PROSODY AND PARSING IN A DOUBLE PP CONSTRUCTION IN HEBREW

by

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ABSTRACT

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It is a standard finding that speakers reliably produce prosodic cues to *clause* boundaries and listeners use these cues in parsing sentences. However, considerable uncertainty remains regarding whether the same applies to syntactic *phrase* boundaries. A long series of studies in the parsing literature on ambiguous PP attachment constructions, such as *Susan hit the man with the umbrella*, has yielded mixed results.

This dissertation investigates the prosody-syntax interface in the processing of a double PP construction in Hebrew. Selection restrictions force the first prepositional phrase (PP1) to attach low, but attachment of the second one (PP2) is ambiguous: it can attach maximally high to VP (as an argument of *described*) or maximally low to the NP inside PP1 (modifying *marriage*).

Dana	**VP[**	te'ara	'et	**NP[**	ha-kšayim	**PP1[**	be-nisu'e-ha	**PP2[** la-šadran
Dana		described	ACC		the-difficulties		in-marriage-her	to the-broadcaster

A length contrast in PP2 was also examined. PP2 was either short (as here) or long (with addition of a modifier to the short version).

This double PP construction exhibits a sharper structural contrast between the two potential attachment sites than the long-studied single-PP construction: there is a greater discontinuity in the syntactic tree for the high attachment analysis, which could encourage a stronger prosodic break before the ambiguous PP, yielding more reliable results than for the single-PP construction. An advantage of conducting the experiment in Hebrew is that the acoustic markers of prosodic phrase boundaries, which include a final high boundary tone, are clearer than in English.

Two experiments were conducted. The first was a combined production-comprehension study examining the relationship between preferred interpretation and preferred prosodic phrasing in reading aloud. The results showed a reliable association between high attachment of PP2 and the presence of a prosodic break immediately preceding it, though as predicted there were significantly more instances of this pattern (prosodic break + high attachment) for long than for short PP2. The second experiment tested comprehension of the same items in silent reading. PP2 length effects on attachment were very similar in silent reading and reading aloud, providing new insight into the Implicit Prosody Hypothesis (Fodor 2002).

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CHAPTER 1

INTRODUCTION

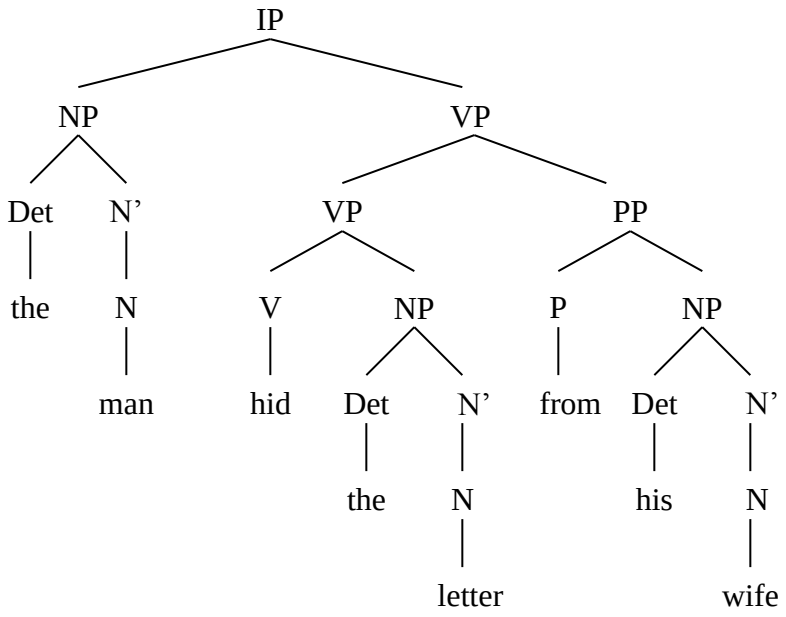
1.1 Background: The single-PP attachment construction

Ambiguities of prepositional phrase attachment have attracted much interest in the field of sentence processing. The specific construction that has been most extensively studied, illustrated in (1), concerns the attachment of a prepositional phrase (PP) to the VP (modifying the verb 'hid'), as shown in tree diagram 2(a)[1], or to the immediately preceding NP (modifying the noun 'letter'), as shown in tree diagram 2(b).

(1) The man hid the letter from his wife.

V NP PP

(2) a.



[1] Although syntacticians have argued for more complex structural representations, relatively simple traditional structures suffice in general for purposes of prosody assignment.

b.

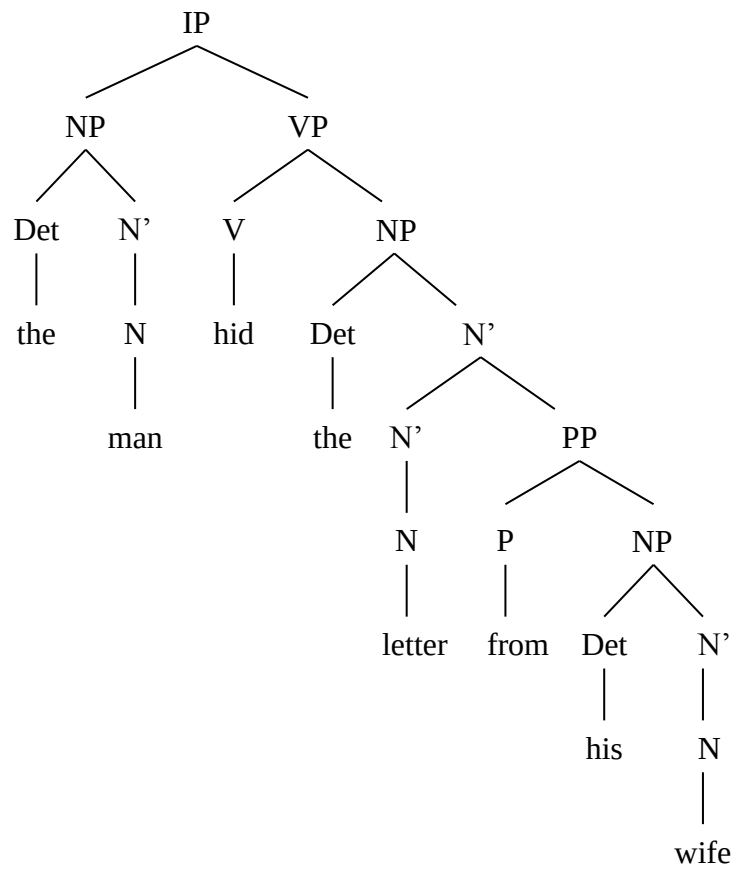


Figure 1-1: Syntactic structure of high and low PP attachment to VP and NP respectively

For silent reading of English, a preference for VP attachment over NP attachment has been thoroughly documented in the literature (Rayner, Carlson & Frazier, 1983; Ferreira & Clifton, 1986; Altmann & Steedman, 1988; Clifton & Ferreira, 1989; Perfetti, 1990; Clifton, Speer & Abney, 1991; Britt, Perfetti, Garrod, & Rayner, 1992; Rayner, Garrod & Perfetti, 1992; Britt, 1994, among others) but it nevertheless remains something of a mystery. One reason is that it is an apparent exception to the Late Closure strategy, which states that incoming material is preferentially attached to the most recently processed phrase (Frazier, 1978). It is possible that Late Closure is overridden here by Minimal Attachment, which favors connecting an incoming word into the syntactic structure using

as few nodes as possible, favoring attachment to VP. Some psycholinguists have suggested instead that high PP attachment to VP is due to a preference for argument roles over adjunct roles (Abney, 1989; Clifton, Speer, & Abney, 1991; Speer & Clifton, 1998; Kennison, 1999; Schütze & Gibson, 1999). However, many of the examples tested over the years have had PPs headed by the preposition "with" (as in: "They opened the safe with the dynamite"), and when a with-PP is attached to VP it is not clearly an argument of the verb but is instrumental in nature, often classified as an adjunct. Alternatively, since "with" is semantically ambiguous, it is possible that the other sense of 'with' (meaning 'which has' as in "they opened the safe with the diamonds') is simply lexically less frequent. Of relevance to the present dissertation is the possibility of an explanation for the VP attachment preference based on the prosody associated with the construction.

1.2 The role of prosody in PP attachment

It has been proposed that the default prosody for a string of the form *V Det N PP* has a prosodic break before the PP (see below), which would favor high attachment on the assumption that prosodic and syntactic phrases align (Selkirk, 2000). Alternatively, it might be that the default prosody phrases the VP as a single prosodic unit containing three prosodic words: the verb, the noun and the PP. If a sentence has an odd number of prosodic words, it cannot exclusively group them into binary prosodic phrases in accord with universal preferences (BinMaP; Selkirk, 2000), but must have at least one phrase that contains either three prosodic words or only one. Since English tends to favor long prosodic phrases, it is more likely to favor a single ternary phrase, rather than breaking it into shorter phrases. A ternary prosodic phrase could favor a ternary syntactic structure

(though not all syntactic theories permit that), which would amount to attaching the PP to VP.

Some studies have investigated the prosody-attachment connection in PP attachment ambiguities and could therefore suggest whether prosody could be involved in the VP attachment preference of the PP. Listening studies (Pynte & Prieur, 1996; Snedeker & Trueswell, 2003; Kraljic & Brennan, 2005; Schafer, Speer & Warren, 2005; Watson & Gibson, 2005) have shown that a break preceding the ambiguous PP constituent encourages high attachment and that lack of a break at that position, or a break following the verb, encourage low attachment. These and related studies will be discussed in detail in Chapter 2. The findings do show a connection between prosody and attachment in the PP attachment ambiguity, indicating that prosody may play a role in the VP attachment preference, and yet it is not clear that the prosodic contours which serve to disambiguate attachment height for listeners are required or even natural in normal productions of this construction. In the next chapter I review inconclusive findings from production experiments over many years. The present chapter provides an informal introduction to some of the puzzles concerning prosody and parsing of the (single) PP attachment construction illustrated in (1) and (2), which suggest that this construction is not a very stable target for sentence processing research, at least until a better understanding of its linguistic properties is achieved. In subsequent chapters I report results of experiments investigating a double PP construction (e.g., *She described the difficulties in her marriage to the broadcaster*), where the syntax-prosody relationship can be expected to be clearer than for the single-PP construction.

Selkirk (2000) proposed the $Align_R$ XP constraint for English, which creates a prosodic boundary following every major syntactic phrase (XP), except where that is overridden by other alignment constraints (such as Wrap; Truckenbrodt, 1995) or eurhythmic constraints concerning phrase length and uniformity. Selkirk illustrated the effect of the $Align_R$ XP with the example in (3), where it is quite natural to impose a prosodic break after 'rollerblades', i.e., before the PP.

(3) She loaned her rollerblades to Robin.

(Note that there is no ambiguity in this example; lexical compatibilities force the PP to attach to VP, so there is definitely a syntactic right edge of NP preceding the PP.) However, this judgment is highly sensitive to variations in phrase length (as Selkirk herself demonstrates). For example, a break after the NP is intuitively much less natural in (4), which differs from (3) only in syllable count and word frequency.

(4) She gave her skates to Pat.

This might be a case in which Wrap and length considerations override $Align_R$ XP. But on the other hand it could suggest to the contrary that the break in (3) is not due to alignment after all but is induced by the prosodic length (or weight) of 'loaned her rollerblades'. Even (5) seems less likely to contain a prosodic break in everyday speech.

(5) She lent her rollerblades to Robin.

Thus, it seems possible that $Align_R$ XP may not after all apply to this construction (for whatever reason), even with a clearly high-attaching PP. A break between the NP and PP

is acceptable when motivated by phrase lengths, and no doubt also – regardless of phrase lengths –when the attachment of the PP is ambiguous and the speaker wishes the intended meaning to be clear, as in (1) above, or (6).

(6) The chef lifted the chicken with two forks.

For sentences with unambiguous low attachment of a PP, such as (7), the PP is an internal constituent of the NP so there is no right edge of NP for a prosodic break to align with.

(7) She cleaned the rug from the antique store.

A break before the PP could therefore only be motivated by length/weight considerations, as perhaps in (8):

(8) She cleaned the beautiful old rug from Bill's favorite antique store.

A break before the object NP may occur, but it would sound very odd in (7). Again, it becomes acceptable if there is some length reason for it. For example, in (9) the heavier 'steam-cleaned' may invite a following break unlike 'cleaned' in (7).

(9) She steam-cleaned the rug from the store.

In cases of potential ambiguity, as in (10), it is not uncommon for a speaker to insert a break before the object NP, thereby grouping it together with the following PP.

(10) The chef basted the chicken with chestnut stuffing.

But as noted, there is no syntactic edge there that an alignment constraint could apply to. Any such break (in absence of length motivation) thus appears to be pragmatically motivated, for purposes of disambiguation only.

These few examples obviously do not constitute definitive evidence, but they hint at the possibility that for PP constructions there may be a mismatch between general principles of prosody-syntax alignment and the performance of speakers confronting practical demands. As Selkirk (2000) notes, there are other influences on the production of prosodic phrasings in addition to alignment principles; for example, constituent length and focus interact with alignment principles in the production of prosodic phrasings. Because PPs can attach at so many different loci in a syntactic structure, this is a construction that is unusually likely to be syntactically/semantically ambiguous. It may also be unusual in that grammatical principles do not define two distinctive prosodic disambiguations for it (as in the case of other familiar ambiguities such as "When Bill leaves the house is/it's dark" or "I met Jill and Ted and Sam met you", where it would be odd not to use a distinguishing prosody). For PP attachment, therefore, speakers may resort – sometimes – to helpful prosodic groupings that fall beyond the scope of the grammar itself, and then hearers may take advantage of these useful cues. While this is only a speculation, it might serve to explain why there have been inconstant findings in previous experiments on PP attachment (discussed in Chapter 2).

Further study of this construction is clearly needed, but in Chapter 4 I will turn away from single-PP attachment, to begin exploring an interesting double PP attachment construction, which may offer clearer outcomes.

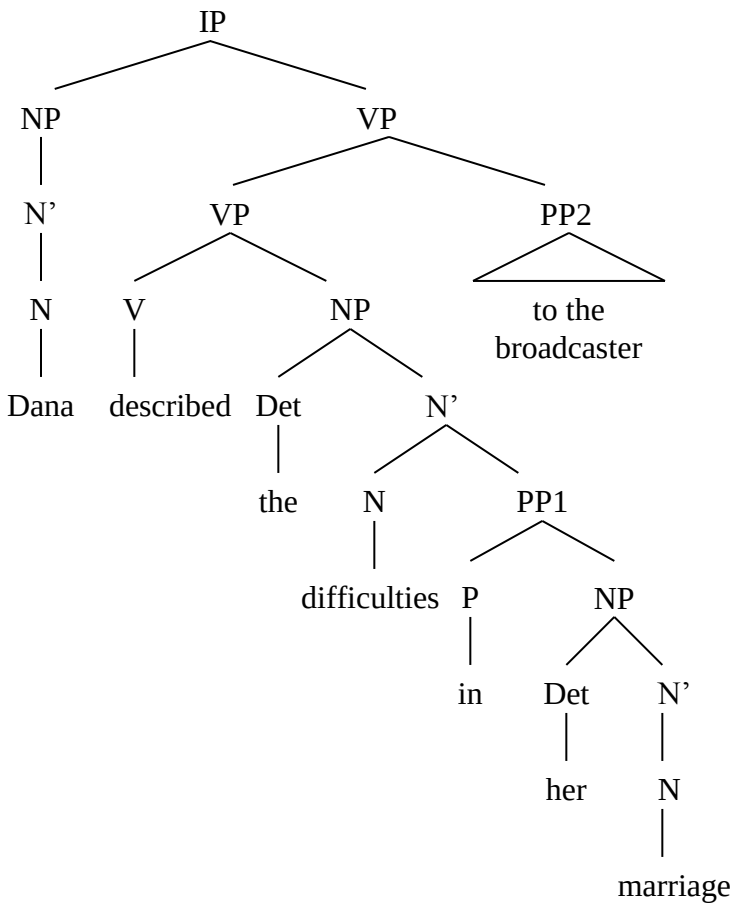
1.3 The Double-PP attachment construction: preview

To approach an explanation of the standard PP attachment data for English it may be productive to broaden the perspective to a wider range of constructions that contrast high and low PP attachment. While there are several other such constructions to explore, of particular interest is the case in which the choice of attachment is between the VP level (as usual) and attachment to a lower site: not the object NP itself, but a PP inside that object NP. This is what I will call the Double-PP attachment ambiguity. It is illustrated in English in example (11). (Hebrew examples will be presented in section 4.2.)

(11) Dana described the difficulties in her marriage to the broadcaster.

VP NP PP1 PP2

(12) a.



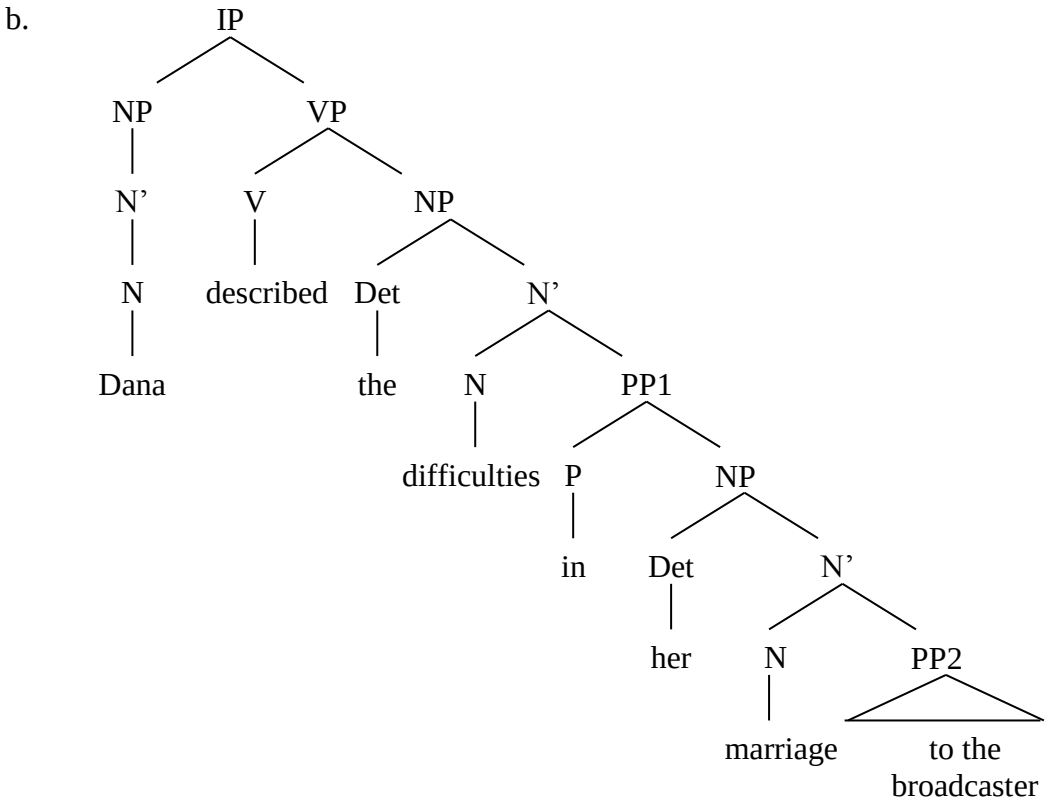


Figure 1-2: Syntactic structure of high and low PP2 attachment to VP and NP respectively

By design, PP1 can only sensibly attach low, to the NP, not to VP ('difficulties in her marriage', not 'described in her marriage'). Thus there is no ambiguity here: NP and PP1 form a constituent (a complex object NP). The only ambiguity concerns the attachment of PP2. In all examples tested, PP2 cannot modify the complex object NP (not 'difficulties to the broadcaster'). So the choice is between attaching maximally low, to the NP inside PP1, thus modifying the noun 'marriage', or attaching maximally high, at the VP level, thus modifying the verb 'described'. Note that this increases the disparity in terms of right-edge XP brackets between the two potential attachment sites compared with the single-PP attachment construction, since for high attachment both PP1 and the complex NP that includes PP1 are closed (i.e., have right edges) immediately preceding

PP2. Thus, if edge-alignment is indeed a significant factor in the phrasing of PP constructions, a sharper or more reliable prosodic contrast may be observed in this case.

1.4 Contributions of this research

Theoretical proposals concerning the syntax-prosody interface have traditionally been based on a rather small body of data consisting primarily of intuitive judgments by linguists. However, as Selkirk (2000) has noted, it is important to substantiate the theory on the basis of experimental data on various constructions drawn from a variety of languages. The current study contributes to the wider body of data on prosody-syntax interface relationships from a language that has not been studied extensively in this respect: Hebrew. In addition to providing data specific to Hebrew prosody, it will provide some evidence on whether Hebrew abides by the interface principles that have been proposed for other languages; if so, it will provide further support for their universality. The choice of Hebrew as the target language also has the benefit that its prosodic boundaries are acoustically more sharply drawn than in English (see Chapter 4).

The ambiguous double-PP construction that is the target of investigation has not been systematically studied, to date, in any language. It is like the more familiar single-PP construction in that it involves the attachment of a phrase rather than a clause, and so it addresses the still open question of whether prosody marks syntactic phrase boundaries consistently, a matter on which there has been some uncertainty (see Chapter 2). At the same time, the structural contrast is more robust than for single-PP attachment and so may yield more consistent results. Finally, it is hoped that this study may – indirectly –

throw some light on the uncertain role of prosody in the processing of the single-PP construction.

CHAPTER 2

PROSODIC EFFECTS ON PP ATTACHMENT

2.1 Introduction: Inconclusive findings from prior research

Research on the syntax-prosody interface has shown that, in many contexts, prosodic contours reflect syntactic structure in language production and influence syntactic parsing in listening to spoken language. (Studies exhibiting this relationship are reviewed by Cutler, Dahan & van Donselaar, 1997; Wagner & Watson, 2010, among others.) Results have been generally robust for Intonational Phrase (IPh) boundaries, in both production and perception. However, the relationship between ip (intermediate phrase) boundaries and syntactic phrasal boundaries is less secure and is worth studying further, as will become evident from the studies reviewed below.

My focus here is on prosodic effects in the production and perception of PP attachment constructions. To narrow it still further, I limit discussion to temporarily or globally ambiguous constructions in which a PP can attach either into a Noun Phrase (NP) or to a Verb Phrase (VP) node, as in example (1) diagrammed in example (2) in Chapter 1.

(1) The hostess greeted the girl with a smile. (Lehiste, 1973, from Stageberg, 1958)

This excludes other constructions containing a PP such as the ambiguity of main vs. subordinate clause attachment as in example (2) (Clifton, Carlson & Frazier, 2002), and also the ambiguity of attachment to a higher or lower noun as in example (3) (based on Hemforth, Petrone, d'Imperio, Pynte, Colonna & Konieczny, 2006).

(2) Susie learned that Bill called on Monday.

(3) Le nouveau juge a consulté l'assistant de l'avocat de Gallu.

'The new judge consulted the assistant of the lawyer from Gallu.'

In what follows I will refer to examples like (1) as instances of 'single-PP attachment' despite the fact that (2) and (3) also involve only a single-PP; this is because type (1) will be contrasted in the remainder of the dissertation with a double PP construction as in (4):

(4) Dana described the difficulties in her marriage to the broadcaster.

In Chapter 1 it was noted that for the single-PP attachment, the relationship between attachment and prosodic boundaries is somewhat tenuous, with sometimes conflicting experimental results. On intuitive grounds we even considered the possibility that no prosodic breaks are required at all by the syntax/prosody interface principles in the production of V NP PP constructions, regardless of the intended interpretation, except as may be motivated by constituent length and other factors. When breaks do occur in this construction, however, there may well be natural affiliations between the two potential syntactic structures and certain prosodic break patterns.

In this chapter I review the data available in the literature concerning the single-PP attachment ambiguity. In each case I will summarize the method and results, and then draw attention to aspects of the study (materials and procedures) which might help to explain why its outcomes differ from those of some other studies. The overall goal is to reconcile the mixed findings where possible. It is important for the general theory of the syntax/prosody interface to get to grips with these uncertainties concerning prosodic relations with syntactic phrasal structure. Possible explanations for the lack of a robust

syntax/prosody relationship for single-PP constructions will be considered in the concluding chapter.

2.2 From 1973 to the present

Lehiste (1973) conducted the pioneering study of whether the intended meaning of ambiguous sentences can be made explicit by prosody. Fifteen pairs of syntactically ambiguous sentences, two of which contained ambiguously attached PPs, were recorded by four speakers. The speakers were first recorded reading the sentences without being informed of the ambiguity. They were then made aware of the structural ambiguities and their possible meanings and were asked which interpretation they had had in mind while reading the sentences. Subsequently, they were instructed to read each sentence two more times to reflect the two possible interpretations ("with consciously attempted disambiguation" p. 109). (Thus, each sentence was read three times by each speaker, once before being made aware of the ambiguity and twice following it. Effects of awareness on prosody and parsing are discussed in section 2.3.) All of these recordings were presented to 30 listeners who were asked to identify the meaning intended by the speaker. Listeners were able to reliably disambiguate only the items whose interpretations differed in their surface syntactic structure[2], including the two PP ambiguities. Lehiste represented the two syntactic structures of one of these PP sentences as shown in example (5). Note that the bracketed strings represent the same structural configurations as in the tree diagrams (2a) and (2b) in Chapter 1.

[2] An important discovery by Lehiste was that for examples like '[[Visiting] [relatives]] can be a nuisance', where the two meanings correlate with a difference in deep structure but have the same surface structure configuration, speakers did not reliably distinguish the two meanings.

(5) a. The hostess [[greeted [the girl]] [with a smile] – VP attachment

b. The hostess [greeted] [[the girl] [with a smile]] – NP attachment

Impressionistically, Lehiste reported that prosodic boundaries were often signaled by "a drawl". She indicated that "intonation appears to have been less systematic" (p. 114). She reported durational data as supporting evidence of the differential placement of prosodic phrase boundaries in accord with the syntactic structure. She found that (in the successfully disambiguated sentences) the duration of a segment was greater when it contained a syntactic (phrase) boundary. For example (5) the duration of the segment "greeted the girl" was greater in the low attachment production than in the high attachment production - but only for two of the four speakers. These results were interpreted as suggesting a prosodic break in the low attachment production at the boundary between the verb and the direct object (see (5b) above), but no prosodic break within that segment in the high attachment production, where no syntactic boundary is present (see (5a) above). (In this study, somewhat surprisingly, it appears that Lehiste did not compare durations for the sequence 'the girl with a smile', which could have indicated presence or absence of a prosodic break before the prepositional phrase.) Disambiguation by the listeners was successful only for the two speakers whose prosodic phrasing aligned in this fashion with the syntactic phrasing. Results for sentence (6), which is the second single-PP sentence that Lehiste tested, were also somewhat mixed.

(6) The police stopped fighting after dark.

Thus, for PP attachment performance was not a uniform success. To conclude, it appears that when speakers produced appropriate prosodic contrasts for the two interpretations, the listeners were able to perceive the intended meanings correctly but not all speakers were consistent in this respect. A following study by Lehiste, Olive & Streeter (1976) largely replicated these results with the addition of manipulation of the duration of the segment 'girl with a smile' in (5) above, as well as the segment 'greeted the'. She found a significant correlation between segment duration and meaning judgment for both of these segments. If the increased durations do signify presence of a prosodic break, then this study showed high attachment encouraged by a break before the PP, as well as low attachment encouraged by a break before the direct object.

This work was a very important foundation for all subsequent research on the syntax/prosody interface. However, it clearly could not constitute the final word on syntax prosody alignment in production and perception. Although a range of different constructions was tested, for each one there were very few items; the number of speakers was also very small and their performance varied considerably. Lehiste herself placed great emphasis on the extent of individual variation, particularly in production. To the best of my knowledge this aspect of the matter has not been pursued in any subsequent research (except for extreme cases of prosodic insensitivity reported in clinical studies), though it is clearly of interest. There are also important issues concerning the extent to which speakers and listeners were aware of the ambiguities. These will be discussed in section 2.3.

Other studies followed in the footsteps of this one. Cooper & Paccia-Cooper (1980) conducted a production study that investigated durational differences in globally

ambiguous sentences, which in this case were read either in isolation or embedded within disambiguating paragraphs. They tested several structural ambiguities, one of which was the single-PP attachment ambiguity. In the isolated sentence condition, ten native speakers of English read a short list containing two single-PP sentences, shown in examples (7) and (8) below, together with some filler sentences. The target items were presented with their interpretations in parentheses, as can be seen in sentences (7) and (8) below. The speakers read each sentence first and then recorded it. They were asked to read in a natural manner.

(7) a. Lieutenant Baker instructed the troop with a handicap.
(The Lieutenant was handicapped.)

b. Lieutenant Baker instructed the troop with a handicap.
(The troop was handicapped.)

(8) a. Jeffery hit the cop with a stick.
(Jeffery had a stick.)

b. Jeffery hit the cop with a stick.
(The cop had a stick.)

Duration was measured both for the noun immediately preceding the PP and for the following optional pause. The measurements revealed longer durations in the noun for the VP attachment reading, though this was significant only for example (8). The mean duration of the following pause was significantly longer for VP attachment in both sentences. Thus the results did not fully agree across the two items.

Cooper & Paccia-Cooper (1980) also reported durations in the same sentence regions, for sentence (8) only, in the condition in which it was embedded in disambiguating paragraphs, one supporting the VP attachment interpretation and one

supporting the NP attachment interpretation. In contrast to the testing of sentences in isolation, in this condition the speakers were not made aware of the ambiguities. Ten participants read each paragraph silently and then aloud into a microphone. There were no significant differences in the duration of either the noun or the following pause. Numerically, the result for the noun was in the predicted direction, but the pause showed the reverse pattern. The authors suggest that "the greater magnitude of lengthening observed for isolated sentences… may be attributed to the speaker's awareness of the ambiguity in these sentences and, hence, a conscious attempt to disambiguate the strings via prosodic information. In the context of full paragraphs, the semantic environment provides sufficient clues to disambiguation, eliminating the need to disambiguate via prosody." (p.45). See further consideration of this type of explanation in discussion of the study by Straub (1997) in section 2.3 below.

This work adds a further dimension to the Lehiste study, but for the single-PP attachment ambiguity in particular the number of items is still extremely limited and the results are still mixed.

Warren (1985) conducted a combined production and perception study (like Lehiste) with various structural ambiguities, one of which was a *locally* ambiguous single-PP, disambiguated pragmatically as the examples below show: There were five examples of this general type in the experiment[3]. Nine or ten[4] native speakers of British

[3] This report on Warren's study is derived from Schafer (1997) since Warren's dissertation is unavailable. The other four instances of single-PP attachment are not presented by Schafer.
[4] It is not clear from Schafer (1997) whether nine or ten native speakers of British English read aloud the experimental sentences.

English read aloud the experimental sentences[5] (see example (9) below), which were interspersed among many fillers.

(9) a. John broke the clock **with his bare hands** (VP attachment)

b. John broke the clock **with a gold face** (NP attachment)

An acoustic analysis revealed significant tonal and durational differences between sentence versions immediately preceding the PP. However, those differences were smaller than for the other 3 constructions studied. These included examples such as (10), (11) and (12) below:

(10) a. Before the king rides his horse takes ages to groom.
b. Before the king rides his horse Ted gives it a groom.

(11) a. The actor learnt the text and knew his role.
b. The actor learnt the text amused the cast.

(12) a. The women's journal said that the park acts mainly as a lunchtime retreat.
b. The women's journal said that the park acts meant a violation of rights.

A perception study followed, with one speaker reading aloud the same materials, producing similar prosodic contrasts as in the production study. The ambiguous regions were then spliced out of the recordings. The participants listened to the sentence fragments and selected one of two possible completions, which were displayed in writing ('with his bare hands' vs. 'with a gold face' in example (9)). The results for the other three constructions showed very accurate discrimination, but for the single-PP construction discrimination was only 57% correct. Thus, just as in the production study, the PP construction was the least differentiated by prosody.

[5] It is not clear from Schafer (1997) whether the speakers were trained or non-naïve.

These results conform with those of the preceding ones in showing that the single-PP structure does show prosodic effects but they are not especially robust. This study also employed five examples of single-PP attachment rather than just one or two. In addition, it makes a methodological contribution by using the sentence completion task in the listening study. Together with the fact that the items were only temporarily ambiguous, disambiguated by the content of the PP, this made it possible to obtain data online, in the sense that listeners responded at the location in the sentence at which the presence or absence of a prosodic break provided potential prosodic disambiguation. A possible disadvantage of this, on the other hand, is that the contents of the two PP continuations might have contributed some bias to the selection that listeners made.

Price, Ostendorf, Shattuck-Hufnagel & Fong (1991) conducted a study employing a variety of types of surface structure ambiguities, including just two single-PP sentences, one of which is shown in (13). The speakers in this study, unlike in the preceding ones, were professional speakers - radio announcers, instructed to use a radio style of speech. The authors note that a pilot study had revealed that this style had "more clearly and consistently marked prosodic cues that a non-professional speaking style… while sounding acceptably natural" but they also warn that "care must be taken in generalizing our results to spontaneous speech" (p. 2959). The ambiguous sentences were embedded in context paragraphs (see example (13) below) that disambiguated their meanings (and which may also have deflected attention from the target sentences).

(13) a. Where did Andrea move the bottle? *Andrea moved the bottle under the bridge.* (VP attachment)

b. There was one bottle under the bridge and another on the park bench. *Andrea moved the bottle under the bridge*. (NP attachment)

The target sentences were spliced out of the recordings and presented to listeners. For each speaker, between 12 and 17 listeners attempted to match a recorded version of an ambiguous sentence with one of its two disambiguating contexts presented together in writing. They succeeded overall in 84% of the cases, with better performance for syntactic clause boundaries than for syntactic phrase boundaries. The three single-PP sentences, together with two other sentences involving high or low attachment ambiguity of a phrase, were correctly interpreted in 71% of the cases but the result was not significantly greater than chance. Since the prosodic data were not reported for individual items, it is not entirely clear whether for the PP attachment items the speakers did not produce reliable prosodic cues or whether the listeners were insensitive to them. However, the authors do report that the high attaching utterances, as opposed to the low attaching utterances, "showed a tendency to have the largest break index in the sentence before the phrase to be attached to a 'far' site" (p. 2964) (i.e., immediately before the PP in the single-PP items). Overall, the authors concluded that speakers reliably associate prosodic breaks (marked by a boundary tone, phrase-final lengthening, and sometimes a pause) only with clause boundaries. In general, they found that boundary tones were less useful cues than duration and pauses, but detailed data are not reported for the PP construction.

This study contrasts with the ones summarized above in that its results are even weaker than theirs for the PP attachment ambiguity. This is especially noteworthy because of the use of expert speakers, who it was expected would employ particularly clear prosody. A possible reason is that this study resembles the study by Cooper & Paccia-Cooper which employed paragraph contexts for the target sentences, and which likewise obtained no significant discrimination of PP attachment by listeners. Also, the Price et al. study (unlike the Cooper & Paccia-Cooper study) specifically departed from previous methodology by minimizing the awareness of ambiguity on the part of the speakers: "We tried to avoid exaggeration of any disambiguating strategies on the part of speakers and listeners by separating the ambiguous pairs from each other in time (no two members of an ambiguous pair occurred in the same session either for speakers or for listeners)" (p. 2958).

A production study by Avesani, Hirschberg & Prieto (1995), with a follow up study by Hirschberg & Avesani (2000), investigated the prosodic properties of several ambiguous constructions, including three instances of the PP attachment ambiguity in each of English, Italian and Spanish. Each sentence was embedded in a disambiguating paragraph to establish a high or low attachment of the PP. The participants, four native speakers for each language, were recorded reading the paragraphs aloud. For English, three out of the four speakers did prosodically distinguish the two PP attachment sites (in the one PP construction that was tested: '*He won the woman with the die*') "by the presence of an intonational phrase boundary[6] setting off the PP from the direct object to indicate VP attachment, compared to the presence of an intonational boundary between

[6] It is not entirely clear whether the authors were referring to an Intonational Phrase (IPh) as contrasted with an intermediate phrase (ip). The former seems improbable in this sentence.

the verb and the direct object or the absence of any internal prosodic boundary for the NP-attached reading…the fourth speaker…produced no prosodic differences between the two readings."(p.175). For the Italian counterpart of that sentence, all four native Italian speakers placed a prosodic phrase boundary preceding the PP for the VP-attachment interpretation; for the NP-attachment reading three speakers created just one intonational phrase while the fourth inserted a boundary after the verb. The Spanish speakers were less consistent in disambiguating PP-attachment. Two pronounced the sentences in the same fashion as the Italian speakers, but two made no distinction between the interpretations. The 2000 study which addressed only English and Italian had six participants for each language, three PP attachment examples in each language and provided more data. An additional precaution was introduced: the participants answered some comprehension questions after the recordings, designed to elicit the interpretation they had in mind while uttering the sentences, to make sure their understanding in fact correlated with the contextually established meaning. Hirschberg & Avesani report (pp. 90-91) that "English speakers make no clear prosodic distinctions in their production of sentences ambiguous with respect to PP attachment. So, sentences such as '*He managed to find the woman with the binoculars*' are produced similarly, whether the VP or the NP attachment of the prepositional phrase is favoured by context." For the Italian speakers, only 11 of the 18 PP attachment utterances were disambiguated prosodically, most by means of a H- or L- phrase boundary tone preceding the PP.

This is another study in which the evidence for prosodic disambiguation of PP attachment is mild at best. Hirschberg & Avesani sum up: "Phenomena such as attachment decisions, in particular, which seem intuitively easy to disambiguate

intonationally, rarely *were* so disambiguated, in context, even by subjects who understand their ambiguity, in contrast to phenomena such as focus location and scope of negation." (pp. 94-95) Hirschberg & Avesani offer the explanatory comment that "sentences in which attachment may be signaled by the variation of internal phrase boundaries may usually be produced without internal boundaries in either condition, if the ambiguity is resolvable by other means. Thus the disambiguating contexts in which target sentences were embedded may in fact have allowed subjects felicitously to produce intonationally ambiguous utterances" (p.95). This is remarkably like the conclusion of Cooper & Paccia-Cooper noted above.

Cooper & Paccia-Cooper (1980) reached that conclusion when testing ambiguous sentences both in isolation and embedded in a disambiguating context, but also the studies which tested just one of these conditions show that tendency: Price et al. (1991) and Avesani & Hirschberg (2000) found few or no prosodic cue differences between high and low attachment in the production and perception of the single-PP sentence in disambiguating context, similar to the findings of Straub (1997) in her production study discussed below. On the other hand, Lehiste (1973) who tested sentences in isolation found strong prosodic differences between the two attachment structures, stronger than in all the other studies incorporating disambiguating context reviewed here. This is a potentially important variable, which I will discuss below (see section 2.3).

Pynte & Prieur (1996) examined the role of prosodic breaks in the parsing of semantically disambiguated French single-PP sentences of the form NP1 V NP2 PP. The experiments compared sentences with "ditransitive" verbs (taking an optional PP argument) as in (14), and sentences with "monotransitive" verbs (a PP must be an

adjunct) as in (15); both verb types permitted both high and low attachments. The sentences were read by a professional speaker in two versions: with a boundary between V and NP2 only, or a boundary between V and NP2 and between NP2 and PP. Then the sentences were acoustically manipulated to vary the positions of prosodic breaks creating four different contours (see (16) below), and the duration of a break was uniformly set to 150ms. Pynte & Prieur did not distinguish between full Intonational Phrase boundaries and intermediate phrase boundaries; they refer to both neutrally as "prosodic breaks" (PB) and represent them with #.

NP1 V NP2 PP

(14) a. Les espions informent les gardes du complot.
'The spies inform the guards of the conspiracy.'

(Ditransitive verb, semantically disambiguated to high attachment)

b. Les espions informent les gardes du palais.
'The spies inform the guards of the palace.'

(Ditransitive verb, semantically disambiguated to low attachment)

(15) a. L'étudiant choisit un appartement avec soin.
'The student chooses a flat with care.'

(Monotransitive verb, semantically disambiguated to high attachment)

b. L'étudiant choisit un appartement avec balcon.
'The student chooses a flat with a balcony.'

(Monotransitive verb, semantically disambiguated to low attachment)

In contrast to the studies reported above, Pynte & Prieur found strong effects of prosody on listeners' interpretations. They summarize the findings of their Experiments 1 and 2 as: "The presence of a PB after the verb was shown to hinder the VP-attachment

interpretation (# The spies inform # the guards of the conspiracy #), whereas the presence of a second PB in front of the PP seemed to neutralize the effect of the first break (# The spies inform # the guards # of the conspiracy #)… These results clearly indicate that PBs can influence sentence parsing." (p.165) Pynte and Prieur's results seem to be in line with Schafer's (1997) observation (see discussion below) that "it is really the prosodic structure which affects parsing, not simply the local effect of a prosodic boundary at a point of syntactic ambiguity..." (p. 56). This study needs to be considered carefully, in order to understand why the results appear to have been more robust than in other experiments on this construction. One reason might be that this study was on French, which may have more clearly marked ip boundaries than in English. (Millotte, René, Wales & Christophe, 2008) also obtained strong results for ip in French, in a different ambiguity.) However, the design characteristics of these experiments may be partly responsible, as discussed below.

Four different prosodic contours were tested in all, indicated in (16) together with the experiments in which they were compared.

(16)	(a) Subj Verb # Det Noun PP	One break, after the verb, Expts 1, 2, 4
	(b) Subj Verb # Det Noun # PP	Two breaks, first after the verb, Expts 1, 2, 4
	(c) Subj # Verb Det Noun PP	One break, before the verb, Expts 3, 4
	(d) Subj # Verb Det Noun # PP	Two breaks, first before the verb, Expts 3, 4

An on-line word-monitoring task was employed. A target word was displayed to the subjects on a computer screen for two seconds before the spoken sentence was presented. The subjects pressed a button as soon as they heard the target word. (In Experiment 4, the

target word presentation was timed to coincide with the last word of the spoken sentence; see discussion below.) In experimental items, the target word was always the final word in the sentence, the noun inside the PP. The detection times of the target words in the two prosodic phrasing conditions were taken as a measure of the attachment preference.

Some of the findings reported by Pynte & Prieur involved comparison of response times in VP attachment sentences with those in NP attachment sentences, as in (17), where the target word differed. Other comparisons were between response times in sentences with ditransitive verbs and those in sentences with monotransitive verbs, as in (18), where the sentences were completely different.

17) a. Les espions informent les gardes du complot.
b. Les espions informent les gardes du palais.

18) a. Les espions informent les gardes du complot.
b. L'étudiant choisit un appartement avec soin.

Therefore these comparisons are not informative. Since monitoring response times can vary with word frequency and predictability in context, the only valid comparisons are between lexically identical strings. Thus the one legitimate type of comparison that can be made in the Pynte and Prieur study is of response times for sentences that differed only in their prosodic contours.

The following discussion focuses on the results of Experiment 4, which is the only one that tested all four prosodic contours for each string of words, e.g., the word string 'Les espions informent les gardes du complot' was tested with all four contours in (16) above. The four prosodic patterns in (16) above were crossed with four attachment conditions shown in (19) below. Pynte & Prieur suggest that ditransitive verbs have an

inherent preference for high PP attachment while monotransitive verbs have an inherent preference for low PP attachment. Conditions (a) and (b) in (19) have a conflict between argument structure and attachment while conditions (c) and (d) concur in their argument structure and attachment.

(19) a. CONFLICTING/HIGH: high-attachment with a monotransitive verb

b. CONFLICTING/LOW: low-attachment with a ditransitive verb

c. NON-CONFLICTING/HIGH: high-attachment with a ditransitive verb

d. NON-CONFLICTING/LOW: low-attachment with a monotransitive verb

Reliable effects of prosody were found only for the two conflicting conditions (see Pynte & Prieur, 1996, p.188). In those cases, responses in the word-monitoring task were faster when the prosodic break pattern was appropriate to the actual attachment, reinforcing the correct attachment against the counter-pressure of the verb's argument structure; responses were slower when the prosodic break pattern was in accord with the verb's argument structure, reinforcing the tendency towards incorrect attachment. The fact that prosody had an effect only when the other two factors clashed means these data provide no clear evidence of a dramatic difference in the strength of the prosodic effect of PP attachment for French compared with the various previous studies on English, since the latter did not pit argument structure preference and attachment against each other. In fact it seems that in the English studies some care was taken (at least informally) to use well balanced verbs which were equally compatible with both syntactic structures.

To summarize: The Pynte & Prieur (1996) study of single-PP attachment in French takes its place among the collection of studies on single-PP attachment in English.

With regard to the syntax-prosody interface: where the prosodic patterns in this study resemble those tested in English the effects of the prosody are similar. The French data support the affinity between prosodic grouping of constituents and syntactic grouping of them (low attachment), and also the tendency of a prosodic separation of constituents to lead to their separation in the syntactic tree (high attachment). However, except where the argument structure of the verb opposed the correct (semantically disambiguated) attachment, the observed effects of prosodic phrasing on ease of processing are surprisingly weak. The main discovery from this research is that appropriate prosodic phrasing can provide a significant boost to a syntactic attachment that is otherwise difficult to achieve because it conflicts with lexical properties of the verb.

Schafer (1997) conducted a perception study with 16 single-PP items. A native speaker of English was instructed to read each sentence in four prosodic versions that differed in the placement of ip breaks (ip= phonological phrases in Schafer's terminology):

(20) a. (The bus driver angered the rider) ip (with a mean look).
b. (The bus driver angered) ip (the rider with a mean look).
c. (The bus driver angered the rider with a mean look).
d. (The bus driver) ip (angered) ip (the rider) ip (with a mean look).

Forty eight participants listened to the 16 target sentences, each participant was presented with just one version of each sentence and with 92 fillers of different structures. After listening to each utterance the participants answered a visually presented question intended to reveal the attachment choice (e.g., *Who had a mean look?*). A significant VP attachment preference was not found for a prosodic boundary preceding the PP (prosodic phrasing (a): 61.5%; prosodic phrasing (d): 52.6%) but there were significantly fewer

high attachment responses in the presence of a break preceding the NP (prosodic phrasing (b): 44.3%; prosodic phrasing (d): 52.6%) than in its absence (prosodic phrasing (a): 61.5%; prosodic phrasing (c): 59.9%). Schafer argues that the effect of the break at [NP on the PP attachment is evidence "that the subtle acoustic cues provided by phonological phrase boundaries are sufficient to cause significant effects on interpretation" (p. 54). Schafer accounts for the effect of the NP boundary and lack of effect of the PP boundary on the PP attachment by the Prosodic Visibility Hypothesis according to which "the salience of a potential attachment site is highest when it is in the same phonological phrase as the material currently being processed, and lowers with each preceding phonological phrase" (p.49). Thus, since the NP 'the rider' in example (b) is in the same ip as the PP, the PP is more likely to attach to it than to the VP, as the NP node is more visible than the VP node is to the PP while the PP is being processed. In (d), the NP node is less visible to the PP than in (b) due to an intervening ip boundary at [PP but it is still more visible to the PP compared with the VP node, which is two ip boundaries away from the PP. As a result, the VP attachment rate is lower, compared with a counterpart phrasing that has no break at [NP, such as (a). Another possible explanation for the missing effect of a break at [PP on PP attachment could be that ambiguity involving a phrase is not always resolved by the prosody, as seen already in studies reported above.

Schafer also maintains that the fact that a break at [NP had an effect on PP attachment shows that parsing is not affected only by prosodic boundaries located at the point of syntactic ambiguity. Also, from the fact that this NP boundary affected the attachment decision despite an intervening ip boundary at [PP in prosodic phrasing (d)

she concludes that what affects parsing is the whole prosodic structure and not just individual prosodic boundaries.

It should be noted that this is the first study (except for Pynte and Prieur's) which tested the syntactic effects of more varied prosodic contours (involving not only one with a break at [NP and one with a break at [PP as in previous studies) in the single-PP construction.

Watson & Gibson (2005) examined the single-PP construction in English in a comprehension study, with the aim of adjudicating between alternative theories of the sentence locations at which a prosodic boundary facilitates on-line comprehension versus locations at which it hinders comprehension. Unlike most earlier studies of the single-PP construction, they employed an on-line measure, with responses timed at the preposition which disambiguated the intended syntactic structure (earlier than disambiguation by the final noun, as in the Pynte & Prieur study). The task was a cross-modal lexical decision task (see Marslen-Wilson, Tyler, Warren, Grenier & Lee, 1992 and Kjelgaard & Speer, 1999): subjects listened to the beginnings of sentences recorded by a trained speaker, up to the post-verbal noun, as illustrated in the examples in (21) below, and then made a lexical decision response to a visually presented preposition. In target sentences the preposition was always either 'to' for VP-attachment or 'of' for NP attachment. Target sentences were interspersed among many filler sentences containing other prepositions. In target sentences the full PP was never presented, either auditorily or visually.

(21)	audio presentation	visual presentation	(VP attachment)
(a)	The museum lent the sculpture…	to	
	audio presentation	visual presentation	(NP attachment)
(b)	The museum lent the sculpture…	of	

Target stimuli differed with respect to whether or not there was a prosodic boundary after the object noun at the end of the spoken fragment, immediately preceding visual presentation of the lexical decision target. This was the only locus for a prosodic break that was tested (e.g., no break after the subject or the verb as in some other studies such as Pynte & Prieur's study). Argument structure was not systematically varied: all of the verbs could take a *to*-PP argument but not an *of*-PP argument.

For both prepositions responses were faster when the audio presentation had a prosodic boundary before the preposition. This facilitation was significantly greater in the VP attachment condition. Watson and Gibson concluded that listeners interpret prosodic phrase boundaries as denoting the end of a constituent, and prefer not to attach incoming material to words preceding the boundary. This is their Anti-Attachment Hypothesis (AAH); cf. Schafer's Visibility Hypothesis (1997). As far as the prosody-syntax interface is concerned, this result reflects the basic alignment relationship for PP attachment that was observed also by Lehiste and the other studies summarized above: a break before an ambiguously attachable phrase promotes high attachment. Watson and Gibson emphasize that the AAH represents a performance constraint, not a linguistic constraint (cf. Selkirk 2000). What the cross-modal decision task contributes is an on-line demonstration, revealing the immediacy of prosodic influences on syntactic structure.

Still more studies on the single-PP construction will be discussed in the next section. But this is a good point at which to take stock of the research reviewed above. Despite almost 40 years of research no very clear answers have emerged for the questions with which we began: are syntactic *phrase* boundaries, in particular PP boundaries, reliably correlated with prosodic boundaries in production, and if so, do they reliably

influence comprehension? There are some reasons to suspect that linguistically the relation between ip boundaries and syntax is less robust than the relation between IPh and clausal boundaries, or more specifically, that alignment constraints are optional in the case of ip boundaries or are influenced by other constraints such as length and focus, as suggested in Selkirk (2000). (This explanation will be discussed in Chapter 6). But it is also possible that aspects of the methodology used in previous studies have contributed to uncertainty on this topic. Quite apart from small numbers of items and participants, production studies have almost invariably used read speech whose prosody is commonly criticized as being atypical of spontaneous speech. In creating materials for comprehension studies, trained speakers are often used whose speech may be even less natural. There are also issues concerning how experimenters indicate to participants the intended meaning of an utterance to be produced, or find out what meaning has been assigned to an utterance by a listener. These methods in many cases are artificial and more importantly they may draw attention to ambiguities in the materials to which prosody might be relevant. This issue has been referred to as "awareness" and it will now be discussed in detail.

2.3 Effects of awareness

The factor of awareness or non-awareness of the ambiguity under study might offer a way to sort previous research into studies which obtained significant effects associated with ip boundaries and those which did not. That may well be so, but whether other factors might be equally important is not clear at this point. The idea that awareness matters is not new; it has been explored by many researchers from Lehiste onward. A

much cited recent study is by Allbritton, McKoon & Ratcliff (1996) which addresses a variety of constructions though not including PP attachment ambiguities. A production study compared two different conditions: one in which no attention was drawn to the ambiguity, and one in which the two meanings were explained by the experimenter and the participants were told that the recordings would be used in future experiments on language comprehension and were instructed to read "as if they were telling a story to someone that they wanted them to understand" (p. 716). In the latter condition, speakers used clear prosodic cues to distinguish the two interpretations. By contrast, there was little prosodic disambiguation when the speakers were not made aware of the ambiguity.

There were two production experiments with speakers not informed about the ambiguity. They differed with respect to whether the speakers were professional or not. Neither the non-professional nor the professional (actors and broadcasters) produced sufficient prosodic cues for the listeners to successfully disambiguate the sentences. Context paragraphs were used as the means of indicating to the "unaware" speakers which interpretation to express. The fact that this was the condition that showed no prosodic sensitivity is reminiscent of similar observations by Cooper & Paccia-Cooper (1980) and by Hirschberg & Avesani (2000) discussed above.

Unlike the Allbritton et al. study, a series of experiments by Straub (1997) focused on the single-PP construction. The speakers were told that some passages might contain ambiguous sentences and that they should read in such a way that "any subtleties in the text of the messages be clearly conveyed" (Appendix 4, p. 206). All items were presented in paragraphs. In one condition (context biased condition) the paragraph called for one interpretation of the ambiguous target sentence, as in the Allbritton et al. study. In

another condition (which Straub called “Non-Biasing”), the context paragraph was neutral with respect to the intended meaning, which was signaled by some means of disambiguation involving brackets (details unclear) at the top of the page. The speakers were told that “in some cases [they] will also get information in square brackets that should remove the ambiguity about the intended interpretation” (Appendix 4, p. 206), and that listeners would not be exposed to that extra information. It seems proper to regard this condition not as “non-biasing” but as explicitly disambiguating, with attention clearly drawn to the ambiguity.

Acoustic measures were taken of fundamental frequency, duration and pauses. Many of the findings were statistically marginal. They can be summarized very briefly as follows: with explicit disambiguation, the acoustic measures showed marginal prosodic differences between high and low PP attachment of the familiar kind (longer durations of the NP and pause immediately preceding the PP when attachment was high than when attachment was low). In the condition with the biasing paragraphs, the prosodic cues in the utterances were found to be non-significant. Somewhat unexpectedly, the perception results were more positive: when disambiguation was explicit listeners were able to reliably detect the intended meanings.

The results of this research thus fall into line with the other studies above which compared explicit indicators of the intended meanings versus disambiguating paragraph contexts and no explicit mention of the ambiguity. The latter apparently discourages the use of distinctive prosodic contours by participants. However, this may be true only of constructions where disambiguation would be by ip boundaries and/or by boundaries which are optional. There are some preceding studies which have noted constructions

where prosodic disambiguation occurs despite embedding in disambiguating paragraphs, for example, the scope of negation ambiguity tested by Hirschberg & Avesani, and the left vs. right attachment of a middle phrase or a word tested by Price et al. (as in, 'they rose early in May', where 'early' attaches right, to the verb 'rose', or left, to the PP 'in May').

Another way of looking at this issue of awareness is that awareness of the ambiguity may lead speakers to use unnatural or artificial prosodic contours, in which case the proper conclusion could be that ip boundaries are *not* normally associated with syntactic phrase boundaries. That is, awareness opens the possibility that a speaker might exaggerate the usual spontaneous prosodic cues in an attempt to assist the listener to extract the intended meaning. This is what has been called *Audience Design* (Bell, 1984) in language production; clearly it would distort our understanding of the properties of natural conversational prosody. Audience design is a long-standing concept in sociolinguistics introduced by Allan Bell whose relevance to sentence processing research is now being recognized. Some experimenters have endeavored to minimize any such distortion by devising new methods for eliciting utterances; see discussion of Schafer, Speer & Warren (2005) in section 2.4 below.

An interesting debate about the centrality of audience design is represented in papers by Snedeker & Trueswell (2003) and Kraljic & Brennan (2005). Snedeker & Trueswell (see also Snedeker, Gleitman, Felberbaum, Placa & Trueswell, 2000) tested sentences with an ambiguous single-PP attachment, like (22) below, using an elicitation task in two different communicative situations.

(22) Tap the frog with the flower.

In the first situation a speaker and a listener were each given a set of toys for an act-out task, such as an unadorned frog, a flower, and a frog wearing a flower. It was made clear to the participants that they both had the *same* toys. The speaker gave an instruction, worded as in (22), to the listener after the speaker had been shown the sentence typed on a card and had observed a demonstration (not visible to the listener) of the intended action that the listener should perform with the objects. Although the sentence was ambiguous in relation to the set of toys provided, the action demonstration disambiguated it for the speaker.

An acoustic analysis revealed significant differences in the prosodic properties of the two readings of the sentences as cued by the action demonstrations. Snedeker and Trueswell report greater duration of the object noun for the VP attachment reading, with a following pause in 68% of cases, compared with greater duration of the verb for the NP attachment reading, with a following pause in 40% of cases. These data reflect the same prosody-syntax associations familiar from the previous studies of single-PP attachment.[7] The effectiveness of these prosodic differences was evidenced by the ability of the listeners to correctly act out the intended instruction for moving the objects in 70% of cases. Importantly, a post-experiment questionnaire revealed that most of the speakers and listeners had been aware of the ambiguity.

In a second experiment the communicative situation was the same as in the first, except that now the speakers were presented with a set of toys relative to which the

[7] Snedeker & Trueswell offer an interesting new detail: that the duration of the ambiguously attached PP was shorter for NP attachment than for VP attachment. This seems very plausible, i.e., 'with the flower' is shorter as part of the ip 'the frog with the flower' than as an ip on its own. Snedeker & Trueswell suggest that perhaps this was "because this prosodic pattern forced the subject to cram most of the utterance into a single prosodic unit" (p.110). However, this is unlikely to have been a major influence since it could not have taken much "cramming" to package 'the frog with the flower' as one ip.

instruction was unambiguous, such as an unadorned frog, a leaf, and a frog wearing a flower (NP attachment), or an unadorned frog, a flower, and an elephant wearing a hat (VP attachment). The listeners were still given the original set of toys relative to which the instruction was ambiguous. Thus, for the speakers, less attention was drawn to the existence of ambiguity than in the previous version of the experiment. Also, the speakers were unaware of the differences between the two toy sets, so they had no way to know that the sentence would be ambiguous for the listener. In the results, in contrast to the previous experiment, there was now essentially no acoustic evidence of prosodic disambiguation by the speakers, and the listeners' actions did not reliably differ depending on whether the action demonstrated to the speaker entailed VP-attachment or NP-attachment. The contrasting results in these two different versions of the experiment were taken to imply that speakers provide prosodic cues only when needed for communicative purposes. This is in line with the view that specific patterns of prosodic phrasing are not linguistically obligatory in this construction, though they are known to language users and can be utilized when helpful.

An elicitation study by Kraljic & Brennan (2005) employed sentence materials such as (23), with an ambiguously attaching PP ('in the basket' in (23)). Relevant objects were provided: a dog in a basket, a dog not in a basket, an empty basket placed on top of a star, and a star with nothing on it.

(23) Put the dog in the basket on the star.

The speaker and hearer looked at the very same display of objects, so they could not doubt that their partner's objects were the same. Speakers were shown pictures on a card

(unseen by the hearer) with arrows indicating what action the hearer should perform. The procedure was thus not unlike that of Snedeker and Trueswell's first experiment except, importantly, that the actual sentence to be uttered by the speaker was not specified by the experimenter. Note also that the construction in (23) differs from the sentences tested by Snedeker and Trueswell. Most notably, Kraljic & Brennan's sentences contained two PPs. Kraljic & Brennan's speakers were told to begin all sentences with either 'Put' or 'Place'. Unlike the verbs employed by Snedeker & Trueswell (e.g., 'tap'), both 'put' and 'place' *require* a Goal argument, typically a PP. The first PP ('in the basket' in (23)) could be attached on-line either high as the Goal (VP attachment), or low as modifier of the preceding noun (NP attachment). In the first case the second PP ('on the star') would attach within the Goal phrase ('the basket on the star'). In the latter case, the second PP served as the obligatory goal ('on the star'). Note that attachment of the second PP is not ambiguous once a particular attachment of the first PP has been selected.[8] It is present only to ensure that the lexical requirements of the verb are satisfied on both analyses.

The means by which Kraljic & Brennan elicited these constructions did not exclude other sentence forms such as in (24) and (25) which are unambiguous regardless of prosody.

24) Put the dog *that's* in the basket on the star.

25) Place the dog *into* the basket on the star.

Of the 480 speakers' utterances in the experiment, 248 were free of speech errors and other defects. Of these 248 utterances, 93 (37.5%) were of the form in (23) and the others were as in (24) and (25). Results for these 93 items showed that the speakers were

[8] To avoid confusion, I note here that this construction with two PPs is different from what is called the *Double-PP construction* in my experiments reported below, as explained in section 2.4.

distinguishing the two interpretations by marking syntactic boundaries prosodically. The locations of interest were the first noun ('dog' in (23) above) and the second noun ('basket' in (23)); no measurements were made of the verb or the final PP. Longer durations (of the noun and any following pause) occurred at the first locus for high attachment of the ambiguous first PP ('in the basket'), and at the second locus for low attachment of that PP.

Contrary to the Snedeker & Trueswell study, Kraljic & Brennan report that in this study the speakers produced comparable disambiguating prosodic cues regardless of whether or not the visual situation was ambiguous for the hearer, and also regardless of whether or not the sentence uttered was ambiguous as in (23) or non-ambiguous as in (24) and (25). Kraljic & Brennan attribute this to the fact that they elicited the ambiguous utterances during relatively spontaneous interaction between the speaker and addressee. They conclude that "speakers disambiguate syntactic boundaries prosodically when speaking spontaneously, and they do so regardless of addressees' needs" (p.226). This could be interpreted as showing that patterns of prosodic breaks in this construction are controlled, wholly or partly, by the grammar rather than by purely communicative considerations.

However, the move from the single-PP construction tested by Snedeker & Trueswell to a structure with two PPs as tested by Kraljic & Brennan also has the effect of changing the nature of the prosodic contrasts that speakers might produce either intentionally or not. This might provide another reason why prosodic disambiguation of (27) below was robust, while prosodic disambiguation of (26) was deployed only when motivated by communicative needs. The materials in the two studies are compared here,

where # marks the locations of the prosodic boundaries that were examined. In what follows, the first PP in these examples will be referred to as PP1 and the second one as PP2.

(26) a. S&T: Tap the frog # with the flower. (VP Attachment)

b. S&T: Tap # the frog with the flower. (NP Attachment)

(27) a. K&B: Put the dog # in the basket on the star. (VP Attachment)

b. K&B: Put the dog in the basket # on the star. (NP Attachment)

In Chapter 1 it was noted that intuitively (26a) does not *need* any boundary and it is short enough to be pronounced without one – unless the speakers has some reason to emphasize the high attachment. Note that for the low PP1-attachment in (26b), the only locus for a potentially disambiguating break is between the verb and the object NP as shown, but this creates oddly unbalanced phrase lengths (*tap – the frog with the flower*); the single-syllable ip *tap* is particularly unlikely in English[9]. One could surmise that no speaker would consider using such a contour *except* for purpose of audience design[10]. By contrast, in (27b) low PP1-attachment can instead be signaled by grouping the object and PP1 together, to the exclusion of PP2, by placing a prosodic break between PP1 and PP2. That encourages semantic unity of PP1 with the object, and also signals high attachment of PP2[11], without creating any length-anomalous one-word prosodic phrases. It might be

[9] This point was noted in Millotte, Wales & Christophe (2007) in their discussion of the role of ip in disambiguating syntax.

[10] The fact that there were 40% of pauses following the first word of the sentence "Tap" although this is an unusually short prosodic phrase suggests that the participants' productions were considerably more deliberate than in normal spontaneous speech.

[11] In fact, signaling high attachment of PP2 is the primary role of the break in (27b). That entails that PP2 attaches high to the VP as the obligatory Goal, which has the secondary consequence that PP1 is not the Goal (or part of the Goal) and hence must be grouped with the NP.

anticipated, therefore, that the Kraljic & Brennan study might elicit more realistic and more consistent prosodic disambiguation than the Snedeker & Trueswell study.

Kraljic & Brennan also mention the unnatural prosody of the Snedeker & Trueswell materials. They note that the Snedeker & Trueswell utterances were short and "as a result there may have been less opportunity for contrasting prosodic boundaries"[12] (p.227) However, Kraljic & Brennan put more emphasis on procedural differences between their study and Snedeker & Trueswell's, involving spontaneity and communicative interaction. Snedeker and Trueswell's task did not allow the addressee to ask for clarification, which could prevent misunderstandings and also alert the speakers to the possibility of ambiguity. (However, clarification requests occurred rather rarely, in only 22 out of the 480 trials, in Kraljic & Brennan's study.) More importantly, Snedeker & Trueswell's Experiments 1 and 2 differed from each other in that Experiment 1 with ambiguous referential contexts presented both high attaching and low attaching items to the same speakers, while Experiment 2 with unambiguous referential contexts presented only high attaching items to some speakers and only low attaching items to others. This may have been intended to minimize the chance of the speakers noticing the ambiguity. But it may have the disadvantage, as Kraljic & Brennan note, that in Experiment 2 "it is possible that speakers may have simply fallen into using routine, uninformative prosody" (p.227). This in itself might have been sufficient to account for the lack of prosodic effects in Experiment 2. On the other hand, the target items in Experiment 2 were interspersed

[12] In fact Trueswell, Sekerina, Hill & Logrip (1999) had used longer sentences with a second PP, like those used by Kraljic & Brennan, in an earlier study with children. Trueswell et al.'s example "Put the frog on the napkin in the box" has become a famous sentence. It is of interest that Snedeker & Yuan (2008) found that child listeners were responsive to prosodic disambiguation of the shorter construction 'Tap the frog with the flower' when perseverative responses were avoided.

among filler items which "contained a variety of objects and sentence types" (p.107), which could have resulted in a variety of prosodic contours.

Thus, despite these two major studies on audience design, the issue is unresolved at present and will remain so until further research is able to clarify the relative importance of the many contributing factors in these experiments.

2.4 The Double-PP construction

In the remainder of this dissertation, I will present experimental data on a double-PP construction in Hebrew, parallel to the English example (28):

(28) Dana described the difficulties in her marriage to the broadcaster.

This resembles the Kraljic & Brennan examples (27a, b) above in that it contains a direct object and two PPs, repeated here for convenience in (29):

(29) Put the dog in the basket on the star.

It should be noted that the patterns of ambiguity in these constructions are different. We will call examples like (29) "Type A". In the Type A Double-PP construction, it is PP1 whose attachment is ambiguous. Once that is decided, the role of PP2 is unambiguous. By contrast, in the construction in example (28), which we will refer to as the "Type B" Double-PP construction, the PP1 unambiguously attaches low to the object NP, and it is the PP2 whose attachment is ambiguous. PP2 ('to the broadcaster' in (28)) can attach either low to the NP inside PP1 ('her marriage') or high to the verb ('described'). The

Type B construction is of special interest for research on the syntax-prosody interface, for reasons discussed below.

Apart from Kraljic & Brennan, only two studies have examined the Type A construction. Babyonyshev, Gibson & Kaan (2000) presented the example in (30) in which PP1 tends to be attached high to the VP on-line but then needs to be reassigned as a modifier of the object NP once PP2 is encountered. PP2 is disambiguated as attaching high to the verb by plausibility information (the bowl is unlikely to be in the ice-cream), which is the cue that triggers the reanalysis of PP1 as a modifier of the direct object ('strawberries'). Thus in this version of the Type A Double-PP construction, an on-line choice of high attachment of PP1 induces a garden path in which processing is disrupted by the subsequent disambiguation to low attachment of PP1 (unlike Kraljic & Brennan's globally ambiguous Type A Double-PP construction).

(30) Mary will put the strawberries <u>in the bowl</u> <u>in the ice-cream</u>.
PP1 PP2

Babyonyshev et al. compared this with a similar sentence with 'into' in place of 'in'. In that case, there is still a garden path (misattachment of PP1) but now the cue for reanalysis of PP1 is the unambiguously high attaching preposition 'into', i.e., a lexical syntactic cue. They conducted a self-paced word-by-word reading experiment on materials of this kind to establish which kind of cue for reanalysis was more potent. The results confirmed Fodor and Inoue's (1994) hypothesis that syntactic cues are stronger than semantic or plausibility cues. This does not bear on the syntax/prosody interface as Babyonyshev et al. did not examine the prosody of this construction, but only the syntactic parsing.

Maia (2008) tested the Type A Double-PP construction in Brazilian Portuguese. An eye-tracking experiment confirmed the garden path phenomenon when a disambiguating second PP was encountered. A self-paced silent reading experiment found an on-line effect of visual segmentation. Since a self-paced listening experiment showed similar segmentation effects, Maia concluded that "subjects treat segment boundaries as signaling prosodic boundaries, as predicted by the Implicit Prosody Hypothesis" (p.464). (See discussion of the Implicit Prosody Hypothesis in Chapter 5.)

It appears that there has been only one systematic study to date on the Type B Double-PP construction[13]. Schafer, Speer & Warren (2005) explored the relation between PP attachment and prosody in a double-PP construction as in (31) below in a two-person cooperative board game task involving a set of pre-scripted sentences, which were used spontaneously to negotiate moves of game-pieces from starting positions to goal positions. Just two ambiguous sentences of this form were used in the experiment; in addition to (31) there was also 'I am able to confirm the move of the square with the triangle'.

(31) I want to change the position <u>of the square</u> <u>with the triangle.</u>

V NP PP1 PP2

Within the context of the game there was a house-like shape called 'the square with the triangle', with PP2 thus attaching low to 'square'. It was also possible to use a triangle to

[13] Price et al. (1991) included one Type B Double-PP sentence in their production experiment ('I read a review about nasality in German'). However, they do not report the results separately for this example; for group results for five adjunct attachment ambiguities see section 2.2 above. Schütze & Gibson (1999) tested more elaborate double-PP constructions such as 'The salesman ignored a customer with a child with a dirty face and a wet diaper / one with a wet diaper / one with a baby with a wet diaper', in which a final phrase modifies either the direct object or the NP in one or the other of the two PPs.

move a square, in which case PP2 was attaching high to the verb. In their discussion of PP attachment, Schafer et al. did not categorize Double-PP constructions separately from single-PP constructions, perhaps because the Type B Double-PP constructions resemble the single-PP constructions in that in both cases the ambiguity concerns the attachment height of a sentence-final PP. Below it will be argued that in fact there is an important distinction between them.

Acoustic and transcription (ToBI coding system) analyses were performed at the locus of a possible boundary between PP1 and PP2. It was found that the high-attached PP2s were marked by lengthening of the noun in PP1 and sometimes a pause immediately preceding the PP2, while for the low-attached PP2s these prosodic markers of a pre-PP2 break were significantly weaker. This comports with the general finding of other studies that a break before a constituent is associated with high attachment. However, it is not completely clear that these data are informative about the processing of a Type B Double-PP construction, because of the possibility that in this experiment, the constant repetition of the same sentence frame may have created a fixed collocation with the verb and object and the following preposition ('change the position of') locked together so that they were treated by the participants as like a single complex verb ('I want to verb the square with the triangle'), making a whole construction like a *single*-PP construction. For these reasons it will be more informative to study double PP examples where both PPs are playing a full semantic role in the sentence.

2.5 Motivations for the current study

In light of the review above, this study is designed to circumvent some of the problems that have been discussed.

It was decided to study the Type B Double-PP construction, as in the English version (28) above, repeated here for convenience.

(32) Dana described the difficulties in her marriage to the broadcaster.

The reasons for this decision were as follows:

- It is longer than the single-PP construction, making it more likely that the sentence will have to be divided at some point to avoid overlong prosodic phrases, and offering more different loci at which a break could occur.
- There is a greater structural disparity between low and high attachment of PP2 than between low and high attachment of the PP in a single-PP construction. (Recall that the Type B construction is designed so that the only attachment sites are to the VP at the highest level and to the NP inside PP1 at the lowest level. The direct object is selectionally incompatible with PP2; in (32) 'the difficulties' cannot be modified by 'to the broadcaster'.) According to Selkirk's (2000) Align_{R} XP principle, "The right edge of any XP in syntactic structure must be aligned with the right edge of a MaP [an *ip*; RWS] in prosodic structure." This predicts a major prosodic boundary before PP2 for high attachment, not for low attachment. Fodor (2002) interpreted the Align_{R} XP principle as a graded processing principle according to which more syntactic right edges at a locus predict greater probability and/or strength of a break there. Thus, since there is one more right

edge of an XP immediately preceding PP2 than preceding the PP in the single-PP construction (PP1 ends there and so does the whole complex object NP that contains PP1, as shown in examples (33a) and (33b) below respectively), it is expected that high attachment of PP2 (discontinuity in the syntax) would be more likely to be associated with a break, or with a stronger break, at that position (discontinuity in the prosody), than in the single-PP construction.

(33) a. <u>High PP2 attachment</u> <u>Low PP2 attachment</u>

…marriage **]$_{NP}$]$_{PP1}$]$_{NP}$** to the broadcaster …marriage to the broadcaster

(Dana described the difficulties in her marriage to the broadcaster)

b. <u>High PP attachment</u> <u>Low PP attachment</u>

.... letters **]$_{NP}$** from his wife … letters from his wife

(Rafi hid the letters from his wife)

- The Type B Double-PP construction avoids the garden path in the disambiguated Type A version. Since our interest is in stable relations between prosody and syntax, it is preferable not to complicate the participants' task by misleading them into an incorrect analysis on-line (high attachment of PP1). In that case there would be some likelihood that speakers would stumble or hesitate before completing the reading of PP2, disrupting the prosodic contour.
- In this study readers were free to assign whatever prosody they preferred, without any constraint from lexical, syntactic, semantic or pragmatic disambiguation. In

conjunction with a well-designed pre-test to exclude any such non-prosodic biases (see section 4.2.1.2. below), this could reveal the "default prosody" of the Double-PP construction. Default prosody is the prosodic contour that is the most natural for a construction when no other biasing pressures are in force. The default may differ from one language to another, and for this reason it has been invoked to explain certain cross-language differences in syntactic parsing preferences (Fodor, 2002). However, for ambiguous constructions it can be difficult to establish what the default prosody is, since each reading of the ambiguity is associated with a syntactic structure that could have its own default prosody due to syntax/prosody interface principles.[14] It is of interest, however, if one prosodic pattern tends to prevail when the two readings are well-matched in other respects, since that could influence the parser's preference for one syntactic structure over the other.

- The experimental materials included a systematic contrast between long PP2s and short PP2s. A length contrast in an ambiguously attaching modifier has been consistently found to be effective in experiments on the relative clause attachment ambiguity (as in Lovrić, 2003, and other studies since), with longer relative clauses more likely to attach high than short ones. This is standardly ascribed to the fact that a long modifier is likely to constitute a prosodic phrase by itself, with a prosodic boundary separating it from prior material, whereas a short modifier may need to combine prosodically with a preceding constituent and will therefore tend to attach closely to it. In the present case, it can be anticipated that a long

[14] Alternatively, it may be possible to make a case for the default prosody of an ambiguous construction on the basis of general prosodic tendencies within the language, e.g., toward short prosodic phrases, or balanced prosodic phrases within an utterance, or a general tendency to break (or not break) at a certain type of syntactic boundary, such as the opening of a PP (see Lovrić, 2003).

PP2 will be more likely to be preceded by a prosodic break than a short PP2 is, and will correspondingly be more likely to attach high to the VP than a short PP2 will. The fact that constituent length (when not confounded with other factors such as semantics) is independently known to affect prosodic phrasing (Selkirk, 2000) provides support for the hypothesis that syntactic parsing preferences are influenced by prosodic preferences, if it is found that syntactic parsing preferences are correspondingly influenced by constituent length.

It appears that the only previous study on PP attachment that has systematically manipulated the length of the PP was a study by Hemforth, Petrone, d'Imperio, Pynte, Colonna & Konieczny (2006) on a single-PP construction in French (see example (3) in Chapter 2 above). They obtained a reliable effect of PP length when they added content material to the PP but not when they added semantically empty material, as in lengthening a proper name (e.g., from *Aix* to *Aix-en-Provence*). The authors were inclined to regard this as due to the increase of information in the former case, rather than to prosodic influence, but the matter remains unresolved. The PPs in other previous PP attachment studies have not been controlled for length; typically they have consisted of only the preposition, a determiner and a noun (which would be classified as "short" in the present study). Thus the present study adds a new dimension to standard PP attachment studies.

The procedure in this study was specifically designed to minimize awareness of the ambiguity. This was achieved by the following means:

- The ambiguity was not mentioned to the participants, nor were the two interpretations illustrated for participants by means of brackets, arrows or action demonstrations.
- The target sentences were interspersed among varied filler sentences in a ratio of one target to two fillers (see examples in section 4.2.1.3).
- The target sentences were globally ambiguous so that whichever interpretation the reader attributed to the sentence was acceptable. This avoided situations in which the reader had one interpretation in mind and then encountered material in the sentence that contradicted it, which could have alerted the reader to the existence of alternative interpretations.
- Even if ambiguity awareness could not be entirely eliminated by these means, the prosody assigned to the sentence was protected from influence of awareness by the fact that the participants read the sentence without preview, starting to read aloud as soon as the sentence appeared on the screen. Also, to avoid exaggerated prosody, participants were asked to read naturally at a normal pace (and they were not told their recordings would be listened to by other participants). Thus it can reasonably be assumed that the prosody assigned was the default prosody (see definition above), a concept which can have an explanatory role in accounting for preferred interpretations.

The statistical power of the study was greater than most previous ones for the following reasons:

- There were 24 target sentences and 40 participants.

- The experiment was conducted on Hebrew with the aim that prosodic breaks would be clearly detectable by coders, providing 'clean' data. A pilot study had been conducted on English with similar materials but three expert prosodic coders had found it extremely difficult to distinguish between presence and absence of ip breaks. Hebrew ip boundaries are realized with a phrase-final pitch rise as well as lengthening and optional pause. It seems likely that for this reason ip boundaries in Hebrew would be more readily detectable than in English where they are mostly realized with falling pitch, which does not offer such a sharp contrast with the normal F0 declination through the sentence (but see section 4.3.1 below). In this respect Hebrew more closely resembles French, for which several studies have shown strong alignment results for ips, suggesting that French exhibits particularly clearly marked ip boundaries (Pynte & Prieur 1996; Pynte 2006; Millotte et al. 2008).

There are two aspects of previous PP attachment studies that our methodology does not improve on:

- Rather than attempting to elicit these complex sentences we presented them in writing to participants to read aloud. As has often been observed, read speech may not reflect natural speech patterns.
- Following the reading of each sentence, a comprehension query was presented in the form of two written phrases from which the participant was to choose the one that he/she considered most closely related to the meaning of the sentence. Being presented with this choice might have drawn attention to the two possible

interpretations of a target sentence[15]. However, it was hoped that the impact of this would be softened by the fact that two thirds of the sentences were unambiguous fillers for which only one comprehension answer was correct, so participants might have gotten used to the idea that there was a unique correct answer for each sentence.

[15] In a study on the single-PP construction in Brazilian Portuguese, Maia, Lourenço-Gomes & Moraes (2004) presented a globally ambiguous target sentence followed by another sentence expressing one or other meaning of the target sentence, and the participants had to respond 'yes' or 'no' to whether the second sentence was compatible with first. (In English translation an example is: 'The clerk located the passenger with the cell phone' followed by either 'the clerk had a cell phone' or 'the passenger had a cell phone'. Although this avoids presenting both alternatives together, it has the disadvantage that the proper response to the reader's dispreferred interpretation is neither 'yes' nor 'no', but 'can't tell'; so subjects may simply guess (e.g., whether the clerk had a cell phone).

CHAPTER 3

PHRASE AND SENTENCE LEVEL PROSODY IN HEBREW

3.1 Phrase boundaries in Hebrew

This review of Hebrew prosody will focus on the prosodic properties of syntactic phrases and sentences, which will be relevant to the experiments on prosody and sentence processing reported in the following chapters. There has been very little research on prosodic phrasing in Hebrew[16]. The major contribution is due to Laufer (1987, 1996), though there have been a few more recent experimental studies, mentioned below. Laufer (1987) and Laufer (1996) overlap partially in content. In discussion below I will not reference these works individually, except where relevant.

Laufer notes the general assumption that prosodic boundaries reflect a combination of breathing needs and the syntactic rules of the language. Thus, although his theoretical framework differs in some respects from current views, he does address the prosody/syntax interface. He adopts Jones' (1956) distinction between two types of prosodic units: a 'breath group' and a 'sense group'. A breath group is a speech unit between two successive breaths and usually correlates with sentential units in the syntax. It thus appears to correspond with what is now standardly called an Intonation Phrase (IPh). According to Pierrehumbert (1980) and Beckman & Pierrehumbert (1986), an utterance is composed of one or more IPhs, which are marked by a high (H%) or low (L%) boundary tone in final position. A sense group is defined as a subpart of the breath group and at the syntactic level it normally constitutes a smaller unit than a sentence,

[16] There has been research on intonational contours and the realization of focus in Hebrew, by Mixdorff and Amir (2002) and by Amir, Almogi and Gal (2004). I will not discuss these phenomena as they have little bearing on my study of prosodic phrasing in sentence processing.

such as a clause[17], a phrase or even a single word. The break following the sense group is shorter than the one following the breath group (see data in an experimental study by students of Laufer discussed below) and it is not used for taking a breath. Laufer's sense group thus appears to largely correlate with what will be termed an intermediate phrase (ip) in this dissertation (also known in the literature as a *phonological phrase* or a *minor phrase*). Beckman & Pierrehumbert (1986) define an ip as a subunit of the IPh which has minimally one pitch accent. The end of an ip is marked by a high (H-), low (L-) or downstepped high (!H-) phrase accent. Laufer notes that the division into sense groups and even breath groups is determined by both syntactic and durational criteria: there is a tendency for speech units to align with syntactic constituents, but at the same time there is a limit on the duration of a speech unit. For example, when speech is slow, a sentence may need to be divided into more speech units than when it is fast. Thus Laufer's approach recognizes the two factors that are generally considered to be the major contributors to the prosody/syntax interface: alignment and phrase length.

Laufer discusses the physical cues for a sense group boundary in Hebrew. He argues that the primary signal for the boundary is a pitch change, as it occurs at every sense group boundary. In a pitch change, the pitch falls or rises from the last stressed syllable (nucleus) to the sense group boundary. Then, at the beginning of the following sense group, there is a resetting of pitch. If the preceding group ended with a falling pitch, the following group will start at a higher pitch, and conversely. A pitch change is often accompanied by a change in speech rate and a pause (see below).

[17] A clause is normally (though not exclusively) associated in the literature with an IPh rather than with an ip (the strongest prosodic boundary was often observed at clause boundaries, e.g., Price et al., 1991 and Warren, 1985, among others). Thus, it is possible that the definition of a sense group by Laufer is somewhat broader than that of an ip.

A change in speech rate is almost as frequent in Hebrew in signaling the sense group boundary. It involves lengthening of the last syllables at the end of the sense group, even if they are unstressed, and then an increase of the speech rate at the beginning of the next group. For example, Laufer notes that in the sentence (1) below, each syllable in the unstressed 'sita' at the end of the first group is much longer in duration than the unstressed syllables in 'bixlal ša' at the beginning of the following group. (The stressed syllables of the words in the end and beginning of the two sense groups are shown in bold font in (1); the other syllables are unstressed.) Laufer uses the vertical line to mark the division between sense groups.)

(1) Kše-nasati la-uni**ver**sita | bixlal ša**xax**ti mikol ha-'inyan
When I went to the university at all I forgot from all the matter
'When I went to the university I completely forgot about the whole thing.'

The third physical cue discussed by Laufer is the pause (silence). As opposed to the two other cues, a physical pause is not consistently present as an indicator of a sense group boundary in Hebrew. The optionality of the pause at a sense group boundary was confirmed by an experiment conducted in Laufer's course "The intonation of spoken Hebrew" whose results were summarized and reported in a seminar paper by his student G. Drori. A script of ten-minute T.V. interviews was divided into sense groups and breath groups by three students in the course[18] and pause durations were measured. The average duration of the silent pause between the sense groups was 22 ms[19], and importantly, in 40% of the loci that the perceptual analysis identified as sense group boundaries, there

[18] It is not mentioned whether this division was based on the students' intuitive judgments or whether they were guided by Laufer's criteria for identifying sense groups and breath groups.
[19] Laufer does not specify the average duration of the silent pause between breath groups but he does mention that the range of pause durations at the 158 detected breath groups was 0 to 117 ms.

was no measurable physical pause. This supported his claim that the physical pause is only a secondary cue to a sense group boundary.

Laufer seems to imply that differences in pause length may not be informative, since there can be differences between speakers; even within the speech of one single speaker, pauses at sense group boundaries can range from zero duration to relatively long durations. However, he also appears to assign some linguistic significance to pause length, in claiming that "the looser the relationship between the word groups, the longer the pause is, and conversely, the tighter the relationship between the words groups, the shorter the pause is" (pp. 279-280, 1996; translated from Hebrew by RWS). Laufer may perhaps be referring here to the degree of structural closeness between word groups. This would relate to the general observation, discussed in section 2.5, that discontinuity in the syntax is typically correlated with discontinuity in the prosody.

Amir, Silber-Varod & Isre'el (2004) and Silber-Varod (2005) also discuss the acoustic cues to prosodic boundaries in Hebrew. They analyzed the occurrences of prosodic boundaries in natural spontaneous production of Hebrew and employed the same criteria as Laufer (pause, final syllable lengthening, fast speech at the beginning of the next prosodic unit, and pitch reset). Their premise was that the basic structural unit of speech, which they called the Intonational Unit (IU) (or the Prosodic Unit, PU, in Silber-Varod, 2005), ought not to be associated in the study of spoken language with any particular type of syntactic units. Their definition of the IU/PU can encompass syntactic phrases or clauses and even incomplete (interrupted) sentences. They recognize only one level of prosodic unit, so it must also encompass what other prosody researchers would

classify as either ip or IPh units. Thus, this approach does not offer assistance in distinguishing ips from IPhs in Hebrew.

Amir et al. analyzed a narrative by a native speaker of Hebrew who was involved in conversation. The sample was parsed into prosodic units by four researchers, native speakers of Hebrew, who were instructed to disregard syntactic cues. There was full agreement among the informants regarding the parsing of 47 IUs (out of 54 IUs reported in total). A sense of the size of an IU is given by the following data: the mean IU length was 3 written words (range from 1 to 6), consisting of 6 syllables (range from 1 to 14), and the mean IU duration was 950 ms (range from 310 ms to 1780 ms). The perceived prosodic boundaries of the 47 agreed upon IUs were then analyzed acoustically, to identify the acoustic correlates of IU boundaries. The results showed that 24% of the perceived IUs conformed to all four prosodic criteria; 81% showed final syllable lengthening (criterion: final syllable duration that exceeded more than 10% of the average syllable duration within the entire IU); and 70% exhibited pitch reset (criterion: the difference between the stressed and unstressed syllables was greater than 15 Hz.) with an average pitch reset of 51 Hz. Reset downwards occurred in 75% of all the pitch reset cases, and reset upwards in the remainder. (Interestingly, this confirms our claim in section 2.5 that prosodic phrases in Hebrew typically end with a pitch rise, except if sentence-final.) Pauses with duration longer than 20 ms were associated with 55% of the IU boundaries. Finally, fast speech rate at the beginning of an IU was found in 34% of the IUs (criterion: the ratio of the mean syllable duration before the most prominent syllable, in the IU in which speech rate was measured, to the mean syllable duration in that same IU, was less than 0.9). These findings by Amir et al. were matched more or less closely

by the subsequent analysis by Silber-Varod (2005) of three other narratives[20] where 64% of the IUs exhibited final syllable lengthening, 60% showed pitch reset, 47% had pauses and 44% had fast speech at the beginning of the next speech unit.

It should be noted that the ranking of the prosodic cues according to their probability of occurrence in the studies by Amir et al. (2004) and Silber-Varod (2005) differs from the ranking reported by Laufer (1996). Final syllable lengthening in Amir et al.'s and Silber-Varod's data is ranked higher in probability of occurrence than pitch reset and fast speech rate, and pause is ranked higher than fast speech rate, compared with Laufer who ranked pitch above final lengthening. These differences could be due to the fact that differently defined speech units were being examined. As noted above, Laufer distinguished two levels of units: breath groups and sense groups, the former being composed of the latter, while Amir et al. and Silber-Varod recognized only one level which embraced all prosodic units that satisfied any one of their acoustic criteria. In this respect, Laufer's descriptive system is closer to the framework that will be adopted in the present study, which recognizes two levels of prosodic constituents: IPh and ip, the former composed of the latter.

3.2 Prosody of PP attachment structures in Hebrew

According to the widely accepted linguistic theory of the prosody/syntax interface proposed by Selkirk (1984, 2000), languages are parameterized with respect to whether they align prosodic boundaries with the left or the right edges of syntactic constituents.

[20] Both Amir et al. (2004) and Silber-Varod (2005) took the narratives they studied from the Corpus of Spoken Israeli Hebrew (*CoSIH*).

Though not exceptionless, it seems that syntactically right-branching languages typically exhibit right-edge prosodic alignment, while syntactically left-branching languages exhibit left-edge prosodic alignment. Thus it might be anticipated that in Hebrew, as in English, high attachment of a single PP (to VP), as shown in the tree diagram (2a) in section 1.1 above, would be signaled by a prosodic break at the right edge of the completed object NP; this amounts to a break immediately before the PP. This would contrast with low PP attachment (into the object NP), shown in tree diagram (2b) in section 1.1 above, where the edge-alignment theory predicts no prosodic break before the PP, because no syntactic phrase (XP) ends there.

In Hebrew there has been no empirical study testing this relationship between syntax and prosody with respect to the single-PP. Yet, while discussing the implication of sense group (ip) boundaries on syntactic parsing, Laufer (1987, 1996) presents three examples of the single-PP ambiguity in Hebrew (among several other ambiguities), which to his judgment, show that the location of boundaries between the sense groups can resolve the ambiguity. The examples presented for the single-PP attachment ambiguity are as follows:

2) Katavti l-aiš ba-mitbax
I wrote to the man in the-kitchen
'I wrote to the man in the kitchen'

3) Hirbacti la-yeled im ha-makel
I hit to the-boy with the-stick
'I hit the boy with the stick'

4) Cavati 'et ha-tmuna be-'adom
I painted ACC the-picture in-red
'I painted the picure red'/'I painted the red picture[21]

[21] These are the two possible meanings of the sentence. No one English translation can convey the two meanings.

Sentence (2), for example, is ambiguous between 'I wrote to the man who was in the kitchen' and 'I wrote to the man while I was in the kitchen'. When 'in the kitchen' is a noun modifier, 'the man in the kitchen' constitutes one sense unit and is not interrupted by a boundary (*Katavti* │ *l-aiš ba-mitbax*, 'I wrote │ to the man in the kitchen'). However, when 'in the kitchen' is an adverb, it will attach to the non-adjacent verb and a prosodic boundary will therefore occur between 'the man' and 'in the kitchen' (*Katavti l-aiš* │ *ba-mitbax*, 'I wrote to the man │ in the kitchen'). Thus, the prosodic boundary in this construction in Hebrew appears to play a role in syntactic ambiguity resolution as has also been maintained for English, French and other languages (see references in section 2.2). That is to say, a break preceding the ambiguous PP constituent encourages high PP attachment, and a break following the verb encourages low attachment. Examples (2), (3) and (4) above of the single-PP in Hebrew are important for my study as they suggest that the double PP ambiguity that I am going to investigate, which has an extra PP with additional opportunities for prosodic breaks (see section 2.5), may also involve a prosodic resolution.

However, the same question arises for Hebrew as has troubled the literature on English and other languages: whether native speakers of the language reliably produce breaks in these positions. According to my own native intuitions, Laufer is right that breaks in these positions do disambiguate the sentence as he describes, but in my judgment this sentence could be naturally produced without any breaks at all. In the latter case, my intuition is that high PP attachment is preferred. So in Hebrew as in English, we can expect to benefit from investigating the more complex Double-PP construction. As for the Double-PP construction, my intuitive judgment is that it is possible to pronounce

the whole sentence without any break; this is natural if all constituents are relatively short as in (5a), but becomes more awkward if PP2 is long, as in (5b), especially at slower rates of speech.

(5) a. Short PP2
dana te'ara 'et ha-kšayim be-nisu'e-ha /la- šadran/
Dana described ACC the- difficulties in-marriage-her to the-broadcaster
'Dana described the difficulties in her marriage to the broadcaster.'

b. Long PP2
dana te'ara 'et ha-kšayim be-nisu'e-ha /la- šadran ha-mefursam
Dana described ACC the- difficulties in-marriage-her to the-broadcaster the-famous
'Dana described the difficulties in her marriage to the famous broadcaster.'

If there is a break in the sentence with a short PP2, my intuition suggests that it will tend to occur immediately preceding PP1, not before the short PP2, whereas when there is a long PP2 in the sentence, a break would be more likely immediately before PP2. The next chapter describes an experiment which puts these informal judgments to the test.

CHAPTER 4

PRODUCTION AND ATTACHMENT IN A DOUBLE PP CONSTRUCTION IN HEBREW

4.1 Hypotheses

Experiment 1 investigates the preferred prosodic phrasings and preferred interpretation of the double-PP construction in Hebrew. These preferences are elicited with a task that involves production and comprehension.

The interaction between alignment constraints and length constraints described above (see Chapter 2) was predicted to have implications for the prosodic phrasing and attachment preferences in the Double-PP construction, which could differ between the long and short versions of PP2 and the two different syntactic structures (high attachment and low attachment of PP2). The alignment and length constraints were proposed in the context of Optimality Theory in which they interact with each other (Selkirk, 2000). Thus they are soft constraints and can be violated when other constraints outrank them.

According to the BinMaP principle, the optimal length of an intermediate prosodic phrase is two prosodic words. This predicts a higher incidence of prosodic breaks at [PP2[22] for a long PP2 (from two to three words in this experiment, e.g., *la-šadran ha-mefursam*) than for a short PP2 (always one prosodic word in this experiment, e.g., *la-šadran*); a long PP2 would be long enough to comprise a prosodic phrase on its own while a short PP2 would need to join with the preceding prosodic unit to form an

[22] In this chapter the abbreviation [XP will be used to signify the position immediately preceding the XP. For example, "a break at [PP1" denotes a break immediately preceding the PP1 in the Double-PP construction.

optimal sized prosodic phrase. If syntactic and prosodic breaks align, we also expect to observe more high attachment of long PP2 than of short PP2.

For a sentence with a short PP2 there might be no break at all or else a break in some other position such as at [PP1. (A break between the subject, which was always a pronoun, and the verb, or a break between the verb and the Object-NP (a determiner + a noun), would be less likely due to the shortness of these items. In addition, the close semantic relationship between the verb and the object may also discourage a break between them.) When PP2 is short, PP1 and PP2 are likely to be grouped together to form a prosodic phrase, which is long enough to stand alone, i.e., with a break before it. The verb and the NP might also group together to form an ip, creating a balance of two prosodic words preceding and following the break at [PP1. When PP2 is long, a prosodic break is not expected at [PP1 if there is a break at [PP2 as discussed above. Breaks at both locations are possible but not optimal since PP1 always consisted of a preposition and a noun (e.g., *be-nisu'eha*) and was thus too short to stand alone comfortably. As an alternative, PP1 may group with the immediately preceding Object-NP. The verb is likely also to be included in that prosodic grouping because, as noted, length considerations disfavor its standing alone with the preceding unstressed pronominal subject as a prosodic phrase.

It should be borne in mind that there are two forces that could weaken the tendency discussed above for a break at [PP1 when PP2 is short and has no break before it. First, the Wrap-XP constraint (Truckenbrodt, 1995) predicts that each syntactic XP must be contained in a phonological phrase. In the present case this favors grouping PP1 with Object-NP, due to the semantic design of the materials: in all cases selection

restrictions insured that PP1 modified the Object-NP, not the verb (e.g.,'difficulties in her marriage', not 'described in her marriage'). A second factor discouraging a break at [PP1 (with no break at [PP2), has to do with the timing of on-line processing. The feasibility of combining a short PP2 into the same phrase as PP1 is a strategic judgment to be made at the moment at which it is seen that PP2 is short. Significant look-ahead would therefore be needed in order to make a break at [PP1 in anticipation of maybe wanting to combine PP1 with a short PP2. In this study the participants were told to read the sentences aloud as soon as they saw them (no preview). They did not have the opportunity, before being recorded reading aloud, to read the sentence silently in order to get acquainted with its content and structure. Assuming that it is relatively unlikely that they would make a long look-ahead in order to discover that the PP2 is short[23], the tendency to break [PP1 when the PP2 is short may be weakened. In light of these two factors, the tendency to break at [PP1 for short-PP2 items may be expected to be less strong than the tendency to break at [PP2 in long-PP2 items.

Since the Wrap XP constraint, as mentioned above, does not favor a break at PP1, a break may occur before the short PP2. However, this prosodic phrasing is the least likely because it involves a double violation of the length constraint: the first prosodic unit is too long (constitutes more than two prosodic words) and the second is too short (constitutes less than two prosodic words).

In no other locations are breaks expected in the Double-PP construction, including not inside the long PP2, which is constructed of a preposition and a noun (the part that the short and long-PP2 items share) which are succeeded by one of the following: an

[23] This can only be a speculation. Very little is known about the on-line sub-processes by which prosodic phrasing decisions are made by the parser.

adjective (in 17 out of the 24 target items), a possessive pronoun[24], another noun which forms a construct state[25] together with the first noun or a family name[26]. In all these combinations, the first noun and the following element form a NP, and a prosodic break immediately following the first noun in the middle of the NP would be completely unnatural.

The underlying hypothesis in our study is that constituent lengths would influence prosodic phrasing in accord with optimal phonological length principles acting over minor morphosyntactic phrases, and that the reader's preferred syntactic attachment of major phrases such as PP2 would then be guided by the length-induced prosodic phrasing. This cannot be established directly but it leads to specific predictions.

A break at [PP2 is predicted to encourage a high PP2-attachment preference (for both short and long-PP2 items) in accord with the alignment principles that relate syntactic phrasing and prosodic phrasing.

The predicted relationship between PP2-attachment height and [PP1 breaks is indirect. Prosodic breaks at [PP1 are expected to encourage low PP2-attachment by

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[24] Both adjectives and possessive pronouns in Hebrew follow the noun they modify.

[25] A construct state is a complex nominal, common in Semitic languages, which contains two (or more) nouns expressing a genitive relation, for example, *bakbuk yayin* (bottle wine; meaning 'bottle of wine'). Its meaning is identical to the Free State nominal *bakbuk shel yayin* 'bottle of wine', though it differs from it syntactically and phonologically. The Construct State lacks the preposition *shel* 'of', and has stress on the second noun only; this often gives rise to morpho-phonological alternations on the unstressed first noun (for example, compare the free form *dira* 'house' to the form of the first noun in the Construct State *dirat studentim* (house students; meaning 'house of students'). Unlike the Free State nominal, which contains two phonological words, the Construct State is considered one phonological word despite its internal syntactic structure.

[26] Long PP2 containing an adjective: ba-radio ha-ezori
in the-radio the-regional (on the regional radio)
Long PP2 containing a construct state: le-o'vdey ha-xevra
to-workers the-company (to the company workers)
Long PP2 containing a family name: mi-tami toledano
from-Tami Toledano (from Tami Toledano)
Long PP2 containing a possessive pronoun: ba-ši'urim šelo (in his lessons)
in the-lessons his

weakening the tendency to break at [PP2, as noted above, thus grouping PP2 with PP1 prosodically. Then, once PP1 and PP2 form a prosodic phrase, the Sense Unit Condition (SUC) would come into play: the SUC states that the immediate constituents in a prosodic phrase must entertain a head-argument or head-modifier relationship (Selkirk 1984). Thus, the SUC would want a PP2 that is in a prosodic phrase with PP1 to modify the head noun inside PP1; thus low PP2 attachment would follow.

The absence of a prosodic break at [PP1 may indirectly encourage high PP2-attachment by grouping NP and PP1 together, thereby increasing the likelihood of a break at PP2. However, if there is no break at either PP1 or PP2, it is less clear what the attachment preference would be. It might be evenly divided between high and low attachment, in the absence of prosodic support for either one. On the other hand, there is some evidence in the literature for the existence of a syntactically-based Late Closure (Recency) strategy in addition to prosodic influences on attachment (Kjelgaard & Speer, 1999; Fernández, 2003; Augurzky, 2006), which would lead to low PP2 attachment when prosody is neutral[27].

[27] Kjelgaard & Speer (1999) conducted an end-of-sentence comprehension task and cross modal naming task with early and late closure sentences such as: *When Roger leaves the house, it's dark / When Roger leaves, the house is dark.*They found that when prosody was neutral or in conflict with the syntax, the parser followed the syntactically-based Late Closure strategy in accord with morpho-syntactic information. Likewise, Augurzky (2006) conducted an ERP study in German with two forms of relative clause attachment ambiguity: a genitive form that did not include a preposition between the two NPs of a complex NP and a prepositional form (von-DP) equivalent to the NP1-of-NP2 structure in English. These two types of relative clauses were tested with congruent and incongruent prosody. When prosody was congruent with the syntax, both high and low attachment structures were processed easily. However, when prosody was incongruent with the syntax, low attachment was processed more easily than high attachment for both RC forms, in accord with the Late Closure principle.

Thus, the patterns of prosodic phrasing with their corresponding attachment preferences that are most expected to occur are as schematized below:

(1) a. [subj-pronoun verb obj-NP PP1] [long PP2] – High PP2-attachment

b. [subj-pronoun verb obj-NP PP1] [short PP2] – High PP2-attachment

c. [subj-pronoun verb obj-NP] [PP1 short PP2] – Low PP2-attachment

d. [subj-pronoun verb obj-NP PP1 short PP2] – ? PP2-attachment

Thus, while long-PP2 sentences are expected to largely occur with PP2 breaks, prosody for short-PP2 sentences is likely to vary between [PP1 breaks, [PP2 breaks or no breaks. If attachment is sensitive to prosodic phrasing, it can thus be predicted that long PP2 is likely to prefer high attachment, while there may be no consistent attachment preference for short PP2.

4.2 Method

4.2.1 Materials

The following is an example of a target item from the experiment. It consists of two sentences, followed by two phrases corresponding to the two possible meanings of the second sentence. In (2) it is presented in Hebrew in the format of presentation in the experiment. In (3) it is shown in transliteration with English translation.

(2) דנה הרגישה צורך לדבר על בעיותיה.
היא תארה את הקשיים בנישואיה לשדרן.

נישואיה לשדרן תיארה לשדרן

(3) Dana hirgiša tsorex ledaber ‘al be’ayote-ha.
Dana felt need to talk about problems-her.
‘Dana felt the need to talk about her problems.’

Hi te’ara ‘et ha-kšayim be-nisu’e-ha la-šadran.
She described ACC the-difficulties in-marriage-her to the-broadcaster
‘She described the difficulties in her marriage to the broadcaster.’

te’ara la-šadran nisu’e-ha la-šadran
described to the-broadcaster marriage-her to the-broadcaster
‘described to the broadcaster’ ‘her marriage to the broadcaster’

I will discuss the crucial properties of such items beginning with the form of the second sentence, which was the target construction containing a PP2-attachment ambiguity.

4.2.1.1 Target sentences

The investigated construction contains a subject, a verb and a direct object followed by two consecutive PPs (see example 4).

(4) Subject Verb Object-NP PP1 PP2
hi te’ara ‘et ha-kšayim be-nisu’e-ha la-šadran (ha-mefursam)
she described ACC the-difficulties in-marriage-her to the-broadcaster (the-famous)
‘She described the difficulties in her marriage to the broadcaster (to the famous broadcaster)’

The target sentences were constructed in such a way that the PP1 can only attach low, to NP, not VP (‘difficulties in her marriage’, not ‘described in her marriage’). Thus the PP1 is part of the direct object in all cases. The PP2 in final position (‘to the broadcaster’), on the other hand, can either attach high to the VP, thus modifying the verb ‘described’, or can attach low to the NP inside PP1, thus modifying the noun ‘marriage’; both meanings are felicitous. Under the high attachment analysis, PP2 reveals to whom the difficulties in Dana’s marriage were described, and under the low attachment

analysis, it indicates to whom she was married. The final PP2 was either short (la-šadran) or long (la-šadran ha-mefursam).

The target sentences were constructed to be evenly balanced with respect to the two possible interpretations, with no bias toward either of them. To achieve balanced ambiguity, care was taken that the semantic and pragmatic content of both interpretations would be equally plausible. Balancing the two interpretations in this manner was important because it was of primary interest in this study to learn about the preferred interpretation of the target structure when meaning (semantic and pragmatic) is not the determining factor.

Some criteria were established with the aim of avoiding a bias toward one of the interpretations. First, the noun inside PP1 had to be able to stand on its own without a required complement[28]. A strong need for a complement could bias the preference toward low attachment of the final PP. For example, in sentence (5) the word *kni'a* 'giving in' requires more information to be semantically complete. One would need to know who or what was being given in to. Therefore, a complement following the word *kni'a* such as *la'ovdim* 'to the workers' would be naturally associated with it. The result would be a strong tendency for low attachment. Such examples as (5) were, thus, not included in the experiment.

(5)	Subject	Verb	Object-NP	PP1		PP2
	ha-menahel	hivhir	'et 'emdat-o	legabey	ha-kni'a	la-'ovdim
	the-manager	made clear	ACC position-his	regarding	the-giving in	to the- workers
	'The manager made his position regarding giving in to the workers clear'					

[28] The decision whether or not a complement was required by the noun inside PP1 was the author's in consultation with several native speakers of Hebrew. In any event, a pre-test, which will be discussed below, made it possible to rule out sentences in which the verb or the nouns required complements.

In addition, collocations or nouns that are often associated with one another[29], such as 'love' and 'children' (as in "I wrote a book about *love* for *children*") were avoided in PP1 and PP2 in order to prevent a low attachment bias. Likewise, verbs that require an additional complement following the direct object, or are strongly associated with the preposition in PP2, were not selected, in order to avoid a high attachment bias. For example, the verb *hini'ax* 'put' in sentence (6) below is strongly related with the preposition *be* 'in', and therefore the information about where the baker put the cake is expected in the sentence. As a result, there is a strong tendency to attach PP2 to the verb.

(6) Subject Verb Object-NP PP1 PP2

ha-'ofe hini'ax 'et ha-'uga la-mesiba ba-xacer
the-baker put ACC the-cake to the-party in the-courtyard

'The baker put the cake for the party in the courtyard.'

Second, nouns in the direct object position that were plausible hosts for PP2 attachment and as such could allow an additional ambiguity were also avoided in order that the (most prominent) ambiguity would be between VP attachment and PP1 attachment of PP2. For example, the direct object 'the letters' in the sentence "the man hid *the letters* about the divorce from his wife" allows the interpretation according to which the letters were from his wife, in addition to the two interpretations of interest here, where 'from his wife' reveals who the letters were hidden from (VP attachment of PP2: 'hid them from his wife') or who the divorce is from (PP1 attachment of PP2). The 'mid-level' interpretation ('letter from his wife') is possible pragmatically and syntactically. It can be excluded, however, by replacing the NP 'the letters' by an NP such as 'his anger',

[29] The decision which nouns are often associated with one another were based on the author's intuitions.

which cannot take PP2 as a complement (not 'anger from his wife'). For this reason, the NPs selected for direct object position in the experimental materials constituted unacceptable hosts for PP2 on grounds of plausibility and/or grammaticality.

Third, sentences in which one interpretation entails or includes the other, so that the two meanings are not sharply distinguishable, were avoided. For example, a sentence such as "The father solved the problem of the housing for his daughter" was ruled out on grounds that the high attachment meaning 'solved the housing problem for his daughter' strongly implies the low attachment meaning 'the housing was for his daughter', and vice versa.

Fourth, adjectives, construct states[30] and negation words were not included in the experimental examples, so as to keep the sentences simple and prevent unnecessary variability in length or parsing complexity across target sentences. This is important because length differences may influence the speakers' assignment of prosody to the ambiguous sentences (as explained in section 2.5) which in turn might bias the syntactic/semantic interpretation.

Another reason for avoiding construct states is that a construct state might be analyzed as consisting of an NP modified by a PP with a phonologically null preposition (see Shaked, 2009 for a more detailed report on the construct state form) and it was in general considered important not to introduce any additional PPs, over and above PP1 and PP2, into the experimental sentences. Construct state constructions often appeared as the subject of the introductory sentence (see discussion of 'preamble' below) and were then referred to in the target sentence by a pronoun.

[30] Adjectives and construct states were only included in the long-PP2 version of the experimental sentences. Adding adjectives and construct states into PP2 was one of the ways to turn a short PP2 into a long PP2.

Each experimental item was prepared in two versions with either a long or a short version of PP2. In the short version, PP2 contained one prosodic word, and in the long version it contained two to three prosodic words. To create a long PP, one or two prosodic words were added to the short PP. The words that were added did not carry information that significantly changed the meaning of the PP. These were proper names or other words that could not greatly alter meaning. For example, in the experimental item, 'Gadi tried to speak quietly. He whispered the joke about the present to Dafna (Avramovski)', the short PP (to Dafna) consists of a first name while the long PP (to Dafna Avramovski) comprises a first name and a family name. Since names are standardly analyzed as having reference but not meaning, adding the family name does not modify the meaning of the PP (see Hirose, 2003). Also, in the experimental item 'The commander was in the base. He saw the group of escapees from the (north-western) window', mentioning the location of the window in the long PP2 version of the sentence is unlikely to alter the meaning of the PP to the point that it would affect the attachment choice. In a few cases, there was a slight difference in the preposition and/or first noun between the short and long versions of PP2 due to morphological requirements. For example, the short PP2 ***la-'ovdim*** ('to the-workers') changed in the long PP2 into ***le-'ovdey*** *ha-xevra* ('to-workers the-company', i.e., 'to the company workers') in the process of creating a construct state. These changes were unlikely to cause any semantic differences between the long and short-PP2 sentences and hence could not affect interpretation. The purpose of minimizing semantic differences between the short and long versions of PP2 was to ensure that any prosodic effects of phrase length on attachment would not be confounded with semantic influences.

A preamble (a prior sentence) in a mini-discourse was created for each pair (short PP2 / long PP2) of target sentence (see the first sentence in example (4), in section 4.2.1). The preamble introduced an individual that would serve as the subject of the target sentence. The target sentence which followed began with a pronoun in subject position referring back to its antecedent in the preamble. A pronoun, which constitutes one syllable, in the subject position of all the experimental sentences, minimized length differences at that locus across the sentences. This is important because length differences in the subject position could affect prosodic phrasing in the critical region of PP2 later in the sentence (Bradley, Fernández & Taylor, 2004) which in turn might influence participants' interpretation of the ambiguously attached PP. In addition, a pronoun, compared with a full noun phrase, reduced the length and complexity of the target sentences.

The preambles were 3-8 words long (mean 5 words); the target sentences were 5-9 words long (mean 7 words), with a range of 5-8 and a mean of 6.46 for the short target sentences, and a range of 6-9 and a mean of 7.54 for the long target sentences. The preambles were kept fairly short to prevent processing and memory overload, which could negatively affect performance on the comprehension task that followed (see below). They were also designed to be neutral between the two interpretations of the target sentences, as example (7) in English below shows (the parentheses include the long version of PP2). Since the preambles were included in the pre-test of the materials (see description in section 4.2.1.2 below) together with the target sentences, there was further reason to believe they were not biased toward either interpretation.

(7) Dana felt the need to talk about her problems. She described the difficulties in her marriage to the broadcaster (to the famous broadcaster).

Following the preamble and target, two phrases (which will also be referred to here as 'answers') were presented, one compatible with the interpretation in which PP2 modifies the verb (high attachment) and the other reflecting the interpretation in which PP2 modifies the immediately preceding noun in PP1 (low attachment). The former consisted of the verb plus PP2, and the latter consisted of the noun from PP1 plus PP2. For example, for the example target in (4) above, the two phrases were as follows:

(8)

te'ara la-šadran	nisu'e-ha la-šadran
described to the broadcaster	marriage-her to the broadcaster
תיארה לשדרן	נישואיה לשדרן

4.2.1.2 Pre-test

The 24 target items used in Experiment 1 were a subset of 40 ambiguous Double-PP items (preambles plus target sentences), each in a long and short-PP2 version, constructed to meet the criteria described above. This section describes a pre-test used to identify the 24 items that were most evenly balanced with respect to the two possible interpretations and that had the least differences in plausibility between the short and long versions of PP2.

4.2.1.2.1 Design

The 40 items in their short and long versions were each presented to expert judges (see below) in two lists. Each list contained an equal number of long and short versions;

the long and short versions of the same item were in different lists. The materials were pseudo-randomized, and any runs of more than two short or long sentences were eliminated manually. (See Appendix A-2 for all materials in the pre-tests.)

4.2.1.2.2 Judges

The materials in the pre-test were evaluated by four native speakers of Hebrew, all of whom have some linguistics background (a Ph.D. in Speech and Hearing and a Bachelor degree in Linguistics, a Ph.D. student in Linguistics, a Ph.D. student in cognitive/developmental psychology, and a teacher of Hebrew as a second language).

4.2.1.2.3 Procedure

Each judge was administered one of the two versions of the questionnaire. The judges were asked to read each item (preamble plus target sentence) and make a judgment about the plausibility of the two interpretations of the ambiguous PP in the target. Judgments were made using a seven point scale. Each item was displayed in the format shown in (9). (The Hebrew example is followed here, though not in the pre-test, by a transliteration and an English gloss. The example in (9) has the long version of the PP2.)

(9) האומן מבצלאל ביקר בבית היתומים. הוא צייר ציור עבור הילד עם המכחול הכחול.

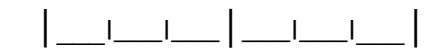
|___ו___ו___|___ו___ו___|

צייר עם המכחול הכחול הילד עם המכחול הכחול

(10) ha-‘oman mi-bezal’el biker be-vet hayetomim. hu ciyer ciyur ‘avur ha-yeled
the-artist from-Bezalel visited in-the orphanage. he painted a picture for the-boy

‘im ha-mikxol ha-kaxol.
with the-brush the-blue.

‘The artist from Bezalel visited the orphanage. He painted a picture for the boy with the blue brush.’



ha-yeled ‘im ha-mikxol ha-kaxol	ciyer ‘im ha-mikxol ha-kaxol
the-boy with the-brush the-blue	painted with the brush the-blue
‘the boy with the blue brush’	‘painted with the blue brush’

The two interpretations offered are identical to the answers in the main experiment and they also reflect the length differences between the long and short versions of the same answers (e.g., the long version of the sentence in example (10) included in the answers the extra material in the long PP2, i.e., *blue,* as in: ‘the boy with the blue brush’ and ‘painted with the blue brush’). In addition, the two phrases in the translation are presented in the same order as in the Hebrew pre-test, where answer position was not counterbalanced: high attachment response on the right, low attachment response on the left. Hebrew is written/read from right to left so the participant will read the response on the right first.

The judges were instructed (see Appendix B-3) to circle one mark on the scale to indicate the extent to which each of the two statements could be implied by the sentence. The closer the mark was to one end, the more strongly it represented the meaning of the sentence indicated on that side and the less it implied the meaning indicated on the other end. Thus, for example, selecting the outermost mark at one of the ends of the scale indicated that the sentence could mean only the interpretation at that end. Likewise,

selecting the mark in the center indicated that the sentence could mean each of the interpretations to the same extent. In addition to the written instructions, the procedure was illustrated by three examples of possible markings, one displaying two equally plausible meanings for an item, the second showing there was only one interpretation possible and the third showing one interpretation was more likely than the other.

4.2.1.2.4 Assessment method

Each item received four judgments in total, one from each judge. Two judgments were for the short version and two were for the long. Judgments corresponding to the three rightmost marks on the scale represented the high attachment meaning, judgments corresponding to the three leftmost marks represented the low attachment meaning, and judgments in the center of the scale represented a balanced ambiguity. To qualify as acceptable, a given item had to satisfy two criteria: First, of the four judgments, no two should exhibit a difference greater than two points on the scale[31]. This ensured the selection of items the judges had general agreement on. It also made sure that any semantic/pragmatic disparity between the short and long versions of a sentence would be minimal. Second, a sentence was deemed unacceptable if any of its four versions was rated at the extremes of the scale (i.e., as fully unambiguous) by any of the judges. In fact, judgments at the extremes of the scale were given only once. In addition, a sentence was excluded if it was not rated by all four judges (e.g., if a judge failed to rate it on the

[31]An exception was made to this rule for one item, which had a difference of more than two points of the scale for two scores but received a balanced ambiguity score of 4 for both the short and long versions (it received the scores 3 and 4 for the long version, and 4 and 6 for the short version).

grounds that it was unclear or that the two meanings were not distinguishable). There were four such cases, all by the same judge.

4.2.1.2.5 Results

Judgments were converted into a numerical scale ranging from 1 to 7. The ratings of three of the judges were scattered in similar ways across the scale. They exhibited a standard deviation of 0.5, 0.8 and 0.8. The ratings of the fourth judge revealed a higher standard deviation of 1.0. That same judge also had four missing data points (unrated items), while the others had none.

Twenty nine sentences met the criteria above. Of those, the author selected the 24 sentences that she deemed the most equally plausible on both interpretations.32 (See appendix A-1 for the full list of experimental sentences)

The mean score for all the selected sentences was 4.1, the short receiving a score of 4.0 on average, and the long, a score of 4.2. A t-test including item type (selected item/non-selected item) as the independent variable and ambiguity score as a dependent variable revealed that the difference between the mean score of the selected sentences and the center scale point 4 was not reliable, $t(23) = 1.51$, $p > .01$, and nor was the difference between the mean score of the short and long items $t2\ (23) = 1.19$, $p > .20$. The range of the mean score across all the selected sentences was 3-5. The mean score for the items that were not selected was 4.5, the short receiving a score of 4.3 on average, and the long,

[32] Based on the feedback that the judges gave after performing the pre-test, a few minor changes were made to some of the items that were selected to be in the experiment. For example, in the sentence *hu histir 'et ha-ka'as šelo'al ha- gerušin mi-tami (mi-tami 'aharonovitš)*, 'He hid his anger about the divorce from Tami (from Tami Aharonovich)', the family name may be pronounced by some Hebrew speakers without the syllable 'ha' and as a result for some speakers the long PP may be slightly shorter than intended. As a result, it was decided to change the family name in the experimental item from 'Aharonovich' to 'Toledano'. (See Appendix A-1)

a score of 4.633. The difference between the long and short sentence means was not reliable here too, t2 (15) = 1.24, p > .20. These properties of the sentences are summarized in Table 4-1.

Table 4-1: Comparison of mean scores between the selected and non-selected items for the experiment and standard deviation (SD)

	Selected items	SD	Non-selected	SD
Overall mean score	4.1	0.69	4.5	1.08
Mean score long	4.2	0.70	4.6	0.98
Mean score short	4.0	0.67	4.3	1.17

Thus, on the whole, the selected sentences, short and long, exhibited a close to perfect balanced ambiguity; the verb, and the noun inside PP2 were found equally plausible hosts for PP2. To summarize: for the selected items, the results of the pre-test do not show a preference for one interpretation over the other for semantic or pragmatic reasons and therefore the sentences satisfy the requirement for equal plausibility on both low and high attachment readings.

4.2.1.3 Filler items

Forty eight unambiguous filler items were constructed to create a 1:2 ratio of experimental to filler items. One more filler was added right after the mid-test break as a block protector (see section 4.2.2 below). Each filler item contained two sentences, to resemble the preamble + target format of the experimental items. Half of the fillers were of varied construction and contained no preposition (Filler type A), and half comprised four groups of six fillers with prepositions. Of these four, the first (Filler type B) and

[33] The overall mean value was closer to the long mean value because there were more missing data points for the short sentences.

second (Filler type C) groups had a PP in the preamble or the target sentence respectively, but none in the answers. The third (Filler type D) and fourth (Filler type E) groups contained a PP in the preamble or target sentence respectively, and the same PP in the answers. In the fillers the PP always appeared in first position preceding the subject of the sentence it appeared in (the first or second sentence). For example, in sentence (11) a PP appears in the preamble in first position. (The PP is shown in bold for the purpose of the example. It was not in bold in the experiment itself.) The example is presented first in Hebrew and then with transliteration and English gloss.

(11 **בחלומו** אורי ראה גנב נכנס הביתה.
הוא התעורר מיד.

אורי חלם הגנב חלם

(12) **be-xalom-o** ‘uri ra’a ganav nixnas ha-bayta
in-dream-his Uri saw a thief enter the-house
hu hit’orer miyad
he woke up immediately

ha-ganav xalam ‘uri xalam
the-thief dreamed Uri dreamed

The purpose of this distribution of filler items, such that some do not have a prepositional phrase and some do but in varying positions (preamble, target and/or answers), was to disguise the fixed prepositional phrase pattern in the target construction.

Additional strategies were used to distract attention away from the target items. First, the second sentence of some fillers was constructed to be equal in length to the target sentences in the experimental items (5-9 words), while others were shorter or longer. The same was true of the first sentence, which was shorter, longer or the same length as the preamble in the experimental items. Second, while in the experimental items

all the target sentences had a pronoun in subject position, in the fillers only about half of the second sentences had a pronoun in subject position. Third, since the filler sentences were not ambiguous, the two phrases presented for participants to choose between were not both compatible with the preceding sequence of sentences. In each case one was and one was not, so there was a unique correct answer, unlike for the experimental items. The aim of displaying one correct and one incorrect answer was to encourage the participants to assume there is always a single correct answer, so that they do not become too aware of the ambiguity of the target items.

Fourth, in the experimental sentences, both answers referred back to the second sentence but in approximately half of the filler items the correct answer was given by the first sentence. Fifth, in contrast to the experimental items, which contained adjectives only in the preamble and the long PP2's, adjectives were often used in the fillers in either sentence, and in the answers.

In addition to deflecting subjects' attention from the properties of the target sentences, the fillers made it possible to exclude from the data analyses the results of any subjects who were not attentive to the task. To ensure that, the correct answer required attention to the given sentence pair and was not predictable from real life situations. For example, in the filler item below (shown here only in English translation), based on general knowledge, one would expect the editor, rather than the correspondent, to shorten the article; however, the sentence itself points to the other answer. This criterion was designed to make it evident if a participant skipped reading the sentences and just picked the answers that seemed more likely, since then their answers would be incorrect.

(13) The newspaper editor convinced the correspondent to shorten the article.
In the end it contained only half a page.

the editor shortened the correspondent shortened

To be able to identify inattentive participants, it was also important to avoid priming the correct answer: if a word in the correct answer appeared in the same form that it did in the first or second sentences, while a word in the incorrect answer appeared in a different form than it did in the first or second sentences, a participant might favor the correct answer, even if they were not attentive to the task. The example in (14) illustrates in English an unacceptable item by this criterion:

(14) The wind was strong.
With difficulty the captain **persuaded** the sailors **to replace** the sails.

persuaded with difficulty replaced with difficulty

The word *persuaded* in the correct answer, *persuaded with difficulty*, uses the exact form of the verb as in the second sentence in the item, while the word *replaced* in the incorrect answer uses a different form from the one in which it appears in the second filler sentence (*to replace*). Thus, care was taken that the filler items did not include sentences in which the correct answer matched the form in the sentence while the incorrect answer did not. Instead, either only the incorrect answer or both the correct and incorrect answers matched the form in the sentence. Alternatively, neither the correct nor the incorrect answer corresponded with the form in the sentence.

4.2.2 Design

The four versions of the 24 basic target materials were distributed across four lists, corresponding to the experiment's 2x2 design that crossed PP2 Length (short/long) and Order of Presentation of the Answers (high attachment right/high attachment left[34]). The 24 target items were divided into two main lists, each containing 12 sentences in the long version and the other 12 sentences in the short version. Each of the two lists was further divided into two additional lists which differed in the order of presentation of the answers: one list uniformly displayed the answers with the high attachment meaning on the right hand side and the answers with the low attachment meaning on the left hand side, while the other list presented the answers in the reverse order. The purpose was to make it possible to detect any bias either toward the answer that was read first (if a participant did not bother to read the second answer) or toward the answer that was read last (which might be more salient). Although order of answers' presentation was a factor in the design, it will not be included in the statistical analysis as a preliminary test revealed this factor had no effect on the attachment results (see section 4.6.2). Finally, the 48 fillers (plus a covert filler immediately following the break; see section 4.2.1.3) were constant across all four lists, with order of presentation of correct/incorrect answers counterbalanced. Each participant saw only one version of each of the target sentences (short or long), and an equal number of long and short target sentences.

To avoid order of presentation artifacts, all the items, experimental and fillers in the four lists, were divided into six scrambled blocks, each containing 12 scrambled items. Each block included all the item types in the experiment and maintained the same proportion among them as in the full list of items. Thus, each block contained: four

[34] Since Hebrew is read from right to left, the answer that appears on the right is the first to be read.

experimental sentences, two with short PP2's and two with long PP2's; four fillers with prepositions, one of each of the four filler groups that contained a preposition (filler types B-E); and four fillers from the fifth group that had no prepositions (filler type A). In each block, of the four fillers with a preposition, two correct answers were presented on the right, and two on the left. This was also the case for the four fillers that had no prepositions. The right/left positions of correct answers for the fillers in half of the blocks were reversed in the other half of the blocks.

The experimental set of 24 targets and 48 fillers was presented in a different pseudo-random order to each participant as a result of scrambling the blocks and the items within the blocks. These materials were preceded by three overt practice items (after which participants were allowed to ask questions about the procedure) and four covert practice items (fillers). Half way through the experiment, participants had the option of taking a break. The break position was followed by an additional filler, intended to warm up the participants to the task before resuming the experiment.

All in all, the experiment included three overt practice items, four covert fillers at the beginning, one covert filler after the break point, and 24 targets interleaved among 48 more fillers to make a total of 80 items.

4.2.3 Participants

A total of 53 native speakers of Hebrew participated in the experiment. Prior to the main experiment, each participant filled out a language background questionnaire (see Appendix C-1) that was intended to check that they were native speakers of Hebrew who

had had little exposure to English, so as to minimize foreign language influence on performance.

Of the 53 participants, 40 were included in the data analysis. The 13 participants who were disqualified failed to meet pre-set performance criteria (no more than 15% comprehension errors on fillers, no more than 15 speech errors in reading aloud[35], or more than two missing or cut off recordings).

The participants were B.A. students of psychology in the Open University in Israel. They were 26 females and 14 males, mean age 28.32 (range 23-45). They participated in the experiment as part of a requirement toward their degree. They were naïve with respect to the purpose of the experiment.

4.2.4 Procedure:

The experiment was conducted in the Psychology Laboratory of the Open University in the main branch in Ra'anana, Israel. The experiment was run on a computer with the use of DMDX software (Forster and Forster, 2003). The participants were tested in a quiet room, one at a time. After signing an informed consent form, and filling out the language background questionnaire, the participants read a printed sheet of instructions explaining how to perform the task. The practice session which followed and the experiment itself were conducted on the computer and were self-paced. Of the three filler sentences in the practice session, one was ambiguous, to implicitly prepare the participants for the types of items they would encounter during the experiment. The experimenter made no mention of ambiguity in the sentences. During the practice session

[35] Speech errors mainly included false starts, omissions or substitutions of phrases, words or syllables. (See details on the production data in section 4.2.5).

the experimenter answered any queries the participant had about the procedure. No participant asked about the ambiguity in the ambiguous example and how to answer in such a case.

The task consisted of two parts: reading a preamble and target sentence aloud, and then selecting one of the two offered answers, which indicated how the sentence had been comprehended at the time of making the choice.

Each item was presented in three frames, as illustrated in Figure 4-1 below. The first frame displayed a + sign in the center of the screen to inform the participant a new item was about to be introduced. The participant pressed the space bar and a sentence pair was presented simultaneously, each sentence centered on the computer screen, one beneath the other. The participant, who was wearing a headset with a microphone, read each preamble and target sentence aloud into the microphone as soon as the sentences appeared on screen (i.e., the sentences were not read silently prior to their recording), and then pressed a keyboard key marked with a red sticker. Immediately after the red key was pressed, the two answers were added on the screen beneath the sentences, one on the right and one on the left, separated by a substantial space between (see illustration in (11) above). The participants were asked to read the two answers silently and then choose the one they considered more compatible with the two sentences they had read. The selected statement was read aloud by the participant and recorded. To end the recording of the answer, and initiate presentation of the next item, the participant pressed the red key again. Although the experiment was self-paced, there was a time-out at 20,000 ms for completing recording, i.e. recording the preamble and target sentence, and then recording

the answer. This procedure was repeated for each of the subsequent items. The whole sequence took approximately 22 minutes.

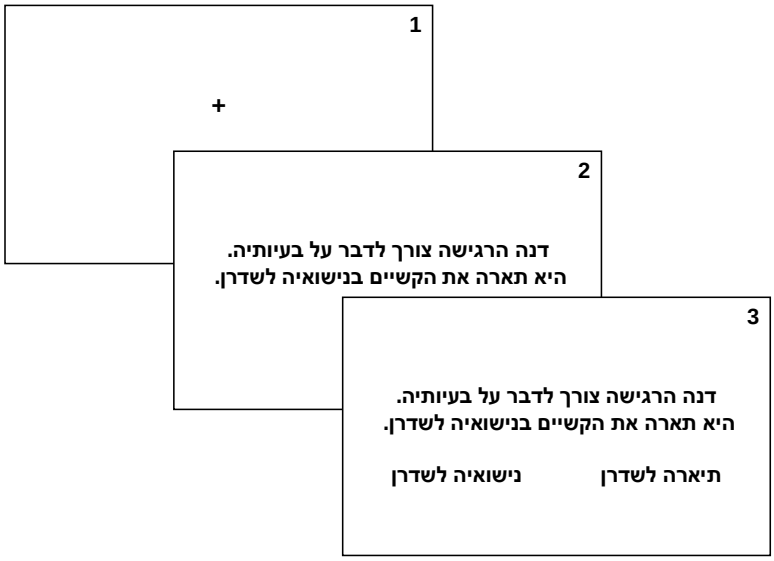


Figure 4-1: Display frames in Experiment 1

4.3 Ear Judgments

Two types of methods were employed to identify the prosodic phrasing patterns associated with the long and short Double-PP sentences. The first involved ear judgments that employed a ToBI- like coding system adapted to Hebrew (Shaked, 2007). The second was an acoustic analysis (discussed in section 4.4) that examined duration of Object-NP and PP1 as an indicator of prosodic breaks in the produced utterances. The

assumption was that ear judgment analysis and acoustic analysis of the same recordings should yield compatible estimates of the prosodic contours. The ear-judgment analysis will be discussed first.

4.3.1 Data treatment

I first listened to all the target utterances produced in the experiment (except those produced by three participants who were excluded from the data analysis due to errors on fillers; see treatment of comprehension data in section 4.6.1) and marked speech errors. The most common speech errors were false starts (repetitions of syllables, words or phrases), substitutions (replacement of the correct syllable or word with another syllable or word), and omissions (leaving out one syllable or more in a word). As noted above, participants were excluded from the data analysis if they made more than 15 speech errors, or if they had more than three missed recordings or cut off utterances[36] (with more than one syllable missing). Ten additional participants were thereby excluded, leaving 40 participants remaining for the data analysis. Of the remaining 960 anticipated target recordings (24 target sentences produced by 40 participants), four were missing or corrupted because of technical error. Another five target recordings corresponded to utterances for which there were missing interpretation judgments in the ambiguity resolution task; these trials (totaling slightly less than 1% of the complete dataset) were treated as missing data in the analyses of the ear judgments.

[36] A cut off utterance occurred when a participant stopped the recording prior to completing reading a sentence. A cut off that excluded more than the last syllable of PP2 would count towards excluding a participant from the analysis. However, the cut off utterance itself would not be excluded from the analysis if the cut off region did not include prosodic evidence relevant to the hypotheses, i.e., if it did not exclude a potential position for a prosodic boundary.

The prosodic properties of the remaining set of 951 produced utterances were then determined, so that they could be related subsequently with the participants' PP2-attachment preferences. Identifying intermediate phrase boundaries was the main goal, as it was of primary interest to find out whether intermediate phrase boundaries in the double PP construction in Hebrew are related to attachment decisions in syntactic parsing. Intonational Phrase boundaries are acoustically stronger, and may well have a more powerful effect on syntactic parsing but they are rare before a PP and the ear judgments did not in fact detect any.

As discussed in Chapter 3, the work of Laufer (1987, 1996) indicates that there are three prosodic cues for an intermediate phrase boundary in Hebrew. First, there is a pitch change from the last stressed syllable (nucleus) in a phrase to the phrase boundary, followed by resetting of the pitch at the beginning of the following phrase. This is the primary indicator of an intermediate phrase boundary in Hebrew. The second prosodic cue for an intermediate phrase boundary is syllable lengthening at the end of a phrase followed by a faster speech rate at the beginning of the next phrase. The third cue is a physical pause, which may or may not occur at an intermediate phrase boundary.

To analyze the prosodic contours of the productions of the target constructions, a notational system was needed to record the presence or absence of these cues. The transcription system used in this study was an informal adaptation of the ToBI (Tones and Breaks Indices) system originally developed for English by Beckman & Hirschberg, 1994; Beckman & Ayers-Elam, 1997; Beckman, Hirschberg & Shattuck-Hufnagel, 2005, and extended to other languages since. While there is as yet no fully articulated ToBI

system for Hebrew, the Beckman system has been adapted for Hebrew by Shaked (2007, 2009), and I employed that adaptation.

The ToBI system is a system for transcribing intonation patterns which has conventions for the coding of tones and break indices. The modern American English ToBI system postulates two main types of tones: 1) pitch accents which occur on every accented syllable. 2) phrase tones and boundary tones which occur at intermediate or intonation phrase boundaries respectively. There are two basic tone levels; H (high) and L (low), and complex tones. A star sign (*) appended to L or H indicates the tone that occurs on the stressed syllable in the word that bears that accent, (and in complex tones it marks which part of the complex tone aligns with the stressed syllable), a minus sign (-) indicates a phrase tone and a percentage sign (%) indicates a boundary tone. The Break Indices system is used for assessing the strength or degree of a boundary between any two adjacent words. There are five values for Break Indices that range from 'no break' (clitic boundary) to 'maximal break' (following a full intonation phrase). Shaked adapted the ToBI system to account for the break indices in Hebrew, as presented in Table 4-2 (Shaked, 2007).

Table 4-2: Proposed break indices (BI) for Hebrew and their definitions by Shaked (2007), modeled on the ToBI system of Beckman and Hirschberg, 1994; Beckman and Ayers-Elam, 1997; Beckman, Hirschberg and Shattuck-Hufnagel, 2005).

Break index	Definition
BI=0	Phonetically marked boundaries internal to the clitic group (e.g., *ha-* 'the')
BI=1	Clitic-group boundaries which are not prosodic word boundaries (e.g., boundaries internal to compounds and construct state nominals).
BI=2	Minor/accentual phrase boundaries: Word boundaries marked by pitch accents.
BI=3	Major/intermediate phrase boundaries: phrase boundaries marked by a single rising phrase accent and optional pausing/lengthening.
BI=4	Full intonation phrase boundaries, marked by a falling boundary tone and obligatory pausing/lengthening.

BI=3 in the table refers to intermediate phrase breaks and is therefore the break that is of relevance to the reported study.

Shaked (2007) further created a notation system (see Table 4-3) that takes into account the phonological characteristics described in the Hebrew literature, which are associated with intermediate phrase breaks (see section 3.1 above). Specifically, the notation system provides a transcription method for the perceived pitch excursions and durations (pre boundary lengthening, and pauses) at intermediate phrase boundaries.

Table 4-3: A notation system for identifying Hebrew intermediate phrase boundaries. Definitions are based on (Beckman and Hirschberg, 1994; Beckman and Ayers-Elam, 1997; Beckman, Hirschberg and Shattuck-Hufnagel, 2005), with Shaked's adaptations.

Notation	Definition
3	Pausing/lengthening indicating an intermediate phrase boundary
3-	Uncertainty about strength of pause/lengthening (whether it is BI=2 or BI=3)
3p	Prolongation suggesting hesitation, or markedly long pauses
H-	Lexical stress ('peak accent') + rising boundary accent on final syllable
H-?	Uncertainty over the tonal value on final syllable (whether it is only a pitch accent (H*) or also a phrasal accent (H*H-))
L-	Lexical stress ('low accent') + falling boundary tone on final syllable
L-?	Uncertainty over the tonal value on final syllable (whether it is only a pitch accent (L*) or also a phrasal tone (L*L-))

Ear judgments were made independently by two trained judges: the author of the dissertation and a Ph.D. student in psychology at the Tel Aviv University in Israel. Both judges are native speakers of Hebrew. The second judge was naïve with respect to the purpose of the study. In a training session, the second judge was provided with explanation and exemplification of each type of notation mark. Then, for the purpose of practice, both judges performed ear judgments on 40 utterances, each recorded by one of the 40 participants. The 40 analyzed utterances comprised the 24 target sentences in the study in an alternating order of short and long sentence versions. Each of the 24 items appeared in only a short or long version. Since there were 40 participants but only 24 target sentences, the first 16 sentences were analyzed a second time for the remaining 16 participants. When the judges completed the practice, their judgments were compared and

the training judge (the author of the dissertation) provided the second judge feedback on her ear judgments, commenting on those ear-judgments that were clearly incompatible with the perceived phrasing patterns. Following the practice part, the judges worked alone until the final stage of reconciling discrepant judgments, as noted below. Each judge listened to all the target utterances of one participant (24 for each participant) before moving on to the next. The purpose was to tune the ear to each participant's prosodic tendencies since speech rate and F0 range can differ considerably across speakers. There were three phases in the judgment process. In Phase 1, for each utterance the judge first marked pitch changes (rise or fall), and then duration phenomena (pause and final syllable lengthening) before moving to the next utterance. There was no limit on how many times a judge could listen to an utterance to make sure all boundary cues had been identified.

In Phase 2 of the judgment process, the judge listened to all the utterances again in the same sequence as before (all utterances by one participant, then all by another) in order to make final forced-choice decisions regarding boundaries at positions that had been marked uncertain in Phase 1 (i.e., markings 3-, H-? and L-?). If they decided a prosodic signal for an intermediate phrase boundary was present, they wrote above the initial marking the corresponding marking indicating certainty (i.e., 3, H- and L-). If the final decision was that no intermediate phrase boundary was present, no marking was made above the initial markings.

In the process of making the ear-judgments, the author of this dissertation noticed that almost every verb and noun in the sentences involved a small pitch rise and lengthening on the last syllable. This included even the first noun inside the long PP

which was followed by another noun or adjective; since the first noun and the following word inside the long PP2 form a NP, an intermediate phrase boundary between them, right in the middle of the NP, was unlikely. At the same time, there were often stronger pitch rises at the end of the segment preceding the PP1 and PP2 constituents. We reached the conclusion that the milder pitch rises are simply a realization of lexical stress in Hebrew while the stronger pitch rises which were often followed by a pause were the cues we were looking for for ip boundaries. The decision to make this distinction between the milder and stronger pitch rises was guided by some phonological properties of Hebrew words: Hebrew has a general principle that assigns lexical stress to the last syllable of nouns and verb stems[37]. That stress, like the ip boundary, involves vowel lengthening[38] and a high tone[39] (Becker, 2003). This suggests that prosodic cues to intermediate phrase boundaries would often coincide with prosodic manifestatins of lexical stress. An investigation by Silber & Kessous (2008) of the location of lexical stress in relation to pitch rise and lengthening at the end of the IU (see definition of IU in section 3.1) confirmed that. It was found that in final-stress words lengthening and pitch rise at the end of an IU fully coincide with lexical stress. However, lengthening and pitch rise in that position did not align with penultimate stressed syllables but rather with the

[37] In Hebrew, main stress assignment in words is a result of interplay between the phonological and lexical components (Bolozky 1997, 2000; Graf 2000; Graf and Ussishkin 2002; Amir, Silber-Varod and Isre'el, 2004). A default phonological rule assigns main stress to the final syllable of the word and a secondary stress is placed on every alternating syllable to the left. At the same time, the nominal stress system is controlled by the lexical properties of the stem and suffixes. As a result, the lexical and phonological specifications may conflict, in which case the demands of the former would be satisfied. For example, at the affixation of the feminine suffix 'et' to the masculine form of the noun *arnáv* ('rabbit'), as in, arnáv (mas) → arnévet (fem), the phonological pattern demands stress on the last syllable, whereas lexical specifications impose stress on the immediately preceding syllable.

[38] Becker (2003) reports that phonetic measurements revealed that "vowels in stressed syllables are twice as long as vowels in stressless syllables" (p. 47).

[39] Becker argues there is a general principle that shifts the high pitch to the following syllable. However, he notes that in the case of final-stress words the word boundary may block the high tone shift to the next word.

last unstressed syllable[40] (see also Laufer, 1996, who argues, as noted in secion 3.1, that there is lengthening of the last syllable of the sense group, even if it is unstressed). Since lexical stress and ip boundaries seem to involve similar prosodic manifestations that often overlap, we were careful in our ear-judgments to consider as prosodic cues to phrases only those pitch rises and duration cues that were stronger compared to those in other word-final positions in the sentence.

For these ear judgments made independently by the two judges, the inter-rater agreement rate was 98% for presence/absence of an intermediate phrase boundary at any particular sentence location.

In Phase 3 of the process, points of disagreement were re-examined and discussed by the two judges, until an agreed-upon judgment was arrived at. Of the 2% of points that needed this reconciliation process, 75% were resolved in favor of the first judge (the author of this dissertation) and 20% in favor of the second judge; the remaining 5% resulted in new judgments for sentences.

4.3.2 Results

The ear judgments on the production recordings revealed 4 main prosodic phrasing patterns in the target sentences: no breaks anywhere in the utterance, a break before PP1 only, a break before PP2 only, and breaks before both PP1 and PP2 and

[40] Silber & Kessous (2008) suggest that in stress-final words at the end of an IU lengthening might spread over the last two syllables. As for the observed pitch pattern, they hypothesize that either Hebrew prosody 'overwrites' the stress pattern in penultimate stress words at the ends of IU, or that the pitch accent pattern at boundaries is independent of the stress assignment at the word level in Hebrew. However, Silber & Kessous note that their corpus included only 22% penultimate stress words (48 in number) at final IU positions, compared to 78% final-stress words, and therefore further study is required to validate their suggestions.

nowhere else. These categories will be referred to here as No Breaks, [PP1 Break, [PP2 Break and Both Breaks respectively. A total of 16 utterances (less than 2% of the complete dataset) had perceived phrasal patterns different from the four described above. These data were excluded from the analysis. Thus, the total number of utterances remaining in the data analysis was 935 (470 short-PP2 utterances and 465 long-PP2 utterances).

The distribution of occurrences of the four prosodic phrasing patterns in the long-PP2 sentences and the short-PP2 sentences (see Table 4-4 and Figure 4-3(b) below) showed that PP2 length had a significant effect on the produced prosody, as predicted. Long-PP2 targets were more often produced with a [PP2 Break than with any of the other three phrasing patterns. The second most frequent pattern for long PP2 was No Breaks. The incidence of [PP1 Breaks and Both Breaks was negligible. A series of T-tests for paired comparisons examined the differences in number of utterances between each two prosodic phrasing patterns for long and short-PP2 sentences separately. For long-PP2 items, the T-tests revealed a reliably greater number of [PP2 Breaks than of No Breaks, $t_1(39) = 4.55$, $p < .001$, $t_2(47) = 5.62$, $p < .001$. There was also a greater number of No Breaks than of [PP1 Breaks, $t_1(39) = 5.15$, $p < .001$, $t_2(47) = 6.81$, $p < .001$ and of Both Breaks, $t_1(39) = 4.61$, $p < .001$, $t_2(47) = 5.96$, $p < .001$. There was no significant difference between the number of [PP1 Breaks and Both Breaks, $t_1, t_2 < 1$. (See Table 4-4 and Figure 4-3(b) below). For short-PP2 targets, as predicted, prosody was more varied: short-PP2 targets were most often produced with No Breaks or else with [PP1 Breaks; there were fewer [PP2 Breaks. There was no reliable difference between the numbers of No Breaks and [PP1 Breaks, $t_1(39) = 1.18$, $p > .20$, $t_2 (47) = 1.35$, $p > .15$. In addition,

[PP1 Breaks exceeded the number of [PP2 Breaks, $t_1(39) = 8.04$, $p < .001$, $t_2(47) = 6.92$, $p < .001$, and [PP2 Breaks exceeded the number of Both Breaks, $t_1(39) = 3.83$, $p < .001$, $t_2(47) = 4.590$, $p < .001$.

Table 4-4: Number (and percentage) of occurrences of the four major prosodic phrasing patterns in the long-PP2 and short-PP2 utterances, based on ear judgments.

Phrasing Pattern	Long PP2	Short PP2
No Breaks	126 (27.0%)	195 (41.5%)
[PP1 Break	36 (7.7%)	160 (34.0%)
[PP2 Break	269 (57.8%)	84 (17.8%)
Both Breaks	34 (7.3%)	31 (6.6%)
Total	465	470

In general, the predictions in the hypotheses section (4.1) regarding PP2 length and prosody relationship were borne out. There is an overwhelming preference for a prosodic break immediately preceding a long PP2. As expected, there are very few [PP1 Breaks for long PP2; note that even the No Breaks pattern is more frequent than a [PP1 Break. For short PP2, as predicted, there is a substantial number of [PP1 Breaks and of No Breaks, and relatively few [PP2 Breaks. The Both Breaks category is represented by just a handful of items, for both short and long-PP2 items, as expected. Perhaps the least expected aspect of these data is the substantial proportion of No Breaks prosody for these quite long and complex sentences, especially in view of the results obtained by Shaked (2009) indicating that Hebrew in general tends to prefer shorter over longer prosodic phrases. However, there has been a growing number of studies (De Vincenzi & Job, 1993, Fernández, 2000/2003, and Augurzky, 2006, among others) that suggest there is an interplay of syntactically driven (such as Late-Closure strategy) and prosodically driven (such as optimal phrase length) processing strategies. Such an interplay could explain the

large number of No Breaks in the long-PP2 sentences: it is possible that syntactic Late Closure was fighting against a [PP2 break: it encouraged low attachment of PP2, which in turn inhibited a break at PP2 by aligning syntactic and prosodic phrasing. In any event, the large rate of no breaks for long-PP2 sentences is (at least) in keeping with expectations that the No Breaks pattern was less frequent for the long-PP2 items than for the short-PP2 items.

4.4 Acoustic analysis

4.4.1 Data treatment

In addition to the ear judgment analysis, an acoustic analysis of segment durations was performed to further identify the prosodic phrasing patterns of the Double-PP construction and thus further test the predictions in the hypotheses. The duration markers of a prosodic boundary in Hebrew are longer duration of the segment preceding the boundary, specifically final syllable lengthening, and an optional following pause (see section 3.1 for a more detailed description). The method was to measure the duration of pre-determined regions in each sentence, and the duration of any pauses immediately preceding PP1 and PP2 (see example (15) below). Differences in average duration for these regions are taken to be indicators of differences in likelihood of a phrasal break. The null hypothesis was that all regions have the same duration across long and short versions of the sentences, since the lexical content does not change (with the exception of the short-PP2 region - see below).

A sample of the target utterances recorded in Experiment 1 (200 out of 960 utterances, approximately 20%) was selected for the duration analysis, by criteria outlined below. There was one missing recording of the 200 utterances to be segmented resulting in 99 short-PP2 utterances, rather than 100, as shown in Table 4-5.

Table 4-5: Number (and percentage) of occurrences of the four major prosodic phrasing patterns in the long-PP2 and short-PP2 utterances, based on the ear judgments for the utterances chosen for acoustic analysis.

Phrasing Pattern	Long PP2	Short PP2
No Breaks	26	42
[PP1 Break	8	23
[PP2 Break	60	23
Both Breaks	6	11
Total	100	99

The segments that were measured are shown in (15a) and (15b). PP2(start) is the string in the long PP2 which is identical to the string in the short PP2; PP2(continuation) is the remaining material in the long PP2 which is not part of the short PP2.

(15)

(a) pronoun+verb / object NP / pause /PP1/ pause / PP2(start) /extra material in long PP2
PV / NP /pause-0/ PP1/ pause-1/ PP2(start) / PP2(continuation)

(b) pronoun+verb / object NP / pause / PP1 / pause / short PP2
PV / NP / pause-0 / PP1 / pause-1 / PP2

The durations of the object NP plus any following pause (pause-0), and of PP1 plus any following pause (pause-1), in long and short-PP2 items, were measured in order to assess whether the durational indicators of a prosodic boundary agreed with the ear judgments, and whether the boundaries so estimated occurred in the predicted positions: most often immediately preceding PP1 in short-PP2 items, and most often immediately

preceding PP2 in long-PP2 items. (See section 4.1 for discussion of hypotheses regarding the prosodic break locations in the Double-PP construction.) A predicted break at position PP1 was reflected in the measurements as lengthening or pausing at that position; a predicted break at PP2 was reflected in the measurements as lengthening or pausing at that position. The PV and PP2 segments served as control regions. The PV region was expected to involve no change in duration between long and short-PP2 items while the PP2 region (PP2(start) in long-PP2 items and PP2 in short-PP2 items) was predicted to exhibit greater durations when PP2 was short than when it was long, due to phrase final lengthening (the tendency of speech to slow down at sentence final position; Edwards, Beckman & Fletcher, 1991; Byrd & Saltzman, 2003, among others).

Ten target sentences in their short and long versions out of the total 24 target items in Experiment 1 were selected for the duration analysis, five from each of the two item sets in the experiment. (Each item set contained 12 sentences in the long version and the other 12 sentences in the short version. Half of the participants were exposed to one item set and the other half to the second item set. See section 4.2.2). The selected recordings of the 10 target items were those produced by the 20 participants who were assigned to the list with the high attachment meaning answers on the right hand side and the low attachment meaning answers on the left hand side[41]. Ten of the participants read five sentences from each of the two item sets, and the other 10 read the remaining five sentences from each of the two item sets such that the two groups of participants read the

[41] It was decided to include in the acoustic analysis utterances produced by half (20) of the participants and that this half would be one of the groups that differed with respect to which order of answers they were presented to in the experiment (20 participants were assigned to a list of items in which the high attachment responses were on the right and the low attachment responses were on the left, and the other 20 participants were assigned to the list with the reverse order of answers). The choice of which group of twenty participants to include was arbitrary. The only difference between the selected and non-selected 20 participants was the order of presentation of the answers. We assumed that this difference was unlikely to affect the reading, especially because the participants read the sentences before they saw the answers.

same sentences but with different lengths (long or short). The 10 selected target items were the ones with the most complete data (for the 20 selected participants), i.e., those that contained the least speech errors and missing recordings. In the selected target items set, a total of 10 data points (1.25%) had missing data due to speech errors or missing recordings. The selection process described above resulted in 200 utterances for the acoustic analysis.

The acoustic analysis was performed by the author of the dissertation with the help of Speech Analyzer, acoustic analysis software (SIL International, 2007). The waveforms for each recorded utterance in the acoustic analyses were manually segmented into the predetermined regions described above in example (15). Boundaries for the regions were located by identifying the acoustic signatures of the phonemes which started the new segment (or ended the preceding segment) and using the associated visual cues for these in the display, confirmed by audio cues. For example, vowels are characterized by a rapid increase in intensity at the beginning of the vowel which drops gradually approximately one quarter of the way through the vowel. This results in a gross waveform that decreases gradually in size. As Figure 4-2 below illustrates, the second segment, *'et hašmu'ot* ('the rumors'), and third segment, *'al hitpatruto* ('about his resignation'), can easily be identified by the large waveform shape that marks the beginning of the vowel. In addition, oral stops are characterized by full closure of the vocal tract followed by release. During closure, voiceless stops involve a period of no resonance that is marked by silence ("gap") on the spectrogram while voiced stops may (also) involve vertical striations at the bottom of the spectrogram ("voice bar") indicating voicing. Thus, the fourth segment in Figure 4-2, which begins with the voiced stop [b],

was identified by the gap at the beginning of the region and a voice bar right below it at the bottom of the spectrogram.

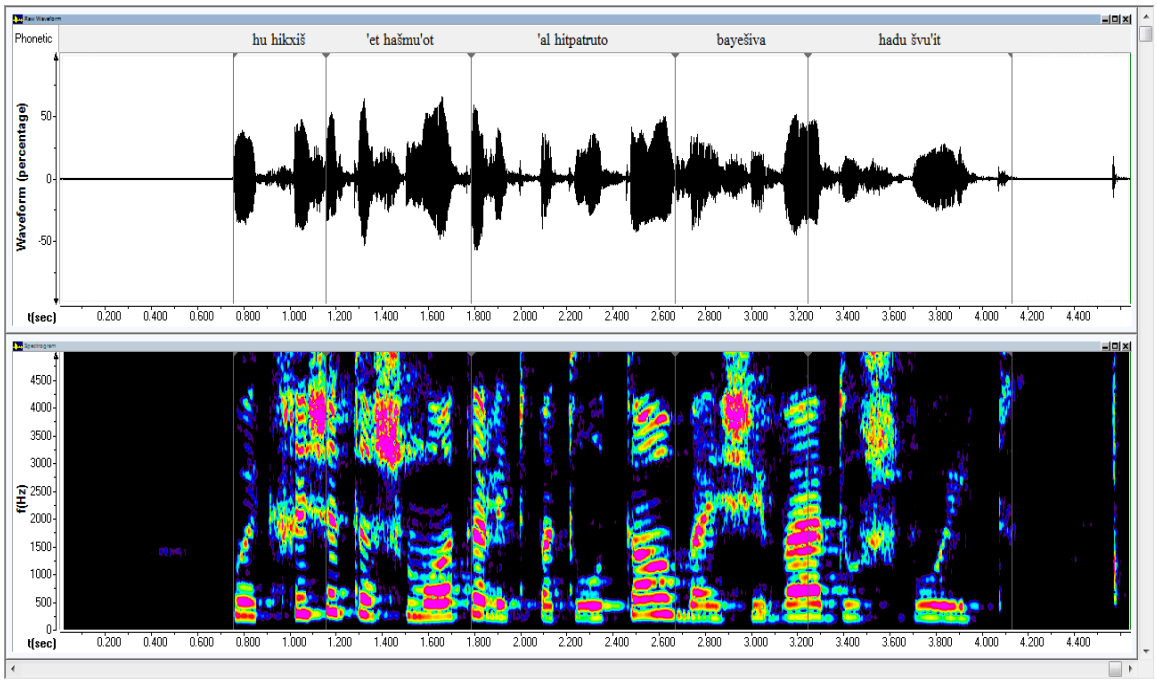


Figure 4-2: Segmentation of the utterance *hu hikxiš ‘et hašmu’ot ‘al hitpatruto bayešiva hadu švu’it*. (‘He denied the rumors about his resignation in the bi-weekly meeting’). The segments are: *hu hikxiš* (PV) *‘et hašmu’ot* (NP) *‘al hitpatruto* (PP1) *bayešiva* (PP-start) *hadu švu’it* (PP2-continuation).

In cases where it is difficult to distinguish the end of a segment from the beginning of the following segment, because both contain the same vowel or consonant, a boundary was imposed before the neighboring syllable, whose beginning could easily be distinguished from the end of the preceding phonetic content. Shifting the position of the boundary was performed for both the short and long versions so that it does not affect the comparison between them. For example, in the acoustically analyzed target item ‘he leaked the news about the bonus to the workers’, the segmentation was as follows: pronoun+verb / object NP+preposition of PP1+definite article of the following noun

inside PP1 / Noun inside PP1/PP2 (He leaked / the news about the / bonus / to the workers. In Hebrew: *hu hidlif / 'et hayedi'a 'al ha / bonus / la'ovdim*.) The change in the segmentation pattern was because in that particular item the object NP ended with the vowel /a/ and the immediately following PP1started with the same vowel. Following the original segmentation would have made it difficult to distinguish the end of the object NP from the beginning of PP1. In addition, it would have been difficult to distinguish the border of the preposition in PP1 and the following definite article because native speakers of Hebrew tend not to pronounce the /h/ sound in that phonological environment and so 'al ha' is pronounced as /ala/. As a result, it was decided to (also) include the definite article inside the object NP segment rather than in the segment of the noun inside PP1. The same has been done to the short and long versions so it could not have affected the results of the comparison between them.

After segmenting the utterance, a duration file was extracted which contained the duration of each of the segments. A two standard deviation cut-off was applied to segment durations and it affected 23 data points (2.9%) of the complete data set.

4.4.2 Results

Table 4-6, below, presents mean durations for the segmented regions. As Table 4-6 shows, NP durations were greater when PP2 was short than when it was long. A one-way ANOVA which included length (long/short) as the single factor revealed that this difference was significant in the participant-based analysis, $F1\ (1,18) = 14.38$, $p < .01$, and approaching significance in the item-based analysis, $F2\ (1,8) = 4.94$, $p = .057$.

The PP1 durations were significantly greater when PP2 was long than when it was short for the participant-based data and item-based data, $F_1(1,18) = 10.39$, $p < .01$, $F_2(1,8) = 8.95$, $p < .05$.

As for the control regions, the expected results were observed as well. In the PV region, no duration difference was found between short and long-PP2 items, $F_1(1,18) = .65$, $p > .05$, $F_2(1,8) = .01$, $p > .05$. In the PP2 (start) region, the duration was greater in short-PP2 sentences than in long, $F_1(1,18) = 9.78$, $p < .01$, $F_2(1,8) = 18.23$, $p < .01$.

Table 4-6: Mean durations in milliseconds of the segments and standard deviation of segment duration in the four measured regions in long and short-PP2 sentences

	Long	SD	Short	SD
PV	425	94	432	94
NP+Pause	619	185	695	246
PP1+Pause	744	263	652	209
PP2	492	144	565	128

To summarize, all predictions were confirmed; differences between short and long-PP2 items emerged in the NP and PP1 target regions where there were reasons to expect prosodic boundaries: the NP durations were greater when PP2 was short than when it was long, indicating a prosodic boundary immediately before PP1, and the PP1 durations were greater when PP2 was long than when it was short, denoting a prosodic boundary immediately before PP2. With regard to the regions where prosodic boundaries were not expected, in the PV region there were no differences in duration between long and short-PP2 items, and in the PP2 region there were greater durations in short PP2 than in long in PP2 (start) segments (as expected due to phrase final lengthening).

Since we used globally ambiguous sentences specifically constructed and normed to be unbiased by semantic and pragmatic influences (see pre-test in section 4.2.1.2 above), we can argue that the prosody projected onto the sentences by the participants (as described above) is the most natural prosody for the construction and thus that we attained our goal of revealing the default prosody for the long and short versions of the Double-PP construction.

4.5 Comparison of ear-judgments and acoustic analysis

The results of the acoustic analysis seem to be in line with the ear judgments. The finding that the NP durations were greater when PP2 was short than when it was long is compatible with the ear-judgments: When PP2 was short, there were more [PP1 breaks than when it was long. Thus, the duration data at this location conform well with the ear judgment data.

PP1 durations were significantly greater when PP2 was long than when it was short for the participant-based data and item-based data. So here too, the findings of the acoustic analysis are consonant with the ear-judgment findings. Both show a greater tendency for a prosodic boundary to occur immediately preceding PP2 in long-PP2 sentences than in short-PP2 sentences.

Since only a subset of the utterances were included in the duration analysis, it is important to note how representative they are of the total dataset, as assessed by their distribution of prosodic breaks identified by the ear judgments. Figure 4-3 below presents the incidence of the four major prosodic phrasing patterns, as identified by the ear judgments, for (a) the subset of 199 utterances segmented in the acoustic analysis, based

on the numbers in Table 4-5 above; (b) the complete dataset, based on the numbers in Table 4-4 above. Despite the difference in the absolute number of data points, the two figures show very similar proportional distributions of the four prosodic patterns.Both figures reveal more instances of the No Break and PP1 Break phrasing patterns in short-PP2 sentences than in long, and more instances of the PP2 Break prosodic pattern in long-PP2 sentences than in short. The Both Breaks phrasing pattern is more prevalent in the short-PP2 items than in the long-PP2 items in the duration-measurement sample dataset (Figure 4-3(a)), but demonstrates the opposite pattern in the complete dataset (Figure 4-3(b)) with a larger number of Both Breaks in the long-PP2 items than in the short-PP2 items. However, the Both Breaks category represents only a very small proportion of the duration analysis data set (6 utterances for the long-PP2 data set and 11 for the short-PP2 data set) so differences between them are not reliably interpretable. The similarity between the two data arrays indicates that the subset of the utterances acoustically analyzed do have approximately the same distribution as the total data set with respect to the four prosodic phrasing patterns as assessed on the basis of perceptual judgments.

(a) (b)

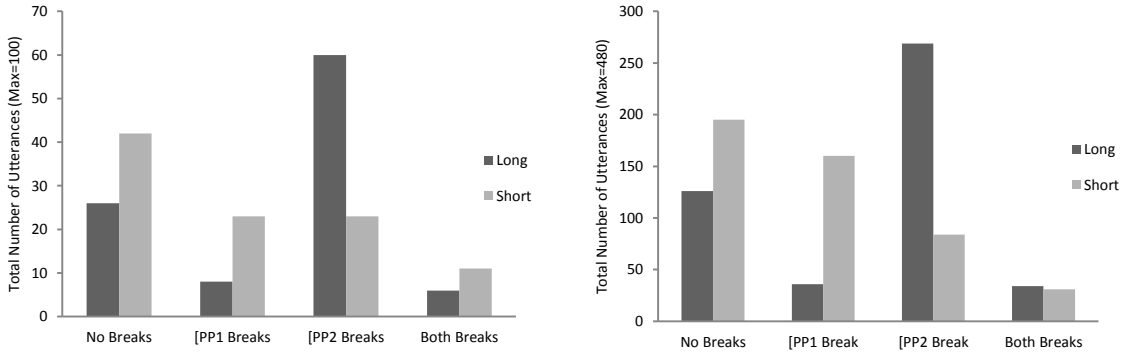


Figure 4-3: Incidence of the four major prosodic phrasing patterns, as identified by the ear judgments, for (a) the utterances chosen for acoustic analysis (100 recordings for long items; 99 for short, due to a missing recording) and (b) all utterances in the complete dataset (465 recordings for long items, 470 for short).

Thus, the largely similar patterns of ear-judgment distribution in both datasets confirms that the items chosen for duration analysis are representative of the larger data set. [42]

In sum, the acoustic analysis exhibited strong parallels to the ear-judgments. In both, there was found a reliably stronger tendency for prosodic breaks to occur immediately preceding PP2 in long-PP2 items than in short-PP2 items. There was also a stronger tendency for prosodic breaks immediately preceding PP1 in short-PP2 items than in long-PP2 items, though this comparison was only marginally reliable in the duration data.

[42] The biggest discrepancy appears to be for short-PP2 sentences – whether [PP1 breaks equal or exceed [PP2 breaks. Figure 4-3(a) is based on a smaller sample than Figure 4-3(b) and therefore presents less stable results. However, in any event, the main interest is that there are more [PP1 breaks when PP2 is short than when it is long, which is unaffected by this discrepancy.

4.6 Attachment

4.6.1 Data treatment

The comprehension data were tabulated. Responses to the target sentences were coded as either high attachment or low attachment responses, and were summed separately for the short and long-PP2 items. In addition, the number of incorrect answers on fillers was counted for each participant. Three participants made more than 15% errors on fillers and were therefore excluded from the prosody data analysis above, and the attachment data analysis. (After excluding participants on various accounts, including errors on fillers, 40 participants remained. See section 4.3.1).

A 2x2 design with Length (long/short) and Order of Presentation of Answers (high attachment responses on the right/low attachment response on the right) as factors was implemented.

4.6.2 Results

PP2 length had a significant effect on sentence comprehension. Long-PP2 targets were more likely to be attached high (56.4%) than short-PP2 targets (46.3%), F_1 (1,38) = 9.35, $p < .01$, F_2 (1,46) = 13.87, $p < .01$. There was no reliable attachment difference between the two orders of presentation of answers, F_1, $F_2 < 1$, and Order of Presentation of Answers did not interact with Length, $F_1 < 1$, $F_2(1,44) = 3.24$, $p > .05$. Therefore, the analysis collapsed order of presentation of answers (as stated in section 4.2.2).

Table 4-7: Percentage of high attachment interpretations in long-PP2 and short-PP2 sentences

Attachment	High
Long PP2	56.4
Short PP2	46.3

4.7 The relationship between interpretation and prosody

As shown in section 4.6.2, there is a clear relationship between comprehension and PP2 length. In order to learn whether this relationship is maintained when prosody is matched, we juxtaposed preferred interpretations with the related prosodic phrasing patterns in short and long-PP2 items (see Figure 4-4 below) and we performed a 2x3 ANOVA with Length (long/short) and Prosodic Phrasing Patterns (No Breaks/PP1 Break/PP2 Break) as factors. (For the purposes of the ANOVA, the "Both Breaks" category from the ear judgments data was excluded, because it comprised only 7% of the total number of utterances.) The pattern that emerges from this comparison suggests that comprehension was related to produced prosody even more closely than it was related to PP2 length, in accord with the hypothesis that the effect of PP2 length on PP2 attachment is mediated by the effect of PP2 length on prosody.

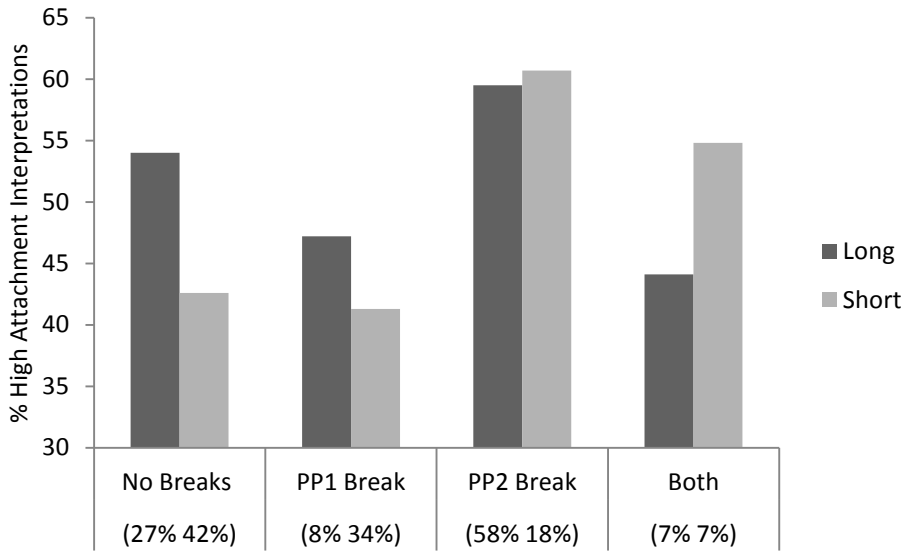


Figure 4-4: Percentage of high attachment for the four major prosodic phrasing patterns for long-PP2 and short-PP2 targets. The numbers in parentheses indicate the percentage of occurrences of each prosodic phrasing pattern (of the complete ear judgment database) in the long-PP2 and short-PP2 utterances.

Let us consider first the effect of length on attachment preference, for utterances produced with each of the various phrasing patterns. With a break at [PP2, attachment preference was just about the same regardless of PP2 length: 59.5% for long PP2; 60.7% for short PP2. ($F_1 < 1$; $F_2(1,46) = 1.66$, $p > .20$). With a break at [PP1, attachment preference was numerically different for long (47.2%) versus short (41.3%) materials, but the difference was not reliable ($F_1(1,38) = 3.46$, $p > .05$, $F_2 < 1$). For sentences produced with no breaks, there were also no reliable differences ($F_1(1,38) = 3.33$, $p > .05$, $F_2(1,46) = 2.15$, $p > .05$).

Collapsing, then, over the length manipulation, we can examine the effect of produced phrasing on attachment preference. Overall, utterances produced with a break before PP2 had a substantially greater high attachment rate (60.1%) than utterances produced with a break before PP1 (44.25%) ($F_1(1,38) = 8.64$, $p < .01$; $F_2(1,46) = 5.79$, p

< .05) and than utterances produced with no breaks (46.9%; $F_1(1,38) = 8.40$, $p < .01$; $F_2(1,46) = 4.99$, $p < .05$). However, prosody type did not show a reliable effect for [PP1 breaks: utterances produced with a break before PP1 did not differ in attachment preference from utterances produced with no breaks ($F_1 < 1$; $F_2 < 1$), although there was a numerical difference of 2.65%.

These results indicate a strong relationship between prosody and attachment for a [PP2 break, in line with prediction, but they do not support the predicted prosodic effect for [PP1, despite the numerical trend in the predicted direction noted above: a [PP1 break was not reliably associated with more low attachment of PP2 compared with the No Breaks (neutral prosody) condition. This null result does not, of course, disconfirm the prediction for [PP1; it may be attributable to a lack of statistical sensitivity due to the sparsity of relevant data points (see Table 4-4 and Figure 4-3(b) above) in the [PP1 Break prosody category, especially for long-PP2, as indeed was predicted in section 4.1. The small number of the data points in the PP1 Break prosody type is the result of the methodology in Experiment 1: the participants in the experiment were free to use whatever prosody they chose, therefore we could not control for the number of data points obtained for each prosody type. A perception study which would present the participants with an equal number of utterances in each prosody type would be able to elicit a numerically more balanced array of attachment data across all the tested prosodic phrasing patterns and allow us to examine the relationship between prosody and interpretation for all those prosody types. Another possible explanation for why the No Breaks category did not exhibit a higher attachment rate than that of [PP1 Breaks is that the syntactically-based Late Closure principle prevails when prosody is neutral

(Kjelgaard & Speer, 1999; Fernández, 2003; Augurzky, 2006. See also section 4.1) resulting in a lower attachment rate than expected in the No Break prosody category.

In summary, the production analysis in Experiment 1 revealed four main prosodic phrasing patterns which are associated with the Double-PP construction: no breaks anywhere in the utterance, a break before PP1 only, a break before PP2 only, and breaks before both PP1 and PP2 and nowhere else. As expected, long-PP2 sentences were most associated with a break at [PP2 while short-PP2 sentences exhibited a more varied prosody, with preference for no breaks and [PP1 breaks. The attachment data revealed an effect of PP2 length on sentence comprehension, as predicted: the long-PP2 targets were significantly more likely to be attached high than short-PP2 targets. Finally, an investigation of the relationship between prosody, length and interpretation revealed no effect of length on interpretation when prosody was matched, but it did find an effect of [PP2 breaks on interpretation. These findings were in accord with the hypothesis that the effect of PP2 length on PP2 attachment is mediated by the effect of PP2 length on prosody.

While Experiment 1 explored the relationship between length, prosody and interpretation in reading aloud, Experiment 2 will examine this relationship in silent reading, when prosody is not explicit but rather is mentally produced.

CHAPTER 5

ATTACHMENT IN THE DOUBLE PP CONSTRUCTION IN SILENT READING IN HEBREW

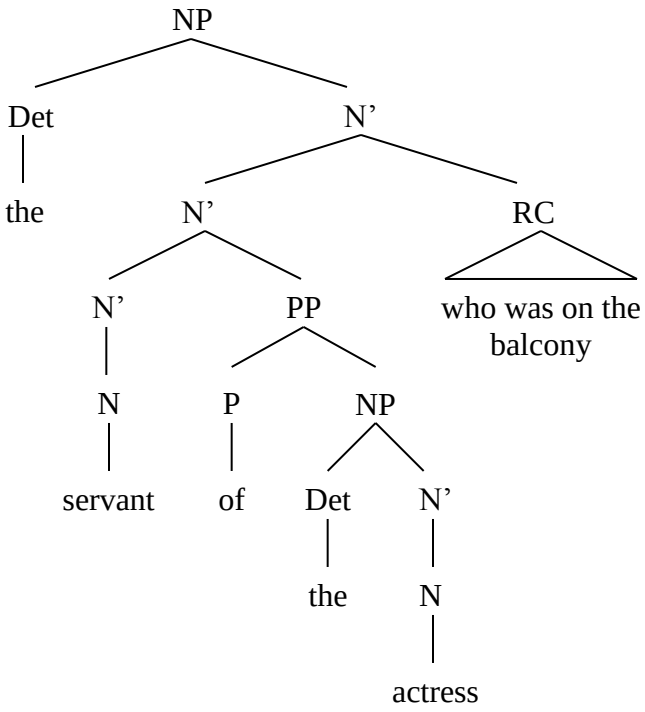
5.1 Implicit Prosody: Overview

It has been proposed (Bader, 1998; Fodor, 1998, 2002) that there are prosodic influences on syntactic parsing not only in listening, when prosody is overt, part of the input stimulus, but also in reading, where any prosody must have been generated by the reader. This is of particular interest when the reading is silent, so that there is no external requirement to generate a prosodic contour, as there is in the case of reading aloud. The involvement of prosody in silent reading is formulated in the Implicit Prosody Hypothesis (IPH; Fodor, 2002), which states that a default prosodic contour is projected onto a sentence in reading (even in silent reading), and in ambiguous sentences it favors the syntactic analysis that is normally associated with that prosody.

The original motivation for the IPH was the finding in silent reading tasks that certain languages differ in their attachment preferences for a relative clause (RC) in an ambiguous complex NP structure (see (1) below). This cross-linguistic variation was first noted by Cuetos & Mitchell (1988) who compared the RC-attachment preference in English and Spanish. They discovered a bias towards attachment of an RC to the lower of two nouns in English, and a bias towards attachment to the higher noun in Spanish. Example (1) (from Cuetos & Mitchell) illustrates the high attachment and low attachment structures of this construction.

(1) Someone shot the servant of the actress who was on the balcony.

a) High attachment



b) Low attachment

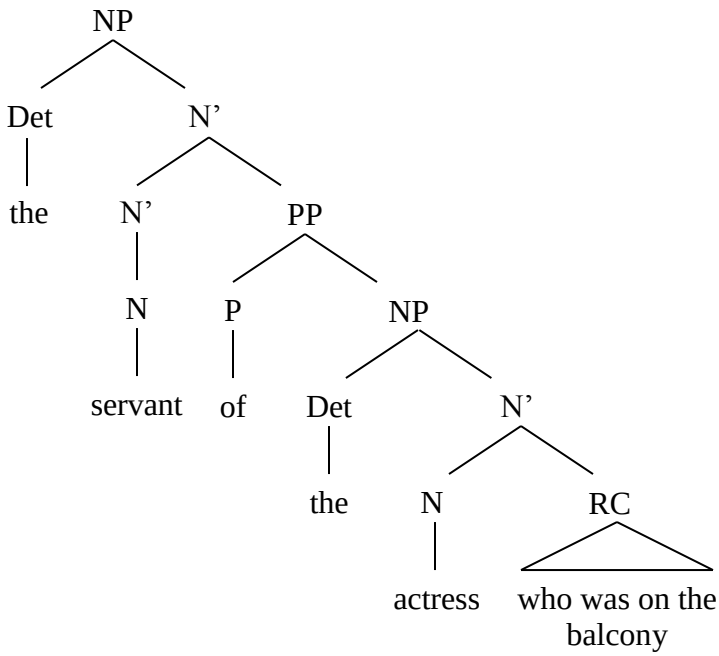


Figure 5-1: Syntactic structure of high and low RC attachment to a preceding complex nominal

Subsequent work has confirmed this difference, and extended the finding to a wider array of languages. Spanish (Fernández, 2000/2003), French (Pynte & Colonna, 2000; Quinn, Abdelghany & Fodor, 2000), Croatian[43] (Lovrić, 2003), German[44] (Hemforth, Konieczny, Scheepers, & Strube, 1998; Hemforth, Konieczny, Seelig & Walter, 1999; Hemforth et al., 2000; but see Augurzky, 2005), Brazilian Portuguese (Maia, Lourenço-Gomes & Morae, 2004), have been reported to prefer the RC to modify the higher (more distant) noun in the complex NP while other languages, such as English (Cuetos & Mitchell, 1988), Norwegian, Romanian, and Swedish (Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999), and Egyptian Arabic (Abdelghany, 2009) have been reported to prefer the RC to attach to the lower (more recent) noun.[45]

This cross-linguistic variation posed a serious challenge to the hypothesis that the human sentence parsing mechanism is universal and hence presumably innate. Moreover, the high attaching languages apparently violated a general tendency that had been observed in syntactic processing of other structures for adjacent words in a sentence to stay close together in the hierarchical tree structure. This parsing strategy is widely known as Late Closure (Frazier, 1978), also as Recency (Gibson, Pearlmutter, Canseco-González & Hickock, 1996). It states that new incoming material is preferentially

[43] Lovrić's (2003) study on Croatian compared two forms of the ambiguous RC construction, one with a preposition between the two nouns as in the studies of English and Spanish (the +prep form), and one with no preposition but only genitive marking on the second noun (the –prep form). He found an overall high attachment preference for the –prep form and a low attachment preference for the +prep form.

[44] The German data are mixed. Hemforth, Konieczny, Scheepers & Strube (1998) and Hemforth, Fernández, Clifton, Frazier, Konieczny & Walter (2002) tested the –prep form and found a high attachment preference. Augurzky (2005) tested both the +prep and –prep forms; she found no preference for the -prep form, and low attachment for the +prep form.

[45] For data on RC attachment in Hebrew see Shaked (2009). Hebrew has two forms of the RC ambiguity construction. The Free State form is a +prep construction which showed no clear attachment preference in silent reading for RCs of a typical length. Short RCs, however, showed a significant low attachment preference. Thus the Free State showed the usual RC length effect which has been attributed to implicit prosody. The Construct State form is a –prep construction, but unlike the –prep form in Croatian and German it is a morphologically integrated unit which constitutes a single prosodic word. The Construct State showed little sensitivity to prosody.

attached to the most recently processed phrase. Thus the high RC attachment posed two challenges for previously accepted psycholinguistic theory. The IPH seemed to provide an answer to these challenges since it predicts that attachment preferences may differ across languages – even in silent reading, as in the studies referenced above – if the languages differ in their prosodic phrasing tendencies.[46] That is, it is proposed that the parsing mechanism and processing strategies are universal, yet the individual grammars, of which prosodic rules are a part, differ between languages and constrain parsing.

Implicit prosody, as opposed to overt prosody, cannot be observed or measured directly[47]. It can only be validated by showing it provides a satisfactory account for parsing behavior. To test the IPH, some working assumptions need to be made. It was proposed by Fodor (2002) that silent prosody could be assumed to be the same as the preferred overt prosody for a given structure in an identical context. Then a factor that can affect overt prosody (such as constituent length; see below) needs to be found and it has to be shown that the overt prosodic difference caused by this factor influences ambiguity resolution. Subsequently, the same factor is incorporated into a silent reading task. If, in the presence of the manipulated factor, the attachment preferences exhibited in the silent reading task are comparable to those in the overt prosody task, where prosodic effects can be observed directly, it is plausible to maintain (as long as there is no

[46] Other hypotheses as well, such as the Tuning, Construal, Attachment-Binding and Information Load hypotheses, were proposed to explain the cross-language variability, but as reviewed by Lovrić (2003) none had been able to account for all the languages studied.

[47] Implicit Prosody may be more directly observed if ways can be found to reveal its presence through brain monitoring methods. Hwang and Steinhauer (in-press), extending the work of Hirose on Japanese (1999, 2003), conducted an ERP study of Korean which employed a rapid serial visual presentation (RSVP) task. The study revealed the presence of an IP h boundary in silent reading, motivated by phrase length. Another way of accessing implicit prosody more directly than in previous studies was devised by Abdelghany (2010). In Arabic, liason vowels occur inside a prosodic phrase only. In a vowelized text (texts in Arabic are not normally vowelized), the absence of liason vowel diacritics indicates a prosodic boundary. A silent reading task (experiment 4) required the participants to vowelize RC-attachment ambiguity sentences. This revealed the participants' mentally projected prosody/implicit prosodic phrasing in silent reading of this construction.

plausible *direct* influence of the factor on attachment) that implicit prosody is responsible for the ambiguity resolution in the silent reading task. That is, by analogical reasoning silent prosody would be deemed responsible for syntactic ambiguity resolution preferences in silent reading as overt prosody is in listening (see references in Chapter 2).

5.2 Purpose of Experiment 2

The aim of this experiment was to contribute data relevant to evaluating the IPH from Hebrew and in the Type-B Double-PP construction, which had never been tested with respect to the IPH. In order to do so, I compared interpretation preferences in reading silently with those already obtained for reading aloud. Experiment 1 provided evidence that interpretation of the Type B Double-PP construction is influenced by the prosodic contour assigned to the sentence, specifically by whether or not the ambiguously-attaching PP2 is preceded by a prosodic boundary, which is more common for long PP2 than for short PP2. In studies of silent reading no prosodic contours can be directly observed, so the data are inevitably less rich than for reading aloud; only attachment data can be obtained. But the IPH does make the prediction that the relationship between PP2 length and preferred interpretation in silent reading should match the one found in Experiment 1 for reading aloud. A series of studies over the last decade (such as the RC-attachment studies above, and also Hirose, 1999; Hwang & Schafer, 2009, and Hwang & Steinhauer (in-press) on a different construction) have shown support of the IPH in that the same relationship found between preferred attachment and factors that affect prosody in spoken language also holds in silent reading. Following these studies, we expected to find interpretive effects comparable to those in

Experiment 1 in a silent reading version of the Type B Double-PP experiment in Hebrew. Experiment 2 evaluated this prediction. Since this construction had not previously been systematically studied even in reading aloud, it therefore provided novel data regarding silent reading[48].

To test the IPH on the basis of this construction, it was crucial to relate the overt prosody data involving production and comprehension in Experiment 1 with the preferred ambiguity resolution in a silent reading study. The overt production data from Experiment 1 was necessary to establish the default prosody for the Double-PP construction. This was important because the IPH predicts that the parser will prefer the syntactic analysis that is associated with the default prosody for the construction in the particular language. The comprehension data from Experiment 1 permitted a comparison of attachment preferences in silent reading with those in reading aloud. If these attachment preferences are comparable, and particularly if they show a similar sensitivity to PP2 length, it would be reasonable to conclude that implicit prosody is the source of the silent reading attachment data.

As described in section 5.3 below, the silent reading experiment reported in this chapter used exactly the same language materials and applied an almost identical method to that in the production-comprehension experiment. Procedural differences are detailed in section 5.3. The major contrast was that participants read the preamble and target sentence silently before selecting between two answer choices representing the two

[48] Studies on effects of implicit prosody on PP attachment are relatively rare. Hemforth et al. (2006) explored ambiguity of PP attachment to a higher or lower noun in silent reading. Maia et al. (2004) found effects of PP length in silent reading of a single-PP attachment construction in Brazilian Portuguese and attributed them to implicit prosody. Maia (2008) examined a Type A Double-PP construction in Brazilian Portuguese containing a garden path as in example (29) in section 2.4 above, and found an effect of visual segmentation on the on-line attachment of the first PP in self-paced silent reading.

possible meanings of the ambiguous target sentence, the one that they deemed more compatible with the meaning of the sentences they had read. Their choice was assumed to reveal their attachment preference for PP2: high to the VP, or low to the NP within PP1.

In order to keep the experimental session free of any spoken language, answer selection in Experiment 2 was performed by a button press, compared with spoken responses in Experiment 1. Thus any prosody mentally projected onto the sentences by participants would have to have been spontaneous, not induced by the procedure.

5.3 Method

5.3.1 Materials and Design

Experiment 2 was identical to Experiment 1 in terms of materials and design. Like Experiment 1, it involved a 2x2 design with Length (long/short) and Order of Answers' Presentation (high attachment responses on the right/low attachment response on the right) as factors.

It may be recalled from Chapter 4 that the target items had been pre-tested and selected for balanced ambiguity, with no semantic or plausibility bias toward one attachment or the other.

5.3.2 Procedure

The task in Experiment 2 was a modified version of that in Experiment 1. Instead of reading the sentences aloud into a microphone, the participants read the sentences silently. Also, to select the answer the participants used the shift keys on the keyboard,

instead of reading the answer aloud into the microphone. Thus, there was no voice recording at all in Experiment 2, because the purpose of the experiment was to reveal the preferred interpretations in the Double-PP construction when any prosody is mentally projected in silent reading. Including a spoken response might have undermined it by putting participants into a speech mode.

In the third frame for each item the answers appeared on the screen alone, without the preamble and target sentence. The decision to present the answers after the disappearance of the sentences was based on the assumption that participants might not take the trouble to read the sentences silently before pressing the key to see the possible answers, but might instead preview the answers first and then seek the relevant information in the sentences. This would depart from a normal right to left reading process and would thereby disrupt the assignment of default implicit prosody that could otherwise be projected onto the sentence. In Experiment 1 the participants could not employ this tactic of previewing the answers, because the answers were not shown until they had finished reading the sentence aloud, so there was no need for this precaution. A more likely risk for Experiment 1 seemed to be that the participant might make errors due to forgetting some details of the sentences (such as the names of the characters) in the time it took to make the recording; this could be minimized by retaining the sentences on screen along with the answers. It is perhaps not ideal that the procedure differed in this respect across the two experiments, but each experiment was designed to be optimal in itself, and there is no reason to think that this divergence makes it impossible to draw relevant comparisons between their outcomes.

With these changes, the procedure was as follows. As in Experiment 1, each item was introduced by a frame displaying the + sign. The participant pressed the space bar, causing the preamble and target sentence to appear simultaneously in the center of the screen one below the other. The participant read the sentence pair silently and then pressed a key (the right shift key) which was covered with a green sticker. At that point the preamble and target sentence disappeared from the screen and the two answers appeared instead. The participants were instructed to read the answers silently and select the one which they considered more compatible with the sentences they had read. To select the answer on the right, the participants pressed the right shift key; to select the answer on the left, they pressed the left shift key[49]. The left shift key was covered by a red sticker.

5.3.3 Participants

A total of 70 participants took part in this study. They were drawn from the same population as for Experiment 1: they were all B.A. students of psychology in the Open University in Israel who voluntarily participated in the experiment as part of a requirement toward their degree. They were naïve with respect to the purpose of the experiment.

[49] Just as in Experiment 1, the two different orders of answers (high attachment interpretation on the right and low attachment interpretation on the left, and the reverse) were tested such that there were four rather than two versions of lists (see detailed description of the four lists in section 4.2.2) to keep the two experiments as parallel as possible in this regard.

Of the 70 participants, a total of 10 were excluded from the data analysis on language history grounds[50] (14% of the total sample). (Appendix C-1 presents the language history questionnaire.) Of those remaining, one participant was excluded because of a technical error, and five were excluded because they failed to meet the performance criterion of committing fewer than 15% errors on filler items. Of the 56 remaining participants, 40 participants were selected - the first 10 assigned to each of the four lists. Thus the final analysis included data from 40 participants, 10 for each list to parallel the number of participants in Experiment 1.

5.4 Results

Experiment 2 with silent reading provided only attachment data (summarized in Table 5-1), not prosodic data. A two-way ANOVA of Length (long/short) and Order of Presentation of Answers (high attachment response on the right/low attachment response on the right) revealed that PP2 length significantly affected comprehension in silent reading: long-PP2 targets were more likely to be attached high (55.6%) than short-PP2 targets (45.8%), $F_1(1,38) = 9.64$, $p < .01$, $F_2(1,46) = 11.29$, $p < .01$. This closely matches the results of Experiment 1 with reading aloud.

As in Experiment 1, there was no reliable difference in attachment preference between the two orders of presentation of the answers, $F_1(1,36) = 1.25$, $p > .05$, $F_2 < 1$, and there was no interaction between length and order of presentation of answers. $F_1(1,36) = 1.93$, $P > .05$, $F_2(1,44) = 1.84$, $p > .05$

[50] Of the ten participants who were excluded from the data analysis three were not native speakers of Hebrew, six lived outside of Israel at one point for more than a year and one was bilingual.

Table 5-1: Percentage of high attachment interpretations in long and short-PP2 sentences in silent reading.

Attachment	High
Long PP2	55.6
Short PP2	45.8

5.4.1 Comparison of results for comprehension in reading aloud (Experiment 1) and comprehension in silent reading (Experiment 2):

The percentages of high attachment interpretations were extremely similar across the two experiments, for both short-PP2 items and long-PP2 items. A series of four Independent Samples T-tests with experiment number (Experiment 1/Experiment 2) as the independent variable and attachment height as the dependent variable were performed. No significant difference in attachment height between experiments was found for short PP2-sentences in either participant-based analysis, $t_1(78) = 0.11$, $p > .05$, or item-based analysis, $t_2(94) = .07$, $p > .05$. Likewise, no significant difference in attachment height between experiments was found for long PP2-sentences in either participant-based analysis, $t_1(78) = .17$, $p > .05$, or item-based analysis, $t_2(94) = .17$, $p > .05$.

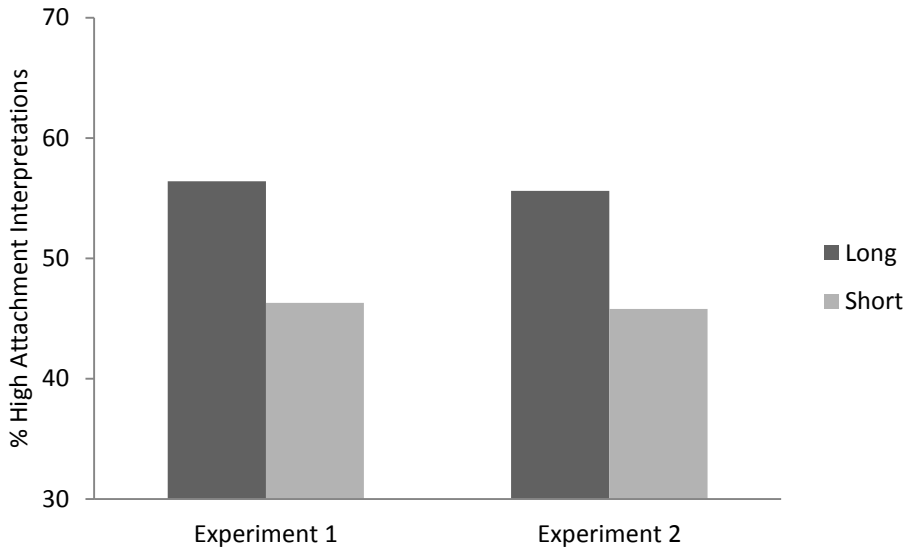


Figure 5-2: Percentage of high attachment interpretations in Experiments 1 and 2. This figure re-plots data presented in Table 4-7 and Table 5-1.

Thus the IPH-based hypothesis was borne out by Experiment 2 in relation to Experiment 1: attachment preference was sensitive to PP2 length in a manner entirely consonant with that observed for reading aloud.

The remarkable similarity between the results of the two studies with different participants requires a slight reconsideration of the IPH. Fodor's formulation of the IPH is: "In silent reading, a default prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, the parser favors the syntactic analysis associated with the most natural (default) prosodic contour for the construction (Fodor, 2002)." Assuming that the default prosodic contour is evidenced as the most frequent overt prosodic contour in reading aloud, the data from Experiment 1 indicate that the default contour for the Double-PP construction in Hebrew has a prosodic boundary before PP2 for a long PP2, and for a short PP2 either no prosodic break at all or a [PP1 break. (There was no significant difference between the number of No Breaks and

[PP1 Breaks in the short-PP2 utterances, although numerically the number of No Breaks was greater; see section 4.3.2) Fodor's statement of the IPH seems to imply that a silent reader would mentally impose a prosodic boundary before PP2 for a long PP2, and no prosodic break or a break before [PP1 for a short PP2 *in all cases.* Then these prosodic contours "may influence" the attachment of PP2, though not necessarily in every case. (If they influenced attachment in every case, the attachment preferences would be more extreme in silent reading than in reading aloud; this was never an intended aspect of the IPH.) The IPH makes no quantitative prediction for the extent of the influence on syntactic attachment of a given prosodic pattern – though it might be expected to mirror, in somewhat muted fashion, the extent of influence of the same prosody on attachment listening (see Shaked, 2009, Chapter 7).

On a too literal interpretation of the IPH, claiming that the default (i.e., most favored) prosodic contour is *always* projected onto the stimulus in reading, the close similarity in attachment results for reading aloud and reading silently would be just a coincidence. In the present case, as it happens, having the most frequent of the possible prosodies (PP2 breaks in long-PP2 items and No Breaks or a [PP2 Break in short-PP2 items) extended to all cases in silent reading is not incompatible with the data. But in general it seems psychologically implausible, particularly for a construction which has several natural prosodic patterns, without there being one that is strongly dominant, and each of which has a different impact on attachment. In any event, supposing that similarity of outcomes is not merely a coincidence when there are several natural prosodic patterns for a given construction, an explanation for it could be that readers project different prosodic contours *in the same proportions* when reading silently as they

do in reading aloud. This is not implausible as a psycholinguistic hypothesis, and it may be linguistically superior to the original IPH since it allows for the existence of constructions, such as the Double-PP construction with short PP2, for which there is no single strongly preferred prosody which would dominate interpretation, but rather a spectrum of alternative contours. I propose, then, a new statement of the IPH as follows.

> Implicit Prosody Hypothesis (revised): "In silent reading, a prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, a given contour is projected with the same probability in silent reading as in reading aloud, and it influences the parser's preference for one syntactic analysis over another to much the same extent in silent reading as it does in listening."

This goes far beyond what the present experiments can establish, but I believe it is worth considering in future studies on implicit prosody. Whether it is indeed empirically superior to the original formulation remains to be investigated with data from a wider range of constructions. But some modest support for it can be found in the parallelism of attachment preferences in overt and silent reading in earlier studies: Hirose (1999) found a subject reanalysis interpretation in overt and silent reading respectively in 52% and 55% of the cases when the subject was short and in 79% and 73% of the cases when the subject was long; Lovrić (2003) found high attachment interpretation in overt and silent reading respectively in 45% and 48% of the short RC cases with -prep, in 26% and 31%

of the short RC cases with + prep, in 70% and 66% of the long RC cases with –prep, and in 56% and 53% of the long RC cases with +prep.

In sum, Experiment 2 revealed length effects on interpretation in the Double-PP construction in silent reading in Hebrew. A comparison of the attachment preferences in silent reading with those obtained in Experiment 1 for reading aloud revealed very similar percentages of high attachment interpretations across the two experiments and similar sensitivity to PP2 length. As a result, it was concluded that implicit prosody is the source of the attachment data in silent reading in the same way that overt prosody was the source of the attachment data in reading aloud (rather than PP length per se, which had been demonstrated in Experiment 1 to have no direct effect on attachment). Thus Experiment 2 provided more evidence for the IPH: from the Double-PP construction, which had never been investigated with respect to the IPH, and from Hebrew, which had been tested only once in relation to the IPH (Shaked, 2007). In addition, the remarkable similarity in the attachment results in the reading aloud and silent reading experiments gave rise to a new statement of the IPH.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Summary of results

This research included two experiments. The first was a combined production and comprehension experiment. It tested the prosody and comprehension of read aloud ambiguous Double-PP sentences in Hebrew. The length of the ambiguously-attached PP2 was manipulated, making it possible to examine the effect of PP2 length on prosodic phrasing and attachment preference. As expected, the ear judgments revealed that prosody involving a break at [PP2 only was the most preferred for long-PP2 targets (58% of the long-PP2 prosody data). This result was in line with the prediction of the Bin(MaP) principle (Selkirk, 2000) (according to which the optimal phrase length is two prosodic words) that a long PP2, which comprised 2-3 prosodic words in the present materials, would be long enough to stand on its own, preceded by a break. However, unexpectedly, prosody involving no break anywhere in the produced utterance was observed in 27% of the long-PP2 items. This is surprising because a long-PP2 sentence, which constitutes five or six prosodic words, would be expected to exhibit a strong tendency to break at some point in the utterance to avoid overlong phrases. It is possible that an interplay between the syntactically-based Late Closure strategy and prosodically-based length principles (see De Vincenzi & Job, 1993; Fernández, 2000/2003; Augurzky, 2006, among others) led to the relatively large incidence of no breaks in the long-PP2 items: although length considerations predict a break at [PP2, Late Closure may have encouraged low PP2-attachment, which is likely to be associated with no break at [PP2 in accord with

alignment principles[51]. Finally, the incidence of [PP1 Breaks and Both Breaks prosodic phrasings was negligible for long-PP2 sentences, as predicted.

The prosody for short-PP2 sentences was predicted to be influenced by other constraints, in addition to length constraints, and indeed it was more varied than that for long-PP2 sentences; the most preferred prosodic phrasings were No Breaks (42%) and [PP1 Breaks (34%). Breaks at [PP1 were in accord with the length constraint which predicted that the short PP2 would group with PP1 to form a prosodic phrase which is long enough to stand on its own, with a break before it. The large incidence of the No Breaks prosodic phrasing was interpreted as reflecting the pressure of the Wrap XP constraint on the Object NP and PP1 to be in the same phonological phrase, resulting in no break between the two. Finally, there were fewer breaks at PP2 (18%) and negligible incidence of Both Breaks, as predicted. The acoustic analysis results agreed with ear judgment results: they showed a greater tendency for a prosodic boundary to occur immediately preceding PP1 in short-PP2 sentences than in long-PP2 sentences, and immediately preceding PP2 in long-PP2 sentences than in short-PP2 sentences.

The attachment results obtained in the comprehension task of Experiment 1 revealed, as expected, that PP2 length had a significant effect on sentence comprehension: long-PP2 targets were significantly more likely to be attached high (56.4%) than short-PP2 targets (46.3%). This finding was in line with the $Align_R$ XP constraint (Selkirk, 2000) which relates prosodic structure and syntactic structure: there

[51] The high proportion of no-break items could also be related to the conservative approach adopted in making the ear-judgments, which took into consideration Hebrew prosody characteristics. In Hebrew, lexical stress often falls on the last syllable of the word and the stress involves a high tone and lengthening (Becker, 2003). Therefore, in the ear-judgments, an intermediate prosodic boundary was registered only when the pitch rise was stronger compared to the pitch rise in other word final positions in the sentence. Though great care was taken in applying this criterion, it is a possibility that this cautious approach resulted in identification of fewer phrasal breaks than actually occurred.

were more breaks before long PP2s than before short PP2s, and more cases of high attachment when PP2 was long than when it was short.

These findings provide evidence for PP2 length effects on both prosodic phrasing and attachment. However, previous studies, specifically implicit prosody studies of relative clause attachment (Lovrić, 2003, Hirose, 1999, among others), made the assumption that attachee length does not *directly* affect attachment (as long as it is clear that the additional material in the long version of an ambiguous sentence does not alter the semantics in a way that could change the relative plausibility of the two attachments). Therefore, we wanted to test the hypothesis that PP2 length did not directly affect attachment but rather that prosody induced by length did. Indeed no effect of length on interpretation was found when prosody was matched, within any of the three prosodic phrasing patterns, despite numerical differences in the No Breaks and [PP1 Breaks prosodic phrasing patterns between the short and long-PP2items. On the other hand, as predicted, prosody type was reliably associated with interpretation for [PP2 Breaks: regardless of length, utterances produced with a break only before PP2 had a substantially greater high attachment rate than utterances produced with a break only before PP1 and utterances produced with no breaks. But contrary to expectations, prosody type did not show a reliable effect on interpretation for [PP1 Breaks; a [PP1 Break was not reliably associated with more low attachment of PP2 compared with the No Breaks (neutral prosody) condition. Though not as predicted, this result does not disconfirm the prediction for [PP1 Break versus No Breaks since it may be attributable to a lack of statistical sensitivity due to the sparsity of relevant data points in these categories. Another possibility is that the syntactically-based Late Closure strategy prevails when

prosody is neutral (Kjelgaard & Speer 1999, Fernandez, 2003 & Augurzky, 2006) and encouraged low attachment in the No Break category, to a degree more or less comparable to the effect of a [PP1 Break.

The second experiment investigated attachment preferences in the Double-PP construction in silent reading. The purpose was to contribute data relevant to evaluating the IPH (Fodor, 2002) from Hebrew (see Shaked, 2009, the only study on the IPH in Hebrew to date) and in the Type-B Double-PP construction, which has never been tested with respect to the IPH.

It was found that PP2 length affected comprehension in silent reading: long-PP2 targets were more likely to be attached high (55.6%) than short-PP2 targets (45.8%). To test whether prosody influences syntactic parsing not only in reading aloud, when prosody is overt, but also in reading silently, when prosody is mentally produced, as predicted by the IPH, we compared interpretation preferences in reading silently with those obtained already for reading aloud. There were very similar percentages of high attachment interpretations across the two experiments, for both short-PP2 items and long-PP2 items. Thus the IPH-based hypothesis was borne out by Experiment 2 in relation to Experiment 1: attachment preference was sensitive to PP2 length in a manner entirely consonant with that observed for reading aloud. The most natural explanation is that there was implicit prosody mediating between the PP2 length and its interpretation in silent reading.

6.2 Conclusions

The goal of this study was to investigate the prosody-syntax interface in the processing of the Double-PP construction in Hebrew. This investigation revealed that the Hebrew Double-PP construction supports proposed universals of the prosody-syntax interface. First, the greater tendency observed in the reading aloud study for prosodic breaks to occur before PP2 when it was long than when it was short revealed an effect of attachee length on prosodic break locations in accord with length constraints on phrasing (see section 6.1 above).

Second, when PP2 was short, there was found no consistent pattern of prosodic breaks except avoidance of a break at [PP2. The most preferred prosodic phrasings were the No Break and [PP1 Breaks patterns. This may reflect a competition between constraints which have been proposed in the context of optimality theory: a break before PP1 is in accord with length constraints which encourage the short PP2 to group with PP1 to form a prosodic phrase which is long enough to stand on its own, with a break before it; no break between the Object NP and PP1 (in the No Break prosodic phrasing pattern) could reflect the requirement of the alignment Wrap XP constraint that these two phrases which form a syntactic constituent (complex object NP) be in the same phonological phrase. Thus, there were multiple pressures on the ip boundary positions which resulted in various break positions.

Third, the greater high attachment with a break at [PP2 than with no break at [PP2 (the tendency of a [PP2 prosodic break to be interpreted by the readers as denoting discontinuity in tree structure), provided further evidence for prosody-syntax edge alignment.

The results of the production-comprehension experiment had implications for the syntax/prosody interface. This was a reading study, so all prosody was projected by the reader. Though the participants were reading aloud (rather than silently), the findings are compatible with the IPH which proposes that a default prosodic contour is projected onto a sentence in reading (even in silent reading), and in ambiguous sentences it favors the syntactic analysis that is normally associated with that prosody. The study indeed provided evidence that the prosodic contour influenced the attachment of PP2: phrase length affected prosody but length did not have a significant effect on attachment when prosody was matched. Further, comprehension was reliably related to the produced prosody, in the case of a [PP2 Break. The best explanation is that the attachment preferences observed in the ambiguity resolution data were influenced by the prosodic contour assigned in reading.

One of the aims of this study was to provide more clarity on the production and comprehension of prosodic cues to phrasal boundaries (ip boundaries) for which results have been inconsistent in the past. The Double-PP construction, like the long-studied single-PP construction, involves phrasal ambiguity, but it was expected to yield clearer results because it is longer, so it may encourage more breaks, and because it exhibits a sharper structural contrast between the two potential attachment sites than the single-PP construction (more syntactic edges separating the two attachment sites predict greater probability or strength of a break, Fodor, 2002). However, the prosodic cues to ip boundaries and prosodic effects on interpretation that were observed were not particularly strong, in line with previous findings for single-PP attachment. We did find a significant PP2 length effect on produced prosody and a reliable prosodic effect of [PP2 breaks on

interpretation, but the results were not remarkably robust: prosodic breaks at long [PP2s occurred for only 58% of the utterances, and utterances produced with [PP2 breaks exhibited no more than 60% high attachment. It is possible that the mixed and inconsistent results in studies on past PP attachment constructions may simply indicate that ip boundaries are not so tightly constrained by the syntax/prosody interface of the grammar as IPh boundaries; alignment constraints may be optional in the case of ips (See discussion of this in Millotte, Wales & Christophe, 2007). Alternatively, the constraints on ips may be 'soft' constraints which interact with other interface constraints, including rhythmic constraints on optimal phrase lengths, which may outrank them (see Selkirk 2000), whereas IPhs are less sensitive to such factors. The prosodic phrasings of ips in the current study were accounted for by several constraints related to the syntax/prosody interface other than edge-alignment (length, and possibly the Wrap XP constraint). It seems reasonable to suggest that a variety of constraints may play a role in determining prosodic phrasing in PP constructions and that the resulting mixed distribution of prosodic breaks may be used by listeners to interpret structure. Since the resulting prosodic phrasings may not all encourage the same attachment choice, there may not be a single highly dominant attachment preference, as was often evident in the studies of the single-PP construction.

Another purpose of this study was to contribute new data relevant to evaluating the IPH. As summarized in section 6.1, this study indeed supported the IPH but it also called for a slight change in its formulation. The revised IPH proposed here extends the applicability of the IPH to constructions such as the Double-PP construction with short PP2, for which there is no single strongly preferred prosody that would dominate

syntactic structure assignment. In such cases, it is proposed that a prosodic contour influences the parser's preference for an attachment choice to the same extent in silent reading as in reading aloud. As indicated above, this combines two claims: that the proportions of prosodic patterns assigned to a sentence are the same in silent reading as in reading aloud, and that the impact of a particular prosodic pattern on syntactic structure building is comparable in both silent reading and reading aloud. Together, these predict similarity in the proportions of the alternative interpretations of an ambiguity in reading aloud and reading silently, as found in the current study and in others in the implicit prosody literature.

An important advantage in the current study, as mentioned above, is that it involved a length contrast of the ambiguously attaching PP. Length effects on prosodic phrasing and attachment are commonly observed in experiments on the relative clause attachment ambiguity *(*Lovrić, 2003, Fernández, 2000/2003, Augurzky, 2005, among others*).* However, studies of PP constructions have never involved length variation of the ambiguous PP (with the exception of Hemforth et al., 2006; see section 2.5) and so this study provided novel evidence for prosodic sensitivity to length variation in a PP construction. In addition, manipulating PP2 length allowed us to test the effect of prosody on interpretation. Each long PP2 differed from its corresponding short PP2 by addition of material that was intuitively semantically neutral, and this was reinforced in the materials pre-test for selecting items to be used in the main experiments, by requiring the expert judgments of interpretation bias for the long and short versions of an item to be clustered on the scale. Therefore the PP2 length contrast employed in the current experiments was semantically neutral, and can reasonably be regarded as not directly responsible for the

observed differences in attachment. Thus, the PP2 length effects observed on interpretation called for an explanation in terms of prosodic mediation between length and interpretation.

In general, our predictions regarding the syntax/prosody interface were borne out. The results revealed effects of length on prosodic phrasing and an effect of [PP2 Breaks on attachment. However, prosody type did not show a reliable effect for [PP1 Breaks: a [PP1 Break was not reliably associated with more low attachment of PP2 compared with the No Breaks (neutral prosody) condition. This, however, can be attributed to the methodology of Experiment 1: the current study allowed the speakers to produce whatever prosody they wished, making it possible to reveal the prosodic phrasings associated with the construction. However, this method could not control the amount of data obtained for the four prosody types and as a result the relationship between prosody and attachment could not be reliably established for all the conditions: the small number of the [PP1 Breaks prosody type did not suffice to test the prediction that this pattern exhibits a lower attachment tendency than the No Breaks prosodic pattern. A (future) listening study in which the four main produced prosodies would be introduced to the participants in balanced proportions could complement our present results.

APPENDICES

APPENDIX A: MATERIALS

APPENDIX A-1: Experimental items for Experiments 1 and 2

This appendix lists the 24 experimental items in Experiment 1 and 2 in their long and short versions. The first sentence in each item is the preamble and the second is the target sentence. Where the two interpretations translate differently into English, the translation shows the high-attachment version before the low-attachment version. An asterisk inside the parenthesis indicates there is a slight change in the preposition or first noun of the PP2 when PP2 is long (see section 4.2.1.1). In that case the whole PP2 is included in the parenthesis. An arrow indicates a change that was made to an experimental item following the pre-test, in response to the judges' comments.

(1) gadi nisa ledaber be-šeket. hu laxaš 'et ha-bdixa al ha-matana
Gadi tried to speak in-quiet. he whispered ACC the-joke about the-present
le-dafna ('avramovski)
le-dafna (Avramovski)
'Gadi tried to talk quietly. He whispered the joke about the present to/for Dafna (Avramovsky)'

(2) rafi lo 'ohev laxsof 'et rigšot-av. hu histir 'et ha-ka'as šelo 'al ha-
Rafi not like to expose ACC feelings-his. he hid ACC the-anger his about the-
gerušin mi-tami (toledano)
divorce from-Tami (Toledano)
'Rafi doesn't like to expose his feelings. He hid his anger about the divorce from Tami (Toledano).'

aharonovitš → toledano
Aharonovich Toledano

(3) ha-profesor le-limudim mizraxiyim melumad beyoter. hu katav bikorot
the-profesor for-studies eastern learned extremely. he wrote reviews
'al širim be-'aravit (palestina'it)
about poems in-Arabic (Palestinian)
'The Prof. of Eastern Studies is extremely learned. He wrote reviews about poems in (Palestinian) Arabic.'

(4) Ha-kcinim hitkansu le-diyun xašuv. hem ‘arxu ‘et ha-
the-officers convened for-discussion important. they conducted ACC the-
taxkir ‘al ha-lexima ba-layla (ba-layla ha-‘axaron)
debriefing about the-fight in the-night (in the-night the-last)
‘The officers convened for an important discussion. They conducted the debriefing about the fighting at night (last night).’

(5) ha-metargemet ‘avda kaše letargem ‘et ha-proyect. hi tirgema ‘et ha-
the-translator worked hard to finish ACC the-project. she translated ACC the-
mismaxim šel ha-mumxe le-sinit (cantonezit)
documents of the-expert to/for-Chinese (Cantonese)
‘The translator worked hard to finish the project. She translated the documents of the expert to/for (Cantonese) Chinese.’

(6) menahel ha-xevra ne’elac lehagiv ‘al divrey ha-‘anašim
manager the-company was compelled to respond on talks the-people
sviv-o. hu hikxiš ‘et ha-šmuot ‘al hitpatrut-o ba-yešiva
around-him. he denied ACC the-rumors about resignation-his in the-meeting
(ha-du švuit).
(the-bi weekly)
‘The manager of the company was compelled to respond to what people were talking about around him. He denied the rumors about his resignation in the (bi-weekly) meeting.’

(7) ha-rav šel ha-'ir matif le-nedivut. hu hidgim ‘et ha-
the-rabbi of the-city preaches for-generosity. he demonstrated ACC the-
xašivut šel ha-netina la-kehila (ha-yisra’elit)
importance of the-giving to the-community (the-Isra’eli)
‘He demonstrated the importance of the contribution to the (Israeli) community.’

(8) sar ha-tikšoret dogel be-liberaliyut. hu hibi’a ‘et
minister the-communication advocates in-liberalism. he expressed ACC
hitnagdut-o le-cenzura ba-radyo (ha-‘ezori)
objection-his for-censorship in the-radio (the-regional)
‘The minister of communication is liberal. He expressed his objection to censorship on the (reginal) radio.’

(9) ha-hanhala ko'eset 'al menahel ha-proyect. hu hidlif ‘et ha-yedi'a
the-management angry 'on manager the-project. he leaked ACC the-news
‘al ha-bonus la-‘ovdim (*le-ovdey ha-xevra)
about the-bonus to/for the-workers to/for-workers the-company)
‘The management is angry at the project manager. He leaked the news about the bonus to/for the (company) workers.’

(10) ha-patolog ha-xadaš mecuyan. hu pi'ane'ax 'et ha-gorem la-mavet
The-pathologist the-new superb. He deciphered ACC the-cause to the-death
ba-nitu'ax (ha-xadšani)
in the-surgery (the-innovative)
'The new pathologist is superb. He deciphered the cause of the death in the (innovative) surgery.'

(11) yo'av soxe'ax 'arukot ba-telefon ha-'erev. hu hivhir 'et ha-siba
Yoav talked a long time on the-phone this-evening. he clarified ACC the-reason
la-nesia'a le-savat-o (ha-kšiša)
to the-trip to-grandmother-his (the-old)
'Yoav talked a long time on the phone this evening. He clarified the reason for the trip to his (old) grandmother.'

(12) ha-kalkelan 'ose 'avoda yocet min haklal. hu xaza 'et ha-hekef šel
the-'economist is doing job exceptional. he predicted ACC the- extent of
ha-'inflaci'a be-yuni (ha-'axaron)
the-inflation in-June (the-last)
'The economist is doing an excellent job. He predicted the extent of inflation in June (last June).'

(13) sigal racta še-yaxševu še-yeš la harbe xaverim. hi talta
sigal wanted that-(people) will think that-there is to her many friends. she hang
cilum šel ha-'ovdim be-misrad-a (ha-xadaš)
picture of the-workers in-office-her (the new)
'Sigal wanted people to think she has many friends. She hang a picture of the workers in her (new) office.'

(14) 'alon hivti'ax le-xaver-to še-hu yetapel ba-kol. hu
alon promised to-girlfriend-his that-he will take care in the-everything. he
yaxin 'et ha-'uga la-mesiba be-šabat (ha-krova)
will make ACC the-cake for the-party on-Shabat (the-close)
'Alon promised his girlfriend he'll arrange everything. He will make the cake for the party on Saturday (next Saturday).'

(15) ha-mefaked šaha ba-basis. hu ra'a 'et ha-kvuca šel ha-nimlatim
the-commander was in the-base. he saw ACC the-group of the-escapees
me-ha-xalon (ha-cfoni-ma'aravi)
from-the-window (the-north-western)
'The commander was in the base. He saw the group of escapees from the (north-western) window.'

(16) dana hirgiša corex ledaber 'al be'ayot-eha. hi te'ara 'et ha-
dana felt need to talk about problems-her. she described ACC the-
kšayim be-nisu'e-ha la- šadran (ha-mefursam)
difficulties in-marriage-her to the-broadcaster (the-famous)
'Dana felt the need to talk about her problems. She described the difficulties in her marriage to the (famous) broadcaster.'

psixolog → šadran
psychologist broadcaster

(17) hitmana xoker xadaš la-mikre. hu 'asaf 'eduyot la-peša
assigned investigator new for the-case. he gathered testimonies for the-crime
ba-kele (*bekele ma'asiyahu)
in the-prison (in prison Maasiyahu)
'A new investigator was assigned for the case. He gathered testimonies for the crime inside (Ma'asiyahu) prison.'

(18) ha-komikay hitra'ayen le-toxnit televizya. hu te'er 'et ha-
the-comedian was interviewed to-program TV hi described ACC the-
koši šel ha-ktiva be-humor (yehudi tipusi)
difficulty of the-writing in-humor (Jewish typical)
'The Comedian was interviewed to a TV show. He described the difficulty of writing (typical Jewish) humor.'

(19) 'etmol dani sixek trivi'a. hu gila pitaron le-xida ba-'iton
yesterday Dani played trivia. he found solution for a-riddle in the newspaper
(ha-mada'i)
(the-scientific)
'Dani played Trivia yesterday. He found a solution for a riddle in the (scientific) newspaper.'

(20) ha-zamar ha-mevukaš 'avad gam ba-xag. hu hišmi'a kta'im me-
the-singer the-demanded worked also in the-holiday. he played parts from-
hofa'a-to ba-park (*be-park hayarkon)
show-his in the-park (in-Park Hayarkon)
'The popular singer worked in the holiday too. He played parts of his show in the park (in Hayarkon Park).'

(21) la-mištara hayta haclaxa bilti cfuya. he tafsa 'et ha-xašudim ba-
to the-police there was success not expected. she caught ACC the-suspects in the-
prica be- xacor (haglilit).
Break-in in-Hatzor (Haglilit).
'The police had an unexpected success. They caught the suspects in the break-in in Hatzor (Haglilit).'

(22) ha-pelefon šel ha-'av ha-tari cilcel. hu kibel ‘et ha-bsora ‘al ha-
the-cellphone of the-father the-fresh rang. he got ACC the-news about the-
leda ba-monit (*be-monit ha-šerut)
delivery in the-taxi (in-taxi the-service)
‘The cellphone of the new father rang. He received the news about the delivery in the taxi (sevice).’

(23) ha-xotfim hištaltu 'al ha-matos. hem hesitu ‘et ha-maslul šel ha-tisa
the-hijackers took over on the plane. they diverted ACC the-course of the-flight
le-gine'a (ha-xadaša)
to-Guinea (the-new)
‘The hijackers took over the plane. They diverted the course of the flight to (New) Guinea’.

cfon kore’a → gine'a ha-xadaša
North Korea Guinea the-new
North Korea New Guinea

(24) ha-more le-tzuna hu 'iš mikco'a recini. hu takaf ‘et ha-
the-teacher to-nutrition is person profession serious. he attacked ACC the-
tofa’a šel ha-nišnuš ba-ši’ur (*ba-ši’urim šelo)
phenomenon of the-snacking in the-class (in the-classes his)
‘The nutrition teacher is a professional. He criticised the phenomenon of snacking in class (in his classes).’

APPENDIX A-2: Experimental items in the pre-test

This appendix lists the 16 items included in the pre-test but not selected for Experiments 1 and 2, in their long and short versions. (The items in the pre-test which were selected for Experiments 1 and 2 appear in Appendix A-1.) Where the two interpretations translate differently into English, the translation shows the high-attachment version before the low-attachment version. An asterisk inside the parenthesis indicates there is a slight change in the preposition or in the first noun of the PP2 when PP2 is long (see section 4.2.1.1). In that case the whole PP2 is included in the parenthesis.

(1) ha-menake he'ela ve-horid dvarim ba-madregot. hu 'ibed
the-cleaning person took up and-took down things in the-stairs. he lost
'et ha-maftexot šel ha-dayarim ba-martef (*be-martef ha-binyan)
ACC the-keys of the-tenants in the-basement (in-basement the-building)
'The cleaning person went up and down the stairs carrying things. He lost the keys of the tenants in the (building's) basement.'

(2) 'orex hadin hitkadem be-haxanat ha-tik. hu kibel 'et ha-ktovet šel
the lawyer made progress in-preparing the-case. he got ACC the-address of
ha-mixtav me-ha-xašud (ha-'ikari)
the-letter from-the-suspect (the-primary)
'The lawyer made progress with the case. He got the address of the letter from the (primary) suspect.'

(3) 'orit 'ovedet ba-cafon. hi menahelet 'et ha-'asakim šel xavert-a me-ha-
Orit works in the-North. she runs ACC the-business of friend-her from-the
Galil (ha-'elyon)
Galilee (the-Upper)
'Orit works in the North. She runs the business of her friend from the (Upper) Galilee.'

(4) 'amir makir 'et kol ha-mi va-mi ba-'ir. hu te'er 'et ha-
Amir knows ACC all the-who and-who in the-city. he described ACC the-
hitraxašuyot ba-mesiba la-katav (ha-mefursam)
goings on in the-party to/for the-reporter (the-famous)
'Amir knows the who's who in the city. He described the goings on at the party to/for the (famous) reporter.'

(5) ha-šef šel malon dan hofi'a be-toxnit 'eru'ax. hu limed texnikot šel
the-chef of hotel Dan appeared in-program hosting. he taught techniques of
bišul be-rega (*be-kama rega'im)
cooking in-moment (in-a few moments)
'The Dan Hotel chef participated in a talk show. He taught techniques for cooking in (a few) seconds.'

(6) sgan ha-sar hitra'ayen 'etmol. hu sikem 'et ha-
deputy the-minister was interviewd yesterday. he summarized ACC the-
hašlaxot šel ha-švita ba-radyo (ha-mamlaxti)
implications of the-strike in the-radio (the-national)
'The minister deputy was interviewed yesterday. He summarized the implications of the strike on the (national) radio.'

(7) yor ha-hanhala hitrakex. hu hici'a toxnit šel hatavot la-
chairman the-management softened. he offered plan of benefits to/for the-
sxirim (ha-vatikim)
employees (the-veteran)
'The management chairman softened. He offered a plan of benefits to/for the (veteran) employees.'

(8) ha-me'argenim sikmu 'et turnir ha-bridge. hem pirsemu 'et
the-'organizers summed up ACC tournament the-bridge. they published ACC
ha-toca'ot šel ha-misxakim ba-'internet (*be-'atar ha-'internet)
the-results of the-games in the-internet (in-site the-internet)
'The organizers tallied up scores for the bridge tournament. They displayed the results of the games on the internet (website)'

(9) Revital me'od 'ohevet xalav. hi šateta 'et ha-še'erit šel ha-xalav
Revital very love milk. she drank ACC the-remains of the-milk
me-ha-bakbuk (ha-kaxol)
from-the-bottle (the-blue)
'Revital loves milk very much. She drank the remains of the milk from the (blue) bottle.'

(10) no'a aninat ta'am be-'ofna. hi hizmina smalot šel me'acvim mi-paris
Noa (has) refined taste in-fashion. she ordered dresses of designers from-paris
(ha-'ofnatit)
(the-fashionable)
'Noa has refined taste when it comes to fashion. She ordered dresses of designers from (fashionable) Paris.'

(11) mayk mištadel linhog be-axrayut. hu xasax xaci mi-maskort-o ba-bank
Mike tries to act in-responsibility. he saved half from-salary-his in the-bank
(ha-yašir ha-rišon)
(Ha-yashir Ha-rishon)
'Mike tries to act responsibly. He saved half of his salary in (Hayashir Harishon) bank.'

(12) ha-balaš ha-dagul patpetan. hu xasaf ‘et ha-zehut šel ha-
the-detective the-distinguished talkative. he revealed ACC the identity of the-
ha-roce'ax ba-mo’adon (*be-moa’don ha-yam hatixon)
the-murderer in the-club. (in-club the-Mediterranean)
‘The distinguished detective is talkative. He revealed the identity of the murderer in the (Mediterranean) club.’

(13) guy makpid lehagen 'al zxuyot-av. hu higiš ‘et ha-tvi’a ‘al
Guy pedantic to defend on rights-his. he submitted ACC the-claim regarding
ha-tašlum la-bitu’ax (ha-le’umi)
the-payment to the-insurance (the-national)
‘Guy is pedantic about defending his rights. He submitted the claim regarding the (national) insurance payment.’

(14) yuval nimna mi-lehaxbid 'al ha-'anašim sviv-o. hu he’elim ‘et
Yuval avoids from-to burden on the-people around-him. he hid ACC
ha-gorem le-xašašot-av me-’ex-av (ha-mevugarim)
the-cause for-fears-his from-brothers-his (the-elder).
‘Yuval avoids burdening the people around him. He hid the cause for his fears from his (older) brothers.’

(15) ha-'oved ha-raxlan me'udkan tamid. hu šama ‘et ha-bsora ‘al ha-
the-worker the-gossip updated always. he heard ACC the news about the-
piturin be-yuli (ha-’axaron)
lays-off in-July (the-last)
‘This gossipy worker is always updated. He heard the news about the laysoff in (last) July.’

(16) yosi hu xima'i muxšar. hu mamci taxširim le-nikuy be-kalut
yossi is chemist talented. he invents products for-cleaning in-ease
(raba)
(great)
‘Yossi is a talented chemist. He invents products for cleaning with (great) ease.’

APPENDIX A-3: Fillers in Experiments 1 and 2

This appendix lists the fillers in Experiments 1 and 2. Each filler item contains 2 sentences, to resemble the "preamble + target" format of the experimental items. Half of the fillers are of varied construction and contain no preposition (Filler type A), and half comprises 4 groups of 6 fillers with prepositions. Of these four, the first (Filler type B) and second (Filler type C) groups has a PP in the preamble or the target sentence respectively, but none in the answers. The third (Filler type D) and fourth (Filler type E) groups contain a PP in the preamble or target sentence respectively, and the same PP in the answers. In addition, there is a covert filler of fillers type B that was placed right after the break point. The PP always appears in first position preceding the subject of the sentence it appears in (the first or second sentence).

Filler Type A: No PP (neither in preamble nor in target sentence)

(1) mišpaxat goldman ʻohevet musika. ha-yladim lomdim lenagen ve-ha-horim
family goldman loves myusik. The-children learn to play and-the-parents
xovevey ʻopera.
lovers opera.
ʻThe Goldman family loves music. The children learn to play (an instrument) and the parents are opera lovers.'

ha-yeladim menagnim	ha-horim menagnim
the-children play	the-parents play
ʻThe children play'	ʻThe parents play'

(2) dani lo sam lev še-le'a cilma ʻoto. hu gila zot me'uxar yoter ve-
Dani not notice that-Lea took a picture him. he found it late more and-
ka'as nora
was angry terribly
ʻDani didn't notice that Leah took a picture of him. He learned it later and was very angry.'

dani cilem	dani culam
Dani took a picture	Dani was taken a picture of
ʻDani took a picture'	ʻDani was taken a picture of'

(3) ha-‘ax ha-katan hix’is ‘et ha-‘axot ha-gdola. Hu histir ‘et
the-brother the-little made angry ACC the-sister the-big. Hi hid ACC
ha-na’alayim šela.
the-shoes her.
‘The little brother made the big sister angry. He hid her shoes.’

ha-‘axot ka’asa	ha-‘ax ka’as
the-sister was angry	the-brother was angry
‘The sister was angry’	‘The brother was angry’

(4) merkazanit kav ha-xerum ha-xadaša zriza me’od. hi ‘itra miyad ‘et
operator line the-emergency the-new quick very. she located immediately ACC
ha-mitkašer še-‘ibed ‘et ha-yeled.
the-caller who-lost ACC the-boy
‘The new emergency line operator is very quick. She located immediately the caller who lost the boy.’

ha-yeled ‘utar	ha-mitkašer ‘utar
the-child was located	the-caller was located
‘The child was located’	‘The caller was located’

(5) ha-macav ha-kalkali mad’ig ‘et ha-kalkelan. hu yevakeš lexanes
the-situation the-economical worries ACC the-economist. he will ask to convene
‘et yešivat ha-kabinet.
ACC meeting the-kabinet.
‘The grave economical situation worries the economist. He will ask to convene a Cabinet Meeting.’

ha-kalkelan mud’ag	ha-kabinet mud’ag
the-economist is worried	the-Cabinet is worried
‘The economist is worried	‘The Cabinet is worried.’

(6) ha-‘axbar hifxid ‘et mixal. hi barxa maher.
the-mouse frightened ACC Michal. she ran away quickly
‘The mouse frightened Michal. She ran away quickly.’

mixal paxada	ha-‘axbar paxad
Michal was frightened	the-mouse was frightened
‘Michal was frightened’	‘The mouse was frightened’

(7) ha-mištara kibla haxlata yocet dofen. ha-šoter še-yimca ‘et ha-‘asir
the-police got decision unusual. the-policeman who-will find ACC the-convict
še-barax yekabel pras.
who-escaped will get reward.
‘The police reached an unusual decision. The policeman who will find the escaped convict will get a reward.’

ha-mištara hexlita	ha-šoter hexlit
the-police decided	the-policeman decided
‘The police decided’	‘The policeman decided’

(8) ha-šofet še-he’eniš ‘et ha-na’ara hirgiš rigšot ‘ašam. hu xašav
the-judge who-punished ACC the-teenager felt feelings guilt. he thought
še-ta’a
that-he was wrong
‘The judge who punished the teenager had guilty feelings. He thought that he was wrong.’

ha-šofet hirgiš ‘ašem	ha-na’ara hirgiša ‘ašema
the-judge felt guilty	the-teenager felt guilty
‘The judge felt guilty’	‘The teenager felt guilty’

(9) sarit ra’ata ‘et ha-menaka gonevet kesef. hi pitra ‘ota miyad.
Sarit saw ACC the-cleaning lady stealing money. she fired her right away.
‘Sarit saw the cleaning lady stealing money. She fired her right away.’

sarit ganva	ha-menaka ganva
Sarit stole	the-cleaning lady stole
‘Sarit stole’	‘The cleaning lady stole’

(10) Moše hitxil lilmod ci’ur. hu mešarbet ‘anašim rokdim u-smexim
Moshe started learning drawing. he sketches people dancing and-happy.
‘Moshe started learning drawing. He sketches people dancing and happy.’

moše roked	moše mecayer
Moshe dances	Moshe draws
‘Moshe dances’	‘Moshe draws’

(11) shney ha-‘axim ‘ohavim dvarim šonim. eytan baxar lilmod ‘omanut ve-caxi
two the-brothers love things different. Eitan chose to learn art and-Tsachi
baxar lilmod mada’im.
chose to learn sciences.
‘The two brothers love different things. Ethan chose to study art and Tsachi chose the sciences.’

caxi ma’adif limudey mada’im
Tsachi prefer studies sciences
‘Tsachi prefers science studies’

caxi ma’adif limudey ‘omanut
Tsachi prefers studies art
‘Tsachi prefers Art studies

(12) šlomi lo šar yafe kmo cvi. hu lo lamad lašir.
Shlomi not sing nicely as cvi. he not learned to sing
‘Shlomi doesn’t sing as nicely as Zvi does. He didn’t learn how to.’

šlomi šar paxot yafe
Shlomi sings less nicely
‘Shlomi sings less nicely’

cvi šar paxot yafe
Zvi sings less nicely
‘Zvi sings less nicely’

(13) ‘anašim nehenim lišmo’a ‘et sar haxuc no’em.
people enjoy to hear ACC the Minister of Foreign Affairs gives a speech.
yeš lo harbe karizma.
there is to him lot of charisma.
‘People enjoy hearing the Minister of Foreign Affairs give a speech. He has a lot of charisma.’

sar haxuc nehene
The Minister of Foreign Affairs enjoys
‘The Minister of Foreign Affairs enjoys’

sar haxuc karizmati
The Minister of Foreign Affairs charismatic
‘The Minister of Foreign Affairs is charismatic

(14) nexmad še-yeš ‘orxim. tal ‘ohev le’are’ax xaverim kol sof šavu’a
nice that-there are guests. Tal loves to host friends every end week
‘It’s nice to have guests. Tal likes to host friends every weekend.’

tal nexmad
Tal is nice
‘Tal is nice’

tal me’are’ax
Tal hosts
‘Tal hosts’

(15) ‘over ha‘orax še-hora lifnot yemina bilbel ‘et ha-tayeret. hi nixnesa
the passer-by who-instructed to turn right confused ACC the-tourist. she entered
la-šxuna ha-lo nexona
to the-neighborhood the-not right
‘The passerby who instructed her to turn right confused the tourist. She entered the wrong neighborhood.’

‘over ha’orax hit’a	ha-tayeret hit’ata
the passer-by misled	the-tourist misled
‘The passer-by misled’	‘The tourist misled’

(16) dani hufta me’od. Kšehu nixnas habayta hu ra’a šloša ‘anašim zarim
Dani was surprised very. When he entered home he saw three people strangers
yošvim le’exol.
sitting to eat.
‘When he came home, he saw three strangers sitting at the table and eating.’

ha-‘anašim axlu	dani axal
the-people ate	dani ate
‘The people ate’	‘Dani ate’

(17) ha-baxura hayta kol kax yafa še-ha-baxur hismik. Kaše lo lehastir ‘et
the-girl was so pretty that-the-guy blushed. Hard for him to hide ACC
bayšanut-o
shyness-his
‘The girl was so pretty that the guy blushed. It’s hard for him to hide his shyness.’

ha-baxur yafe	ha-baxur bayšan
the-guy pretty	the-guy shy
‘The guy is handsome’	‘The guy is shy’

(18) ha-sefer rodef ha-‘afifonim mecuyan. rak ha-hatxala kcat meša’amemet
the-book chaser the-kites excellent. only the-beginning a little boring
‘The book “The Kite Runner” is excellent. Only the beginning is boring.’

ha-sefer meša’amem	ha-sefer me’ule
the-book boring	the-book excellent
‘The book is boring’	‘The book is excellent’

(19) moti hu šef ha-misa'ada ha-xadaš. hu kava še-ha-melcarim crixim lehatxil
Moti is chef the-restaurant the-new. he determined that-the-waiters have to start
'et ha-'avoda mukdam yoter
ACC the-work early more
'Moti is the new restaurant's chef. He decided that the waiters have to start work earlier.'

moti ya'avod mukdam yoter.	ha-melcarim ya'avdu mukdam yoter
Moti will work early more	the-waiters will work early more
'Moti will work earlier'	'The waiters will work earlier'

(20) 'arxitect 'ulam ha-koncertim 'asa ta'ut. Ha-ma'ake mastir 'et ha-bama
architect hall the-concerts made mistake. The-rail hides ACC the-stage
'The Concert hall's architect made a mistake. The rail hides the stage.'

lo ro'im 'et ha-koncert	lo ro'im 'et ha-bama
not see ACC the-concert	not see ACC the-stage
'People cannot see the concert'	'People cannot see the stage'

(21) pestival ha-seret ha-zar hikrin ha-šana harbe sratim 'italkiyim. sratim
festival the-movie the foreign screened this-year many movies Italian. movies
carfatiyim lo hucgu.
French not presented
'The foreign movie festival screened many quality movies this year. French movies were not presented.'

hištatfu sratim carfatiyim	hištatfu sratim 'italkiyim
participated movies French	participated movies Italian
'French movies participated'	'Italian movies participated'

(22) 'aluf ha-šaxmat ha-yisra'eli yiceg 'et yisra'el. hu hevis 'et yeriv-o
champion the-chess the-Israeli represented ACC Israel. he beat ACC rival-his
ha-'argentina'i
the-Argentine
'The Israeli chess player champion represented Israel. He beat his Argentine rival.'

ha-yisra'eli hevis 'et ha-'argentina'i	ha-argentina'i hevis 'et ha-yisra'eli
the-Israeli defeated ACC the-Argentine.	the-Argentine defeated ACC the-Israeli.
'The Israeli defeated the Argentine.'	'The Argentine defeated the Israeli.'

(23) ha-zamar ha-mefursam lo kol kax muxšar. hu populari biglal levuš-o
The-singer the-famous not so talented. he popular because of outfit-his
ha-provokativi
the-provocative
'The famous singer is not so talented. He is popular because of his provocative outfits.'

mafgin kišaron	mafgin provokativiyut
demonstrates talent	demonstrates provokativeness
'demonstrates talent'	'demonstrates provokativeness'

(24) ha-lakoxot xašvu še-yo'ec ha-haška'ot ba'al nisayon u-te'udot
the-clients thought that-counsultant the-investments has experience and-certificates
'academiyot. ha-šarletanut šelo 'alta lahem harbe kesef.
academic. the-charlatanism his cost to them a lot money
'The clients thought the finance consultant has experience and academic certificates. His charlatanism cost them a lot of money.'

ha-yo'ec 'akademay	ha-yo'ec šarletan
the-consultant academic.	the-consultant charlatan
'The consultant is an academic'	'The consultant is a charlatan'

Filler Type B: PP in the preamble - no PP in the answers

(25) be-mišpaxat kohen xalukat tafkidim yocet dofen. ha-ba'al megadel 'et ha-
in family Cohen division roles exceptional. the-husband raises ACC the-
yeladim ve-ha-'iša yocet la'avod.
children and-the-wife goes out to work.
'In the Cohen family there is an exceptional role division. The husband raises the children and the wife goes out to work.'

ha-ba'al 'oved	ha-'iša 'ovedet
the-husband works	the-wife works
'The husband works'	'The wife works'

(26) be-wašington ha-kayic kaved. ha-laxut gvoha ve-en gešem
in Washington the-summer heavy. The-humidity high and-there is no rain
'In Washington the summer is oppressive. The humidity is high and there is no rain.'

ha-kayic lax	ha-kayic gašum
the-summer humid	the-summer rainy
'The summer is humid'	'The summer is rainy'

(27) mi-siba lo brura ‘anat he’esika ‘et ben dod-a. hu haya ‘asir toda.
from-reason not clear Anat employed ACC cousin-her. he was grateful.
‘For some reason Anat employed her cousin. He was grateful.’

ben ha-dod ho’asak	‘anat ho’aska
the-cousin was employed	Anat was employed
‘The cousin was employed’	‘Anat was employed’

(28) lifney šavu’a sufa xazaka nipca ‘et ha-xalonot ve-heziza ‘et ha-tmunot.
before week storm strong smashed ACC the-windows and moved ACC the-pictures.
ha-bayit notar hafux u-me’ubak.
the-house was left messed up and-dusty.
‘A week ago a strong storm smashed the windows and moved the pictures. The house was left messed up and dusty.’

ha-xalonot nupcu	ha-tmunot nupcu
the-windows were smashed	the-pictures were smashed
‘The-windows were smashed’	‘The-pictures were smashed’

(29) be-xalom-o ‘uri ra’a ganav nixnas ha-bayta. hu hit’orer miyad.
in-dream-his Uri saw thief entering the-house. he woke up immediately
‘In his dream Uri saw a thief entering the house. He woke up immediately.’

uri xalam	ha-ganav xalam
Uri dreamt	the-thief dreamt
‘Uri dreamt’	‘The thief dreamt’

(30) bizman ha-švita sar ha-‘ocar u-ncigey ha-morim nifgešu. hem
during the-strike minister the-treasury and-representatives the-teachers met. they
nisu limco derex liftor ‘et ha-mašber ha-noxexi.
tried to find way to solve ACC the-crisis the-current
‘During the strike, the Minister of the Treasury and the teachers’ representatives met. They tried to find a way to solve the current crisis.’

xipsu pitaron	mac’u pitaron
looked for solution	found solution
‘looked for a solution’	‘found a solution’

(31) be-yadayim ro'adot nas'a ha-melcarit 'et ha-magaš ha-kaved. menahel
in-hands shaking carried the-waitress ACC the-tray the-heavy. manager
ha-misa'ada ma'avid 'ota kaše[52]
the-restaurant makes work her hard
'With shaking hands the waitress carried the heavy tray. The restaurant manager makes her work hard.'

ha-melcarit 'ovedet kaše	ha-menahel 'oved kaše
the-waitress works hard	the-manager works hard
'The waitress works hard'	'The manager works hard'

Filler Type C: PP in the target sentence - no PP in the answers

(32) dali'a mora muzara. lelo siba hi 'ilca 'et 'amos lehitnacel.
Dalia teacher weird. without reason she forced ACC Amos to apologize.
'Dalia is a weird teacher. She made Amos apologize for no reason.'

ha-mora hitnacla	'amos hitnacel
the-teacher apologized	Amos apologized
'The teacher apologized'	'Amos apologized'

(33) ha-tabax xam mezeg. bli laxšov pa'amayim hu šavar 'et ha-calaxot ve-
the-cook hot temper. without thinking twice he broke ACC the-plates and-
šata 'et kol bakbuk ha-yayin.
drank ACC all bottle the-wine
'The cook is hot tempered. He broke the plates and drank all the wine bottle without thinking twice.'

ha-calaxot nišberu	ha-bakbuk nišbar
the-plates broke	the-bottle broke
'The plates broke'	'The bottle broke'

[52] This filler is a covert filler placed after the break point in the middle of the experiment.

(34) moti lo merukaz hayom. bli mesim hu nasa ‘axora ve-hipil
Moti not focused today. Without attention he drove backward and-knocked over
panas rexov
torch street
‘Moti is not focused today. Without paying attention, he drove backward and knocked over a street light.’

panas rexov nafal	moti nafal
light street fell	Moti fell
‘A street light fell’	‘Moti fell’

(35) kol šana ‘oto davar. ba-xagim ha-tisot mitmal’ot ve-ha-rexovot
every year same thing. in the-holidays the-flights are filled and-the-streets
mitroknim.
empty.
‘Every year it’s the same thing. On the holidays the flights are filled (with people) and the streets are empty.’

ha-tisot rekot	ha-rexovot rekim
the-flights empty	the-streets empty
‘The flights are empty’	‘The streets are empty’

(36) ‘orex ha-‘iton šixne’a ‘et ha-katav lekacer ‘et ha-ma’amar.
editor the-newspaper convinced ACC the-correspondent to shorten ACC the-article.
basof hu hexil rak xaci ‘amud.
at the end it contained only half page.
‘The newspaper editor convinced the correspondent to shorten the article. At the end it contained only half a page.’

ha-’orex kicer	ha-katav kicer
the-editor shortened	the-correspondent shortened
‘The editor shortened’	‘The correspondent shortened’

(37) ba’alat ha-bayit šalxa ‘et ha-‘ozeret liknot dagey salmon. beta’ut hi
owner the-house sent ACC the-maid to buy fish salmon. By mistake she
hevi’a dagey tuna.
brought fish tuna.
‘The householder sent the maid to buy salmon. By mistake she brought tuna fish.’

ba’alat ha-bayit kanta	ha-‘ozeret kanta
owner the-house bought	the-made bought
‘The householder bought’	‘The maid bought’

Filler Type D: PP in the preamble – PP in the answers

(38) be'emca ha-hofa'a ha-saxkan ha-raši šaxax 'et ha-milim. me'uxar yoter hu
in middle the-show the-actor the-main forgot ACC the-words. Later more he will
yekabel nezifa.
get reprimand.
'In the middle of the show, the main actor forgot the words. Later he will get a reprimand.'

ninzaf be-'emca ha-hofa'a šaxax be-'emca ha-hofa'a
was reprimanded in the-middle the-show forgot in-the middle the-show
'was reprimanded in the middle of the show' 'forgot in the middle of the show'

(39) be-hitlahavut gdola ha-kore'ograf hidrix 'ex lirkod 'et ha-rikud.
in-enthusiasm big the-choreographer instructed how to dance ACC the dance
hu haya kicbi ve-soxef.
it was upbeat and-sweeping.
'With great enthusiasm the choreographer taught [how to dance] the dance. It was upbeat and exciting.'

hidrix be-hitlahavut lirkod be-hitlahavut
instructed in-enthusiasm to dance in-enthusiasm
'instructed with enthusiasm' 'to dance with enthusiasm'

(40) 'axrey ha-hacba'a ha-sarim niš'aru lesoxe'ax. rak roš ha-memšala
after the-vote the-ministers stayed to talk. only head the-government
u-sgan-o ' 'azvu 'et ha-makom.
and-deputy-his left ACC the-place.
'After the vote the ministers stayed to talk. Only the Prime Minister and his deputy left the place.'

kol ha-sarim 'azvu 'axrey ha-hacba'a roš ha-memšala 'azav 'axrey ha-hacba'a
All the-ministers left after the-vote head the-government left after the-vote
'All the ministers left after the vote' 'The Prime Minister left after the vote.'

(41) bizman ha-xufša yoram nehena ledamyen ‘et ‘acmo ve-‘et-dafna
during the-vacation yoram enjoyed to imagine ACC himself and-ACC-Dafna
mitxatnim. hu hexlit lehaci’a la nisu’im
getting married. he decided to propose to her marriage.
‘During the vacation Yoram enjoyed imagining himself and Dafna getting married.
He decided to propose to her.’

dimyen bizman ha-xufša	hitxaten bizman ha-xufša
imagined during the-vacation	got married during the-vacation
‘imagined during the vacation’	‘got married during the vacation’

(42) be-sof ha-seret mitgale ha-roce’ax. zot hayta hafta’a.
at-end the-movie is revealed the-murderer. it was surprise
‘At the end of the movie the murderer was revealed. It was a surprise.’

ha-roce’ax ne’enaš be-sof ha-seret. ha-roce’ax nexsaf be-sof ha-seret.
the-murderer is punished at-end the-movie. the-murderer is revealed at-end the-movie
‘The murderer is punished at the end of the movie.’ ‘The murderer is revealed at the end of the movie’

(43) bi-štayim ha-nasi siyem lin’om ‘et ne’um-o. ha-ma’azinim ve-
at-two the-president finished to deliver ACC speech-his. the-listeners and-
civtey ha-televizya lo hitrašmu
crews the-television not were impressed
‘At two the President finished giving his speech. The listeners and the TV crews were not impressed.’

ha-ne’um ne’erax bi-štayim	ha-ne’um histayem bi-štayim
the-speech took place at- two	the-speech ended at-two
‘The speech took place at two’	‘The speech ended at two’

<u>Filler Type E:</u> <u>PP in the target sentence – PP in the answers</u>

(44) ‘erez xošev še-’axot-o lo ‘axra’it. be-xoser racon hu limed ‘ota linhog
Erez thinks that-sister-his not responsible. in-lack will he taught her to drive
‘Erez thinks his sister is irresponsible. Against his will he taught her how to drive.’

limed be-xoser racon	linhog be-xoser racon
taught in-lack will	to drive in-lack will
‘taught without any will’	‘to drive without any will’

(45) no'am hu 'av yoce dofen. be-kor ru'ax hu 'oded 'et ban-av
Noam is father exceptional. in-composure he encouraged ACC sons-his
likpoc bunji.
to jump bungee
'Noam is an exceptional father. With composure he encouraged his sons to bungee jump.'

'oded be-kor ru'ax	likpoc be-kor ru'ax
encouraged in-composure	to jump in-composure
'encouraged with composure'	'to jump with composure'

(46) ha-ru'ax hayta xazaka. be-koši rav šixne'a rav haxovel 'et ha-malaxim
the-wind was strong. in-difficulty great persuaded the captain ACC the-sailors
lehaxlif 'et ha-mifrasim
to replace ACC the-sails
'The wind was strong. With great difficulty the captain persuaded the sailors to replace the sails.'

šixne'a be-koši rav	hexlif be-koši rav
persuaded in-difficulty great	replaced in-difficulty great
'persuaded with great difficulty'	'replaced with great difficulty'

(47) ši'ur ha-ciyur histayem. 'al ha-šulxan niš'aru cva'im u-mikxolim, ve-ha-
class the-drawing ended. on the-table remained paints and-brushes, and-the-
talmidim lakxu 'et ha-ciyurim.
students took ACC the-drawings.
'The drawing class ended. On the table the paints and brushes remained, and the students took the drawings.'

notru cva'im 'al ha-šulxan	notru ciyurim 'al ha-šulxan
were left colors on the-table	were left drawings on the-table
'Paints were left on the table'	'Drawings were left on the table'

(48) 'ani ma'adif nehiga 'al tisa. be-rexev 'ani margiš batu'ax ve-ragu'a.
I prefer driving on flying. in-vehicle I feel safe and-calm
'I prefer driving to flying. In a vehicle I feel safe and calm.'

xared be-rexev	šalev be-rexev
anxious in-vehicle	peaceful in-vehicle
'anxious in vehicle'	'peaceful in a vehicle'

(49) menahel ha-televizya hibi'a 'i svi'ut racon. ba-layla yeš harbe
manager the-TV expressed lack content. in the-night there are many
toxniyot televizya aval 'en cofim.
programs TV but there aren't watchers.
'The TV manager was not pleased. At night there are many TV programs but no watchers.'

hibi'a ba-layla	'en cofim ba-layla
expressed at the-night	there aren't watchers at the- night
'expressed at night'	'no watchers at night'

APPENDIX B: INSTRUCTIONS FOR PARTICIPANTS

APPENDIX B-1: Instructions for Experiment 1

Hebrew

<u>הנחיות לניסוי</u>

- בתחילת כל פריט ניסוי יופיע על המסך סימן +. לחץ על מקש הרווח ואז יוצגו על המסך שני משפטים. כשהם יופיעו, הינך מתבקש לקרוא אותם בקול לתוך המיקרופון. קרא בצורה שוטפת וטבעית ככל האפשר.

- כאשר תסיים את הקריאה, לחץ על המקש האדום. על המסך יתווספו שני משפטים קצרים. אנא החלט איזה מהם תואם ביותר למשפטים שקראת. בחר את התשובה בלי לחשוב זמן רב או להתעמק בה. כאשר מדובר בשפה, לעיתים קרובות אין תשובה אחת נכונה בלבד. אנחנו רק מעוניינים בשיפוטך האישי. <u>אנא הקפד לקרוא את שתי התשובות לפני שאתה בוחר אחת מהן</u>.

- קרא בקול לתוך המיקרופון את התשובה שבחרת ולאחר מכן לחץ שוב על המקש האדום. לאחר הלחיצה יופיע שוב סימן ה + שיציין שהגעת לפריט הבא. חזור על אותן הפעולות בכל הפריטים הבאים.

- שים לב, בנוסף לפריטי הניסוי יופיעו משפטי הנחייה שיורו לאיזה שלב של הניסוי הגעת (למשל, תרגול, התחלת הניסוי או הפסקה). לאחר שקראת משפטים אלה לחץ על מקש הרווח כדי לעבור למסך הבא. כלומר, לחץ על המקש האדום אך ורק כאשר אתה מסיים לקרוא את המשפטים או התשובה לתוך המקרופון. בכל שאר המקרים לחץ על מקש הרווח.

<u>לסיכום</u>

<u>לחץ על מקש הרווח</u>:
- כשמופיע הסימן +
- במשפט הנחייה (הגעת לתרגול, התחלת הניסוי או הפסקה)

<u>לחץ על המקש האדום</u>:
- בסיום הקראת משפט או תשובה

<u>דוגמה</u>:

+

(לחץ על מקש הרווח)

ההורים המודאגים לא שמעו מבתם כל היום.
בחצות היא סוף סוף צלצלה.

(קרא בקול את שני המשפטים לתוך המיקרופון)

(לחץ על המקש האדום)

קיבלו צלצול **קיבלו אי-מייל**

(קרא בקול את המבע שתואם יותר למשפטים שקראת)

(לחץ על המקש האדום)

+

(חזור על אותן פעולות)

כעת נעבור לתרגול על המסך.

English translation

Instructions for the experiment

- On the screen the + sign will appear. Press the Space Bar key and two sentences will appear. When they appear, you should read them aloud into the microphone. Read in an as much as possible clear and natural manner.

- When you finish reading, press the red key. On the screen additional two brief statements will appear. Please decide which of them is more compatible with the sentences you read. Make your choice spontaneously without thinking too long or deeply about it. When it comes to language there are often no right or wrong answers. We are interested in your own personal judgments. Please make sure to read the two answers before you select one.

- Read aloud the answer you selected into the microphone and then press the red key again. On the screen will appear the + sign again to indicate you have reached the next item. Follow the same instructions for all the following items.

- Please notice that, in addition to the experimental items, there will also appear sentences that will tell you which stage of the experiment you have reached (practice, beginning of the experiment or a break). After reading these sentences, press the Space Bar key to move into the next frame. In other words, press the red key only when you finish reading the sentences or the answers into the microphone. In all the other cases, press the Space Bar key.

To summarize

Press the Space Bar Key:
- when the + sign appears
- when you see a directive sentence (a sentence which informs you you have reached practice, beginning of the experiment or a break)

Press the red key:
- after reading aloud a sentence or an answer

Example:

+

(press the spacebar key)

The worried parents didn't hear from their daughter the whole day.
At midnight at last she called.

(read the two sentences aloud into the microphone)

(press the red key)

---

received an e-mail **received a phone call**

(read aloud into the microphone the statement that is most compatible with the sentences you read)

(press the red key)

+

(repeat the same instructions)

Now we will turn to a practice session on the screen.

APPENDIX B-2: Instructions for Experiment 2

Hebrew

<u>הנחיות לניסוי</u>

- בתחילת כל פריט ניסוי יופיע על המסך סימן +. לחץ על מקש הרווח ואז יוצגו על המסך שני משפטים. כשהם יופיעו, הינך מתבקש לקרוא אותם בשקט. (במהלך הקריאה, חשוב שתבין את המשפטים כדי שתוכל לענות על השאלות במסך הבא).

- כאשר סיימת את הקריאה והבנת את המשפטים, לחץ על המקש הירוק. על המסך יופיעו שני משפטים קצרים. אנא החלט איזה מהם תואם ביותר למשפטים שקראת. בחר את התשובה בלי לחשוב זמן רב או להתעמק בה. כאשר מדובר בשפה, לעיתים קרובות אין תשובה אחת נכונה בלבד. אנחנו רק מעוניינים בשיפוטך האישי. <u>אנא הקפד לקרוא את שתי התשובות לפני שאתה בוחר אחת מהן</u>.

- אם בחרת את התשובה הימנית, לחץ על המקש הירוק. אם בחרת את התשובה השמאלית לחץ על המקש האדום. לאחר הלחיצה יופיע שוב סימן ה + שיציין שהגעת לפריט הבא. חזור על אותן הפעולות בכל הפריטים הבאים.

- שים לב, בנוסף לפריטי הניסוי יופיעו משפטי הנחייה שיורו לאיזה שלב של הניסוי הגעת (למשל, תרגול, התחלת הניסוי או הפסקה). לאחר שקראת משפטים אלה לחץ על מקש הרווח כדי לעבור למסך הבא.

<u>לסיכום</u>

<u>לחץ על מקש הרווח</u>:
- כשמופיע הסימן +
- במשפט הנחייה (הגעת לתרגול, התחלת הניסוי או הפסקה)

<u>לחץ על המקש הירוק</u>:
- בסיום הקראת 2 המשפטים.
-לבחור את התשובה הימנית.

<u>לחץ על המקש האדום</u>:
-לבחור את התשובה השמאלית.

<u>דוגמה</u>:

+

(לחץ על מקש הרווח)

ההורים המודאגים לא שמעו מבתם כל היום.
בחצות היא סוף סוף צלצלה.

(קרא בשקט את שני המשפטים)

(לחץ על המקש הירוק)

קיבלו צלצול **קיבלו אי-מייל**

(לבחירת התשובה הימנית - לחץ על המקש הירוק)

(לבחירת התשובה השמאלית - לחץ על המקש האדום)

+

(חזור על אותן פעולות)

כעת נעבור לתרגול על המסך.

English translation

Instructions for the experiment

- On the screen the + sign will appear. Press the Space Bar key and two sentences will appear. When they appear, you should read them silently (It is important that you understand these sentences while reading so that you can answer the questions on the next frame).

- When you finish reading and understand the sentences, press the green key. On the screen two brief statements will appear. Please decide which of them is more compatible with the sentences you read. Make your choice spontaneously without thinking too long or deeply about it. When it comes to language there are often no right or wrong answers. We are interested in your own personal judgments. Please make sure to read the two answers before you select one.

- If you selected the answer on the right, press the green key. If you selected the answer on the left, press the red key. After pressing one of the keys, the + sign will appear on the screen again to indicate you have reached the next item. Follow the same instructions for all the following items.

- Please notice that, in addition to the experimental items, there will also appear sentences that will tell you which stage of the experiment you have reached (practice, beginning of the experiment or a break). After reading these sentences, press the Space Bar key to move to the next
  frame.

To summarize

Press the Space Bar Key:
- when the + sign appears
- when you see directive sentence (a sentence which informs you you have reached practice, beginning of the experiment or a break)

Press the green key:
- after reading the two sentences
- to select the answer on the right

Press the red key:
- to select the answer on the left

Example:

+

(press the spacebar key)

The worried parents didn't hear from their daughter the whole day.
At midnight at last she called.

(read the two sentences silently)

(press the green key)

---

received an e-mail **received a phone call**

(press the green key to select the answer on the right)

(press the red key to select the answer on the left)

+

(repeat the same instructions)

Now we will turn to a practice session on the screen.

APPENDIX B-3: Instructions for the pre-test

Hebrew

תינתן לך סידרה של זוגות משפטים. הנך מתבקש לקרוא את שני המשפטים אבל לשפוט אך ורק את המשפט השני. מתחת לכל זוג משפטים תופיע סקלה. בכל אחת מקצות הסקלה יופיע אחד משני הפרושים האפשריים למשפט.
אנא סמן בעזרת הקווים על הסקלה את המידה בה כל אחד מהפירושים מבטא את משמעות המשפט.
ככל שהקו קרוב יותר לקצה הוא מביע קרבה גדולה יותר במשמעות לפירוש באותו קצה. מכאן, למשל, שסימון של הקו החיצוני ביותר מציין שהפירוש באותו קצה הוא הפירוש האפשרי היחיד של המשפט. כמו כן, סימון הקו האמצעי מציין ששני הפירושים מביעים את משמעות המשפט במידה שווה.

לדוגמא, להלן מספר אפשרויות סימון בתגובה למשפט הבא:

האומן מבצלאל ביקר בבית היתומים. הוא צייר ציור עבור הילד עם המכחול.

א) סימון הקו האמצעי מראה שהמשפט יכול להתפרש ע"י הפרושים: האומן צייר עם מכחול ("צייר עם מכחול") ולילד יש מכחול ("הילד עם המכחול") במידה שווה.

צייר עם מכחול |___|___|___|___|___|___|___| הילד עם המכחול

ב) סימון של הקו השמאלי ביותר מראה שהפירוש "לילד יש מכחול" הוא האפשרי היחיד.

צייר עם מכחול |___|___|___|___|___|___|___| הילד עם המכחול

ג) סימון של קו הקרוב יותר לקצה הימני של הסקלה מעיד שהמשפט קרוב יותר למשמעות "האומן צייר עם מכחול" מאשר למשמעות "לילד יש מכחול".

צייר עם מכחול |___|___|___|___|___|___|___| הילד עם המכחול

כשהכנתי את המשפטים ניסיתי ליצור משפטים דו משמעיים בהם שני הפרושים אפשריים במידה שווה. חשוב לי לדעת אם חלק מהמשפטים אינם דו משמעיים לגמרי. על סמך שיפוטכם אבחר לניסוי שלי את המשפטים הכי דו משמעיים.
אל תופתעו אם לא תמצאו צורך להשתמש בקצוות הסקלה משום שיצרתי את המשפטים בכוונה שיהיו דו משמעיים בצורה שווה עד כמה שניתן.

English translation

You will be presented with a series of sentence pairs. Please read the two sentences but judge only the second. Below each sentence pair there will be a scale. At the edge of each side of the scale will appear a statement that will represent one of the two possible meanings of the given sentence. You are asked to use the lines on the scale to mark the extent to which each of the two statements could be implied by the sentence. The closer the line is to the edge, the more strongly it represents the meaning of the sentence stated at that edge. Thus, for example, the last line at the edges indicates that the sentence could mean only the statement at that edge. Likewise, the line in the center indicates that the sentence could mean each of the interpretations to the same extent.

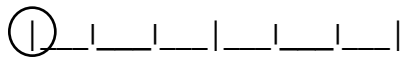
For example, consider the following possible responses to the sentence below:

1) The artist from Bezalel visited the orphanage. He painted a picture for the boy with a brush.

A) Circling the middle line indicates the sentence is equally ambiguous between the meanings: the artist painted with a brush (‘painted with a brush’) and the boy has a brush (‘the boy with a brush’).

painted with a brush  the boy with a brush[53]

B) Circling the line at the left hand edge would indicate the sentence could only mean “painted with a brush”.

painted with a brush  the boy with a brush

C) Circling a line closer to the right hand edge indicates the sentence implies more strongly the interpretation “the boy with a brush” and less strongly “painted with a brush”.

painted with a brush  the boy with a brush

[53] Hebrew is read from right to left therefore the answer on the right is more likely to be read first. To reflect that sequence of reading, the order of presentation of the answers in this translation is in reverse to the order of presentation in the examples in Hebrew above.

When I prepared the sentences, I tried to create them evenly balanced with respect to the two possible interpretations. It is important for me to know if some of them are not as evenly balanced as the others. Based on your judgment, I will choose the sentences that are most balanced. Don't be surprised if you don't use often the ends of the scale, as I created the sentences in the intention of being equally ambiguous.

APPENDIX C: LANGUAGE BACKGROUND QUESTIONNAIRE

APPENDIX C-1: Language background questionnaire for Experiments 1 and 2

מס' קוד

שאלון פרטים אישיים

המידע שיימסר הינו חסוי וישמש לצורכי עבודת המחקר בלבד. השאלון הינו אנונימי.

גיל: ..... מין: □ זכר □ נקבה תעסוקה.....

עיר הולדתך.....ארץ הולדתך .....

מלבד עברית, האם הוריך מדברים שפות נוספות בבית?
□ לא
□ כן אילו?.....

מהי שפת האם שלך? ..... אם לא עברית, באיזה גיל התחלת ללמוד עברית? .....

באיזה גיל התחלת ללמוד אנגלית? .....

מהי רמת הדיבור שלך באנגלית? □ שוטף □ די טוב □ לא כל כך טוב □ מעט □ בכלל לא

האם את/ה יודע/ת שפות נוספות?

השפה	הגיל בו למדת שפה זו	רמת ידע בשפה (ע"פ הדרוג למעלה)
.....	.....	.....
.....	.....	.....
.....	.....	.....

האם בשלב כלשהו בעברך גרת מחוץ לישראל לתקופה ארוכה משנה?
□ לא
□ כן תאר/י בקצרה היכן, מתי, ולכמה זמן: .....
.....

השכלה: האם עברית היא השפה העיקרית בה למדת במוסדות החינוך הבאים?

בי"ס יסודי	□ כן	□ לא	□ בשפה אחרת (ציין איזה).....
בי"ס תיכון	□ כן	□ לא	□ בשפה אחרת (ציין איזה).....
תואר ראשון	□ כן	□ לא	□ בשפה אחרת (ציין איזה).....
תואר שני ומעלה	□ כן	□ לא	□ בשפה אחרת (ציין איזה).....

האם את/ה כותב/ת ביד ימין או שמאל? □ ימין □ שמאל
האם יש לך קרובי משפחה שמאליים? (אנא פרט/י) .....
.....

אנא וודא/י שענית על כל התשובות
תודה על שיתוף הפעולה!

English translation

LANGUAGE BACKGROUND QUESTIONNAIRE

Code No.: …….

All personal information you will provide is confidential.

Age:..... Sex: □ male □ female Occupation:……

City of origin…….Country of origin.....

Besides Hebrew, do your parents speak other languages at home?

□ no
□yes which ones? ……..…

What is your native (first-learned) language?…….…….…….……..

If Hebrew is not your native language, at what age did you start to learn Hebrew? .....

At what age did you start to learn English? ....

What is your speaking level in English? …….

□ fluent □ relatively good □ not so good □ little □ not at all

Do you know other languages?

the language(s)	the age you learned it	level of proficiency (based on the levels above)
……	……...	……
……	……...	….……...
……	……...	……...

Have you ever spent any time longer than a year living outside Israel?
□no
□yes describe briefly where, when and for how long?.....
……

Has Hebrew been the main language for your education in the institutions below:

Elementary school:	yes	no	Other (please specify) …….
High school:	yes	no	Other (please specify) …….
College:	yes	no	Other (please specify) …….
Graduate school:	yes	no	Other (please specify) …….

Are you right-handed or left-handed? □ right-handed □ left-handed
Do you have any left-handed blood relatives? (Please list them)
……
……

Please make sure you answered all the questions
Thank you for your cooperation!

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