point during processing, a principle titled "Generalized Theta Attachment" (Pritchett 1992). Although this assumption was derived by theoretical means, various empirical experiments indicate this is indeed the case. The human sentence processor constructs very rapidly a syntactic analysis for a sentence fragment during on-line processing, provides it with a semantic representation and makes at least some attempt to relate this interpretation to general knowledge (Frazier & Rayner 1982; Rayner, Carlson, & Frazier 1983; Trueswell, Tanenhaus, & Garnsey 1994). If one attempts to predict the inducement of reanalysis, one can conclude that whenever a violation of a principle of syntax occurs, some sort of difficulty (which can be typified) will arise and reanalysis will consequently follow in order to correct the obstacle in accordance to grammar. The difficulty during processing can be detected by technical means, such as ERP[32] experiments, and is of course felt intuitively by humans. The prolific study of processing of ungrammatical sentences has shown that similar ERP patterns arise when processing garden path sentences that invoke a severe processing breakdown (inducing the P600 signal for syntactic violation). For example, in the sentences below, there are subcategorization violation (1a), agreement violation (1b), and violation of phrase structure (1c):

(1)   a. *The woman persuaded *to* answer the door.

        b. *The elected officials *hopes* to succeed.

        c. *The man admired Don's *of* sketch the landscape.

                                  (Hopf, Bayer, Bader, & Meng 1998)

Note that the sentences in (1) do not require structural reanalysis but rather some sort of revision or correction. The difficulty during the parse was associated to the correction of the mismatch between the grammatical features of two constituents. The violations in (1) were measured to have similar ERP patterns to those of garden path sentence, which cause a severe conscious breakdown. Compare:

(2)   ¿The horse raced past the barn fell.

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[31] By principle of grammar is meant: Case Theory, Theta Theory, Binding Theory, Control Theory, and Bounding Theory.

[32] ERP: Event Related Potential, the measurement of the electrical activity in the brain.

Sentence (2) contains main clause-relative NP anomaly, which is purely structural, following Pritchett (1992). Unlike (1), (2) is a perfectly grammatical sentence. Reanalysis is called for in order to satisfy the principles of grammar, namely the theta criterion. The initial decision by the human sentence processor to analyze the phrase as a main clause has been revoked, and it must reanalyze the main clause as a relative NP once the disambiguating verb *fell* is encountered. Clearly, this invokes the severe garden path effect as there was a failure in the formation of a structural representation and the parser was unable to correct this error. Most importantly, the degree of the difficulty varies between sentences (1) and (2). The processing of the sentences in (1) does not invoke the same severity as sentence (2) and the difficulty is felt to a much lesser degree in (1). Hopf *et al.* have also studied sentences with Case ambiguities that induce (as they claim) the garden path effect. Consider the following sentence in German:

(3)   Dirigenten$_{ACC/DAT}$, die ein schwieriges Werk einstudiert haben, kann ein Kritiker ruhig applaudieren$_{DAT}$.

Conductors, who a difficult opus rehearsed have, can a critic safely applaud.

A critic can safely applaud conductors who have rehearsed a difficult opus.

In sentence (3), the readers perceive a Case mismatch when they encounter the dative assigning verb *applaudieren*, because they initially expect a verb that assigns accusative Case to the initial NP. The salient or default accusative Case is assigned to the initial NP, since every principle of syntax should be satisfied, as the Generalized Theta Attachment stipulates. Note that this is not a non-revisable commitment since the assumption we made here stipulates only that the parser *attempts* to maximally satisfy grammar; the final non-revisable Case shall be awarded to the initial NP only once the disambiguating verb is admitted to the tree. Note also that the necessary revision does not affect the structural representation but rather only the Case features of the ambiguous NP *Dirigenten*. It should have been made clear by now that the *severity* or degree of the difficulty cannot be distinguished by ERP measurement methods. Although (2) is a grammatical sentence, it produces similar ERP patterns as the ungrammatical sentences in (1) and the grammatical but temporarily ambiguous sentence in (3). However, (1) and (3) induce varying degrees of difficulty, different from that of (2). Note also that Hopf *et al.* rely on intuitive judgments (p. 267) in order to claim that the difficulty associated with sentence (3) is indeed the garden path effect, as they have no way of knowing that using the ERP

method. However, this is not the case at hand. From intuitive judgments of German speakers, there was merely a mild surprise effect when processing sentence (3) because one expected the initial NP to receive the more frequent accusative Case instead of dative Case, as explained earlier. Here, the initial assumption made by the human sentence processor was found to be erroneous and a revision was called for to correct the match of Case features, not structural reanalysis that causes local violation of a global principle.

The same instance can be found in other languages, such as in Japanese:

(4)　　a. Bob-ga Mary-ni ringo-o tabeta inu-o ageta.

　　　Bob$_{NOM}$ Mary$_{DAT}$ apple$_{ACC}$ ate dog$_{ACC}$ gave.

　　　Bob gave the dog that ate an apple to Mary.

　　b. Bob-ga Mary-ni ringo-o ageta.

　　　Bob$_{NOM}$ Mary$_{DAT}$ apple$_{ACC}$ gave.

　　　Bob gave an apple to Mary.　　　　　(Gorrell 1995, p. 95)

Before reviewing (4), let me assume now that attachments during parsing occur only once a theta assigner has been encountered, i.e. a V or P, following again Reinhart and Siloni (2001). (4a) is reported to induce a surprise effect at the verb *ate*. This verb does not assign dative Case, however *Mary* is marked as a dative NP. Gorrell (1995) states that the surprise effect is attributed to the parser structuring the three pre-verbal NPs into a single clause, i.e. the arguments of a single clause. This creates an expectation for a verb that incorporates three arguments and sentence (4b) shows that this is a grammatical possibility. Note that it is not plausible to attribute the surprise effect at *ate* in (4a) to a complexity effect arising from the need to build the relative clause structure that incorporates all arguments when the verb is encountered. This is because relative clause construction in Japanese is always "*post hoc*" (Gorrell 1995, p. 96, note 3). However, Case expectations, which prove to be inconsonant when the disambiguating licenser enters the parse, demonstrate to invoke surprise effects, they do not require restructuring, and the resultant effect is much different from the severe garden path effect, which is due to syntactic restructuring. Moreover, Mulders (2002) provides an example of a Japanese sentence that does require restructuring but unpredictably does not induce a garden path effect:

(5)   a. Yoko-ga kodomo-o koosaten-de mikaketa onnanoko-ni koe-o kaketa.

        Yoko$_{NOM}$ child$_{ACC}$ intersection$_{LOC}$ saw girl$_{DAT}$ called.

        Yoko called the girl who saw the child at the intersection.

     b. ¿Yoko-ga kodomo-o koosaten-de mikaketa takusii-ni noseta.

        Yoko$_{NOM}$ child$_{ACC}$ intersection$_{LOC}$ saw taxi$_{DAT}$ put-on.

        Yoko put the child on the taxi she saw at the intersection.

Both sentences are initially analyzed as main clauses[33]. Mulders (2002) claims that in (5a) reanalysis is triggered by a non-theta assigner (*onnanoko-ni*, 'girl'), contrary to the assumption made here. There is no garden path effect in (5a) and it is grammatical. In (5b), reanalysis is also caused according to Mulders (2002) by a non-theta assigner (*takusii-ni*, 'taxi'), but here we find a garden path effect. The crucial difference between (5a) and (5b) is that the head noun that forces reanalysis can be constructed as the subject of the relative clause it heads in (5a) but it is impossible in (5b). The reason for that is that *girl* is a possible subject for *saw*; *taxi* is not, since it is inanimate. As Mulders (2002) commented, the sentences were taken from Mazuka & Itoh (1995) who reported that (5b) was not a severe garden path sentence as English cases were. As we have seen, disproved expectations induce a surprise effect, not a severe garden path effect. If Mazuka & Itoh (1995) report that the effect associated with the difficulty of reanalysis in (5b) is milder, then it will be reasonable to assume that this effect is similar to the surprise effect in (4a), not the garden path effect in (2), and that this surprise is due to the inanimacy mismatch, not restructuring (note that *saw* gives rise to the expectation for another constituent with an animacy feature in order to converge the features).

So far, we have seen that ungrammatical sentences, garden path sentences and sentences with disproved expectations that do not require structural reorganization must satisfy all principles of grammar. They differ in the severity of reanalysis, ungrammatical sentences having the easiest reanalysis, which is more like revision, disproved expectations (especially Case and animacy) induce a 'surprise' effect considered milder than the garden path effect, and that garden path sentences induce the most severe

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[33] This assumption is predicted within Pritchett's theory (1992). It is widely accepted by other theories and various empirical results demonstrate this type of initial decision.

difficulty[34]. In the following section, I shall briefly review the predictions of the theories mentioned above.

A.2   Different references to processing difficulties

Within the garden path model, processing difficulty according to Frazier and Fodor (1978) arises whenever there is a need for reanalysis given the parser has realized it made an error:

> The parser chooses to do whatever costs it the least effort; if this choice turns out to have been correct, the sentence will be relatively simple to parse, but if it should turn out to have been wrong, the sentence will need to be reparsed to arrive at the correct analysis" (Frazier & Fodor 1978, pp. 295-296).

Recall that difficulty is explained by the assumption that revising an incorrect analysis of the sentence is not cost-free (Frazier 1983). Thus in a sentence such as (2), the parser decides that it did a mistake when it stumbles upon *fell*, having misanalyzed *the horse raced past the barn* as a main clause. Syntactic reanalysis is required and this is the source of difficulty associated with the garden path effect. However, the model fails to account for the different difficulties in sentences (1), (3) and (5). As we have seen so far, it is a simple and unavoidable fact that some reanalyses rise to consciousness, some only invoke surprise, and some cause a sense of ungrammaticality or revision.[35] Frazier and Fodor (1978) disregard this fact, predicting that the difficulty in sentences (1), (3) and (5) would also be severe, since any local error that requires reanalysis will be labeled a garden path. Finally, Frazier (1983) herself claimed that MA and LC did not specify how the structural analysis of the sentence was influenced by non-syntactic factors. That is to say that LC and MA do not entail reference to factors that are not purely structural, such as animacy and Case mismatch as we have seen.

On the other hand, Pritchett (1992) has stipulated that once a local parsing decision has been proven inconsonant with a global grammatical representation, and the parser was unable to perform reanalysis necessary to obtain the grammatical

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[34] Also, cf. a discussion of the influence of animacy expectations over processing difficulty in Traxler, Morris, & Seely (2002), where readers preferred sentential subject to be the subject of an adjacent relative clause. Whether the sentential subject was a good agent or not, affected the difficulty readers experienced abandoning an initial syntactic misanalysis.

[35] It is conceivable that certain reanalyses do not invoke any difficulty, as in the case of *John knows rex will die*. They do not cause a difficulty felt by the hearer, but perhaps measuring would show slightly longer processing time.

representation, the severe garden path effect shall be invoked. In syntactic terms, a violation of the OLLC will lead to the garden path effect. In the analysis of (2), the human sentence processor makes a local decision (analyzing the first VP *raced* as a main clause) that does not allow satisfaction of the theta criterion (the final VP *fell* has a theta role but cannot discharge it since there is no theta unmarked constituent) and ultimately leads to the violation of Generalized Theta Attachment. The target position of *the horse* in [Spec,IP] of the main clause is not governed nor dominated by the source position (the [Spec,IP] of the final VP *fell*). Thus, the OLLC correctly predicts that this analysis is impossible for the parser, and that satisfaction of the theta criterion requires transferring the operation to the conscious mind, as the parser cannot automatically correct the representation. Pritchett (1992) was also aware of the difficulties that Case mismatch caused. However, he was satisfied with the stipulation provided here, i.e. that every principle of syntax attempts to be maximally satisfied at every point during the parse, and once there is a violation of any syntactical principle, failure is predicted. He also related to the question of difficulty:

> Varying degrees of difficulty…are not relevant to the discovery of the autonomous parser, being, in a sense only measures of hearer's conscious ability to analyze linguistic structure. (Pritchett 1992, p. 96)

This is somewhat surprising as Pritchett himself denounces Frazier and Fodor's principles of Minimal Attachment and Late Closure on the grounds they cannot distinguish between different levels of processing difficulty. Nonetheless, as has been demonstrated, sentences (1) and (3) have distinct levels of difficulty and it is impossible to ignore that by the stipulation that every violation of Generalized Theta Attachment generates a difficulty. In finding the source of the difference of the processing difficulty, Pritchett's theory, at this stage, seems to offer no solution. The theory only distinguishes between sentences (1), (3) and (2), but not between (1) and (3).

Mulders (2002) addressed the problem in (5b) that a non-theta assigner causes reanalysis. Once the parser arrives at the dative marked NP *taxi*, two elements are required to be reanalyzed: the nominative marked NP *Yoko-ga* 'Yoko' and the accusative marked NP *kodomo-o* 'child'. Since there are selectional restrictions on *saw*, it cannot attach the dative marked NP *taxi* as its direct object, and the NP *kodomo-o* must be removed from its assumed Case (and theta-marked position) in order to obtain the

correct syntactical representation of the sentence. This leaves the main clause without the subject NP *Yoko-ga*: it also needs to be reanalyzed, as its attachment location is not yet clear (it cannot assume anymore the subject position of the relative clause, as it is the subject of the matrix clause). Mulders (2002) claims that the parser, when required to reanalyze more than one constituent, cannot perform this action, and this is the source of the difficulty in (5b). She suggests a revised OLLC. Not going into the specifics of her proposal, which are irrelevant to the point made here, she also claims that (5b) invokes an effect similar to "impression of difficulty" (Mulders 2002, page 177), in addition to mentioning Mazuka and Itoh's reservation. The reason for that is that reanalysis of this sort lies within the capabilities of the parser, but since it must carry out two reanalysis operations simultaneously, there is a conscious impression of "complexity of reanalysis", even though those operations are permitted in principle, giving rise to the difference in difficulty between (2) and (5b).

However, several reservations come into mind concerning Mulders' analysis. It is unclear on what basis was the argument based upon that reanalysis, i.e. the indication a wrong attachment has been circumvented, occurred at a non-theta assigner. As shall be demonstrated in the continuation, there is no call for that. On the contrary, assuming that reanalysis is triggered by non-theta assigners goes against the abundance of data that attachment of constituents is guided by theta assigners (Berwick & Weinberg 1986; Gorrell 1995; Weinberg 2001; Pritchett 1992; Reinhart & Siloni 2001; Carlson & Tanenhaus 1988; Frazier 1990; Grodzinsky 1995; Ferreira & McClure 1997; Ferreira & Henderson 1998; McRae, Ferretti, & Amyote 1997; McRae, Spivey-Knowlton, & Tanenhaus 1998). Mulders (2002) makes refinements[36] in the OLLC and predicts severe garden path effects basing her predictions on those changes. If we indeed assume that the *severe* garden path effect is predicted by the refinements suggested by Mulders (2002), then it is uncalled for to claim that operations that transfer two constituents to the buffer (in order to explain (5b) as a garden path sentence) to be "permitted in principle". However, the risk is greater considering the assumption that the parser is automatic. Having to decide how many constituents are permitted to be reanalyzed burdens the

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[36] I shall not go into details about the refinements Mulders (2002) suggested, as they are irrelevant to the problem at hand. Moreover, it shall be proven that they are unnecessary and that if the OLLC does not indeed predict a processing difficulty in the sentences she relies her theory upon, then one must first check whether the severity is indeed the garden path effect. I am quite certain that the sentences demonstrate merely "complexity of reanalysis".

parser further more and there is no evidence that the parser delays to make those decisions, it simply works automatically. So far, it has been demonstrated that syntactical complexity is oblivious to numerations of nodes or numerations of any sort, as Mulders (2002) claims in her discussion against Minimal Attachment (in MA the parser must calculate the attachment that contains the least number of nodes). Despite all of the said above, an important detail in Pritchett's theory has been overlooked. It is this detail that holds the key to the understanding of the problems raised here. In what follows, it shall be demonstrated that, surprisingly enough, Pritchett's theory predicts the difference in difficulty in all of the instances above and that no refinements are required to the OLLC.

A.3   Pritchett's theory makes the right predictions

As things stand now, we are facing the issue that none of the above-mentioned theories has dealt in depth with the variety of response associated to sentences (1), (3) and (5b). Let us now take a close look at the processing algorithm Pritchett (1992) suggested, repeated here (with some adjustments):

(6)   a.   Input a word.

   b.   Recover lexical information, including category and theta grid, and project the appropriate XP(s).

   c.   Maximally satisfy the theta criterion via theta attachment (TA) as constrained by the On Line Locality Constraint (OLLC).

   d.   If input 'ceases' affirm that the resulting structure satisfies all relevant grammatical principles (success); and if not (failure) invoke *conscious* reanalysis, by definition yielding the GP effect; otherwise continue to the next word.

To demonstrate the manner in which this algorithm operates with regard to the questions at hand, let us examine a simple sentence in Japanese:

(7)   Frank-ni Tom-ga Guy-o syookai suru to John-wa emote-iru.

   Frank$_{DAT}$ Tom$_{NOM}$ Guy$_{ACC}$ introduce COMP John$_{TOP}$ think-ing.

   John thinks that Tom will introduce Guy to Frank.   (Pritchett 1992, p. 151)

The parser sweeps over every word, recovers its lexical properties and projects the relevant XP's, satisfying conditions (6a) and (6b). Once it arrives at *introduce*, a theta

assigner, the parser attempts to satisfy condition (6c). Attachments will be carried out as *introduce* selects three arguments (note that *Frank-ni* has been scrambled):

(8)   [IP[NP Frank-ni]$_i$[IP[NP Tom-ga][VP[NP Guy-o] e_i [V syookai suru]]]]

The crucial point here is that before *to*, the complementizer, enters the parse, the processor cannot commit to the status of the higher IP, whether it is a matrix or embedded clause (note that Gorrell (1995) also claimed that this decision is done "*post hoc*"). Only once *emote-iru* has been admitted to the parse can the processor decide upon the status of the previous clause (actually, when input ceases). The parser will make the right decision, attaching the higher IP as an embedded clause, satisfying the relevant global grammatical principles (in accord with the Generalized Theta Attachment) and proclaiming success (satisfying condition 6d):

(9)   [IP[CP[NP Frank-ni]$_j$[IP[Tom-ga Guy-o e_j syookai suru] to]$_i$[NP John-wa]
        [VP e_i [V emote-iru]]].

Now let us turn to sentence (5b), repeated here as (10):

(10)   ?? Yoko-ga kodomo-o koosaten-de mikaketa takusii-ni noseta.

        Yoko$_{NOM}$ child$_{ACC}$ intersection$_{LOC}$ saw taxi$_{DAT}$ put-on.

        Yoko put the child on the taxi she saw at the intersection.

As the parser analyzes this sentence, it arrives at *mikaketa*, and makes the relevant attachments. Once it arrives at *takusii-ni*, the processor cannot decide about the status of the previous clause, as the final disambiguating verb has not been encountered. In that sense, the OLLC is irrelevant here since no transfer of constituents has been carried out, *takusii-ni* is admitted to a buffer until a decision can be made. Alternatively, the processor makes the correct parse, similarly to the parse of (9), and it does not resort to reanalysis. The so-called difficulty that arises, which is actually a surprise effect, is due to animacy mismatch only, which explains why the sentence is not a severe garden path sentence. Therefore, it was marked with two question marks and not the reversed question mark that indicates the garden path effect. This analysis is also valid for sentence (3), where structural reanalysis is not required, but rather only checking the match between Case features of constituents, which ultimately causes only a surprise effect. Consequently, we see that the processing of sentences is carried out according to Pritchett's algorithm. Once *structural* reanalysis is required by the more-able conscious mind after breakdown in the satisfaction of a global grammatical principle (the theta criterion) has occurred, the

severe garden path effect shall be invoked. Once a feature has been assigned to a constituent without this operation being corroborated by the relevant licenser, then structural reanalysis will not be required, and the surprise effect shall be invoked upon encountering the licenser; on condition that there is no match between the feature awarded to the constituent and the feature of the licenser. Ungrammatical sentences require only revision of the feature mismatch as a licenser has been encountered and they invoke neither a surprise nor a garden path effect[37].

A.4   Two modi operandi of the parser

As can be deduced from this analysis, there is a need to define two modi operandi of the parser. The first operation of the parser is the structural analysis of a string of words, which is not influenced by any other factors other than the ones mentioned in (6). If structural reanalysis is required, since a global grammatical principle has been violated, the parser cannot carry out this analysis, and it elevates this operation to the conscious mind, causing the severe garden path effect. The second operation of the parser is the one that checks the match between other properties of a string of words: namely Case, animacy and φ-features. Note that checking the match cannot signal the restructuring of the parsed tree.[38] It cannot influence the syntactic analysis already carried out, i.e. on the first mode of operation of the parser, because we have seen that φ-feature, Case and animacy mismatch do not invoke structural reanalysis. This second operation, once it encounters a mismatch, causes some sort of surprise effect. Surprise effect is invoked once a constituent was awarded an unlicensed feature, whereas revision arises when a licenser appears, but the constituent's features mismatch to those being licensed by the licenser (that is to say when there is a violation of grammar that cannot be corrected). Furthermore, we can conclude that attachments during the first operation are guided by theta assigners, whereas the second operation is only checking the plausibility of the matching between φ-features, the plausible match between the Case assigning verb and a constituent's morphological Case marking, and the plausibility match between the semantic properties of the constituents, i.e. animacy. This is also in correspondence to

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[37] However, it is conceivable that this revision effect is similar to the surprise effect, since certain constituents contain some expectations (such as subcategorization features) that are revoked by an ungrammatical element, and this might in turn cause surprise.

[38] Except perhaps structural Case, but this is not demonstrated by the examples here and it requires a different type of analysis.

Frazier's (1983) ample observations on the working of the parser[39] and a recent eye movement experiment that implied the existence of two modes of operation (Mak, Vonk and Schriefers 2002). Perhaps the best way to describe the independence between the two modes of operations is with the following Hebrew sentence:

(11)   xulca tova'at ba nahar.

(A shirt/was saved) (is drowning/a drowning woman) at the river.

A drowning woman was saved at the river.

This sentence contains two morphologically ambiguous constituents between NP and passive verb form. In the first reading of the sentence, it seems as though *"a shirt is drowning in the river"* is the meaning of the sentence (the first constituent is analyzed as an NP, the second as a verb). The sentence is grammatical and is easily parsed, yet it does not make sense: a shirt cannot drown in a river, since it is inanimate. Despite this mismatch, most readers are not reported to have performed reanalysis in order to reach the intended meaning of the sentence, namely that *"a drowning woman was saved at the river"* (the first constituent is now a passive verb and the second constituent is an adjectival NP). Although readers sense something is wrong in the sentence, that it does not make much sense, they try to give explanations, pragmatic ones, which they invent for themselves, so that it will make sense (for example, that this is a sentence from a fairy tale).[40] Consequently, it can be seen that the "second" modus operandi does not invoke reanalysis of syntactic structure once it has been carried out, although the sentence is senseless and despite the existence of animacy mismatch.

To bring things to a close, it was demonstrated that sentences differ in the effect they induce on the human sentence processor. Pivotal theories that explicate processing breakdown were delineated and demonstrated to be unconcerned with the difference of difficulty. It has been shown that it was important to consider the different responses in order to make the right predictions. It was also shown that Pritchett's processing algorithm predicted the different responses but only if it was assumed that the parser has two distinct modi operandi that were independent of each other, and their functions

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[39] Frazier (1983) assumed there were two separate parsers working, the first was the structural parser and the second the "focused parser", which corresponds here to the second mode of operation of the parser. Regrettably, she did not specify the workings that guide both parsers. Nonetheless, in my opinion, there is no need to assume the existence of another parser; rather it would be a more appealing idea to assume the parser is concerned with several distinct operations during processing.

[40] In the experiment described in chapter 3, 63 out of 106 subjects said (11) was easy, giving rise to the explanation suggested here.

were defined. It remains to be investigated how these two modes operate during on-line processing of other sentences and it is required to further clarify the notion of revision which results in surprise effect.

Appendix 1: Questionnaire of Experiment A

שאלון / יוני 2002

I. האם עברית היא שפת האם שלך? הקיפו : כן / לא

II. הקיפו את המשפט הקשה יותר מבין שני המשפטים הבאים מבחינת זמן הבנתו :

א. בזמן שדן שר שיר התנגן בחנות

ב. בזמן שדן פיהק שיר התנגן בחנות

III. עתה השוו את המשפטים הבאים למשפטים הקודמים (א' ו-ב') והקיפו תשובה **אחת** שתואמת את דעתכם :

שימו לב: יש לענות על המשפטים לפי המספור, מימין לשמאל!

2) בעת שהרב בירך נערים רקדו בחצר א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	1) הדוור מסר מכתב לאישה שפתחה את הדלת א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
4) המלצרית נתנה לבחור שאוהב לשתות מים א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	3) היפנים הבטיחו לתייר שצילם תמונה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
6) האמא הכינה ארוחה לילד שהלך לבית הספר א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	5) הדוור מסר לאישה שמיינה מכתבים חבילה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
8 האמא קילפה לילד שאכל תפוח א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	בשעה שהאישה מיינה מכתבים התפזרו על הרצפה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
10) דן רצח את הזמרת שנמצאה מתה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	9) המשרד סיפק ליבואן שמיבא סוכריות מכלים א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
12) אחרי שדנה שתתה מים זרמו מהברז א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	11) האומן צייר לאישה שמחבבת איורים דיוקן א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
14) הסופר הקדיש לשחקנית את ספרו החדש א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	13) האחות חילקה לחולים שיכולים ללעוס טבליות א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
16) השוטרים שלחו לאזרחים שכתבו גלויות צווים א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	15) לפני שדן הקריא שירים שעממו אותנו א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
18) בעוד שאבא אכל פיצה הובאה על ידי השליח א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.	17) השליח מסר לאישה שפתחה חבילה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.

הפסלת נתנה לעתונאי שאוהב ציורים פסלים (20		בזמן שרן חילק דפים התעופפו לכל עבר (19
א) המשפט שווה מבחינת הקושי שלו לא׳.		(א המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לבי.		(ב המשפט שווה מבחינת הקושי שלו לבי.
היועץ מסר דו״ח לועדה שהתכנסה אתמול (22		הבחור הזמין מהבחורה שבישלה מרק (21
א) המשפט שווה מבחינת הקושי שלו לא׳.		(א המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לבי.		(ב המשפט שווה מבחינת הקושי שלו לבי.
האוצר הקצה ליו״ר שניהל תקציבים כספים (24		אחרי שהעוזרת גיהצה 3 חולצות התקמטו מחדש (2
א) המשפט שווה מבחינת הקושי שלו לא׳.		(א המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לבי.		(ב המשפט שווה מבחינת הקושי שלו לבי.
החברים בילו בבית קפה שנמצא בתל אביב (26		המוסד דורש מהסטודנטים שמסוגלים לשלם מקדמה (25
א) המשפט שווה מבחינת הקושי שלו לא׳.		(א המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לבי.		(ב המשפט שווה מבחינת הקושי שלו לבי.
המרצה חילקה מאמרים לתלמידים שהתעניינו בחומר (28		הירקן הביא לאישה שצורכת מלפפונים עגבניות (27
א) המשפט שווה מבחינת הקושי שלו לא׳.		(א המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לבי.		(ב המשפט שווה מבחינת הקושי שלו לבי.

תודה על שיתוף הפעולה! ☺

Appendix 2: Tables of Frequency and Sentences Used in Experiment A

Table (1): Frequency of the number of people that answered A

Type of sentence	Number of sentence						
	1	2	3	4	5	6	7

FILLER	1	1	6	1	2	0	1
TYPE GP	33	54	55	51	56	55	43
TYPE 1NP	53	50	48	30	41	32	40
TYPE 2NP(ObOb)	11	33	10	21	9	27	19

Table (2) contains the sentences used in the questionnaire according to their type in correspondence to table (1):

Table (2): The sentences[41]

Type of sentence	Number of sentence						
	1	2	3	4	5	6	7
FILLER	Ha davar masar mixtav la iša še patxa et ha delet *The postman delivered a letter to the woman that opened the door (1.7%)*	Ha ima hexina aruxa la yeled še halax le vet hasefer *The mother prepared a meal for the child that went to school (1.7%)*	Dan racax et ha zameret še nimce-a meta *Dan murdered the singer that was found dead (10%)*	Ha sofer hikdiš la saxkanit et sifro ha xadaš *The writer dedicated his new book to the actress (1.7%)*	Ha yo-ec masar dox la va-ada še hitkansa etmol *The adviser submitted a report to the committee that convened yesterday (3.3%)*	Ha xaverim bilu be vet kafe še nimca be tel aviv *The friends had a good time at the café in Tel Aviv (0%)*	Ha marca xilka ma-amarim la talmidim še hit-anyenu ba xomer *The lecturer gave articles to the students that were interested in the material (1.7%)*
TYPE GP	Be-et še ha rav berex ne-arim rakdu ba xacer *While the Rabbi blessed the boys were dancing at the yard (55%)*	Be-ša-a še ha iša miy-na mixtavim naflu al ha ricpa *While the woman sorted out the letters fell onto the ground (90%)*	Axarei še dana šateta ma-im zarmu me ha berez *After that Dana drank water flowed from the tap (91.7%)*	Lifnei še dan hikri širim ši-amemu otanu *Before Dan read aloud songs bored us (85%)*	Be-od še aba axal pica huv-a al yedey šali-ax *While Father was eating a Pizza was brought by a delivery boy (93.3%)*	Bizman še ran xilek dapim hit-ofefu lexol ever *While Ran was giving the papers flew all over (91.7%)*	Axarei še ha ozeret gihaca 3 xolcot hitkamtu mexadaš *After the cleaning woman ironed 3 shirts creased again (71.7%).*

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[41] The percentages in brackets are the crude percentages of the number of people that had answered a sentence was difficult divided in the total number of people in the experiment (60 subjects).

TYPE 1NP	Ha yapanim hivtixu la tayar še cilem tmuna *The Japanese promised the tourist the photographed a picture (88.3%)*	Ha melcarit natna la baxur še ohev lištot ma-im *The waitress gave the guy that likes to drink water (83.3%)*	Ha ima kilfa la yeled še axal tapu-ax *The mother peeled the child that was eating an apple (80%)*	Ha axot xilka la xolim še yexolim lil-os tavliot *The nurse gave the patients that could chew tablets (50%)*	Ha šali-ax masar la iša še patxa xavila *The delivery boy handed the woman that opened a packet (68.3%)*	Ha baxur hizmin me ha baxura še bišla marak *The guy ordered from the girl the was cooking soup (53.3%)*	Ha mosad doreš me ha studentim še mesugalim lešalem mikdama *The institution demands students that can pay an advance (payment) (66.7%)*
TYPE 2NP$_{(ObOb)}$	Ha davar masar la iša še miy-na mixtavim xavila *The postman gave the woman that sorted letters a packet (8.3%)*	Ha misrad sipek la yevu-an še meyabe sukariot mexalim *The office supplied the importer that imports sweets (with) containers (15%)*	Ha oman ci-yer la iša še mexabevet i-yurim dyokan *The artist painted the woman that liked paintings a portrait (18.3%)*	Ha šotrim šalxu la ezraxim še katvu gluyot cavim *The police officers sent the citizens that had written postcards orders (26.7%)*	Ha paselet natna la itonay še ohev ciyurim psalim *The sculptress gave the journalist that liked pictures sculptures (33.3%)*	Ha ocar hikca la yor še nihel takcivim ksafim *The treasure allocated the executive that ran the budget money (40%)*	Ha yarkan hevi la iša še corexet melafefonim agvaniot *The greengrocer brought the woman the consumes cucumbers tomatoes (45%)*

Appendix 3: Questionnaire of Experiment B

<u>שאלון / אוקטובר 2002</u>

I.‏ האם עברית היא שפת האם שלך? הקיפו: כן / לא

II.‏ הקיפו את המשפט הקשה יותר מבין שני המשפטים הבאים מבחינת זמן הבנתו:

א.‏ כשדן שר שיר התנגן בחנות

ב.‏ כשדן פיהק שיר התנגן בחנות

III.‏ עתה השוו את המשפטים הבאים למשפטים הקודמים (א׳ ו-ב׳) והקיפו תשובה

<u>אחת</u> שתואמת את דעתכם:

שימו לב: יש לענות על המשפטים לפי המספור, מימין לשמאל!

2) למרות שהטנק הפגיז בתים נותרו שלמים		1) השכן מסר מכתב לאישה שפתחה את	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
4) המטייל נתן לבחור שאוהב לשתות מים מינרלים		3) מאחר שיפן שבתה חיילים זרים לא קיבל	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
6) האמא הכינה ארוחה לילד שהלך לבית הספר		5) הדוור מסר לאישה שמיינה איגרות ברכה את ה	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
8) האמא קילפה לילד שאכל תפוח אדום		7) בזמנים עברו שייטו ספינות ללב	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
10) דן רצח את הזמרת שהופיעה בשבוע שעבר		9) אלי קנה לעוזרת שמקפלת בגדי קיץ את הסמ	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
12) הבירה של הולנד היא היינקן		11) האומן צייר לאישה שמחבבת רישומי פחם את ה	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
14) הגנב גזל מהאישה שאוהבת לאפות עוגיות חמאה את העוף		13) מוכרים נלהבים ביותר מדברים בכמה	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	
16) שר האוצר מעורה בתקציב על כל סעיפיו		15) בשנה שעברה כשדן לימד שירה שעממה	
א) המשפט שווה מבחינת הקושי שלו לא׳.		א) המשפט שווה מבחינת הקושי שלו לא	
ב) המשפט שווה מבחינת הקושי שלו לב׳.		ב) המשפט שווה מבחינת הקושי שלו לב	

(17) השליח מסר לאישה שפתחה מעטפת	(18) על ראש הגנב בוער הכובע
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(19) בזמן שרן חילק דפים התעופפו לכ	(20) הפסלת נתנה לעתונאי שאוסף ציורי מים את הפסלים
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו ל	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(21) הבחור הזמין מהבחורה שבישלה ארוחת עו	(22) היועץ מסר דו״ח לועדה שהתכנסה אתמול
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(23) אמא של אסתר נפטרה כשהייתה	(24) האוצר העביר ליו״ר שניהל תקציבים גדולים את הכספים
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(25) המוסד דורש מהסטודנטים שמסוגלים לשלם מ	(26) החברים בילו בבית קפה שנמצא בתל אביב
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(27) דנה קנתה אמנון ותמר קנתה ק	המשרד סיפק ליבואן שמיבא סוכריות טופי את המיכלים
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(29) האנשים העיפו לגורילה שאוהבת לאכול בוטנים מלו... הג	(30) לא הוצאתי הגה מהמכונית
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(31) בכיכר מתנשאת מעל הדמות המרשימה של לואי	(32) האחות חילקה לחולים שיכולים ללעוס טבליות מרות
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(33) אחרי שדנה שתתה מים זרמו ...	(34) השוטרים שלחו לאזרחים שכתבו מכתבי מחאה את הצווים
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(35) בעוד שאבא אכל פיצה הובאה על ידי ה	(36) דנה אפתה את העוגה במקפיא
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.
(37) מטפס ההרים התייאש באמצע	(38) לנורית נולד תינוק אשר שמו למעשה
א) המשפט שווה מבחינת הקושי שלו לא	א) המשפט שווה מבחינת הקושי שלו לא׳.
ב) המשפט שווה מבחינת הקושי שלו לב	ב) המשפט שווה מבחינת הקושי שלו לב׳.

(39) המרצה נתנה תרגיל א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(40) הבמאי נתן לשחקנית שמסוגלת לשיר אופרות קלות את התפקיד א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(41) הרכיבה על גמל קלה יותר עם ה... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(42) היפנים הבטיחו לתייר שצילם תמונות נפלאות א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(43) מבוקש פלשתינאי חמק ממצוד מש... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(44) שמעת את הבדיחה שזרקו על ריצ׳רד גיר? א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(45) דן הבטיח לפקחית שער שושן... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(46) המטפלת הגישה לאנשים שיכולים לבלוע אוכל מוצק את המרק א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(47) הרוקח נתן לחולים שיכולים לבלוע בקלות ט... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(48) עיראק עדיין מהווה גורם מאיים על ישראל א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(49) אחרי שהעוזרת גיהצה 3 חולצות התקמטו ... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(50) גיל הביא את השוקולד משוויצריה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(51) האסטרונאוט מהלך בחלל בקלות א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(52) המנהל העביר לפועל שיודע לקרוא תחשיבי מס את הדוחות א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(53) אלון ישב שנתיים עקב הכאת אדם עם... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(54) הסופר הקדיש לשחקנית את ספרו החדש א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(55) חולצה טובעת... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(56) המרפאה שלחה לרופא שמורשה לנתח ילדים את הזקנה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
(57) בשעה שהאישה מיינה מכתבים התפזרו על ה... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(58) נעמה ודן התאהבו בעבודה א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.
( ) המוכר מדד לילדה שאוהבת לקנות נעלי עקב את ה... א) המשפט שווה מבחינת הקושי שלו לא... ב) המשפט שווה מבחינת הקושי שלו לב...	(60) המרצה חילקה מאמרים לתלמידים שהתעניינו בחומר א) המשפט שווה מבחינת הקושי שלו לא׳. ב) המשפט שווה מבחינת הקושי שלו לב׳.

תודה על שיתוף הפעולה! ☺

Appendix 4: Tables of Frequency and Sentences Used in Experiment B

Table (1): Frequency of the number of people that answered A

Type of sentence	Number of sentence							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
FILLER	3	7	6	7	3	9	4	
TYPE GP	80	100	93	77	85	69	90	
TYPE 1NP	62	77	75	72	37	86	*	
TYPE 2NP(ObOb)	23	19	26	13	11	18	17	
TYPE 2NP(ObNon)	27	39	49!	29	28	29	33	50!

* After analysis, it was discovered that one sentence of TYPE 1NP was replaced by a TYPE 2NP(ObNon) sentence. This was straightened out in the statistical calculations.

! Sentence 3 was missing *et*, the accusative marker. In sentence 8, an adjunct to the first NP was missing. Because of these syntactical defects, the sentences were removed from the statistical calculations.

Table (2) contains the sentences used in the questionnaire according to their type in correspondence to table (1):

Table (2): The sentences[42]

Type of sentence	Number of sentence							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
FILLER	Ha šaxen masar mixtav la iša še patxa et ha delet *The neighbor delivered a letter to the woman that opened the door (2.8%)*	Ha ima hexina aruxa la yeled še halax le vet hasefer *The mother prepared a meal for the child that went to school (6.6%)*	Dan racax et ha zameret še hofi-a šavu-a še-avar *Dan murdered the singer that performed last week (5.7%)*	Ha yo-ec masar dox la va-ada še hitkansa etmol *The advisor submitted a report to the committee that convened yesterday (6.6%)*	Ha xaverim bilu be vet kafe še nimca be tel aviv *The friends had a goodtime at a café in Tel Aviv (2.8%)*	Ha sofer hikdiš la saxkanit et sifro ha xadaš *The writer dedicated his new book to the actress (8.5%)*	Ha marca xilka ma-amarim la talmidim še hit-anyenu ba xomer *The lecturer gave articles to the students that were interested in the material (3.8%)*	

TYPE GP	Lamrot še ha tank hifgiz batim notru šlemim *Despite the tank bombarded houses remained complete (75.5%)*	Bešana še-avra keše dan limed šira ši-amema otanu *Last year when Dan taught poetry bored us (94.3%)*	Bizman še ran xilek dapim hit-ofefu lexol ever *While Ran was giving the papers flew all over (87.7%)*	Axarei še dana šateta ma-im zarmu me ha berez *After Dana drank water flowed from the tap (72.6%)*	Be-od še aba axal pica huv-a al yedey ha šali-ax *While father was eating a pizza was brought by the delivery boy (80.2%)*	Axarei še ha ozeret gihaca 3 xolcot hitkamtu mexadaš *After the cleaning woman ironed 3 shirts creased again (65.1%)*	Be-ša-a še ha iša miy-na mixtavim hitpazru al ha ricpa *While the woman was sorting letters scattered on the floor (84.9%)*	
TYPE 1NP	Ha metayel natan la baxur še ohev lištot ma-im mineralim *The traveler gave the guy the liked drinking mineral water (58.5%)*	Ha ima kilfa la yeled še axal tapu-ax adom *The mother peeled the child that ate a red apple (72.6%)*	Ha šali-ax masar la iša še patxa ma'atefet braxa *The delivery boy gave the woman that opened a greeting card (70.7%)*	Ha mosad doreš me ha studenim še mesugalim le šalem mikdama šmena *The institution demands students that can pay a big advance (67.9%)*	Ha axot xilka la xolim še yexolim lil-os tavliot marot *The nurse gave the patients that can chew bad-tasting tablets (34.9%)*	Ha yapanim hivtixu la tayar še cilem tmunnot nifla-ot *The Japanese promised the tourist that photographed marvelous pictures (81.1%)*		

TYPE 2NP(ObOb)	Ha davar masar la iša še miy-na igrot braxa et ha xavila *The postman delivered the woman that sorted out greeting postcards the packet (21.7%)*	Ha oman ci-yer la iša še mexabevet rišumey pexam et ha dyokan *The artist painted the woman that liked charcoal pictures the portrait (17.9%)*	Ha paselet natna la itonay še osef ciyurey ma-im et ha psalim *The sculptress gave the journalist that collected water paintings the sculpture (24.5%)*	Ha ocar he-evir la yor še nihel takcivim gdolim et ha ksafim *The treasury allocated the chairman that ran big budgets the money (12.3%)*	Ha misrad sipek la yevu-an še meyabe sukariot tofi et ha mexalim *The office delivered the importer that imports toffee sweets the tanks (10.4%)*	Ha šotrim šalxu la ezraxim še katvu mixtavey mexa-a et ha cavim *The policemen sent citizens that wrote protest letters the orders (17%)*	Ha moxer madad la yalda še ohevet liknot na-aley ba-it et ha-simla *The seller measured for the child that liked buying (home) slippers the dress (16%)*	
TYPE 2NP(ObNon)	Eli kana la ozeret še mekapelet bigdey ka-ic et ha smartut *Eli bought the cleaning woman the folded summer clothes the rag (25.5%)*	Ha ganav gazal me ha iša še ohevet le-efot ugiot xem-a et ha of *The thief took from the woman that liked baking butter cookies the chicken (36.8%)*	Ha baxur hizmin me ha baxura še bišla aruxat erev of *The guy ordered from the girl that cooked dinner chicken (46.2%)*	Ha anašim he-ifu la gorilla še ohevet le-exol botnim meluxim et ha gar-inim *The people threw at the gorilla that liked eating salted peanuts the seeds (27.4%)*	Ha bamay natan la saxkanit še mesugelet la-šir operot kalot et ha tafkid *The director gave the actress that could sing light operas the part (26.4%)*	Ha metapelet hegiša le anašim še yexolim li-vlo-a oxel mocak et ha marak *The housemaid served the people that could swallow solid food the soup (27.4%)*	Ha menahel he-evir la po-el še yode-a li-kro taxšivey mas et ha doxot *The manager gave the worker that knew to read tax calculations the reports (31.1%)*	Ha mirpa-a šalxa la rofe še murše le-nate-ax yeldaim et ha zkena *The clinic sent the doctor that was authorized to operate on children the old woman (47.1%)*

REFERENCES

Altmann G. T. M. 1999. "Thematic Role Assignment in Context". *Journal of Memory and Language*, 41, 124-145.

Bader M., & Lasser I. 1994. "German-Final Clauses and Sentence Processing: Evidence for Immediate Attachment". In Clifton C., Frazier L., & Rayner K. (eds.), *Perspectives on Sentence Processing*, 225-242. Hillsdale New Jersey: Lawrence Erlbaum Associates.

Baker M. 1988. *Incorporation: A Theory of Grammatical Relation Changing*. Chicago: University of Chicago Press.

Berwick R., & Weinberg A. 1984. *The Grammatical Basis of Linguistics Performance: Language Use and Acquisition*. Cambridge: MIT Press.

Berwick R., & Weinberg A. 1985. "Deterministic Parsing and Linguistic Explanation". *Language and Cognitive Processes* 1(2), 109-134.

Bever, T. 1970. "The Cognitive Basis for Linguistic Structures." In Hayes J. R. (ed.), *Cognition and the Development of Language*. New York: Wiley, & Sons.

Binder K. S., Duffy S. A., & Rayner K. 2001. "The Effects of Thematic Fit and Discourse Context on Syntactic Ambiguity Resolution". *Journal of Memory and Language*, 44, 297-324.

Boland J. D., Tanenhaus M. K., Garnsey S. M., & Carlson G. N. 1995. "Verb Argument Structure in Parsing and Interpretation: Evidence from Wh-Questions". *Journal of Memory and Language*, 34, 774-806.

Carlson G., & Tanenhaus M. 1988. "Thematic Roles and Language Comprehension". *Syntax and Semantics*, 21, 263-288.

Chomsky N. 1986a. *Barriers*. Cambridge: MIT Press.

Chomsky N. 1986b. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky N. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Christianson K., Hollingworth A., Halliwell J., & Ferreira F. 2001. "Thematic Roles Assigned along the Garden Path Linger". *Cognitive Psychology* 42, 368-407.

Connine C., Ferreira F., Jones C., Clifton C., & Frazier L. 1984. "Verb Frame Preferences: Descriptive Norms". *Journal of Psycholinguistic Research*, 13(4), 307-319.

Dowty D. 1991. "Thematic Protoroles and Argument Selection". *Language* 67, 3, 547-619.

Ferreira F., Christianson K., & Hollingworth A. 2001. "Misinterpretations of Garden-Path Sentences: Implication for Models of Sentence Processing and Reanalysis". *Journal of Psycholinguistic Research* 30(3), 3-30.

Ferreira F., & Henderson J. 1998. "Syntactic Reanalysis, Thematic Processing, and Sentence Comprehension". In Fodor J., & Ferreira F. (eds.) *Reanalysis in Sentence Processing*, 73-100.

Ferreira F., & McClure K. 1997. "Parsing of Garden Path Sentences with Reciprocal Verbs". *Language and Cognitive Processes*, 12(2/3), 273-306.

Frazier L., & Clifton C. . 2001. "Parsing Coordinates and Ellipsis: Copy α". Syntax 4:1, 1-22.

Frazier L., & Clifton C. 1998. "Sentence Reanalysis, and Visibility". In Fodor J. D., & Ferreira F. (eds.), *Reanalysis in Sentence Processing*, Netherlands: Kluwer, 143-176.

Frazier L., & Clifton C. 1996. *Construal.* Cambridge: MIT Press.

Frazier L., & Fodor J. D. 1978. "The Sausage Machine: A new two-stage parsing model". *Cognition* 6.

Frazier L., Munn A., & Clifton C. 2000. "Processing Coordinate Structures". *Journal of Psycholinguistic Research*, 29(4), 343-370.

Frazier L., & Rayner K. 1987. "Resolution of Syntactic Category Ambiguities: Eye movements in parsing lexically ambiguous sentences". *Journal of Memory and Language* 26, 505-526.

Frazier L., & Rayner K. 1982. "Making and Correcting Errors during Sentence Comprehension: Eye Movement in the Analysis of Structurally Ambiguous Sentences". *Cognitive Psychology*, 14, 178-210.

Frazier L. 1990. "Parsing Modifiers: Special Purpose Routines in the Human Sentence Processing Mechanism?" In Blota D. A., Flores d'Arcais G. B., & Rayner K. (eds.), *Comprehension Processes in Reading.* Hillsdale New Jersey: Lawrence Erlbaum Associates, 505-528.

Frazier L. 1988. "Grammar and Language Processing". In Newmeyer, F. J. (ed.), *Linguistic Theory: Extensions and Implications.* Linguistics: The Cambridge Survey, 2, 15-34.

Frazier L. 1987. "Sentence Processing: A Tutorial Review". In Coltheart M. (ed.), *Attention and Performance XII: The Psychology of Reading,* Hillsdale New Jersey: Lawrence Erlbaum Associates, 559-586.

Frazier L. 1983. "Processing sentence structure". In Rayner K. (ed.) *Eye Movements in Reading,* New York: Academic Press, 215-236.

Frazier L. 1978. *On comprehending sentences: Syntactic parsing strategies.* Ph. D. diss., University of Connecticut.

Gibson E. 1998. "Linguistic Complexity: Locality of Syntactic Dependencies". *Cognition* 68, 1, 1-76.

Gorrell P. 1998. "Analysis and Reanalysis". In Fodor J. D., & Ferreira F. (eds.), *Reanalysis in Sentence Processing,* Netherlands: Kluwer, 201-246.

Gorrell P. 1995. *Syntax and Parsing.* Cambridge University Press.

Grodzinsky Y. 1995. "Trace Deletion, Θ-Roles, and Cognitive Strategies". *Brain and Language* 51, 469-497.

Gruber J. 1976. *Lexical Structures in Syntax and Semantics.* Amsterdam: North Holland Linguistic Series.

Hale K., & Keyser J. 1993. "On Argument Structure and Lexical Expression of Syntactic Relations". In Hale K., & Keyser J. (eds.), *The View from Building 20*, MIT Press.

Holmes V. M. 1987. "Syntactic Parsing: In search of the garden path". In Coltheart M., (ed.), *Attention and Performance XII: The Psychology of Reading,* Hillsdale New Jersey: Lawrence Erlbaum Associates, 587-599.

Hopf J. M., Bayer J., Bader M., & Meng M. 1998. "Event-Related Brain Potentials and Case Information in Syntactic Ambiguities". *Journal of Cognitive Neuroscience* 10:2, 264-280.

Inoue A., & Fodor J. 1995. "Information-Paced Parsing of Japanese". In Mazuka R., & Nagai N. (eds.), *Japanese Sentence Processing.* Hillsdale New Jersey: Lawrence Erlbaum Associates, 9-64.

Jackendoff R. 1972. *Semantic Interpretation in Generative Grammar.* MIT Press.

Kamide Y., & Mitchell D. C. 1999. "Incremental Pre-head Attachment in Japanese Parsing". *Language and Cognitive Processes* 14 (5/6), 631-662.

Kimball J. 1973. "Seven Principles of Surface Structure Parsing in Natural Language". *Cognition* 2, 15-47.

Konieczny L. 2000. "Locality and Parsing Complexity". *Journal of Psycholinguistic Research*, 29(6), 627-645.

Kratzer A. 1996. "Severing the External Argument from its Verb". In Rooryck J., & Zarig L. (eds.), *Phrase Structure and the Lexicon*, Dordrecht: Kluwer.

Mak W. M., Vonk W., & Schriefers H. 2002. "The Influence of Animacy on Relative Clause Processing". *Journal of Memory and Language* 47, 50-68.

Marcus M. 1987. "Deterministic Parsing and Description Theory". In Whitelock P., Woods M., Somers H., Johnson R., & Bennett P. (eds.), *Linguistic Theory and Computer Applications*. San Diego: Academic Press.

Marcus M. 1980. *A Theory of Syntactic Recognition for Natural Language*. Cambridge: MIT Press.

Mazuka R., & Itoh K. 1995. "Can Japanese Speakers Be Led Down the Garden Path?" In Mazuka R., & Nagai N. (eds.), *Japanese sentence processing*, Hillsdale New Jersey: Lawrence Erlbaum Associates, 295-329.

McRae K., Ferretti T. R., & Amyote L. 1997. "Thematic Roles as Verb Specific Concepts". *Language and Cognitive Processes,* 12(2/3), 137-176.

McRae K., Spivey-Knowlton M. J., & Tanenhaus M. K. 1998. "Modeling the Influence of Thematic Fit (and Other Constrains) in On-Line Sentence Comprehension". *Journal of Memory and Language* 38, 283-312.

Mitchell D. C. 1994. "Sentence Parsing". In Gernsbacher M. (ed.), *Handbook of Psycholinguistics,* 375-409. New York: Academic Press.

Mulders I. 2002. *Transparent Parsing: Head-Driven Processing of Verb-Final Structures*. Netherlands: LOT.

Ni W., Crain S., & Shankweiler D. 1996. "Sidestepping Garden Paths: Assessing the Contributions of Syntax, Semantics and Plausibility in Resolving Ambiguities". *Language and Cognitive Processes,* 11(3), 283-334.

Osterhout L., McLaughlin J., & Bersick M. 1997. "Event-Related Brain Potentials and Human Language". *Trends in Cognitive Sciences*, 1(6).

Osterhout L. 1994. "Event-Related Brain Potentials as Tools for Comprehending Language Comprehension". In Charles C., Frazier L., & Rayner K. (eds.), *Perspectives on Sentence Processing*, Hillsdale New Jersey: Lawrence Erlbaum Associates, 15-44.

Phillips C., & Gibson E. 1996. "The Strength of the Local Attachment Preference". Paper presented at *Ninth Annual CUNY Conference on Human Sentence Processing*, New York, NY.

Phillips C. 1995. "Right Association in Parsing and Grammar". *MIT Working Papers in Linguistics*, 26, 37-93.

Pritchett B. L. 1988. "Garden Path Phenomena and the Grammatical Basis of Language Processing". *Language* 64, 539-576.

Pritchett B. L. 1991. "Head Position and Parsing Ambiguity". *Journal of Psycholinguistic Research* 20, 251-270.

Pritchett B. L. 1992. *Grammatical Competence and Parsing Performance*. Chicago, IL: University of Chicago Press.

Rayner K., Carlson M., & Frazier L. 1983. "The Interaction of Syntax and Semantics during Sentence Processing: Eye Movement in the Analysis of Semantically Biased Sentences". *Journal of Verbal Learning and Verbal Behavior*, 22, 358-374.

Rayner K., & Sereno S. C. 1994. "Eye Movements in Reading: Psycholinguistic Studies. In Gernsbacher M. (ed.), *Handbook of Psycholinguistics*, 57-82. New York: Academic Press.

Rayner K. 1999. "What have We Learned about Eye Movements during Reading?" In Klein M., & McMullen P. (eds.), *Converging Methods for Understanding Reading and Dyslexia*, 24-56. Cambridge: MIT Press.

Rayner K. 1998. "Eye Movements in Reading and Information Processing: 20 Years of Research". *Psychological Bulletin,* 124, 372-422.

Reinhart T., & Siloni T. 2001. Class Lectures.

Reinhart T. 2000. *The Theta System: Syntactic Realization of Verbal Concepts*. Netherlands: OTS.

Reinhart T. 2001. *A synopsis of the Theta System*, MS. available at http://www.tau.ac.il/~reinhart, or at http://www.let.uu.nl/~tanya.reinhart.

Rizzi L. 1990. *Relativized Minimality*. Cambridge: MIT Press.

Sedivy J., & Spivey-Knowlton M. J. 1994. "The Use of Structural, Lexical, and Pragmatic Information in Parsing Attachment Ambiguities". In Clifton C., Frazier L., & Rayner K. (eds.), *Perspectives on Sentence Processing*, Hillsdale New Jersey: Lawrence Erlbaum Associates, 389-413.

Shapiro L. P., Nagel H. N., & Levine B. A. 1993. "Preferences for a Verb's Complements and Their Use in Sentence Processing". *Journal of Memory and Language*, 32, 96-114.

Siloni T. 2003. "Garden Path: Illicit Movement". MS.

Spivey-Knowlton M. J., Trueswell J. C., & Tanenhaus M. K. 1993. "Context Effects in Syntactic Ambiguity Resolution: Discourse and Semantic Influences in Parsing Reduced Relative Clauses". *Canadian Journal of Experimental Psychology* 47:2, 276-309.

Starr M. S., & Rayner K. 2001. "Eye Movements during Reading: Some Current Controversies". In *TRENDS in Cognitive Sciences*, 5(4), 156-163.

Traxler M. J., Morris R. K., & Seely R. E. 2002. "Processing Subject and Object Relative Clauses: Evidence from Eye Movements". *Journal of Memory and Language*, 47, 67-90.

Trueswell J., Tanenhaus M. K., & Garnsey S. 1994. "Semantic Influences on Parsing: Use of Thematic Role Information in Syntactic Disambiguation". *Journal of Memory and Language*, 33, 285-318.

Van Gompel R. P. G., Pickering M. J., & Traxler M. J. 2001. "Reanalysis in Sentence Processing: Evidence against Current Constraint-Based and Two-Stage Models". *Journal of Memory and Language* 45, 225-258.

Weinberg, A. 2001. "A Minimalist Theory of Human Sentence Processing". In Epstein, & Hornstein (eds.), Chapter 11, *Working Minimalist*. Cambridge: MIT Press.

Williams J. S., & Kalita J. K. 2000. "Parsing and Interpretation in the Minimalist Paradigm". *Computational Intelligence*, 16(3), 378-407.

תקציר

תהליך מוגדר באופן בו מעבד המשפטים האנושי מחלק באופן אוטומטי יחידות עיבוד או מורפמות ומעניק לה פירוש מספק. על פי התיאוריה של Pritchett, המבוססת על משפטי Garden Path, יחידות העיבוד משודכות לעץ התחבירי המתהווה בהתאם לתפקידים התמטיים הרלוונטיים שלהם וזאת רק ברגע שבו נתקל המעבד במילה שמעניקה תפקידים תמטיים והחיבור מתבצע מהר ככל האפשר במשך העיבוד, כלומר המעבד עושה שימוש בידע תחבירי בתהליך המקוון. ישנם מקרים מיוחדים בהם מעבד המשפטים האנושי עלול להתקל בשתי אפשרויות שוות להמשך התהליך. הדבר נובע מכך שקיימים שני תפקידים תמטיים זמינים הניתנים להענקה משני מעניקי תפקידים תמטיים ליחידה אחת. אפשרות אחת תוביל לאפקט ה- Garden Path, בעוד שהאפשרות השנייה תגרום למשפט להיות מעובד ללא קושי. במשפטי Garden Path, בהם האופציונליות להענקת תפקידים תמטיים אינה קיימת, יגרם אפקט ה- Garden Path בכל מקרי העיבוד של המשפטים הללו. כאשר קיימות שתי אפשרויות, החיזוי הוא שאפקט ה- Garden Path יורגש בהסתברות צ׳אנס (Chance Distribution) ; בהתאם להחלטה השידוך השרירותית שהמעבד בוחר בה.

תיאוריה נוספת, על פי הצעתה של Frazier, כוללת חיזוי אחר בהקשר למשפטים האופציונליים. ״מודל ה- Garden Path״ מתבסס על שני עקרונות, Minimal Attachment (שידוך מינימלי) ו- Late Closure (סגירה מאוחרת). העקרונות אינם מבוססים כלל על תחביר; הם משקפים תצפיות על ביצוע התהלוך. על פי עקרונות אלה, מעבד המשפטים האנושי מעדיף שידוכים המביאים למספר המזערי ביותר של צמתים בעץ התחבירי (שידוך מינימלי), אבל רק בחלון שבו מתבצע העיבוד באותו רגע (סגירה מאוחרת). כתוצאה מכך, משפטים אופציונליים לפי Pritchett תמיד יגרמו לאפקט ה- Garden Path, מאחר שהמעבד תמיד יעדיף שידוך יחידות מסומנות בתפקיד תמטי מאחר שהן מביאות לשידוך בעל מספר הצמתים הנמוך ביותר, והוא יחבר את יחידות אלה בתור ארגומנט של הצירוף הפעלי המעובד באותו זמן. תיאורית ה- Garden Path חוזה שאפקט ה- Garden Path יתרחש בכל מקרי העיבוד של משפטים אלה, מאחר שבעיבוד הראשוני העקרונות תמיד מובילים לעיבוד השגוי של המשפטים, דבר המצריך עיבוד חוזר שהוא המקור של אפקט ה- Garden Path.

האובליגטוריות של התפקידים התמטיים נלקחה גם היא בחשבון בעיבוד משפטי ה- Garden Path האופציונליים (ככל הנראה). באופן כללי, החיזוי הוא שאם המעבד מתחשב באובליגטוריות במשך העיבוד המקוון, הדבר יוביל לתוצאות שונות ביותר מאלה שבתיאוריות של Frazier ו- Pritchett. אם הנחה זו נכונה, משפטים אלה לא יגרמו לאפקט ה- Garden Path, משום שהעיבוד הראשוני של המשפטים יהיה הנכון.

בעבודה זו, החיזוי להסתברות צ׳אנס אושש מבחינה אמפירית מתוך ביצועי התהלוך של משפטים אופציונליים בהתבסס על שני ניסויים שכללו שאלוני שיפוט. הנתונים מצביעים על כך שמעבד המשפטים האנושי מימש את החיזויים של Pritchett, אך לא אלה של Frazier ושהמעבד האנושי אינו מתחשב באובליגטוריות של התפקידים התמטיים. למרות כל זאת, מהתצפיות עולה ששיקולי תהלוך דומים לאלה של חיבור מינימלי וסגירה מאוחרת ממלאים תפקיד במשך התהלוך אולם הם מסתירים את המנגנון על פיו המעבד האנושי פועל למעשה. שיקולים אלה נקראו בעבודה זו Adjacent Attachment (חיבור סמוך) והיא כוללת גם דיון על מעמדם לשם מחקר עתידי.

תוצאות הניסויים בעלות השפעה עמוקה על הדרכים שבעזרתן מסבירים עיבוד שפה טבעית, מאחר שהיא מערערת על מעמדו של מודל ה- Garden Path כתיאוריה המסבירה באופן מדויק את האופן שלפיו פועל המעבד האנושי. למעשה, בכדי להסביר ביצועי תהלוך על החוקרים להתבסס על ידע בלשני ואין להסתפק בתצפיות על ביצועי תהלוך של בני אדם. בנוסף, הדבר החשוב ביותר הוא ההצלחה בהסברת תופעות עיבודיות בצורה פשוטה ואחידה, כפי המוצע במסגרת התיאוריה של Pritchett, הן באנגלית והן בעברית. העבודה מספקת עדויות מוצקות על כך שלב התיאוריה לעיבוד משפטים, כלומר מנגנון פעולת מעבד המשפטים האנושי, נגזר מהתיאוריה התחבירית.

אוניברסיטת תל-אביב
הפקולטה למדעי הרוח ע״ש לסטר וסאלי אנטין

החוג לבלשנות

הנושא : תהלוך משפטי Garden Path אופציונליים בעברית

חיבור זה הוגש כעבודת גמר לקראת התואר
"מוסמך אוניברסיטה" - M.A. באוניברסיטת ת"א

על ידי
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העבודה הוכנה בהדרכת ד"ר טל סילוני

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