

THE INTERPLAY OF SYNTACTIC PARSING STRATEGIES AND
PROSODIC PHRASE LENGTHS IN PROCESSING TURKISH
SENTENCES

by

NAZİK DİNÇTOPAL-DENİZ

A dissertation submitted to the Graduate Faculty in Linguistics in partial fulfillment of
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ABSTRACT

THE INTERPLAY OF SYNTACTIC PARSING STRATEGIES AND PROSODIC PHRASE LENGTHS IN PROCESSING TURKISH SENTENCES

by

NAZİK DİNÇTOPAL-DENİZ

Advisor: Janet Dean Fodor

Many experiments have shown that the prosody (rhythm and melody) with which a sentence is uttered can provide a listener with cues to its syntactic structure (Lehiste, 1973, and since). A few studies have observed in addition that an inappropriate prosodic contour can mislead the syntactic parsing routines, resulting in a prosody-induced garden-path. These include, among others, Speer et al. (1996) and Kjelgaard and Speer (1999) for English. The studies by Speer et al. and Kjelgaard and Speer (SKS) showed that misplaced prosodic cues caused more processing difficulty in sentences with early closure of a clause (EC syntax) than in ones with late closure of a clause (LC syntax). One possible explanation for these results is that when prosody is misleading about the syntactic structure, the parser may ignore it and resort to a syntactic Late Closure strategy, as it does in reading where there is no overt prosodic boundary to inform the parser about the syntactic structure of the sentence. Augurzky's (2006) observation of an LC syntax advantage for prosody-syntax mismatch conditions in her investigation of German relative clause attachment ambiguities provides support for this explanation.

An alternative explanation considers the possibility that constituent lengths could have influenced the perceived informativeness of overt prosodic cues in these studies, as proposed in the Rational Speaker Hypothesis of Clifton et al. (2002, 2006). The Rational Speaker Hypothesis (RSH) maintains that prosodic breaks flanking shorter constituents are taken more seriously as

indicators of syntactic structure than prosodic breaks flanking longer constituents, because the former cannot be justified as motivated by optimal length considerations. To test these two alternative hypotheses, four listening experiments were conducted. There was an additional reading experiment preceding the listening experiments to explore potential effects of the Late Closure strategy and constituent lengths in reading where there is no overt prosody. In all cases the target materials were temporarily ambiguous Turkish sentences which could be morphologically resolved as either LC or EC syntactic constructions. Constituent lengths were systematically manipulated in all target materials, such that the length-optimal prosodic phrasing was associated with LC syntax in one condition, and with EC syntax in the other.

Experiment 1 employed a missing morpheme task developed for this study. In the missing morpheme task, underscores (length-averaged) replaced the disambiguating morphemes and participants had to insert them as they read the sentences aloud. Results revealed significant effects of phrase lengths in readers' syntactic interpretations as indicated by the morphemes they inserted and the prosodic breaks they produced.

Experiments 2A and 2B employed an end-of-sentence 'got it' task (Frazier et al., 1983), in which participants listened to spoken sentences and indicated after each one whether they understood or did not understand it. Sentences in Experiment 2A had phrase length distribution similar to the SKS English materials. Experiment 2B manipulated lengths in reverse. The stimuli had cooperating, conflicting or neutral prosody. Response time data supported an interplay of both syntactic Late Closure and RSH. Thus it was concluded that constituent lengths can indeed have a significant effect on listeners' parsing decisions, in addition to the familiar syntactic parsing biases and prosodic influences.

Experiments 3A and 3B used a lexical probe version of the phoneme restoration paradigm employed by Stoyneshka et al. (2010). In the phoneme restoration paradigm, the disambiguating phonemes (in the verb, in these materials) are replaced with noise (in this study, pink noise). In the lexical probe version of this paradigm (developed for this study) participants listened to the sentences with LC, EC or neutral prosody, and at the end of the sentence they were presented with a visual probe (one of the two possible disambiguating verbs, complete with all phonemes) that was congruent or incongruent or compatible with the prosody of the sentence they had heard. Their task was to respond to the visual probe either ‘yes’ (i.e., ‘I heard this word in the sentence I have just listened to’) or ‘no’ (i.e., ‘I didn’t hear this word’). Response time to the probe word indirectly taps which of the disambiguating morphemes on the verb the listener mentally supplies when it has been replaced by noise. The materials for Experiments 3A and 3B were identical to those used in Experiments 2A and 2B respectively except that the disambiguating phonemes were noise-replaced.

Results of Experiments 3A and 3B showed that listeners were highly sensitive to the sentential prosody as revealed by their phoneme restoration responses and response time data, confirming Stoyneshka et al.’s findings establishing the reliability of the phoneme restoration paradigm in investigating effects of prosody in ambiguity resolution. Response time data showed a pattern similar to what SKS observed for English (except for one condition in Experiment 3A, with incongruent probes): despite the phrase length reversal in Experiment 3B, there was no influence of phrase length distribution on ambiguity resolution. This has a natural explanation in light of the difference between the ‘got it’ task with disambiguating morphology within the sentence stimulus, and the phoneme restoration task in which the listener can project onto the verb whatever morphology is compatible with the heard prosody. LC and EC were processed

equally well for congruent probes, and there was an LC advantage in the incongruent and compatible probe conditions.

Overall results support the hypothesis that syntactic Late Closure becomes evident in listening when prosody is absent or misleading, and also that phrase lengths can play a significant role.



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LIST OF ABBREVIATIONS

1	First Person
3	Third Person
ABL	Ablative
ACC	Accusative
FN	Factive Nominal
GEN	Genitive
NOM	Nominative
PASS	Passive
PAST	Past
PL	Plural
POSS	Possessive
PROG	Progressive
SG	Singular

CHAPTER 1. INTRODUCTION

1.1. Overview

One of the most influential theories in sentence processing research, the Garden Path Model, maintains that the human language parsing mechanism (henceforth *the parser*) is guided by universal syntactic parsing strategies such as Late Closure, Minimal Attachment (Frazier, 1978) and the Minimal Chain Principle (De Vincenzi, 1991). Consider the ease of reading (1) and (2) below (without any commas indicating the syntactic structure).

- (1) When Roger leaves the house it's dark.
- (2) When Roger leaves the house is dark.

(Kjelgaard & Speer, 1999, p. 153)

According to the Late Closure (LC) principle, whose predictions are tested in this dissertation, incoming words are preferentially attached into the phrase currently being processed. This is the case in (1), where the incoming words, *the house*, attach locally into the verb phrase currently being processed. However, the parser would face difficulty in processing (2) because the LC strategy would favor the analysis *Roger leaves the house*, whereas the correct analysis of (2) has *the house is dark*, with Early Closure (EC) of the first clause *Roger leaves*.

Studies contributing to the original development of the Garden Path Model and other models at the time were based mostly on data from reading studies, because it was cumbersome to study spoken language before adequate software tools became available. Research investigating the processing of spoken language indicates that prosodic cues¹ can have a facilitatory effect when located at syntactically appropriate positions in utterances (Kjelgaard & Speer, 1999; Lehiste,

¹ Prosody is the stress, rhythm, and intonation in spoken utterances, which have measurable acoustic-phonetic correlates, such as variation in fundamental frequency, amplitude and duration.

1973; Marslen-Wilson, Tyler, Warren, Grenier, & Lee, 1992; Nagel, Shapiro, Tuller, & Nawy, 1996; Price, Ostendorf, Shattuck-Hufnagel, & Fong, 1991; Schafer, Speer, Warren, & White, 2000; Speer, Kjelgaard, & Dobroth, 1996; Stoyneshka, et al., 2010). For instance, a pause after *leaves* or an increased pitch accent on *leaves* could prevent the parser being tempted by the incorrect LC analysis in (2). Some studies found prosodic cues to be so influential that they would mislead the parser towards an incorrect interpretation when presented at syntactically inappropriate positions (i.e., a prosodic boundary after *leaves* in (1) or after *the house* in (2)). Speer et al. and Kjelgaard and Speer reported an interesting mis-match asymmetry for such conditions. It was found that incorrect clause boundary prosody disrupted the parsing of EC sentences like (2) more than it disrupted the parsing of LC sentences like (1).

This dissertation study investigates two possible explanations for this asymmetry. (i) Does the LC strategy apply not only when prosody is absent but also when it is not supportive? (ii) And/or do phrase lengths affect the perceived informativeness of prosodic cues? The answers to these questions will have consequences for our understanding of the nature of the interplay between prosodic and syntactic information in human language processing. Experiments are conducted in Turkish, a language well-suited to this study (see Chapter 3) but which has not been previously investigated in relation to the role of prosody in syntactic parsing and comprehension.

1.2. Previous Findings and Their Interpretation

Speer et al. and Kjelgaard and Speer (henceforth abbreviated as SKS) investigated LC/EC ambiguities such as (1) and (2) above, with cooperating, conflicting and neutral (baseline) prosody. They employed acceptability judgment, end-of-sentence comprehension, and cross-modal naming tasks (see Chapter 2 for more details on the SKS experiments). Experimental items had three prosodies: cooperating, conflicting and neutral as in (3). (|| marks prosodic

boundary, / marks syntactic boundary and boldface indicates contrastive focus to elicit neutral prosody elsewhere in the sentence; details of how each prosody was elicited can be found in Chapter 2.)

- (3) a. Cooperating prosody, LC syntax: When Roger leaves the house || / it's dark.
- b. Cooperating prosody, EC syntax: When Roger leaves || / the house is dark.

- c. Conflicting prosody, LC syntax: When Roger leaves || the house / it's dark.
- d. Conflicting prosody, EC syntax: When Roger leaves / the house || is dark.

- e. Neutral prosody, LC syntax: When **Roger** leaves the house / it's dark.
- f. Neutral prosody, EC syntax: When **Roger** leaves / the house is dark.

(Kjelgaard & Speer, 1999, p. 156)

Within the cooperating prosody conditions, LC and EC structures were processed equally efficiently. In the neutral prosody conditions, there was an advantage for the LC structure, which can be attributed to the parser following the syntactic processing strategy of LC, as it does in reading where there is also an absence of prosodic information. For purposes of the present study, the observation of main interest is the finding of an advantage for the LC structure in the conflicting prosody conditions.

SKS list some possible explanations, specific to their study, for this asymmetry (e.g., a possible topicalized noun phrase reading of the ambiguously attached NP in the LC-syntax conflicting conditions, such as *the house, it's dark*). However, a proposal of a general default LC parsing strategy which applies not just when prosody is absent but also when prosody is perceived as uninformative is especially worthy of further investigation because of a similar LC syntax advantage observed in a subsequent study by Augurzky (2006) in a different syntactic construction (relative clause attachment ambiguity) in a different language (German).

Augurzky investigated relative clause (RC) attachment ambiguities in German such as (4) using ERP methodology. It should be noted that the lower RC-attachment site is an instance of

LC syntax and the higher attachment site is an instance of EC syntax as in the corresponding construction in English².

- (4) a. Cooperating prosody, LC syntax (low RC attachment)
Das ist die Köchin / || des Wirts dessen Pudel nervtötend winselte.
- b. Cooperating prosody, EC syntax (high RC attachment)
Das ist die Köchin des Wirts / || deren Pudel nervtötend winselte.
- c. Conflicting prosody, LC syntax (low RC attachment)
Das ist die Köchin / des Wirts || dessen Pudel nervtötend winselte.
- d. Conflicting prosody, EC syntax (high RC attachment)
Das ist die Köchin || des Wirts / deren Pudel nervtötend winselte.

‘This is the cook_{fem} of the publican_{masc} whose_{fem/masc} poodle nervingly (*sic*) whimpered.’

(Augurzky, 2006, p. 180)

The results showed a profile very similar to that of the SKS studies. A negative-going deflection (an N400 effect, indicating processing difficulty) was observed on the relative pronoun for the conflicting prosody condition with LC prosody and EC syntax as in (4d), but this was absent when LC syntax was pronounced with EC prosody or when the prosody and syntactic structure cooperated.

However, a study by Schafer and colleagues (Schafer, et al., 2000) showed an advantage for EC structures in conflicting prosody conditions in a comprehension task. Schafer et al. investigated an LC/EC temporary ambiguity in English similar to that studied by SKS (examples below). In their comprehension experiment, participants listened to the syntactically ambiguous fragment of the temporarily ambiguous sentences (with LC, EC or ambiguous prosody). Their

² Syntactic disambiguation is by gender agreement. The lower attachment site reflects LC syntax since the RC (‘dessen_{masc} Pudel nervtötend winselte’) is associated with the immediately preceding noun ‘Wirts_{masc}’, while the higher attachment site reflects EC syntax, since the phrase ‘die Köchin des Wirts’ is closed off before the RC (‘deren_{fem} Pudel nervtötend winselte’) is attached to that complete phrase, which is headed by the higher noun ‘Köchin_{fem}’.

task was to choose the appropriate continuation of the sentence (LC or EC) presented on a computer screen upon listening to the syntactically ambiguous fragment.

(5)	<i>Spoken fragment</i> When that moves the square ...	<i>Continuations</i> a. LC: ... it should land in a good spot. b. EC: ... will encounter a cookie.

Results for the conflicting prosody condition showed that they chose EC continuations successfully despite the conflicting prosodic cue whereas their performance was at chance for LC continuations. Schafer et al. suggest as an explanation for this asymmetry that prosodic information was lost in some conditions due to truncated sentences (see further details in Chapter 2). However, the fact that the materials in the SKS and Schafer et al. studies had essentially the same syntactic structures makes this contrast in the findings intriguing. The following section discusses the LC advantage in SKS and Augurzky and the EC advantage in Schafer et al. studies from a different perspective.

1.3. A Novel Explanation of the Conflicting Prosody Results

The overlapping outcomes of the SKS and Augurzky studies are intriguing in view of how different the constructions tested were, while the EC advantage in the Schafer et al. study presents a contrast to the SKS studies as the structures tested were very much alike. However, there is another overlap between these experiments which could also possibly explain the data. The alternative explanation is related to the lengths of the prosodic phrases, and it derives from research demonstrating the effects of phrase lengths on the perceived informativeness of prosodic cues. Neither SKS nor Augurzky nor Schafer et al. systematically manipulated the length of the phrases in their sentence materials. However, the Rational Speaker Hypothesis (RSH) formulated by Charles Clifton and colleagues (Clifton, Carlson, & Frazier, 2002, 2006) proposes that prosodic breaks flanking short constituents are treated by perceivers as more

informative about the syntactic structure of an utterance than prosodic breaks flanking long constituents. The rationale is that if a prosodic break might have been produced by the speaker in order to divide up an over-long constituent, then it may not be taken seriously by listeners as an indicator of syntactic structure; however, a prosodic break that has no length motivation is more likely to be attributed by listeners to the needs of the syntactic structure, and thus could have a greater impact on what structure is assigned to the sentence. Thus, a listener might reasonably regard prosodic boundaries flanking short constituents as more likely to reflect the syntactic structure than ones flanking longer constituents. Support for this hypothesis was provided by data from NP coordination and adverb phrase attachment in English (Clifton, et al., 2006)³.

For Kjelgaard and Speer's conflicting prosody conditions (3c) and (3d), repeated below for convenience as (6a) and (6b), it can be observed that the length of constituents before and after the prosodic boundary could have possibly affected the results.

- (6) a. Conflicting prosody, LC syntax: When Roger leaves || the house / it's dark.
- b. Conflicting prosody, EC syntax: When Roger leaves / the house || is dark.

In the EC syntax condition with conflicting LC prosody, (6b), the prosodic break is placed before a short constituent, *is dark* (1 prosodic word (PWd), 2 syllables). According to the RSH, it would be taken as a strong cue to syntactic disambiguation since constituent length cannot justify the break. However, in the LC syntax condition with conflicting EC prosody, (6a), the prosodic break occurs between two longer units (*when Roger leaves* (3 PWds and 4 syllables) and *the house it's dark* (2 PWds and 4 syllables)). The RSH therefore implies that the EC prosodic break in (6a) is not as strong a cue to syntactic disambiguation for perceivers as the LC prosodic break in (6b) is. Thus, the SKS finding of greater resilience of LC syntax to conflicting prosody might

³ Note that Clifton et al. (2006) counted number of syllables in their definition of length. However, I mainly refer to the number of prosodic words in discussion of length.

be due to a tendency for listeners to disregard the EC prosodic break that conflicts with the LC syntax. If so, this would be a fact about the particular sentences used in the SKS experiments, given their specific distributions of phrase length.

Similar length distributions are observed for the conflicting prosody conditions for Augurzky's German materials (favoring LC syntax sentences) and Schafer et al.'s English materials (favoring EC syntax sentences).

In the experimental study in this dissertation, the lengths of the prosodic phrases in the LC and EC prosodic contours will be systematically manipulated, in order to determine whether phrase lengths affect how easily the parser copes with conflicting prosody, as could be expected on the basis of the RSH. This could be investigated in English by expanding the SKS materials set to allow for phrase length variation. However, the Turkish language has some properties which are especially helpful in designing such a study, making it easier to avoid length confounds, and like English it also has temporarily ambiguous LC and EC constructions with distinctive prosodic contours (details in Chapter 3).

CHAPTER 2. BACKGROUND: PROCESSING PROSODY AND SYNTAX

This chapter is organized in four sections. Each section provides background on topics relevant to the research questions addressed in this dissertation as outlined in Chapter 1. Section 2.1 presents the Garden Path Model and the syntactic Late Closure strategy. Section 2.2 examines studies investigating the role of prosody in sentence processing. Section 2.3 presents hypotheses which suggest that constituent lengths could play a role in the perceived informativeness of prosodic boundaries in spoken sentences. Finally, Section 2.4 examines in detail the previous studies whose findings may have shown effects of constituent length distribution on the perceived informativeness of prosodic cues.

2.1. The Garden Path Model and the Syntactic Late Closure Strategy

The *Garden Path Model* is one of the most influential models proposed for the nature of parsing mechanisms in relation to the use of syntactic versus lexical, semantic or discourse-related components of linguistic input. The model assumes that a modular universal parser conducts *serial* syntactic processing, making an initial commitment to a single syntactic structure using only a restricted domain of syntactic information. Only a single analysis guided by syntactic information is available to the parser during first-pass parsing. (Other sources of information are available for reanalysis following a first-pass garden path.) Three syntactic strategies, namely *Minimal Attachment*, *Late Closure* and the *Minimal Chain Principle*, affect processing decisions during the initial parse (De Vincenzi, 1991; Frazier, 1978, 1987; Frazier & Fodor, 1978; Frazier & Rayner, 1982, 1987; Kimball, 1973).

Minimal Attachment: Do not postulate any potentially unnecessary nodes.

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

(Frazier, 1987, p. 562)

Minimal Chain Principle: Avoid postulating unnecessary chain members at surface structure, but do not delay required chain members.

(De Vincenzi, 1991, p. 13)

Primary evidence for the traditional Garden Path Model comes from the processing of sentences including temporary ambiguities. In the case of a temporary ambiguity, if the initial interpretation that the parser builds based on Minimal Attachment or Late Closure strategy or the Minimal Chain Principle turns out to be incorrect, it is assumed that the parser, having been led ‘down the garden path’, attempts to revise the original interpretation during a second stage at a measureable cost in processing time or difficulty. Other potentially relevant sources of information such as semantics or plausibility or discourse context are used during this second stage of parsing. These strategies determine the analysis of ambiguous strings where the structure is not disambiguated by punctuation or by clear prosodic phenomena (Frazier, 1987).

The Late Closure (LC) strategy, one of the main foci of the current study, operates when two equally minimal attachments exist. The LC strategy favors attachments to preceding items over attachment to subsequent items and typically favors attachments to phrases lower in the phrase structure tree than to phrases higher up. The following example from Frazier (1987) illustrates how the LC strategy influences sentence processing.

(1) Joyce said Tom left yesterday.

(Frazier, 1987, p. 563; cf. Kimball, 1973)

In (1) the LC strategy chooses the low attachment of the adverb *yesterday* where it modifies the subordinate VP *left*, the phrase currently being processed, which is lower in the syntactic tree, over the matrix verb *said* which is higher in the syntactic tree. Thus, the sentence is usually understood as *Joyce said that yesterday Tom left* rather than *Joyce yesterday said that Tom left*.

Other approaches, such as *Constraint-Based Lexicalist* accounts have been proposed in the literature, which assume, unlike the Garden Path Model, that while processing a sentence, all sources of information including syntax, semantics and discourse context are activated at the same time and the processor comprehends a sentence or resolves ambiguities using from the outset all the information available from such constraints (e.g., Altmann, van Nice, Garnham, & Henstra, 1998; Tanenhaus, Garnsey, & Boland, 1990; Trueswell, Tanenhaus, & Garnsey, 1994). Within such models, the various constraints favor different structural alternatives, which compete for selection at points of syntactic ambiguity. Since these accounts are not investigated in the current study, they will not be explored in any further detail, but sentential materials used in the current study are pre-tested to minimize any such effects (see Chapter 4).

2.2. The Role of Prosody in Sentence Processing

Most of the early studies contributing to the development of models of human sentence processing relied on reading tasks, which exclude prosodic influences. However, as has been pointed out in more recent research, most language processing in everyday life occurs with spoken input, which does typically include rich prosodic information that could be helpful to the parser. It would be strange if this prosodic information were not accessible to the parser, because it is an integral part of the acoustic signal the parser receives.

Prosodic information can serve several functions such as determining focus and topic, discriminating given and new information, and disambiguating otherwise ambiguous structures.

Among all other functions, its role as a disambiguator has been of special interest to psycholinguistics since ambiguity resolution has long been used as a tool in sentence processing research to shed light on the mechanisms underlying human sentence parsing. The following example illustrates how prosodic boundaries can disambiguate an otherwise ambiguous structure (|| indicates a prosodic boundary):

- (2) a. The hostess greeted || the girl with a smile.
b. The hostess greeted the girl || with a smile.

(Stageberg, 1958; cited in Lehiste, 1973)

When the above sentence is spoken with a prosodic boundary between the verb *greeted* and the direct object *the girl* as in (2a), the prepositional phrase (PP) *with a smile* will modify *the girl* and the sentence is usually interpreted as *The girl had a smile when the hostess greeted her*.

When the same string of words is uttered with a prosodic boundary after *the girl*, the PP *with a smile* is understood to modify the verb *greeted*, and the sentence will be interpreted as *The hostess had a smile when she greeted the girl*.

Prosodic constituents correspond to constituents at other levels of linguistic analyses. Selkirk (2011) argues that the prosodic structure of an utterance closely *matches* its syntactic structure (although certain phonological markedness constraints on prosodic structure may lead to violations of Match constraints and produce nonisomorphism between syntactic constituency and phonological domain structure). Thus, the prosodic structure of an utterance can in principle inform the recognition of other linguistic structures at very early stages of processing and reduce the potential ambiguity of the incoming language signal by providing some information to the parser about the syntactic structure of utterances.

In this section, previous work investigating the role of prosody in syntactic ambiguity resolution will be presented in two sub-sections: studies using offline tasks for investigating the

use of prosody (i.e., tasks performed at the end of sentences), and studies using on-line tasks for investigating the use of prosody (i.e., during real time processing of sentences). The latter will be grouped under two methodologies: behavioral and eye-tracking, and electrophysiological. These differing methods in investigation of sentence processing could shed light on when and how certain types of information are used by the parser. A summary table is provided at the end of each sub-section.

2.2.1. Studies Investigating the Use of Prosody via Offline Tasks

The renowned study by Lehisté (1973) was one of the first experimental investigations to show how prosody could disambiguate syntactic ambiguities in English. She investigated prosodic disambiguation of 15 different types of syntactic ambiguity (one instance of each). Four speakers (two linguists and two non-linguists) read the ambiguous structures aloud without initially being told about the ambiguities. Then, after being informed about the ambiguities (i.e., being shown the two possible meanings), the speakers were asked to indicate the meaning they intended to convey when they read the sentences. The same speakers produced each sentence again twice, making a conscious effort to differentiate between the two meanings. Then 30 listeners (15 linguists and 15 non-linguists) listened to the recordings. The listeners were asked to identify the meaning intended by the speaker.

Results showed that both groups of listeners performed equally well, and were able to identify the disambiguated meaning in ten of the fifteen sentences, reliably above chance. Analysis of sentences successfully disambiguated and sentences which were not disambiguated showed that syntactic structures including more than one bracketing, such as *Old men and women stayed home* were disambiguated easily by the prosody, compared to syntactic category ambiguities such as *Visiting relatives can be a nuisance* which have only one bracketing though different

syntactic category labels on the brackets. This important early observation underlined the fact that sentence-level prosody can provide cues to the groupings of words in a (surface) sentence, but does not disambiguate between word classes such as nouns and verbs when structural groupings are the same.⁴

In addition to demonstrating that speakers and listeners used prosody to disambiguate structures involving bracketing ambiguities, Lehiste also provided data on the type of prosodic phenomenon speakers and listeners used. She noted that speakers lengthened words in regions containing syntactic boundaries. Although stress and intonation also played a part, word durations seemed to be the principal means of disambiguation, at least in English, as revealed by the acoustic analyses.

Building on Lehiste (1973), Price, Ostendorf, Shattuck-Hufnagel, and Fong (1991) examined the use of prosodic information in the processing of 35 pairs of globally ambiguous sentences representing seven different types of structural ambiguity in English. The structures were ambiguous in that the two members of each pair, though they contained the same string of phones or even the same words, could be associated with two contrasting syntactic bracketings (similar to Lehiste's structures that were sensitive to prosodic disambiguation). The ambiguous structures involved parenthetical clauses versus nonparenthetical subordinate clauses, appositions versus attached noun phrases (or prepositional phrases), coordinate versus subordinate clauses, tag questions versus object noun phrases, *far* versus *near* attachment of a

⁴ Natural languages often disambiguate word classes prosodically at the level of word stress, e.g., 'permit' as a verb (pə'rɪt) or as a noun ('pɜrɪt) in English. The focus of Lehiste's work and many subsequent studies since, was supra-lexical prosody. Note that recent experiments (e.g., Breen & Clifton, 2013) investigate the role of stress patterns of words in sentences such as *The brilliant abstract the best ideas from the things they read*, where the noun/verb category ambiguities result in syntactic ambiguities. Such studies are not reviewed here since the focus is on supra-lexical prosody.

final phrase, left-versus right-attachment of a medial phrase, and particles versus prepositions (see Price et al., pp. 2967-2969 for details).

Four professional radio newscasters were presented with structurally ambiguous sentences in context paragraphs, which preceded the sentences and disambiguated them towards one interpretation. The radio newscasters were not told about the purposes of the experiments but were instructed to use their standard radio style of speaking while reading the sentences aloud. The target sentences uttered by a single speaker in disambiguating contexts were presented to listeners auditorily in isolation (i.e., without the context paragraphs). The listeners were then presented with two unambiguous contexts in written form. Their task was to choose the unambiguous context in which the sentence they heard might have been appropriately uttered.

Results showed that on average participants were 84% correct in assigning the sentences to the appropriate contexts. Similar to Lehisté, Price and colleagues concluded that for a variety of syntactic constructions, native English speakers can reliably differentiate meanings on the basis of differences in prosodic information. The acoustic analyses of the productions showed that prosodic boundaries almost always coincided with syntactic boundaries and were marked by lengthening in the phrase-final syllable, or a pause, or a boundary tone such as a pitch range change or a pitch accent. However, although the participants were able to identify the disambiguating context for most of the ambiguities, their responses for coordinate vs. subordinate sentences such as *We'd better agree Orlando (, or Lando) may win again* and near/far attachments such as *Raoul murdered the man with a gun* did not reach significance. For all other types of ambiguities, listeners could reliably identify the disambiguating context. Price et al. mention that the differences could be attributed to including homophones instead of identical words for some sentences. This could have affected listeners' syntactic choices, as

lexical ambiguity might yield greater response biases (i.e., listeners could be strongly biased towards one interpretation of the word rather than the other). The authors also note that the punctuation provided in the written context for the speakers might have affected the results, as the speakers might have exaggerated the prosody in cases where punctuation was available to disambiguate, as in the *Orlando* example above. Nevertheless, despite some differences in listener responses to the types of syntactic ambiguities, the results of the Price et al. study confirm that naïve listeners can, in general, reliably resolve syntactic bracketing ambiguities on the basis of prosody, as Lehiste had found.

Schafer et al. (2000) conducted a twinned production experiment and comprehension experiment to investigate how prosody may be used in natural conversational contexts to disambiguate syntactic ambiguities in English. The naturalness of the auditory input in studies exploring prosodic cues in syntactic disambiguation had been questioned in the literature (Watt & Murray, 1996). It had been argued that prosodic contours uttered by trained speakers in reading tasks might not accurately reflect the natural prosody of the structures in normal use and thus might over-estimate the degree of prosodic disambiguation in everyday speech. In response to such concerns, in their production experiment Schafer and colleagues developed a cooperative game task to elicit natural prosody of sentences including LC/EC ambiguities as in (3) below. In the game, two speakers used utterances from a predetermined set to negotiate moves around game boards. One speaker was a *driver* and the other was a *slider*. Neither participant was aware of the purpose of the study. They negotiated how to move certain shapes on a board. Each member of the pair could see their own board but not that of the other person. The preceding context disambiguated the structures as exemplified in the dialogue in (3) below. Note that in the first two utterances a triangle was used as an instrument to push a square.

- (3) a. Driver: I want to change the position of the square with the triangle.
b. Slider: Which triangle do you want to change the position of the square?
c. Driver: The red one. *When that moves the square it should land in a good spot.*
d. Slider: Good choice. *When that moves the square will encounter a cookie.*

(Schafer, et al., 2000, p. 173)

The authors predicted that the participants would prosodically disambiguate the sentences on the basis of the contextual information (the display on the board and the rules of the game). If so, it could not be claimed that only trained speakers, or participants in a deliberate reading aloud task, exhibit prosodic disambiguation. However, it should be noted that the task was not a very natural one for eliciting untrained speakers' prosodic disambiguation (pre-scripted utterances, the same constructions being repeated many times, with a potential to draw attention to the ambiguity).

Two teams of transcribers transcribed the utterances using Tones and Break Indices (ToBI) labeling. The first team had access to both the acoustic and the syntactic properties of the items. The second team did not; they were presented only with the ambiguous part of the utterances (i.e., *when that moves the square* in (3)). ToBI labels by the first team showed that participants placed a prosodic boundary 96% of the time after *square* but not after *moves* with LC type utterances such as (3c). With EC type utterances such as (3d), there was a prosodic boundary following *moves* but not after *square* 91% of the time. These numbers, though still well above chance, decreased to 83% for LC and 71% for EC type utterances in the coding by the second team, which, according to the authors, was probably due to the loss of phonetic information in the truncated utterances. Phonetic analyses also supported the phonological analyses. Word durations increased before phrase boundaries. These results showed that native speakers of English who were not trained for prosodic disambiguation did disambiguate sentences prosodically, although there was inter-subject variation in the particular prosodic contours used

to disambiguate sentences, such as different phrase accents, pitch accents, and boundary tones for the same morpho-syntactic structure.

In the comprehension experiment, the authors investigated whether untrained listeners would be sensitive to the prosodic cues uttered by the untrained speakers in the production experiment. The participants' task was to listen to syntactically ambiguous fragments of the sentences (including prosodic information) uttered by the untrained speakers in the previous experiment and choose between LC or EC continuations of the sentence fragment (shown in written form on a computer screen). Both the continuations in the original productions and segmentally-crossed continuations were presented. Segmentally-crossed continuations had initial segments matched to those of the opposite condition (e.g., /w/ & /ɪ/ in (4) below) for the original sentences to separate effects of prosodic disambiguation from any disambiguating effects of co-articulation. As shown in Chapter 1, and repeated here in more detail, the stimuli were as follows:

(4) *Spoken fragment*: When that moves the square ...

Original continuations

a. LC: ... it should land in a good spot. b. EC: ... will encounter a cookie.

Segmentally-crossed continuations

a. LC: ...we'll encounter a problem. b. EC: ... is shut off from the best path.

The sentences had cooperating, conflicting and ambiguous (i.e., neutral) prosody. These prosodies were assigned based on transcriptions made by two trained teams of transcribers on the prosody of the sentences uttered by the untrained speakers. An LC prosodic boundary was placed after *square* and an EC boundary was placed after *moves*. Ambiguous prosody did not clearly indicate the syntactic structure of the sentence, thus would be similar to the neutral prosody in the SKS studies. It was predicted that for cooperating prosody, participants would choose the correct continuation successfully above chance, but their choices would be at chance for

ambiguous prosody and below chance for conflicting prosody. Results showed that listeners successfully used prosodic cues in their LC or EC analysis of a temporarily ambiguous fragment in the cooperating prosody condition. For the ambiguous prosody condition, they were also successful above chance in their LC/EC continuation choices, which was not predicted. For the conflicting prosody condition, they chose EC continuations successfully despite the conflicting prosodic cue whereas they were at chance for LC continuations. Schafer et al. suggest that the truncated sentences might have led to loss of prosodic information presented at *square*. This would result in “a tendency for poorer identification than expected for the LC cooperating and LC ambiguous subsets and more successful identification than expected for the EC ambiguous and EC conflicting subsets” (p. 179). However, this tendency became significant only for LC and EC comparison in the conflicting prosody conditions. In other words, there was a significant EC syntax advantage in the conflicting prosody conditions. When the conflicting prosody conditions are examined in more detail (which will be done in Section 2.4), the constituent lengths show a length distribution pattern which may have favored the EC structures.

These three prominent studies investigating use of prosody in comprehension and production of syntactically ambiguous structures via offline methods are summarized in Table 2-1 below. Note that another relevant study for this section, namely Clifton et al. (2006), which also employed offline tasks in investigation of prosody, is discussed in Section 2.3 where the role of phrase lengths in production and perception of prosodic boundaries is presented. Table 2-1 indicates the participant populations, the production and comprehension tasks employed, and the acoustic correlates of prosodic information in the materials. What is clear from the table is that there is substantial agreement among these off-line studies on the acoustic realization of the

relevant prosodic cues, and on the conclusion that speakers can produce, and listeners can respond to, prosodic cues to syntactic structure.



Table 2-1 Summary of offline studies investigating the use of prosody in production and comprehension.

Study	Task	Use of prosody by the participants	Acoustic measures provided in the paper?	Acoustic correlates
Lehiste (1973)	Production: Read aloud (Linguists and non-linguists)	Yes (except for non-bracketing ambiguities)	Yes	Pre-boundary word lengthening, stress, intonation
	Comprehension: Forced-choice paraphrase selection	Yes (except for non-bracketing ambiguities)		
Price et al. (1991)	Production: Read aloud (Radio newscasters)	Yes	Yes	Phrase-final syllable lengthening, pause, and pitch accent
	Comprehension: Forced-choice disambiguating context selection	Yes		
Schafer et al. (2000)	Production: Cooperative game (Untrained speakers)	Yes	Yes	Pre-boundary word lengthening, pitch and phrase accent
	Comprehension: Forced-choice paraphrase selection	Yes		

While the studies reviewed above have shown that listeners and speakers are sensitive to prosodic information in sentence comprehension and production, especially in disambiguating syntactic bracketing ambiguities, they do not provide information about how the parser uses such prosodic information as it becomes available. The following section reviews studies investigating use of prosody during real time processing. These studies are grouped based on two types of methods: behavioral and eye-tracking, and electrophysiological. While the former can inform about whether or not the prosodic information is used as it is presented (resulting in speed-up or delay in performing a behavioral task for instance), the latter can provide more detailed information about the specific time-course of the prosodic information to be integrated (how soon the information is integrated) and it can further provide a measure of processing of stimuli even when there is no behavioral change.⁵

2.2.2. Studies Investigating the Use of Prosody via Online Tasks

2.2.2.1. Studies with behavioral and eye-tracking methods

Marslen-Wilson and colleagues (Marslen-Wilson, et al., 1992) used a task called *cross-modal naming* (adapted from the *cross-modal lexical priming* task employed by Swinney, Ford, Frauenfelder and Bresnan (1988)) to investigate the use of prosodic information in real time processing of temporarily ambiguous sentences. In cross-modal naming, participants listen to a sentence fragment and then name (i.e., read aloud) a visually presented word that immediately follows the auditory fragment. The study included a minimal/non-minimal attachment ambiguity as in (5) below where the ambiguity is due to interpretation of a transitive verb as taking either a

⁵ Note that one eye-tracking study is grouped under behavioral methods due to observable behavioral changes (eye movements) as a measure of processing ease/difficulty. However, eye-tracking data can provide sensitive temporal resolution as opposed to other behavioral tasks reviewed in this section (see Snedeker & Trueswell, 2003).

direct object (MA) or a complement clause (NMA). There were four experimental conditions: non-minimal attachment prosody with a disambiguating overt complementizer (NMA+Comp) as in (5a), non-minimal attachment prosody without complementizer (NMA-Comp) as in (5b), minimal attachment prosody (MA) also without complementizer as in (5c), and an unambiguous but anomalous control containing a number agreement violation (NUM) as in (5d) if the naming target is interpreted as a continuation of the spoken fragment. A prosodic boundary is indicated in (5) by the || symbol, the visual target is in capital letters:

(5) Spoken sentence	Target
a. NMA+Comp: The workers considered that the last offer from the management	WAS
b. NMA-Comp: The workers considered the last offer from the management	WAS
c. MA: The workers considered the last offer from the management	WAS
d. NUM: The workers considered that the last offer from the management	WERE

(Marslen-Wilson, et al., 1992, p. 79)

Materials were presented auditorily up to the end of the ambiguous region (*management* in (5)). The following verb *was/were* (shown in capital letters in (5)) was presented as the visual target for naming (reading aloud). In the case of (5a), the presence of the overt complementizer was predicted to prevent the application of MA, so that *was* would be responded to as an appropriate continuation. For (5b) the prosodic contour over the sentence might also ensure the NMA interpretation, in which case the visual target *was* would be responded to as an appropriate continuation. If this was not the case, i.e., if the prosody failed to disambiguate, then sentences such as (5b) would result in longer naming latencies than (5a) because MA would apply and result in a perceived anomaly when followed by the verb *was*. Sentences like (5c) had MA prosody, so if listeners were sensitive to prosodic disambiguation, the continuation *was* would be responded to as inappropriate since the MA interpretation would exclude a subordinate clause continuation, hence longer naming latencies were predicted. Syntactically unambiguous

sentences such as (5d), followed by a verb that disagreed in number were included to check that the task was sensitive to the fit between the spoken sentence fragment and the visually presented word. There was also a baseline condition with the neutral carrier phrase *The following word is*, which would also be followed by the target word *was* or *were*. After naming the visual probe as quickly as possible, the participants would also indicate, on a score sheet, whether they thought the probe word was a good or a bad continuation of what they heard. This second task was to ensure that they attended to the auditory prime, and specifically that they processed it as a continuation of the spoken sentence.

Results showed that the two NMA conditions did not differ in naming latencies. Rayner and Frazier (1987) had reported an advantage for the NMA condition with the overt complementizer (5a) in an online reading study. By comparison, the prosody of the NMA without an overt complementizer (5b) equally successfully guided parsing towards the NMA interpretation, eliminating the processing advantage introduced by the complementizer in (5a). The NMA prosody condition without the overt complementizer (5b) was also responded to faster than the anomalous control (5d), while the naming latencies for the prosodic MA condition with NMA continuation (5c) patterned with the anomalous condition (5d). The results of the online naming task thus suggest a rapid effect of prosodic cues, at least by the time of the end of the ambiguously-attachable NP, either preventing or encouraging an incorrect structural analysis.

Although the results of the prosodic MA condition with NMA continuation (5c) patterned with the anomalous condition in the naming latencies, the listeners' end-of-sentence acceptability judgments showed a high acceptance rate for the NMA continuation in the prosodic MA condition (i.e., 5c). It seems that the listeners' initial preference as determined by the prosody of the sentence was overridden by the subsequent conflicting morpho-syntactic information which

triggered reanalysis to NMA. Marslen-Wilson et al. argue that although prosodic cues affect parsing decisions, they are given less weight than morpho-syntactic information when the two conflict. The ultimate dominance of morpho-syntax over conflicting prosody seems appropriate, though it appears that no study has directly tested it, e.g., by asking: “What’s the meaning of this sentence?” for an example sentence such as *The workers considered the last offer from the management || was unfair*.

This study by Marslen-Wilson et al. (1992) is the first one in the literature that reports immediate – or at least rapid – use of prosodic information on-line, as it is received by the parser. One caveat concerning this study, though, is that the acoustic properties of the spoken sentence fragments were not documented. A subsequent study by Watt and Murray (1996), which also does not report the acoustic properties of the spoken experimental items, failed to replicate Marslen-Wilson et al.’s (1992) findings.

Watt and Murray (1996) conducted five experiments to investigate further the kinds of prosodic effects that Marslen-Wilson et al. (1992) observed. These experiments included temporary ambiguities similar to Marslen-Wilson et al.’s materials, with a direct object or a complement clause following a transitive verb (with or without a complementizer present). The first experiment was a replication of Marslen-Wilson et al.’s study with a fully crossed design employing recordings from a study by Watt (1992; cited in Watt & Murray, 1996). The Watt (1992) study had employed a mispronunciation detection task as an online measure of processing load. Watt (1992) had reported that there was no indication that the prosody of the initial portion of the sentences influenced parsing of the continuation either favorably or in a misleading manner. Since the Marslen-Wilson et al. study had shown clear effects of prosody on parsing with a cross-modal naming task, Watt and Murray (1996) used cross-modal tasks to investigate

the role of prosody with the same recordings as in Watt (1992): two cross-modal naming tasks and three cross-modal lexical decision tasks. The items used in the experiments were of the types below (the || symbol marks a prosodic boundary; appropriate and inappropriate continuations for naming or lexical decision are shown in capital letters):

(6) Spoken sentence	Continuation (App./Inap.)
a. Direct object: The teacher noticed one girl from her class	IN/WAS
b. That complement: The teacher noticed that one girl from her class	WAS/IN
c. Reduced complement: The teacher noticed one girl from her class	WAS/IN

(Watt & Murray, 1996, p. 229)

Experiments 1 and 2 employed a cross-modal naming task. Experiment 1 had an item recognition test half way through and at the end of the experiment to ensure to ensure that participants paid attention to the auditory sentence fragment. Results showed no significant effects of prosody on the parsing of these items, which replicated the finding of Watt (1992). Experiment 2 used the same task (cross-modal naming) but also included an acceptability judgment task as in the Marslen-Wilson et al. study, requiring participants to relate the visually presented word to the spoken sentence fragment. This experiment fully replicated the findings of the Marslen-Wilson et al. study with respect to the ratings for appropriate continuations, which were higher than for inappropriate continuations. However, the naming times in Experiment 2 failed to replicate Marslen-Wilson et al.'s findings as there was no reliable difference online between appropriate and inappropriate continuations.

Together, the results of Watt and Murray's Experiments 1 and 2 suggested that although prosodic cues affected end-of-sentence judgments, they did not affect early parsing decisions. However, no naming time differences were observed for filler items either. Therefore, Experiment 3 followed up with a cross-modal lexical decision task to see whether it would be

more sensitive than cross-modal naming. The cross-modal lexical decision task was predicted to prevent participants from responding to the visual target without actively processing its linguistic properties.

In the cross-modal lexical decision task, orthographically legal non-words were presented as visual targets for 44% of the filler items, though not for the target items (thus, 22% overall). The results of this experiment, and also of Experiments 4 and 5, which replicated Experiment 3 with slight changes in the method (such as showing the cross-modal target for 400 ms to encourage quicker responses to ensure sensitivity to on-going syntactic load), also showed no significant differences in lexical decision times for appropriate and inappropriate continuations of the experimental items.

The results of the Watt and Murray (1996) study were interpreted as showing that listeners are sensitive to prosodic cues in end-of-sentence acceptability judgments, but do not rely on prosodic cues while making early parsing decisions on-line. In discussing this, Watt and Murray (1996) point out that the different results in the Marslen-Wilson et al. study and their own study might be related to the strength of the prosodic cues provided in their auditory stimuli. It is possible that the prosodic cues in Watt and Murray's stimuli were not strong enough to influence parsing. Watt and Murray state that their sentences had natural prosody; but it is difficult to judge the stimuli as no phonological or acoustic information was provided.

A study by Nagel and colleagues (Nagel, et al., 1996) yielded results that are in line with Marslen-Wilson et al.'s findings rather than Watt and Murray's. They support the hypothesis that prosodic cues are used as soon as they are received by the parser. The Nagel et al. study investigated the use of prosodic cues during online sentence comprehension of a construction similar to that tested by Marslen-Wilson et al. and Watt and Murray, though in a slightly

different format. The study examined whether untrained listeners make use of prosodic boundaries in typical locations where they are associated with syntactic boundaries, as well as which prosodic cues in particular are used by the parser during online comprehension of sentences. The first experiment employed a cross-modal lexical decision task. Twelve pairs of temporarily ambiguous sentences were presented to the participants auditorily. The ambiguity was syntactically resolved either as a direct object (DO) construction or as a complement clause without an overt complementizer (called a “reduced clause”, REC). In (7), DO prosody is indicated via italics; REC prosody is indicated with underlining to show the cross-splicing procedure. The # sign shows probe position.

(7) Spoken sentence

- a. DO control: *The company owner promised the wage increase to # the workers*
- b. REC control: The company owner promised the wage increase would # be substantial
- c. DO spliced: The company owner promised the wage increase *to # the workers*
- d. REC spliced: *The company owner promised the wage increase* would # be substantial

(Nagel et al. 1996, p. 325)

Sentences (7a,b) were recorded in complete form and with natural pronunciations including acceptable prosody (though once again, no documentation of the prosodic properties is provided). The beginnings of sentences were then cross-spliced at the offset of the ambiguous NP (*the wage increase* in (7)), prior to the disambiguating word, to create prosody that mismatches the disambiguating word of the auditory sentence fragment; this yielded (7c) and (7d). A single probe word (unique for each target sentence and unrelated to its meaning) was presented visually immediately after the disambiguating word (at the # sign in (7)) in each auditory sentence. The sentence continued playing without a pause. The probe words were all real words for experimental items. For filler items, both real words and non-words were presented as visual probes. In all cases, the probe word reportedly did not continue the sentence fragment in any

meaningful way, neither for experimental items nor for fillers, but no examples of the real probe words used in the experiments were provided in the paper. Construing the probe word as a potential confirmation was also discouraged by the fact that an immediate confirmation was provided in the spoken sentence itself. Thus, the purpose of the cross-modal lexical decision task employed in this study differed from that in Watt and Murray's study in that it did not measure perceived compatibility with the preceding auditory material, but measured increased processing load following a clash within the auditory material between the prosodic cues and the lexical disambiguation. Participants were asked to attend to the sentences (a sentence paraphrase task after 20% of the trials was included to ensure attention to the auditory stimulus) and make a lexical decision on the visual probe (presented right after the disambiguating word) as soon as they saw it. Reaction times to the lexical decision were recorded.

Results showed longer probe decision times for the sentences with prosody that mismatched the lexical continuation, thus supporting the hypothesis that the prosodic contour of the sentence immediately influenced participants' parsing decisions.

Nagel et al. conducted two further experiments to investigate the prosodic contours speakers use and listeners respond to with the same type of sentences as in Experiment 1. Experiment 2 was a production task to investigate whether or not the sentence types used in Experiment 1 could reliably be distinguished in terms of their prosodic properties. A male speaker naïve to the purposes of the experiment read aloud the same sentences as in Experiment 1. Acoustic analyses showed that in the REC condition, the matrix verb (*promise* in the examples in (7)) had a longer duration than in the DO condition and was associated with a low tone and a following pause, whereas in the DO condition there was no low tone intervening between the verb and its object. This contrast in pronunciation of the materials in the second experiment showed that the prosodic

contours of the sentence versions provided acoustic distinctions which might be used by hearers to disambiguate the temporary ambiguity.

The third experiment investigated whether temporal factors such as pre-boundary word duration and a pause were sufficient to guide syntactic parsing decisions for this ambiguity. Thus, the original sentence fragments from Experiment 2 were resynthesized, holding the F_0 constant at 120 Hz but without changing timing. The mismatching prosody was created by lengthening the duration of the matrix verb and the pause following it in DO conditions and by shortening them in the REC conditions. The same cross-modal lexical decision task as in Experiment 1 was employed. However, this time there were two probe positions. In one condition, the lexical decision probe was presented right before the disambiguating word (*to* or *would* in (7)) and in the other condition it was presented right after the disambiguating word. The additional probe position (before the disambiguating word) was to ensure that any observed reaction time difference at the second position was a result of the prosodic mismatch effect rather than due to any surprise reaction to the manipulations of experimental items. The probe word was the same for each location. No participant was presented with each probe location for the same sentence.

Lexical decision times showed that at probe position 1 (before the disambiguating word), there were no significant effects of prosody for either the DO or the REC structures. For probe position 2, however, longer reaction times were observed for the altered (lengthened) DO condition than for the unaltered (short) DO condition. Similarly, reaction times were longer for the altered (short) REC condition than for the unaltered (long) REC condition. This indicates that the mismatch effect created by manipulating temporal acoustic properties of the experimental items had resulted in a garden-path effect.

The results of Nagel et al.'s study support the view that prosodic information is used early, perhaps immediately as it is encountered, to facilitate the recovery of the syntactic representation of an utterance. The results also show that pre-boundary word and pause duration are sufficient (in English) to affect sentence processing even when the F_0 is held constant across conditions.

As noted briefly in Chapter 1, Speer et al. (1996) and Kjelgaard and Speer (1999) (SKS) investigated the use of prosodic information with LC/EC ambiguities in auditory sentence comprehension via offline and online methods. These methods included an end-of-sentence comprehension task (i.e., 'got it' task), an end-of-sentence pronunciation acceptability task (only in the Kjelgaard and Speer study), and cross-modal naming tasks.

The SKS papers reported on overlapping experiments. In what follows, I will first present the overlapping experiments by noting any differences between reports on a particular experiment and then will present the experiments reported in one but not the other of the papers.

The SKS studies included three types of prosody in the tasks: cooperating, conflicting and neutral (except for Experiment 1 of Speer et al., which had only cooperating and conflicting prosody). The manipulation of syntax and prosody resulted in the following 6 conditions. (Here and henceforth, || indicates a prosodic boundary, / indicates a syntactic boundary and boldface marks contrastive focus unless noted otherwise.)

- (8) a. Cooperating prosody, LC syntax: When Roger leaves the house || / it's dark.
 b. Cooperating prosody, EC syntax: When Roger leaves || / the house is dark.
 c. Conflicting prosody, LC syntax: When Roger leaves || the house / it's dark.
 d. Conflicting prosody, EC syntax: When Roger leaves / the house || is dark.
 e. Neutral prosody, LC syntax: When **Roger** leaves the house it's dark.
 f. Neutral prosody, EC syntax: When **Roger** leaves the house is dark.

(Kjelgaard & Speer, 1999, p. 156; see Speer et al., p. 257 for similar examples)

Cooperating prosody sentences had syntactic and prosodic boundaries aligned. Conflicting prosody sentences were created by cross-splicing the syntactically ambiguous regions of the cooperating prosody sentences. Neutral prosody sentences did not have any prosodic boundary; the neutral prosody was created by placing a contrastive focus (L+H*) on the embedded subject (*Roger* in the examples). This focal accent tends to mute prosodic variation in the remainder of the sentence, diminishing or eliminating any perceived unnaturalness due to absence of prosodic boundary within the sentence. The neutral prosody condition was included to serve as a baseline comparison condition for the cooperating and conflicting prosody conditions.

A series of pre-tests and acoustic analyses were conducted in both studies to ensure that the prosodic features of the experimental sentences were as intended. A normative study to control for verb transitivity bias, a baseline (neutral prosody) uniformity test, acoustic analyses, a pronunciation acceptability judgment, and an intelligibility pre-test (only in the Kjelgaard and Speer study) were conducted in each of the studies. In the normative study, participants were presented with subordinate clause fragments including optionally transitive verbs (e.g., *when Frank performs...*) and they were asked to complete the sentence fragment. On this basis, the authors selected verbs that were transitive-biased, intransitive-biased and non-biased (with an overall slight bias towards transitivity) to be used for sentence materials in the main experiment.

For the baseline (neutral prosody) pronunciation, the criteria were: (i) the prosody should be an appropriate and equally acceptable pronunciation for both LC and EC versions; (ii) it should be as acceptable as the cooperating prosody for either structure. Two trained listeners judged the neutrality of the prosody in the baseline conditions. Sentences that did not meet the criteria were re-recorded and re-judged. Acoustic analyses and tone label transcriptions confirmed that the prosodies were as intended. In sentences with cooperating prosody, the final word of the initial clause was lengthened and there was a drop in the fundamental frequency, followed by a pause, thus providing an intonational phrase (IPh) boundary. Differences between LC and EC structures' prosodies were confirmed by statistical comparisons. In the neutral prosody sentences, produced as a single phrase with neither potential syntactic boundary marked prosodically, the subject of the initial (subordinate) clause received a high pitch accent. Since the conflicting prosody conditions were created by digitally cross-splicing the cooperating materials, the prosodic boundaries retained the acoustic properties of the cooperating prosody conditions but they were placed at misleading syntactic locations. The acceptability of the prosody of all the sentence materials was measured via an acceptability judgment test. In this test, listeners judged the speaker's pronunciation as "erroneous" or "okay". Both neutral and cooperating prosody sentences were highly acceptable with an average of above 90% acceptability. Conflicting prosody conditions were accepted on less than 40% of the trials.

The intelligibility test, included in the Kjelgaard and Speer study only, was conducted to make sure that the critical words (e.g., *it's* or *is* in (8), or *she'll/will* and so on) were comprehensible. Subjects heard each sentence over loudspeakers and chose which of the two sequences (*house it's dark* or *house is dark*) they heard. Sentences that produced more than two intelligibility errors (out of 20 ratings) were re-recorded and re-tested.

Both Speer et al. and Kjelgaard and Speer employed an end-of-sentence comprehension (i.e., ‘got it’) task, in which participants listened to the sentences and pressed a button as quickly as possible when they had understood them. At pseudo-random intervals, the participants were asked to give either a written paraphrase of the most recently heard sentence (Speer et al. Experiments 1 and 2) or answer a comprehension question (Kjelgaard and Speer Experiment 2).

Results for ‘got it’ responses showed shorter reaction times for the sentences with cooperating prosody than for the ones with neutral prosody, and shorter reaction times for the sentences with neutral prosody than for the ones with conflicting prosody. Furthermore, the items with LC syntax were responded to faster than the items with EC syntax in both the neutral and conflicting prosody conditions. No such difference was observed for the cooperating prosody condition.

Although these end-of-sentence comprehension experiments showed that prosodic boundaries have both facilitative and interference effects on syntactic parsing decisions, the offline task could only reveal post-sentence sensitivity to prosody. Thus, a cross-modal naming task similar to the one described in Marslen-Wilson et al. (1992) was used in a subsequent experiment to measure on-line processing of prosody. The examples in (9) from Kjelgaard and Speer (1999) exemplify the materials (see Speer et al., p. 262 for similar examples). The visual probe was the disambiguating word (*is* or *it’s*):

(9) Spoken Fragment	Visual Probe
a. Cooperating Prosody, LC syntax: When Roger leaves the house	it's
b. Cooperating Prosody, EC syntax: When Roger leaves the house	is
c. Conflicting prosody, LC syntax: When Roger leaves the house	it's
d. Conflicting Prosody, EC syntax: When Roger leaves the house	is
e. Neutral Prosody, LC syntax: When Roger leaves the house	it's
f. Neutral Prosody, EC syntax: When Roger leaves the house	is

(Kjelgaard & Speer, 1999, p. 156)

For the cross-modal naming task, participants were instructed to listen to the sentence fragment, played over headphones, and then to name (i.e., to read aloud) as quickly as possible the word that appeared on the screen immediately following the auditory stimulus, and then to complete the sentence. Results of this cross-modal naming experiment were similar to those of the end-of-sentence comprehension task. Naming times were shortest for sentences with cooperating prosody and longest for sentences with conflicting prosody. An LC advantage was observed in both the neutral and conflicting prosody conditions. Thus the results overall showed that a prosodic (IPh) boundary can have an early effect on the analysis initially chosen by the syntactic parsing mechanism.

SKS note the possibility that the acoustic silence at prosodic boundary locations might have provided extra processing time for the syntactic ambiguities, rather than serving as a prosodic cue. Furthermore, in everyday spoken language, prosodic cues are not as salient as the cues typically used in experiments. In the previous experiments the boundary was a full IPh boundary marked by a silent (unfilled) pause and a substantial fall in fundamental frequency. A subsequent experiment with more subtle prosodic cues was conducted. The same design and conditions were used for this experiment. However, the acoustic properties of the items were changed. A

phonological phrase boundary (PPh)⁶ marked by a high phrase tone (H-) was used at the syntactic boundary and the silence was removed. Participants took part in the same cross-modal naming task. Results of this experiment replicated the previous ones. Naming times were longer for the conflicting prosody condition than those for the neutral prosody condition and shorter for the cooperating prosody condition than those for the neutral prosody condition. The same LC advantage was also observed in the neutral and conflicting prosody conditions.

The authors conclude that the prosodic representation of a spoken utterance is available immediately to inform syntactic parsing decisions. Thus, the SKS results replicated the positive findings of Marslen-Wilson et al. (1992) with a design in which materials were carefully controlled for both lexical bias and prosodic properties. Results also showed that quite subtle cues such as PPh boundaries were sufficient to indicate the intended syntactic structure of sentences. The LC advantage observed in the neutral prosody conditions is comparable to the LC advantage in reading studies. In the neutral prosody condition, since there is no reliable prosodic cue to inform the parser about the syntactic structure of the utterance, the parser may have followed the syntactic Late Closure strategy. As for the LC advantage in the conflicting prosody condition, the authors consider the possibility of a potential topicalized reading in the conflicting LC condition. Accordingly, re-analysis in the conflicting LC condition might have led to a less frequent but a well-formed syntactic analysis of the sentence such as *the room, it's dark*, which is consistent with its prosody. This low-likelihood but correct syntactic structure might have provided a re-analysis advantage for the conflicting LC over the conflicting EC condition, whose

⁶ Two levels of prosodic phrasing are standardly assumed in the literature but are referred to under different terminologies. Speer et al. (1996) used the terms *intonational phrase* (IP) and *intermediate phrase* (ip), whereas Kjelgaard and Speer (1999) referred to the same units as *intonational phrase* (IPh) and *phonological phrase* (PPh). I will use the terms IPh and PPh throughout this dissertation.

re-analysis would presumably be more difficult as it would require detaching an argument NP from within a verb phrase and re-assigning it to a subject position in the next clause.

As mentioned in Chapter 1, in this dissertation, two other alternative explanations are considered for the LC advantage in their conflicting prosody condition. The first explanation concerns a default LC strategy that the parser resorts to/uses not only when prosody is absent but also when it is perceived as uninformative. A similar LC advantage in Augurzky's (2006) study, which will be reviewed in Section 2.2.2.2, provides support for this. The second explanation concerns the lengths of prosodic phrases between prosodic breaks and how this might affect the perceived informativeness of the prosodic breaks. This alternative will be discussed in more detail with respect to SKS's sentence materials in Section 2.4 after providing some background on how constituent lengths influence speakers' placement, and listeners' perception, of prosodic boundaries in Section 2.3.

Two other SKS experiments which do not overlap between the Speer et al. and Kjelgaard and Speer papers are worth a quick review since their results did not exactly pattern with the other SKS experiments. These might be relevant to the predictions that will be made in this dissertation, and also relevant for their methodological implications for investigations of the parser's use of prosody in sentence comprehension.

Speer et al.'s first experiment employed an end-of-sentence comprehension (i.e., 'got it') task. However, the sentence materials differed from the subsequent experiments in their constituent lengths. Also there was no neutral prosody condition. The following are examples of the structures tested in the experiment.

- (10) a. Cooperating prosody, LC syntax
Because her grandmother knitted pullovers || / Kathy kept warm in the wintertime.
- b. Cooperating prosody, EC syntax
Because her grandmother knitted || / pullovers kept Kathy warm in the wintertime.
- c. Conflicting prosody, LC syntax
Because her grandmother knitted || pullovers / Kathy kept warm in the wintertime.
- d. Conflicting prosody, EC syntax
Because her grandmother knitted / pullovers || kept Kathy warm in the wintertime.

(Speer et al. 1996, p. 254)

Results of the end-of sentence comprehension task showed that both LC and EC sentences showed a processing advantage for cooperating prosody over conflicting prosody, as expected. Overall, EC sentences were processed slower than LC sentences; however, there was no significant LC advantage in the conflicting prosody conditions, although comprehension times for LC structures were numerically shorter. This lack of LC advantage could actually potentially be due to the constituent length distributions not favoring the LC syntax constructions in these experiments. As mentioned, Section 2.3 will examine how constituent lengths can influence perceived informativeness of prosodic cues. The sentential items in this particular experiment will then be re-examined in this regard (Section 2.4).

The first experiment reported in Kjelgaard and Speer (1999) employed a speeded phonosyntactic grammaticality judgment task in which participants were told to judge sentences (as illustrated above in (8) for the overlapping experiments); i.e., decide whether or not a sentence they heard was “okay” or contained an “error”, basing their response on whether they judged that the sentence they heard was the one intended by the speaker. Their judgments and their judgment response times were recorded. Results showed that the listeners judged cooperating prosody sentences to include fewer errors than neutral prosody sentences. Also,

conflicting prosody sentences were judged to have more errors than neutral prosody sentences, representing the standard pattern of results through all the SKS experiments. The judgment time data showed that sentences with cooperating prosody were judged faster than those in the neutral prosody condition. However, judgment times for neutral and conflicting prosody conditions did not differ significantly from each other in contrast to the standard finding in the SKS experiments (cooperating prosody < neutral prosody < conflicting prosody). The authors suggested that “error” responses could involve additional nonlinguistic checking processes and result in longer response times. Thus, lack of a cooperating prosodic cue could have contributed to longer judgment times in the neutral prosody condition resulting in no reliable difference from the conflicting prosody condition. This would suggest that although an end-of-sentence acceptability judgment task could inform about whether or not listeners use prosodic information in processing sentences, it may not be as sensitive as an end-of-sentence comprehension task.

Ferreira and colleagues (Ferreira, Anes, & Horine, 1996) introduced a novel method called the *auditory moving window (AMW)* technique to investigate online use of prosody. The AMW is analogous to the visual ‘moving window’ presentation, in which each sentence is presented on a computer screen one word at a time, where the words appear in a linear position in the sentence moving across the screen from left to right (i.e., not centered on the screen) and the presentation of each word is controlled by the participant by a key-press. In the AMW, participants receive the auditory input word-by-word (or phrase-by-phrase) by means of successive key-presses. The AMW presentation mode could be an efficient means of providing measures of processing load across a sentence, and thus revealing the influence of processing strategies at several points in an utterance. Ferreira et al.’s study included five different types of ambiguities in English, as

illustrated in (11). These ambiguities were taken from Price et al. (1991) and Cooper and Paccia-Cooper (1980):

- (11) a. Parenthetical/relative clause: The professor knows many languages you know.
- b. Prepositional phrase attachment: Andrea moved the bottle under the bridge.
- c. Particle/preposition: The tires may wear down the road.
- d. Question/relative clause: Tom questioned the clerk who was the fastest worker.
- e. EC/LC: When John leaves Cathy will/ we'll be upset.

(Ferreira, et al., 1996, p. 282)

Five sentences for each type of ambiguity were created. A trained speaker read each sentence twice, once for each interpretation, with a deliberate effort to convey the intended meaning by manipulating prosody. Two unambiguous paraphrases for each ambiguity were presented visually to the participants at the end of the spoken sentence. The task was to choose between the two paraphrases, selecting the one which corresponded to the meaning they thought the sentence conveyed. Two groups of participants took part in the experiment. One group participated in an AMW procedure where the sentences were segmented in small chunks such as *Andrea/moved/the bottle/under/the bridge* for (11b). The other group listened to the sentences unsegmented.

Results showed that proportion correct for every sentence type was lower in the segmented condition than in the unsegmented condition. Thus, it appears that it is harder for participants to obtain the intended meaning of these sentences when they listen to them through the AMW, indicating perhaps that the task distorts the prosody of the sentence to some extent. Ferreira et al. suggest that presenting the auditory sentence in a phrase-by-phrase fashion (i.e., longer chunks) in which prosodic phrases are not disrupted by separate windows of presentation could result in more sensitivity in the AMW task. However, since results were reported only for proportion correct (a sentence final task) but not on key-press time for each auditory window, it is difficult

to judge the merit of the AMW method in investigating on-line parsing load. Furthermore, the chunks themselves could have induced a certain type of prosodic phrasing for the listeners. One last caveat is that the acoustic characteristics of the stimuli were not specified in the report. Thus, it is not clear whether or not the intended prosodic properties were available to the listeners.

A recent study by Stoyneshka et al. (2010) introduced another novel method, namely the *phoneme restoration* method. This builds on the phoneme restoration effect first described by Warren (1970) in which a phoneme in a given word in a sentence was replaced by a cough. When asked, listeners denied that any sound was missing in the word; they thought they had heard a complete sentence with noise overlaid on it. Subsequent experiments (references in the Stoyneshka et al. paper) had established the robustness of this effect, prior to its adaptation by Stoyneshka et al. to the study of prosodic disambiguation of syntactic ambiguities. Stoyneshka et al. tested NP coordination and relative clause (RC) attachment ambiguities in Bulgarian. The rich morphology of this language provided opportunities to use the phoneme restoration effect as a tool to detect the effectiveness of prosodic disambiguation. In Bulgarian, the disambiguating word in such syntactic ambiguities can be a closed class function word with disambiguating number and/or gender agreement. Those features could be rendered ambiguous by noise-replacing just the phoneme(s) within the word which identified the disambiguating morpheme. The following examples, (12) and (13), exemplify the experimental materials. The disambiguating word (copula for NP coordination, and relative pronoun for RC attachment) is shown here in bold face. Its underlined part was replaced by white noise.

(12) NP Coordination (early/late clause closure)

- a. Nakraia srestnahme Ani || i Ivan i Mimi **biaha** vav vaztorg.
 - b. Nakraia srestnahme Ani i Ivan || i Mimi **beše** vav vaztorg.
- ‘In the end (we) met Annie and Ivan and Mimi **were/was** ecstatic.’

(13) RC Attachment (high/low adjunct attachment)

- a. Podtseniha advokata || na pevitsata **koiato** kupi imenieto.
 - b. Podtseniha advokata na pevitsata || **koiito** kupi imenieto.
- ‘(They) underestimated the lawyer_{masc} of the singer_{fem} **who_{fem}/who_{masc}** bought the estate.’

(Stoyneshka et al. 2010, p. 1270)

Stoyneshka et al. note that a non-final prosodic boundary is realized in Bulgarian as pre-boundary lengthening and a rise in pitch optionally followed by a pause. The materials were recorded by a trained native speaker of Bulgarian. The acoustic analyses showed that NP1 and NP2 in each condition differed as intended in terms of duration, pitch movements, and pause. The sensitivity of the phoneme restoration method was tested in three experiments utilizing three different response procedures.

Experiment 1 employed a visual word choice task in which participants listened to the stimulus and then saw two words on a screen. For the experimental sentences, these were the words that disambiguated the interpretations, prior to phoneme replacement. The participants’ task was to indicate which of the two words they (thought they) had heard in the sentence. Participants’ visual word choice results showed that 83 to 95% of the phoneme restorations were congruent with the prosody of the stimuli.

Experiment 2 was a sentence repetition task. This time participants were to repeat the sentence they heard immediately after listening to the stimulus. Their pronunciation of the phoneme-replaced items indicated which agreement morphology the participants were mentally

supplying, thus revealing their syntactic analysis of the sentence. Similar to Experiment 1, most of the phoneme restorations (83 to 98%) were congruent with the prosody of the items.

In Experiment 3, participants took part in a speech shadowing task, in which they were instructed to start repeating the sentence aloud as soon as the auditory input began, while the rest of the sentence was still being heard and processed. Similar to Experiments 1 and 2, phoneme restorations reflected the prosodic structure of the utterances. For the RC attachment ambiguity, however, the rates of congruent restoration in shadowing were lower than in the other two tasks. The authors attributed this to the difficulty of the shadowing task and to the fact that in items like (13b) the critical word occurred immediately following the disambiguating prosodic boundary (details in Stoyneshka et al. 2010).

In all three experiments employing phoneme-replaced stimuli, results showed that the prosody of the stimuli successfully guided the parser in both constructions, although RC attachment ambiguities yielded an asymmetry: a break after NP1 having a stronger effect than the break after NP2, in line with previous observations in other languages with other methods (see Stoyneshka, et al., 2010 for details).

Stoyneshka et al.'s novel method for studying prosodic effects on syntactic parsing is very natural (since noise often accompanies spoken language in daily life) and it eliminates factors such as the difficulty of integration of information across modalities (as in cross-modal naming) and interrupted prosody (as in AMW). It may also yield more spontaneous and natural responses to prosody since it draws little or no attention to the presence of ambiguity and the role of prosody in resolving it.

The Visual World paradigm is another method now in use for investigating whether or not listeners use prosodic information on-line. In the Visual World paradigm, participants' eye

movements over a carefully constructed visual display are monitored as they listen to auditory stimuli. Snedeker and Trueswell (2003) employed the Visual World paradigm in their investigation of prepositional phrase (PP) attachment ambiguities such as *Tap the frog with the flower* in which the PP *with the flower* can either denote an instrument for tapping the frog, or it may modify *the frog* so that the NP would be interpreted as *the frog that has the flower*. There were three experiments.

In Experiment 1, pairs of Speakers and Listeners participated in a referential communication task in which the Listener moved toys to complete an action described by the Speaker. The experimenter would first show the action to the Speaker (not visible to the listener because of a divider between the Speaker and Listener) before the speaker produced the sentence. Acoustic analyses demonstrated that the placement of IPh boundaries (after direct object for instrument, and after verb for modifier interpretation) by the Speaker did provide information that could disambiguate for listeners. Listeners' actions showed that these prosodic cues were an effective means of syntactic disambiguation, as listeners correctly reproduced the action demonstrated by the experimenter on the other side of the divider 70% of the time.

Experiment 2 was the same as Experiment 1 except that the demonstration of alternative meanings of the sentence (instrument or modifier) was used as a between-subjects variable because post-experiment interviews with the participants of Experiment 1 indicated that the participants were aware of the ambiguity in the sentence materials. Results of Experiment 2 did not replicate Experiment 1: the prosody used by the speakers did not clearly indicate which interpretation they received a demonstration for and listeners did not reliably complete the action demonstrated on the other side of the divider. Snedeker and Trueswell proposed that “the production of informative prosodic cues depends upon the speaker’s knowledge of the situation:

speakers provide prosodic cues when needed and listeners use these prosodic cues when present” (p. 119). This relates to the issue of ‘audience design’ which we will not discuss further in this dissertation. (See Kraljic & Brennan, 2005, for further discussion.) Snedeker and Trueswell further suggested that informative prosodic cues might be infrequent in ordinary conversation.

Experiment 3 investigated on-line use of prosody via a Visual World eye-tracking experiment. Eye-tracking methodology has the potential to inform about on-line use of prosodic information with a better temporal resolution than other widely-used methods such as cross-modal naming and could provide a more spontaneous, less artificial measure of sentential interpretation (Snedeker & Trueswell, 2003). The experimental procedure for the speakers was the same as in Experiment 1 but the listeners fixated on a monitor which provided a visual display of the context instead of demonstrating actions with toys. Results replicated the findings of Experiment 1. Results further showed that the prosody of the utterance had a rapid influence on the Listeners’ interpretation of the first noun, within 250 ms of its onset. Although the method/materials in this study have been challenged by subsequent research (Kraljic & Brennan, 2005; Webman Shafran, 2011) it is clear that under some conditions the response to prosodic information can be very rapid.

The following table provides a summary of the studies reviewed in this section.

Table 2-2 Summary of studies investigating use of prosody via online tasks – behavioral methods

Study	Task	Use of prosody by the participants	Acoustic measures provided in the paper?	Acoustic correlates
Marslen-Wilson et al. (1992)	Online: Cross-modal naming	Yes	No	
	Offline: End-of-sentence acceptability judgments	Yes		
Watt and Muray (1996)	Online: Cross-modal naming	No	No	
	Cross-modal lexical decision	No	No	
	Offline: End-of-sentence acceptability judgments	Yes		
Nagel et al. (1996)	Online: Cross-modal lexical decision	Yes	No	Lengthening pre-boundary word, pause at boundary location, changes in pitch accent
	Production: Read aloud	Yes	Yes	
	Online: Cross-modal lexical decision	Yes	Yes	
Speer et al. (1996)	Offline: End-of-sentence comprehension	Yes	Yes	Pre-boundary word lengthening, pitch accent, pause
	Online: Cross-modal naming	Yes	Yes	

Table 2-2 Summary of studies investigating use of prosody via online tasks – behavioral methods
- continues from previous page

Study	Task	Use of prosody by the participants	Acoustic measures provided in the paper?	Acoustic correlates
Kjelgaard and Speer (1999)	Offline: End-of-sentence acceptability	Yes	Yes	Pre-boundary word lengthening, pitch accent, pause
	End-of-sentence comprehension	Yes	Yes	
	Online: Cross-modal naming	Yes	Yes	
Ferreira et al. (1996)	Offline: End-of-sentence paraphrase choice	Yes (except for PP attachment ambiguity)	No	
	Online: Auditory Moving Window (end of sentence paraphrase choice)	Yes (except for PP attachment and LC/EC ambiguities)		
Stoyneshka et al. (2010)	Phoneme restoration			Pre-boundary word lengthening, pitch accent, pause
	Offline: Visual word choice, Sentence repetition	Yes	Yes	
	Online: Speech shadowing	Yes	Yes	
Snedeker & Trueswell (2003)	Offline & Production: Referential communication task	Yes (when speakers were aware of ambiguity) Yes	Yes Yes	Pre-boundary word lengthening, pitch accent, pause
	Online (Eye-tracking): Visual World			

As can be seen in Table 2-2, all of the studies which provided information about the acoustic correlates of the prosodic cues used in their sentence materials yielded data supporting the hypothesis that prosody can inform the parser towards a specific syntactic structure. A caution is that the outcomes of two studies, namely Watt and Murray (1996) and Ferreira et al. (1996), provided only partial support for this hypothesis and the results of Snedeker and Trueswell (2003) suggested that “speakers provide prosodic cues to disambiguate sentences syntactically only when needed” (p.103). The fact that Watt and Murray (1996) and Ferreira et al. (1996) did not provide acoustic measures of their stimuli leaves it unclear whether or not the prosodic boundaries were available to the parser in their stimuli. The results might be attributable instead to the lack of sensitivity of the task used. Snedeker and Trueswell’s finding that speakers’ awareness of ambiguity influences their use of prosodic cues is a topic of current debate in psycholinguistics (e.g., Kraljic & Brennan, 2005) and conclusive remarks must await further investigation.

To sum up: Among the tasks used to investigate online use of prosody, cross-modal naming, speech shadowing using the phoneme restoration paradigm, and the Visual World paradigm appear to be the more sensitive measures. The AMW method, however, may not be an ideal protocol for investigating the online use of prosody, since the pauses between successive chunks of the auditory input seem likely to distort the perceived prosody of the utterances.

Another technique, the monitoring of event-related brain potentials (ERP), also allows online investigation of the use of prosodic and morpho-syntactic information in sentence comprehension, without interrupting the language input and with brain responses closely time-locked to the input. Studies investigating online use of prosody with this technique are reviewed in the following section.

2.2.2.2. ERP studies

Event-related brain potentials (ERPs) are “patterned voltage changes in the ongoing electroencephalogram that are time-locked to the onset of a sensory, motor, or cognitive event” (Osterhout & Holcomb, 1992, p.786). ERP methodology has been employed extensively in psycholinguistics in recent years because it allows sensitive on-line investigation of questions regarding language processing without interrupting the presentation of language stimuli as some behavioral methods do. Furthermore, the several dimensions of the ERP such as polarity, timing, amplitude and scalp location provide richer data than reaction times for behavioral responses. Though some details of the proper interpretation of ERP data remain unsettled, several ERP components have been identified in relation to semantic, syntactic and prosodic features of language input. These include: an N400 (a centro-parietal negativity peaking around 400 ms after stimulus onset) elicited by semantic anomalies (Kutas & Hillyard, 1980); a P600 (a centro-parietal positive shift peaking around 600 ms after stimulus onset) elicited by phrase structure violations and reanalysis (Friederici, 2002; Osterhout & Holcomb, 1992); a LAN (a left anterior negativity around 300-500 ms) elicited for morpho-syntactic violations (Coulson, King, & Kutas, 1998; Osterhout & Holcomb, 1992); and an ELAN (early left anterior negativity observed around 150-200 ms) elicited for word category and phrase structure violations (Friederici, 2002).

A more recently identified ERP component, named the closure positive shift (CPS), has made investigation of online processing of prosodic cues via ERP technology more fruitful, as this component is associated with the processing of prosodic boundaries (Steinhauer, Alter, & Friederici, 1998, 1999). The CPS is a positive-going waveform observed at prosodic phrase boundaries, more specifically at IPh boundaries. It is termed *closure positive shift* because it is believed to reflect the closure of an intonational phrase. Elicitation of this component does not

depend on the presence or absence of a pause marking the prosodic boundary. A CPS effect was found to be associated with prosodic boundaries marked with prosodic changes in pitch, intensity and duration even in the absence of pauses. It is also not a neural response to syntactic structure or morphology or segmental phonology, since it occurs also with prosodic breaks in delexicalized sentences which lack morpho-syntactic cues for phrase closure (Steinhauer, et al., 1998, 1999; Steinhauer & Friederici, 2001).

The discovery of the CPS in addition to the other ERP components provided the basis for investigation of the exact timing of prosody-syntax interactions online. In what follows, studies investigating online use of overt (spoken) and covert (implicit) prosody are reviewed.

The study by Steinhauer et al. (1999) was the first systematic study to investigate online processing of prosody and syntactic information via the ERP method. The study examined minimal attachment (MA) and non-minimal attachment (NMA) ambiguities in German that can be disambiguated via prosody. There were both match and mismatch conditions as exemplified below:

(14)

- a. MA - Match: [Peter verspricht Anna zu arbeiten]_{IPh1} [und das Büro zu putzen]_{IPh2}.
'Peter promises Anna to work and to clean the office.'
- b. NMA - Match: [Peter verspricht]_{IPh1} [Anna zu entlasten]_{IPh2} [und das Büro zu putzen]_{IPh3}.
'Peter promises to support Anna and to clean the office.'
- c. MA - Mismatch: *[Peter verspricht]_{IPh1} [Anna zu arbeiten]_{IPh2} [und das Büro zu putzen]_{IPh3}.

Without prosody, the sentences above are temporarily ambiguous until the second verb *arbeiten/entlasten* (work/support). In (14a), *Anna* is the indirect object of the first verb *verspricht* (promise), and the second verb *arbeiten* (work) is intransitive. In (14b), on the other hand, *Anna* is the direct object of the obligatorily transitive second verb *entlasten* (support). The Minimal Attachment principle predicts that in reading, without helpful prosodic cues, the ambiguous NP *Anna* in these examples would initially be parsed as the object of the preceding verb *verspricht* (promise), resulting in a preference for (14a) over (14b). Thus, a garden-path effect is predicted at the second verb *entlasten* (support) in (14b), which will require revision of the initial analysis to dissociate *Anna* from the upper clause and re-attach it in the lower clause.

The location of IPh boundaries reflecting the syntactic structure of these utterances could disambiguate the sentences before subsequent lexical information becomes available to the parser. In (14a) the IPh boundary is placed after the second verb *arbeiten* (work). In (14b) the IPh boundary is placed right after the first verb *verspricht* (promise), which is predicted to bias the parser towards the NMA interpretation of the temporary ambiguity and preclude a potential garden-path. The mismatch condition, (14c), was created by cross-splicing (14a) and (14b) between *Anna* and the infinitive marker *zu* of the second verb. It was predicted that the prosodic cue before *Anna* in (14c) would bias the parser towards the NMA interpretation but the incoming

lexical information *arbeiten* (work) would resolve the sentence towards the MA interpretation, resulting in processing difficulty induced by the misplaced prosodic boundary.

Acoustic analyses of the spoken sentence materials showed that the two conditions differed significantly in terms of the intonational phrase boundaries as indicated by the duration of the constituents and accent placement. The verb *verspricht* was longer in (14b) than (14a). A major accent was placed on the verb *arbeiten* in (14a) whereas the accentuation was on the NP *Anna* in (14b). Also, there was a pause before *Anna* in (14b).

Two ERP experiments were conducted. Experiment 1 utilized a post-sentence comprehension task, while Experiment 2 employed a prosody judgment task.

Results of the comprehension task in Experiment 1 did not show any significant difference between match and mismatch conditions (i.e., cooperating and conflicting prosody). However, prosody acceptability judgments in Experiment 2 indicated that the listeners were sensitive to the prosody of the structures, as they accepted 80% of items in the match conditions but only 6% in the mismatch condition. ERP results of both Experiment 1 and 2 showed a CPS component at prosodic boundary locations in all conditions: after the second verb *arbeiten* in (14a), after the first verb *verspricht* and the second verb *entlasten* in (14b), and after the first verb *verspricht* and the second verb *arbeiten* in (14c). Furthermore, a biphasic N400-P600 sequence was observed during the intransitive second verb *arbeiten* (work) for the mismatch condition (14c), as compared to the grammatically correct transitive verb *entlasten* in (14b), which indicated processing difficulty induced by the misplaced prosodic boundary. However, because the boundaries were acoustically realized with pauses in the recordings for this experiment, the CPS effect observed at boundary locations could have been due to temporary absence of speech at

these locations, rather than a reflection of processing prosodic boundaries per se. To investigate whether or not that was the case a third experiment was run.

In Experiment 3, the pauses at boundaries were removed but intonational cues were preserved. Participants took part in an end-of-sentence prosody acceptability judgment task. Results were similar to those of Experiment 2. The prosodic acceptability was 73.8% for the match conditions and 10.9% for the mismatch condition. ERP results showed a CPS effect at the boundary locations in all conditions and an N400-P600 effect at the verb *arbeiten* (work) in the mismatch condition. Both behavioral (prosodic acceptability judgments) and ERP results for these new conditions thus confirmed that even without a pause, the prosodic boundary was still perceived by the listeners and informed their initial parsing decisions online. This finding is important support for the claim that the CPS reflects the processing of the prosodic boundary rather than just the perception of silence.

These ERP data provide strong evidence that the syntactic parser can be directly influenced by prosodic information. The prosodic information successfully induced an initial misanalysis in the mismatch condition and elicited an N400-P600 pattern at the disambiguating verb. The N400 effect was interpreted as a reflection of lexical re-access necessary to confirm the violation of the intransitive verb argument structure in the mismatch condition. The P600 effect was taken to indicate the subsequent structural revision concerning the attachment site of *Anna*. The authors note that the observed P600 component might reflect the costs associated with both syntactic and prosodic revisions.

Another ERP experiment by Steinhauer and Friederici (2001) investigated whether commas in materials for silent reading would elicit a brain response similar to that elicited by auditory processing of a prosodic boundary. The study also tested whether or not the CPS component

elicited at prosodic boundaries with lexicalized spoken input would carry over to prosodic boundaries with delexicalized spoken input. Although commas have been recognized as having a disambiguating potential for reading similar to prosodic speech boundaries in auditory processing, it was not clear whether their processing was guided by the same mechanism.

In Experiment 1, sentences similar to those employed in the auditory experiments of Steinhauer et al. (1999) were presented visually word-by-word for silent reading, without commas as in (15a) and (15b), and with commas as in (15a') and (15b').

(15) a. Peter verspricht Anna zu arbeiten ...	b. Peter verspricht Anna zu entlasten ...
a'. *Peter verspricht, Anna zu arbeiten ...	b'. Peter verspricht, Anna zu entlasten ...

(Steinhauer & Friederici, 2001, p. 272)

Commas were intended to mimic the prosodic boundaries of spoken sentences. According to the punctuation rules in German, comma insertion in (15a') after *verspricht* would be incorrect. It could be expected to lead the parser towards a misanalysis of the structure of the sentence. The comma inserted in (15b'), on the other hand, was predicted to guide the parser towards a correct syntactic analysis.

Participants were asked to judge whether a sentence was easy to read or not. For 20% of the trials a comprehension question was presented at the end of the sentence to ensure that the participants attended to the stimuli. During presentation of a sentence, subjects' brain potentials were recorded. At the end of the ERP experiment, the participants performed a pen-and-paper task in which they were asked to insert commas (according to their preferences) in a list of sentences similar to the ones above. The purpose was to observe their punctuation habits, in order to be able to determine how they related to the perception of commas in the experimental items.

The judgment data (easy to read or not) showed that commas in correct positions influenced parsing. Sentences with commas in permissible positions were read more easily than sentences with misleading commas. It was also found that participants who had strict punctuation preferences were more sensitive to the garden-path effects induced by misleading commas. The ERP results showed a CPS effect at comma positions. However, the CPS effect observed with commas was smaller than the one observed with prosodic boundaries in natural speech in the previous experiments. Recovery from wrongly placed commas resulted in a P600 effect similar to a syntactic re-analysis. However, this effect was significant only for participants with strong punctuation habits.

The CPS-like positivity was followed by a large negativity, identified as a potential CNV effect (Contingent Negative Variation, Tecce & Cattanach, 1987; cited in Steinhauer & Friederici, 2001), reflecting the expectation of response-relevant events. The authors argue that the negativity could be caused by an expectation of the disambiguating verb (*arbeiten* or *entlasten*) rather than by the processing of the prosodic boundary introduced by the comma per se. Therefore, a second experiment was conducted with sentences including correct punctuation only (i.e., with (15a) and (15b')), excluding the garden path conditions (15a') and (15b). This would prevent confounding of a syntactic garden-path introduced by morpho-syntactic information with a garden-path introduced by a misplaced comma. However, filler sentences were also included in which garden-path effects would be induced by misplaced commas only. The filler sentences included coordination structures such as the ones below:

- (16) a. Der Mann sah den Jungen, das Mädchen sah den Grossvater und ...
 a'. Der Mann sah den Jungen, das Mädchen, sah den Grossvater und ...
 The man saw the boy, the girl(,) saw the grandfather and ...
- b. Der Mann sah den Jungen, das Mädchen und den Grossvater, während ...
 b'. Der Mann sah den Jungen, das Mädchen, und den Grossvater, während ...
 The man saw the boy, the girl(,) and the grandfather, while ...

(Steinhauer & Friederici, 2001, p. 279)

In German, the comma violates the punctuation rules both in (16a') and (16b'). However, it violates the required phonological phrasing only in (16a'). The illicit commas in both (16a') and (16b') were predicted to elicit a CPS component but only the misplaced comma in (16a') was predicted to result in a garden-path effect, which would be observed at the verb *sah* (saw). No garden-path effect was expected at the conjunction *und* (and) in (16b'). Furthermore, if the negativity following the CPS effect in the previous experiment was related to the expectancy of the disambiguating verb, the CPS component predicted to be elicited by commas would not be followed by a negativity in the filler items in the present experiment.

The procedure was the same as in the first experiment. ERP results showed a CPS at all comma positions in both experimental and filler sentences, which was similar to the CPS observed with overt prosodic boundaries in spoken language input. The negativity following the CPS in Experiment 1 was not found for the items in Experiment 2. In addition, the implausible comma in (16a') but not the one in (16b') resulted in a P600 component at the word *sah*, reflecting the garden-path induced by the comma. This showed that it was not the violation of a comma rule, but rather the recovery from the violation of the required phonological phrasing, which was responsible for eliciting the P600 component. The authors argue that the results support the hypothesis that commas trigger phonological phrasing in silent reading. They also

take their findings to show furthermore that commas and overt prosodic cues not only share the potential of preventing or causing a garden path, but also rest on basically the same mechanism.

Although the data from Experiments 1 and 2 supported the view that the CPS is a reflection of phonological phrasing, and both commas and prosodic cues in spoken utterances result in elicitation of this component, the CPS might also be interpreted as a secondary syntactic processing effect, comparable to the P600. A third experiment was conducted to investigate if the CPS reflects only phonological processing, and not other properties of sentences.

In Experiment 3, the auditory input was delexicalized by removing all segmental information from the sentences that had been used in the auditory study by Steinhauer et al. (1999), but retaining the suprasegmental information. This was achieved by applying a special filtering procedure (PURR, details in Steinhauer, 1999; p. 283) Example sentences are repeated here for convenience:

- (17) a. MA: [Peter verspricht Anna zu arbeiten]_{IPh1} [und das Büro zu putzen]_{IPh2}.
‘Peter promises Anna to work and clean the office.’
- b. NMA: [Peter verspricht]_{IPh1} [Anna zu entlasten]_{IPh2} [und das Büro zu putzen]_{IPh3}.
‘Peter promises to support Anna and to clean the office.’

Participants first listened to a pure prosodic sentence melody of one of these sentences, lacking segmental content, and then after a pause of 2000 ms they were presented with the written form of the sentence in the same way as in Experiment 1 and 2 of this study (i.e., word-by-word) but without the commas. The subjects’ task was to mentally replicate the previously heard sentence melody during silent reading. The information as to whether they had to insert a phrase boundary after the first verb was provided in this case not by a comma but by the melody of the pre-presented auditory input. Half of the visually presented sentences were structurally compatible with the heard prosodic pattern, e.g., prosody of (17b) followed by sentence (17b),

whereas half of them were incompatible, e.g., prosody of (17b) followed by sentence (17a) or vice versa. At the end of silent reading, the participants would decide whether the sentence was easy or difficult to read. It was predicted that the prosodic information provided in the delexicalized sentences would influence the prosodic phrasing of the written input.

The ERP results showed a CPS effect at prosodic boundaries for the delexicalized input. The CPS effect for the written input resembled the one observed in the comma experiments, although its latency was shorter and its amplitude was larger. The authors conclude that the data favor a prosodic rather than a syntactic explanation for the CPS component, since the CPS effect was observed at prosodic boundary locations even with delexicalized input, which provides nothing other than prosodic cues for boundary locations. The resemblance between the CPS effect in this experiment and the comma experiments (Experiments 1 and 2), according to the authors, indicated that processing commas induced a cognitive mechanism similar to auditory sentence processing, via subvocal phonological sentence phrasing.

In order to establish how rapidly prosody can be used during syntactic processing, Eckstein and Friederici (2006) employed lexical ambiguities which can be disambiguated with word-category determining suffixes in German. In an ERP experiment, they examined the influence of prosody on a well-established ERP effect, the ELAN, an early (between 100 and 350 ms post-stimulus onset) left anterior negativity observed in response to word-category violations.

In this study the prosody and syntax were manipulated in a completely crossed manner, in order to investigate whether or not prosodic incongruities encountered prior to word-category information would modulate the ELAN effect. Materials included spoken German sentences that contained a prepositional phrase with mere prosodic violations, mere syntactic violations, or a combination of prosodic and syntactic violations such as the following (* marks syntactic

anomaly, # marks prosodic incongruity, the superscripts in the examples will be explained below):

- (18) a. Maria weiß, dass der Renter im¹ Alte² r⁴ kränkelt¹.
Maria knows that the pensioner in-the seniority ails.⁷
- b. * Maria weiß, dass der Renter im¹ Alte² rt⁵ kränkelt¹.
Maria knows that the pensioner in-the grows-old ails.
- c. # Maria weiß, dass der Renter im¹ Alte³ r⁶ kränkelt¹.
Maria knows that the pensioner in-the seniority ails.
- d. * # Maria weiß, dass der Renter im¹ Alte³ rt⁷ kränkelt⁷.
Maria knows that the pensioner in-the grows-old ails.

(Eckstein & Friederici, 2006, p. 1698)

In these sentences, the critical word is the object of the preposition. It is ambiguous with respect to its word category (verb or noun) when only the stem *Alte* has been heard; the suffix it receives (*-r* or *-rt*) then disambiguates the lexical category ambiguity. (18a) and (18b) were both uttered with congruent prosody. (18a) is correct in its syntax, whereas (18b) is incorrect. In (18a), the suffix disambiguates the word towards a noun interpretation: *Alte-r* (seniority), which is grammatical in the sentential context. In (18b), the suffix disambiguates the word towards a verb interpretation: *Alte-rt* (grows old), which is ungrammatical in the sentence as the preposition *im* should be followed by a noun. Thus, the syntactic manipulation was done by means of the suffix determining the word-category information. It was predicted that an ELAN effect would be observed for (18b) as opposed to (18a) at the offset of the disambiguating suffix.

The prosodically incongruent sentences (18c) and (18d) were created by splicing the critical word-stem (*Alte*) from a source sentence in which it occurred in sentence-final position, signaling the end of the sentence, i.e., the word-stem (*Alte*) originally indicated that the sentence

⁷ (i.e., ‘Maria knows that the pensioner in the old age gets sick.’)

ended, whereas in (18c) and (18d) the sentence does not end there. In (18d), which is both prosodically incongruent and syntactically incorrect, the prosodic incongruity is encountered before the morpho-syntactic disambiguating suffix, allowing the researchers to investigate whether or not the prosodic incongruity would modulate the ELAN effect predicted to be observed for the morpho-syntactic word-category violation. If so, it would indicate a direct link between prosody and syntax in a very early stage of phrase structure building.

Prosodically congruent and incongruent sentences were spliced from well-formed source sentences uttered with natural prosody by a female native speaker of German, such as (19) below⁸. The superscripts in (18) show which source sentence the morphemes were spliced from.

- (19) ¹ Maria weiß, dass der Renter im Alter kränkelt.
² Maria weiß, dass der Renter im Alterk kränkelt.
³ Maria weiß, der Renter kränkelt im Alterk.
⁴ Maria weiß, dass der Renter im Alter kränkelt.
⁵ Maria weiß, dass der Renter im Altert kränkelt.
⁶ Maria weiß, der Renter kränkelt im Alter.
⁷ Maria weiß, dass der Renter ungern altert.

(Eckstein & Friederici, 2006, p. 1698)

The first sentence was the main source sentence. The unhighlighted portions indicate the fragments used to create experimental items. The critical word stem in the prosodically incongruent conditions was spliced from the third sentence, where the prosody indicates that the sentence ends.

Acoustic analyses of the F_0 contours of the experimental sentences indicated that the critical words (*Alter* and *Altert*) in prosodically congruent conditions (18a) and (18b) showed a fall-rise pattern, whereas the same words in prosodically incongruent conditions (18c) and (18d) showed a rise-fall pattern.

⁸ No glosses for these source sentences were provided in the paper.

Participants' task was to judge the grammaticality of the sentences they heard, indicated by pressing one of two buttons. Results of the grammaticality judgment task showed that the participants were 98% correct in their judgments over all four sentence types. ERPs time-locked to the critical word onset showed a broadly distributed negativity in an early time window (300-500 ms) following the mispronounced word for prosodically incongruent conditions (18c) and (18d) as opposed to prosodically congruent conditions (18a) and (18b). There was a reliable ELAN (between 200-400 ms) at the offset of the critical word with incorrect syntax (18b) as opposed to correct syntax (18a), followed by a centro-posteriorly distributed positivity later in time (400-800 ms, P600 effect), indicating re-analysis. The prosodically and syntactically incongruent condition (18d) resulted in an early bilateral negativity (200-400 ms) at the offset of the critical word, followed by a broadly distributed positivity (400-800 ms). This positivity was taken as a P600 effect reflecting re-analysis. The bilateral distribution of the ELAN component in the combined prosodic and syntactic incongruency condition (18d) as opposed to left anterior negativity with mere syntactic violations (18b) supports the view that there is an interaction between prosodic and syntactic information during initial phrase structure building such that when prosodic incongruency is observed in parallel with syntactic anomaly, right hemispheric areas are also recruited, in accord with prior findings.

In another ERP study investigating the interplay between processing prosody and syntax, Augurzky (2006) tested the processing of RC attachment ambiguities in German. The RC attachment ambiguities were of three different types varying with respect to the relation between the first and second NPs: genitive phrases, thematic (*bei* PPs), and non-thematic prepositional phrases (*von* PPs) such as in (20) below:

(20)

- a. Genitive: Holger hörte [_{NPhigh} die Kollegin] [_{NPlow} der Juristin] [_{RC} die lange im Büro war].
Holger heard the colleague of-the judge who long in-the office was.
- b. *bei* PP: Holger hörte [_{NPhigh} die Kollegin] **bei** [_{NPlow} der Juristin] [_{RC} die lange im Büro war].
Holger heard the colleague near the judge who long in-the office was.
- c. *von* PP: Holger hörte [_{NPhigh} die Kollegin] **von** [_{NPlow} der Juristin] [_{RC} die lange im Büro war].
Holger heard the colleague of the judge who long in-the office was.

(Augurzky, 2006, p. 102)

All the sentences above are ambiguous as to which noun (the colleague/the judge) in the complex NP (the colleague of/near the judge) is modified by the RC (who had been in the office for a long time). Since the work of Cuetos and Mitchell (1988) it has been known that RC attachment ambiguities show cross-linguistic variation with respect to the preferred interpretation. A motivating question for this study was whether German speakers would prefer a high NP (the colleague) or a low NP (the judge) attachment; and, importantly, whether this would be influenced by the presence of a preposition between the two potential host nouns. Lovrić (2003) had shown for Croatian that an overt non-thematic preposition between the two nouns, i.e., *od* (of) as opposed to a non-prepositional genitive phrase lowered attachment of the RC. Augurzky was looking for evidence of a similar lowering effect in German. The specific question was whether the non-thematic *von* form (20c) would pattern with the no-preposition version (i.e., the genitive condition, (20a)) that it is synonymous with, or would pattern with the *bei* form (20b) which was expected to show the usual lowering effect due to a thematic preposition (Gilboy, Sopena, Clifton, & Frazier, 1995). The former would suggest that the effect of *von* on attachment is semantic, while the latter would suggest that the effect of *von* is prosodic.

German readers' and listeners' attachment preferences were investigated through several methods. Their attachment preferences during silent reading were investigated through an offline

questionnaire, an online self-paced reading task, another online self-paced reading task including items with commas at disambiguating regions, an oral production task, and three ERP experiments (two word-by-word reading, one auditory processing). Results of the reading experiments and oral production will be briefly summarized here. The reader is referred to the original work for details. The ERP experiment investigating participants' sensitivity to the prosodic information will be explained in more detail since the results of the experiment are more relevant to the discussion here.

Results of the offline and online reading experiments showed that for both types of prepositions (*bei* and *von*), German readers showed a low attachment preference whereas no significant attachment bias was observed for the genitive NPs. This is compatible with the prediction that, as in Croatian, the syntactic prepositional phrase structure for *von* induced a pre-PP prosodic boundary that favored low attachment of the RC (see further discussion in Lovric, 2003; Auguzky, 2006).

In the oral production study, participants were presented with globally ambiguous, or forced high and forced low attachment sentences for reading aloud. For the globally ambiguous target items, with the non-thematic prepositional phrase *von*, participants placed a prosodic boundary immediately preceding the preposition between the two NPs (*colleague* and *judge*). This prosody is as would be expected for low RC-attachment, which was observed in the reading experiments. With genitives, the prosodic boundary was placed between the whole complex NP and the RC, which is commonly associated with high attachment.

The first ERP experiment was a silent reading task in which participants were presented with the sentences in a word-by-word fashion. Experimental items included genitives, *von*-DPs and *bei*-DPs. Each condition had a forced high attachment (High A.) and a forced low attachment

(Low A.) version as shown below. Disambiguation was by number agreement on the copula *be* in the relative clause.

(21) Genitives

- a. High A.: Holger hörte die **Kolleginnen** der Juristin die lange im Büro **waren**.
Holger heard the colleagues_{pl} of-the judge_{sg} who long in-the office were_{pl}.
- b. Low A.: Holger hörte die Kolleginnen der **Juristin** die lange im Büro **war**.
Holger heard the colleagues_{pl} of-the judge_{sg} who long in-the office was_{sg}.

(22) *Bei*-DPs:

- a. High A.: Holger hörte die **Kolleginnen** bei der Juristin die lange im Büro **waren**.
Holger heard the colleagues_{pl} near the judge_{sg} who long in-the office were_{pl}.
- b. Low A.: Holger hörte die Kolleginnen bei der **Juristin** die lange im Büro **war**.
Holger heard the colleagues_{pl} near the judge_{sg} who long in-the office was_{sg}.

(23) *Von*-DPs

- a. High A.: Holger hörte die **Kolleginnen** von der Juristin die lange im Büro **waren**.
Holger heard the colleagues_{pl} of the judge_{sg} who long in-the office were_{pl}.
- b. Low A.: Holger hörte die Kolleginnen von der **Juristin** die lange im Büro **war**.
Holger heard the colleagues_{pl} of the judge_{sg} who long in-the office was_{sg}.

(Augurzky, 2006, p. 106)

Each sentence, presented word by word, was followed by a comprehension question to ensure attention. The ERP results were in accord with those of the behavioral self-paced reading task. A fronto-central positive-going deflection was found for the *von*- and *bei*-DP conditions at the disambiguating region (the sentence final word) when attachment was forced high, compared to their low attachment counterparts. No significant difference between high attachment and low attachment conditions was found for the genitives. The fronto-central positivity obtained for high attachment conditions was associated with the P600 family, and was taken to reflect syntactic reanalysis for high attachment forced conditions, implying an initial analysis of low attachment.

The results of the experiment indicated that RC attachment in German is affected by the existence of prepositions in the complex NP when sentences are disambiguated clause finally.

The readers preferred a low attachment of the RC when there was a preposition, whether or not it was thematic. However, they had no specific attachment preference for complex NPs without a preposition (the genitive examples). In this experiment, the disambiguating word appeared late in the sentence. To investigate whether the results could have reflected later parsing decisions rather than an immediate attachment decision, another ERP experiment was conducted. In the subsequent experiment the disambiguating word was the relative pronoun, which appeared earlier in the sentence at the start of the ambiguously-attachable relative clause.

The procedure was the same as for the first ERP experiment. However, experimental items included genitives and *von*-DPs only, with a forced high attachment version and a forced low attachment version (see (4) in Chapter 1 above). Disambiguation was by gender agreement on the relative pronoun.

(24) Genitives

- a. High A.: Das ist die **Köchin** des Wirts, **deren** Pudel nervtötend winselte.
This is the cook_{fem Nom} of-the publican_{masc, Gen} whose_{fem Gen} poodle nervingly whimpered.
- b. Low A.: Das ist die Köchin des **Wirts**, **dessen** Pudel nervtötend winselte.
This is the cook_{fem Nom} of-the publican_{masc, Gen} whose_{masc Gen} poodle nervingly whimpered.

(25) *von*-DPs

a. High A.: Das ist die **Köchin** von dem Wirt, **deren** Pudel nervtötend winselte.
This is the cook_{fem Nom} of-the publican_{masc, Dat} whose_{fem Gen} poodle nervingly whimpered.

b. Low A.: Das ist die Köchin von dem **Wirt**, **dessen** Pudel nervtötend winselte.
This is the cook_{fem Nom} of-the publican_{masc, Dat} whose_{masc Gen} poodle nervingly whimpered.

(Augurzky, 2006, p. 132)

Results of the comprehension task indicated that with *von*-DPs, error rates were higher for the high attachment condition than for the low attachment condition. No such difference was observed for genitives. The ERP results showed a general disadvantage for high attachment for both genitives and *von*-DPs, which was reflected by a broadly distributed negativity. This finding showed that there is an early low attachment preference for both genitives and *von*-DPs. Furthermore, the results indicated a discrepancy between early versus late decisions when compared to the ERP results of the previous experiment, and to the results of the offline comprehension task in this experiment. Considering early decisions, a broadly distributed negativity was observed with high attachment regardless of the presence of a preposition. By contrast, analogous to the first ERP experiment, offline comprehension error-rates (reflecting late decisions) showed a difference between genitive and *von*-DP conditions, with more errors for high attachment only with *von*-DPs. Augurzky argued that initial decisions were driven by the syntactic late closure principle, while later processing stages were affected by implicit prosody.

The third ERP experiment was a listening task in which the prosody of spoken sentences was manipulated to investigate whether or not listeners' attachment preferences would be sensitive to prosodic cues provided in the spoken input. A trained native speaker of German recorded the sentences with special attention to placing prosodic boundaries between the two NPs (preceding the preposition) in the *von*-DP condition and preceding the RC in the genitive condition.

Prosodic incongruency was created by cross-splicing the beginnings of *von*-preposition and genitive recordings. Recall that *von*-prepositions induced a low attachment prosody and genitives induced a high attachment prosody in the production task. Prosodically congruent and incongruent conditions are presented in (26) and (27). Note that the morphological disambiguation is early (on the relative pronoun) in these materials, as in the previous experiment.

(26) Genitives

- a. High Attachment Prosody, High Attachment Syntax
Das ist die Köchin des Wirts || / deren Pudel nervtötend winselte.
- b. Low Attachment Prosody, High Attachment Syntax
Das ist die Köchin || des Wirts / deren Pudel nervtötend winselte.
- c. High Attachment Prosody, Low Attachment Syntax
Das ist die Köchin / des Wirts || dessen Pudel nervtötend winselte.
- d. Low Attachment Prosody, Low Attachment Syntax
Das ist die Köchin || / des Wirts dessen Pudel nervtötend winselte.

(27) *von*-DPs

- a. High Attachment Prosody, High Attachment Syntax
Das ist die Köchin von dem Wirts || / deren Pudel nervtötend winselte.
- b. Low Attachment Prosody, High Attachment Syntax
Das ist die Köchin || von dem Wirts / deren Pudel nervtötend winselte.
- c. High Attachment Prosody, Low Attachment Syntax
Das ist die Köchin / von dem Wirts || dessen Pudel nervtötend winselte.
- d. Low Attachment Prosody, Low Attachment Syntax
Das ist die Köchin || / von dem Wirts dessen Pudel nervtötend winselte.

This is the cook_{fem} of the publican_{masc} whose_{masc/fem} poodle nervingly whimpered.

(Augurzky, 2006, p. 180)

Participants listened to such sentences and at the end of each sentence, they responded to a *yes/no* comprehension question. ERP results showed different responses to high attachment prosody (boundary preceding RC) and low attachment prosody (boundary between the NPs). While high attachment prosody elicited a CPS around the beginning of the RC, low attachment prosody elicited a CPS at both boundary locations (i.e., between the NPs and before the RC). No perceptual differences between genitives and *von*-DPs were observed regarding the CPS effect.

As for the syntax-prosody interaction: when genitives were presented with high attachment prosody no significant ERP effect was observed at the disambiguating region (i.e., relative pronoun) for either high or low attachment, suggesting no processing difficulty. When genitives were presented with low attachment prosody an early negative going deflection (an N400 effect) was observed for the high attachment condition. For *von*-DPs, high attachment prosody did not affect the low attachment syntax conditions but a negative-going deflection (an N400 effect) was observed with high attachment syntax and high attachment prosody. When *von*-DPs were presented with low attachment prosody, both high and low attachment syntax conditions were processed equally easily at the relative pronoun.

Of special interest in Augurzky's study is that what triggered a brain response (an N400 effect in particular) was not a result of a mismatch between prosody and syntax, or a garden-path induced by a misleading prosody. Rather, it was apparently related to whether the sentences were presented with their *typical* prosody or not. The typical prosody was low attachment prosody for *von*-DPs and high attachment prosody for genitives. The untypical prosody (high attachment prosody for *von*-DPs and low attachment prosody for genitives) created a mismatch effect (N400) only when the syntax was high attachment even if the syntax was congruent with the prosody as in the case of *von*-DPs. Augurzky suggests that when the prosody is untypical,

listeners were unaffected by the prosody and were rather guided by purely structural preferences, which was an overall low attachment preference (i.e., syntactic late closure) for both constructions.

Similar to the behavioral studies by SKS (Kjelgaard & Speer, 1999; Speer, et al., 1996), Augurzky's results show that in the case of prosodic incongruity or unexpectedness (untypical prosody), syntactic parsing preferences are given more weight. This was shown by the fact that an N400 effect, indicating a perceived anomaly, was observed for sentences that were syntactically disambiguated for high attachment (i.e., early closure), which was the overall dispreferred interpretation. In this sense, the study shows similarities to the findings of the SKS studies because the listeners in the Augurzky study showed a dispreference for an EC structure but they could ignore an untypical prosody if the structure resolved toward an LC syntax. This will be discussed further in Section 2.4. with respect to constituent length distribution in Augurzky's sentences.

Pauker, Itzhak, Baum and Steinhauer (2011) investigated LC/EC ambiguities in English similar to SKS's sentence materials via an ERP study. Similar to SKS, Pauker, et al. had cooperating, conflicting and neutral prosody conditions as shown in (28)⁹:

⁹ Note that the Pauker et al. study's experimental conditions were not fully crossed as they were in the SKS studies. What SKS called *neutral* or baseline prosody was referred to as *conflicting prosody* in the Pauker paper. I use the term *neutral* for the cross-spliced condition which yielded no prosodic boundary available to the listener and I use *conflicting prosody* to refer to the condition that yielded two prosodic boundaries, one in line with, one misleading about the syntax.

(28) a. Cooperating prosody - LC syntax:
When a bear is approaching the people || the dogs come running.

b. Cooperating prosody – EC syntax:
When a bear is approaching || the people come running.

c. Neutral prosody – EC syntax:
When a bear is approaching the people come running.

d. Conflicting prosody – LC syntax:
When a bear is approaching || the people || the dogs come running.

(Pauker et al., 2011; p. 2435)

The neutral prosody and conflicting prosody conditions were created by cross-splicing the beginnings of cooperating prosody LC and EC syntax conditions. The splicing was done right after the determiner in the NP *the people*. The participants listened to sentences such as the ones in (28) intermingled with fillers and performed an acceptability judgment (“sounds natural/acceptable or not”) task. Acceptability rates and response times of the behavioral data showed that cooperating prosody LC and EC syntax condition were equally well accepted (>87%) and did not differ in response times. The neutral prosody condition with EC syntax had a lower acceptability rating (53.3%); the conflicting prosody LC syntax condition had the lowest acceptability (28%). A CPS effect was observed for the boundary locations in (28a and b) and only for the first boundary in (28d), where the predicted CPS effect at the second boundary was overridden by a P600, reflecting a re-analysis caused by the wrongly-placed first boundary. The neutral prosody condition elicited a P600 effect on the disambiguating second verb (*come*), which was taken to reflect a re-analysis process induced by a garden-path due to the EC structure of the sentence. This is in line with the previous reading studies and neutral prosody findings of the SKS’s listening experiments. In the conflicting prosody condition (28d), at the second

boundary, a biphasic N400 preceded the P600 effect. The N400 effect was interpreted as a reflection of the first prosody-syntax mismatch.

Pauker et al. proposed the *Boundary Deletion Hypothesis* in light of their findings. According to the hypothesis, mentally deleting an overt prosodic boundary is more costly than projecting a boundary where none is present. The authors argue that the acceptability ratings (higher for neutral prosody than conflicting prosody) and a P600 effect (reduced in amplitude in neutral prosody compared to the P600 in conflicting prosody) support this hypothesis.

To summarize: The ERP studies reviewed in this section have shown that while making its syntactic parsing decisions, the human sentence processor is sensitive, early on, to prosodic cues available in the speech input. Processing of a prosodic boundary is reflected as a CPS effect. When the prosody of an utterance does not match its syntactic structure, it can mislead the parser towards an incorrect syntax and create garden paths as the Steinhauer and Friederici studies have shown. The Augurzky study has shown that the parser may rely on a structural parsing preference when encountering an atypical prosody for a construction. The Pauker et al. study replicated the CPS effect in English and extended its validity. It further confirmed that misplaced prosodic cues can mislead the parser towards an incorrect syntactic analysis. The following table summarizes the studies reviewed in this section.

Table 2-3 Summary of studies investigating the use of prosody via online tasks - ERPs.

Study	Task	Use of prosody by the participants	ERP correlate
Steinhauer et al. (1999)	Online: Listening	Yes	CPS at prosodic boundaries
	Offline: End-of-sentence acceptability judgments	Yes	N400-P600 for prosody-syntax mismatch P600 for re-analysis
Steinhauer and Friederici (2001)	Online: Word-by-word reading silently	Yes	CPS at commas P600 for re-analysis
	Listening to delexicalized input	Yes	CPS at boundary location
	Offline: End-of-sentence acceptability judgments	Yes	
Eckstein and Friederici (2006)	Online: Listening to prosody-syntax match and mismatch conditions	Yes	Bilateral ELAN
Augurzkzy (2006)	Online: Listening to prosody-syntax match and mismatch conditions	Yes	CPS at prosodic boundary locations, N400 for untypical prosody
	Offline: End-of-sentence comprehension questions	Yes	
Pauker et al. (2011)	Online: Listening to prosody-syntax match and mismatch conditions	Yes	CPS at prosodic boundary locations N400-P600 for prosody-syntax mismatch
	Offline: End-of-sentence acceptability judgments	Yes	P600 for re-analysis

2.3. Strength of Prosodic Cues: Phrase Length Effects

This section examines two major hypotheses concerning the potential impact of constituent lengths on speaker-produced or listener-perceived prosody. These are the Rational Speaker Hypothesis of Clifton and colleagues (Clifton, et al., 2002, 2006; Frazier, Carlson, & Clifton, 2006) and the Uniformity Hypothesis, stemming from work by Ghini (1993) in Italian and Sandalo and Truckenbrodt (2002) in Brazilian Portuguese, and supported by studies by Gee and Grosjean (1983) in English and by Pynte (2006) in French. All of these works conclude that constituent lengths could influence the prosodic breaks produced by speakers (Uniformity Hypothesis) and their perceived informativeness by listeners (Rational Speaker Hypothesis).

2.3.1. *The Rational Speaker Hypothesis*

The *Rational Speaker Hypothesis* (RSH) (Clifton, et al., 2002, 2006; Frazier, et al., 2006) maintains that “speakers are self-consistent, employing intonation in a manner consistent with their intended message ... and listeners attend not just to properties of the input signal, but also to the reasons why speakers produce those properties” (Clifton et al., 2006; p. 854). Research on the syntax-prosody interface has shown that the distribution of prosodic boundaries in an utterance depends not only on the syntactic structure (Selkirk, 1984; Truckenbrodt, 1995) but also on the length of the constituents (Gee & Grosjean, 1983; Selkirk, 2000; Watson & Gibson, 2004). Clifton et al. (2006) investigated how listeners deal with alternative (i.e., non-syntactic) reasons for a prosodic boundary. Their findings suggested that “listeners are sensitive to the reasons for a prosodic break. When the constituents are short, the presence of a boundary is often taken to reflect the intended structure of the sentence since constituent length does not justify the break. When the constituents are long, either constituent length or sentence structure might be

responsible for the prosodic break” (p. 857) and so they may be less inclined to treat the break as indicative of syntactic structure.

In a study by Clifton et al. (Clifton, et al., 2006) the RSH was investigated in relation to NP coordination and adverbial phrase attachment ambiguities in two experiments. Experiment 1A tested sentences with short NP conjuncts as in (29) and sentences with long NP conjuncts as in (30). The sentences were presented auditorily, with IPh boundaries at locations indicated here by ||.

(29) Short NP

- a. Pat || or Jay and Lee convinced the bank president to extend the mortgage.
- b. Pat or Jay || and Lee convinced the bank president to extend the mortgage.

(30) Long NP

- a. Patricia Jones || or Jacqueline Frazier and Letitia Connolly convinced the bank president to extend the mortgage.
- b. Patricia Jones or Jacqueline Frazier || and Letitia Connolly convinced the bank president to extend the mortgage.

(Clifton et al. 2006, p. 855)

The early IPh boundary in (29a) and (30a) was predicted to bias the listeners towards the interpretation in which either Pat (1 person) or Jay and Lee (2 people) convinced the bank president; i.e., 1 or 2 people convinced the bank president. The late prosodic boundary in (29b) and (30b) was predicted to bias the listeners towards the interpretation in which either Pat or Jay (one of two people) and Lee (1 person) convinced the bank president; i.e., 2 people convinced the bank president. Clifton et al. investigated whether or not the early boundary would yield more “(X) or (Y and Z)” interpretation and the late boundary would yield more “(X or Y) and (Z)” interpretation. The main point of the experiments however was to investigate whether listeners treated a prosodic boundary as more informative about the syntax when it flanked short

constituents (as in (29)) than when it flanked long constituents (as in (30)). This entails the prediction that if there was any difference in interpretation between the early break and the late break prosodic conditions, it should be larger for the short condition ((29a) versus (29b)) than for the long condition ((30a) versus (30b)).

Participants listened to the sentences, each of which was followed by a visually presented unambiguous paraphrase (e.g., “Pat, (or Jay + Lee) (one or two people)” vs. “(Pat or Jay) + Lee (two people)”). The task was to listen to each sentence and pull a lever once they understood it. Then when the paraphrase appeared, they would pull the lever underneath the paraphrase that most closely matched their understanding of the utterance. The participants’ choice of paraphrase and the time taken to make the choice were recorded.

Results of paraphrase choices and reaction times confirmed the predictions. Paraphrase choice results showed that although participants mostly chose the prosodically appropriate interpretation for both short and long sentences, the percentage of correct paraphrase was higher for short sentences. Furthermore, the effect of an early break versus a late break was greater for short names than long names. Reaction times for paraphrase choice were also shorter for short sentences than for long sentences, presumably due to longer paraphrases in the long NP condition. Also, in line with the results of paraphrase choices, responses were particularly fast for early break short items such as (29a). The authors concluded that the sentences in this condition were the most easily understood and were perceived as the least ambiguous.

To establish the generality of the length effect, another experiment (Experiment 1B) was conducted in which the short condition items remained the same, but names in the long condition were replaced with descriptions as in (31). As in Experiment 1A, the prosodic boundary was an IPh boundary.

- (31) a. The plantation owner || or the tenant farmer and the new caretaker convinced the bank president to extend the mortgage.
- b. The plantation owner or the tenant farmer || and the new caretaker convinced the bank president to extend the mortgage.

(Clifton et al. 2006, p. 856)

Results replicated Experiment 1A with the exception that RTs for responses to short, early boundary sentences were not particularly fast even though the short items were identical to those in Experiment 1A. However, the early versus late break difference was still significant for paraphrase choices.

The effect of phrase lengths was further tested in Experiment 2 with adverbial-attachment ambiguities with short versus long adverbial phrases. This time, only the length of the constituent following the prosodic break was manipulated, as the following examples show: (Note here that there is no prosodic boundary in the a. versions.)

(32) Short AdvP

- a. Susie learned that Bill telephoned last night.
- b. Susie learned that Bill telephoned || last night.

(33) Long AdvP

- a. Susie learned that Bill telephoned last night after the general meeting.
- b. Susie learned that Bill telephoned || last night after the general meeting.

(Clifton et al. 2006, p. 857)

Each sentence contained a final adverbial phrase that could modify either the matrix verb (*learn*) or the complement verb (*telephone*). This phrase was either short as in (32) or long as in (33) and it was either contained in the same IPh as the rest of the sentence as in (32a) and (33a), or separated by an IPh boundary (32b) and (33b). Previous research had shown that presence of

this boundary promoted high (matrix verb, *learned*) attachment in the absence of an equally large boundary after the matrix verb *learned* (Carlson, Clifton, & Frazier, 2001).

Participants were instructed to judge what they “intuitively thought the speaker was trying to convey by how she pronounced the sentences” (p. 857). Each sentence was followed by a visually presented question with a choice of two answers that disambiguated the sentence toward matrix versus embedded verb modification (e.g., *What happened last night? Susie learned something/Bill telephoned*). The participants pulled a lever under the answer that corresponded to their understanding of the speaker’s intention.

A reliable effect of phrase length was observed, as in Experiments 1A and 1B. Matrix modification interpretations were enhanced by the presence of an IPh boundary for short adverb phrases but not for long ones. Thus, it appeared that listeners discounted the syntactic implications of the boundary when the length of the following constituent could justify it.

2.3.2. *The Uniformity Hypothesis*

Gee and Grosjean (1983) provided data for prosodic boundary placement in English which showed a strong tendency toward symmetrical prosodic phrasing (cf. Ghini, 1993; discussed below). Participants in an earlier study (Grosjean, Grosjean, & Lane, 1979; cited in Gee & Grosjean, 1983) were asked to read aloud 14 sentences at different rates. Analyses showed that the prosodic structures (“performance structures”) of the participants’ utterances were hierarchical in their organization. Despite a range in pause durations, the performance structures were found to be more or less symmetrical (i.e., with balanced lengths of sister phrases). While syntactic structure also played some role in the participants’ pause durations, it was found that the main pausal break was located close to the middle of the sentence; then each segment on either side of the break was broken up into more or less equal parts. Gee and Grosjean

formulated an algorithm based on phonological, syntactic and semantic properties of performance structures which predicted the symmetry of performance structures and accounted for 92% of pause variances.

Ghini (1993) maintained that ϕ -constituency (i.e., phonological phrase constituency) in Italian is sensitive to a set of prosodic principles which refer to factors including phonological weight, balance and symmetry that contribute to the eurythmicity of the utterance. Ghini gives evidence from three phonological rules in Italian, namely Stress Retraction, Raddoppiamento Sintattico, and Final Lengthening, in his analysis of how eurythmicity plays a role in ϕ -restructuring in Italian. Stress Retraction is a rule of Standard Northern Italian which applies when two phonological words occur in sequence. If the first word in the sequence has primary stress on its final syllable and the second word has primary stress on its first syllable, the final stress on the first word is retracted toward the left to avoid stress clash. Raddoppiamento Sintattico is a rule of central and southern Italian which also applies to two phonological words that occur in sequence. The rule lengthens the initial consonant of the second word if that consonant is followed by a nonnasal sonorant and the first phonological word ends in a vowel bearing the main stress of the word. The Final Lengthening rule lengthens the vowel bearing main stress in a ϕ -final phonological word.

Ghini's analysis focuses on ϕ -restructuring (i.e., phonological phrase restructuring) in Italian. He argues that ϕ -restructuring is sensitive to phonological rather than syntactic criteria and applies to establish sequences of uniform, average-weight ϕ s.

φ-restructuring: In a sequence of primitive phonological phrases ... where each φ is a complement of the preceding φ, phonological phrases are re-distributed according to the principles of a) uniformity and average weight, b) symmetry and c) increasing units.

- a. A string is ideally parsed into same length φs; the average weight of the φs depends on tempo: at an average rate of speech (*moderato*), a φ contains two phonological words; the number of Ws within a φ increases or decreases by one by speeding up or slowing down the rate of speech.
- b. Strings are symmetrically parsed.
- c. If strings with an odd number of primitive φs are not symmetrically parsed according to (b), φs on the recursive side are heavier than φs on the nonrecursive side.

(Ghini, 1993, p. 56)

The following example from Ghini showing Stress Retraction, Raddoppiamento Sintattico and Final Lengthening reveals φ-restructuring in accord with the principles of uniformity, average weight and symmetry. Stress retraction is shown in bold face, lengthened consonants are geminated and in italics, and lengthened vowels are underlined.

(34) [[Prendr**á**]_V [[gránchi]_N [[di]_P [[ogni]_A [spechie]_N]_{NP}]_{PP}]_{NP}]_{VP}
 'He will catch every kind of crab.'

(35) (Préndra ggráanchi)_φ (di#ogni speeche)_φ

(34) shows an unstructured φ-formation, where the verb *prendrá* (catch) receives final stress and the noun *gránchi* (crab) receives initial stress. If only syntactic factors had applied, there would be a phrase boundary between the verb and the noun (see details in Ghini) which would prevent a stress clash and stress retraction. However, as (35) shows, there is stress retraction on the verb, which indicates that the verb and the noun are restructured into the same phonological phrase, as indicated by the parentheses. (35) further shows that Raddoppiamento Sintattico and Final Lengthening apply. Due to Raddoppiamento Sintattico, the first consonant of the second word (*gránchi*) is lengthened as it occurs in the same φ-phrase as the first word, which is a further indication that the first and second words form a φ-phrase together. The main stress-

bearing syllable of the phrase final word ('á' in 'gránchi') in the restructured first ϕ -phrase (prendrá gránchi) is also lengthened by application of the Final Lengthening rule.

Ghini's data and analyses show that there is a preference for a eurhythmically-motivated uniform, average-weight and symmetric phrasing in Italian.

Sandalo and Truckenbrodt (2002) showed supportive evidence for Ghini's analyses from Brazilian Portuguese. Sandalo and Truckenbrodt similarly investigated stress clash and stress retraction data and their analyses showed that stress retraction in Brazilian Portuguese is also conditioned by phonological phrasing. In Brazilian Portuguese, a word such as café (coffee) has final stress in isolation (here marked by underlining, the accent is orthographic). When it is followed by a word which has initial stress such as quente (hot), the word café retracts its stress to the left, yielding café quente (hot coffee). Sandalo and Truckenbrodt note that such stress retraction does not occur when the two words are separated by a phonological phrase (p-phrase) boundary. In Brazilian Portuguese, a p-phrase boundary is regularly assigned between a subject and a verb. So in a sentence such as café queima (coffee burns), the word-final stress on the word café does not retract to its left, because the p-phrase boundary between the subject (café) and the verb (queima) prevents it.

According to Sandalo and Truckenbrodt (2002), in Brazilian Portuguese the edges of p-phrases are right-aligned with syntactic XPs, following the *align-right* (Align XP, R) constraint (Selkirk, 2000). However the *align-right* constraint cannot predict the stress retraction phenomenon in the following examples in which a verb is followed by an object noun, which are not expected to be separated by a prosodic boundary. (Parentheses indicate p-phrases; underlining indicates stress.)

(36) (V N)
Vendeu livros.
 sold books
 ‘He sold books’

(37) (V) (N A)
Vendeu livros novos. / *Vendeu livros
 sold books new
 ‘He sold new books’

(Sandalo & Truckenbrodt, 2002, p. 293)

In (36), the stress is indeed retracted to the initial syllable of the verb *vendeu* (sold) when it is followed by the noun *livros* (books) which has initial stress. However in (37), there is no stress retraction in the verb *vendeu*, even though in both (36) and (37) the noun *livros* is in the same syntactic XP as the verb. Sandalo and Truckenbrodt propose that the following two familiar Optimality Theory (OT) constraints could account for this apparent violation of the stress retraction rule in (37).

Max-Bin: P-phrases consist of maximally two prosodic words.

Wrap-XP: Each *XP* is contained in a p-phrase.

(Sandalo & Truckenbrodt, 2002, p. 295; cf. Selkirk, 2000)

According to Sandalo and Truckenbrodt, Max-Bin enforces the prosodic phrasing shown in (37). In defining binarity as a maximum, the constraint rules out any phrasing larger than a binary p-phrase, such as (V N A), while allowing a phrasing that includes a smaller-than-binary p-phrase, i.e., (V)(N A) in (37). Other structures such as (V N)(A) and (V)(N)(A) are excluded by the Wrap-XP constraint which requires that the object (N A) be contained in a single phrase.

This is of interest for the discussion of constituent length effects on prosodic phrasing, because the contrast in stress between (36) and (37) is an indirect consequence of the shorter versus longer object NP, which induce different phrasing under the OT constraints mentioned above. However, there was also a eurythmic effect in the Brazilian Portuguese data in relation to the stress retraction phenomenon, which was not explainable by these familiar constraints. The authors proposed accounting for this phenomenon by reference to the *Uniformity Hypothesis*

originally proposed by Ghini (1993) for Italian. The following examples illustrate this phenomenon. (As before, parentheses indicate p-phrases; underlining indicates stress.)

(38) (N A) (V N) <u>Café quente</u> queima a boca. coffee hot burns the mouth. ‘Hot coffee burns the mouth’	(39) (N A) (V) → (N) (A) (V) (N) (A) (V) Café <u>quente</u> queima. / *? Café <u>quente</u>. coffee hot burns ‘Hot coffee burns’

(Sandalo & Truckenbrodt, 2002, p. 296-297)

In (38), stress retraction gives evidence for the joint phrasing of the noun *café* and the adjective *quente* within the subject. (39) is syntactically different from (38) only in not having an object, but this induces a change in the prosodic phrasing of the subject noun and the adjective that modifies it. This is evidenced by the fact that in (39) no stress retraction is observable on the word *café*. Sandalo and Truckenboldt attribute this difference to the Uniformity principle which favors p-phrases of equal length.

Uniformity: A string is ideally parsed into same length units.

(Sandalo & Truckenbrodt, 2002, p. 298; cf. Ghini, 1993)

Uniformity allows the uniform phrasing of 2+2 prosodic words in (38), but it converts the non-uniform phrasing 2+1 in (39) into the uniform phrasing 1+1+1.

Sandalo and Truckenbrodt argue that Uniformity must be stronger than Wrap-XP since Wrap-XP would favor the complex subject to be phrased into a single p-phrase but Uniformity can force the break up of the subject into two p-phrases. However, there is a syntactic restriction on Uniformity. As indicated by further examples, Uniformity applies only under limited syntactic conditions in Brazilian Portuguese, namely between the subject and the verb. Thus, the authors provide the Uniformity constraint in a revised form as follows:

Uniformity, restricted: Subject and verb are phrased in same length units.

(Sandalo & Truckenbrodt, 2002, p. 298)

In short: The Brazilian Portuguese stress retraction data indicate that phonological phrasing, at least in one structure, is subject to a strong eurythmic *uniformity* factor as well as syntactic constraints.

From a listener's perspective, eurythmic constraints such as uniformity might be taken into account in assessing the significance of a prosodic boundary. Though not specifically mentioned in Clifton et al.'s discussion of RSH as it is evidenced in English, this would be in the spirit of RSH. Pynte (2006) indeed found a similar eurythmic uniformity effect in the interpretation of prosodic cues in auditory sentence processing in French. According to Pynte, French listeners expect adjacent prosodic units to have approximately the same length, a generalization of the notion of prosodic balance discussed above. De Cornuiler (1979), cited by Pynte, had found that French speakers tended to equalize the prosodic units they produced. Pynte examined whether or not this preference for uniformity affected French listeners' parsing decisions. If French speakers favor uniformity, then French listeners can rely on the length of previous prosodic units in order to predict the length of an upcoming one, which in turn can constrain the type of syntactic construction they would anticipate. Pynte's study employed prepositional phrase (PP) attachment ambiguities as in (40) and (41).

(40) a. High attachment – Long context - Prosodically balanced

Le lendemain matin || il avait enlevé || cette chaîne **du** vélo ||
'The next morning, he had removed this chain from the bicycle.'

b. High attachment – Short context - Prosodically unbalanced

Ce matin || il enlève || cette chaîne **du** vélo ||
'This morning, he removes this chain from the bicycle.'

(41) a. Low attachment – Long context - Prosodically balanced

Le lendemain matin || il avait enlevé || cette chaîne **de** vélo ||

‘The next morning, he had removed this bicycle chain (lit., chain of bicycle).’

b. Low attachment – Short context - Prosodically unbalanced

Ce matin || il enlève || cette chaîne **de** vélo ||

‘This morning, he removes this bicycle chain (lit., chain of bicycle).’

(Pynte, 2006, p. 248)

In these examples, the optionally bi-transitive verb *enlever* (to remove something from something) results in a temporary ambiguity between a verb modifier interpretation and a noun complement interpretation of the following PP. The preposition *du* (reduction of *de le*) in (40) requires the PP to attach high to the verb, whereas the preposition *de* in (41) requires the PP to attach low to the noun. A sentence completion experiment by Frenck-Mestre and Pynte (1997, cited in Pynte, 2006) had indicated that French sentence beginnings containing a bi-transitive verb resulted in more high PP-attachment than low PP-attachment continuations. The demonstrative determiner *cette* in (40) and (41) also reduced the expectancy of a low attachment interpretation by reducing the NP modifiability. Thus, the structures were generally biased for high attachment. The question Pynte investigated concerned the interaction of syntactic alignment and uniformity of prosodic length. The length of the preceding context was manipulated in both high attachment and low attachment conditions. The sequence *cette chaîne du/de vélo* (this chain from/of bicycle) is preceded either by two prosodic units both of about the same length as the target sequence (the prosodically balanced condition) or by two shorter prosodic units (the prosodically unbalanced condition). For the balanced conditions (40a) and (41a), high attachment interpretations (40a) were expected to be easier than low attachment interpretations (41a). For the prosodically unbalanced conditions, (40b) and (41b), low attachment (41b) would be easier than high attachment (40b) because the preceding contexts

(short units) would create an expectation for a prosodic break to divide up the string *cette chaîne du/de vélo* (this chain from/of bicycle). Thus, this string would be perceived as missing a rhythmically optimal prosodic break, which will be taken as a sign of low PP-attachment. Thus, processing of high attachment will be easier in the balanced conditions due to bias introduced by the bi-directional verbs. However, processing of low attachment will be easier in the unbalanced conditions because the parser will assume that the rhythmically missing prosodic break must be absent due to congruence with low PP-attachment. In other words, since the unbalanced prosody cannot be rationalized on rhythmic grounds, it must be taken seriously as a cue to syntactic structure.

Experiment 1 investigated the effects of such conflicts. Before Experiment 1, Pynte had examined the interaction of syntactic structure and phonological length in French speakers' placement of prosodic boundaries in their utterances. This preliminary experiment was conducted with four trained phoneticians, who were native speakers of French. The participants' task was to read a series of short texts and indicate prosodic breaks without paying attention to the syntactic structure. Participants would insert one, two or three slashes depending on the strength of the break. Results showed that French speakers preferred prosodic units of 4.1 words (lexical items) on average, and both syntactic alignment and metrical constraints played a role in determining positions of slash insertions. The probability of inserting a break in front of a word varied as a function of the position of the previous break. More words since the last break resulted in more pressure to insert a break in front of the next word. The preferred-length data established that the prosodic units in the prior context for examples (40b) and (41b) in the unbalanced conditions were unusually short (only 2 lexical items in each) and would thus, by uniformity, set up an expectation for comparably short phrases to follow as long as this was

compatible with other pressures on prosodic phrasing, including alignment with the syntax. The main experiments investigated whether listeners would be sensitive to violations of uniformity and would interpret them in relation to the syntactic structure of the string.

In Experiment 1, participants were instructed to listen to the sentences and press a key as soon as they detected a target word in the utterance. Target words were presented visually on a computer screen one second before the auditory input and remained on the screen until the participant pressed a key to hear the utterance. For the experimental items, the target word was the sentence-final word. For filler and practice items, its location varied and was not predictable. Prosodic breaks in the experimental items were acoustically realized by a pause and an F_0 rise.

Results showed that for the balanced sentences, high attachment conditions elicited shorter response times than low attachment constructions, as predicted. For the unbalanced sentences, the response time was slightly longer (though not reliably so) for high attachment constructions than low attachment constructions. This was also in line with the predictions. The data suggested that French listeners apply their knowledge of uniformity on-line to decide whether or not the lack of a break inside a structurally ambiguous sequence such as *cette chaîne du/de vélo* should be taken seriously as a cue for low PP attachment. However, in Experiment 1, the target words in the experimental sentences were the last word of the sentence. This would not eliminate the possibility that phrasing preferences might be dependent on the whole prosodic unit (i.e., after the length of all prosodic units are determined). To examine if such a factor affected the results in Experiment 1, Pynte conducted a second experiment, which further investigated whether uniformity plays a role in covert prosodic phrasing.

Experiment 2 employed a self-paced reading task in which sentences such as the following were presented visually in successive units (as shown by slashes).

- (42) a. High attachment - Long context - Prosodically balanced
 Il avait enlevé / cette chaîne du vélo / et l'avait posée / sur l'établi.
 'He had removed this chain from the bicycle and had put it on the table.'
- b. High attachment – Short context - Prosodically unbalanced
 Il enlève / cette chaîne du vélo / et la pose / sur l'établi.
 'He removes this chain from the bicycle and puts it on the table.'
- (43) a. Low attachment - Long context - Prosodically balanced
 Il avait enlevé / cette chaîne de vélo / et l'avait posée / sur l'établi.
 'He had removed this bicycle chain and had put it on the table.'
- b. Low attachment – Short context - Prosodically unbalanced
 Il enlève / cette chaîne de vélo / et la pose / sur l'établi.
 'He removes this bicycle chain and puts it on the table.'

(Pynte, 2006, p. 248)

It was found in previous studies (Mitchell, 1987; Gilboy and Sopena, 1996 cited in Pynte, 2006) that visual segmentation of sentences could influence syntactic parsing decisions. In this experiment, therefore, it was expected that the self-paced procedure would impose a specific phrasing on sentences by controlling the number of words in each successive frame. The syntactic conditions were the same as in Experiment 1, namely the PP could modify the verb (high attachment, with *du*) or the noun phrase (low attachment, with *de*). However, the critical sequences were not at the end of the sentence in Experiment 2. They were surrounded by two same-length phrases in the prosodically balanced conditions and by two phrases shorter than the critical unit in the prosodically unbalanced conditions. Participants read the sentences in phrases via a self-paced reading task and performed an acceptability judgment at the end of each sentence by a key press (yes/no answer).

Results showed that 83% of sentences (including both balanced and unbalanced) were accepted and there was no significant difference between conditions in the acceptability ratings. Pynte notes that this was predicted and suggests that metrical properties do not play a primary

role in acceptability judgments and the presentation mode did not hinder comprehension. Results for response times for the acceptability judgment showed longer latencies for the unbalanced conditions than for the balanced conditions, suggesting that unbalanced conditions were perceived as unnatural by French readers. Analyses of reading times on the last frame, which was identical in all conditions, showed no significant effects. This was not as had been predicted. Pynte argues that the lack of any difference between the balanced and unbalanced conditions for reading times could mean that processing operations were postponed until participants had to respond to the acceptability question. Acceptability response time data showed shorter RTs for high attachment in the balanced length condition, and shorter RTs for low attachment in the unbalanced length condition. Experiment 3 was conducted to investigate whether or not the predicted interaction between length and attachment site would be observed if the participants were primed for the whole sentence phrasing before the sentence was visually presented.

Experiment 3 involved a cross-modal design in which participants were given first an auditory presentation of a sentence and then a visual presentation of either the same sentence (for experimental items) or a different sentence (for some fillers). Their task was to judge whether the two sentences were identical or not by pressing a key. The experimental items were the same as in Experiment 2. Sentences were visually presented as a whole and participants' eye movements were recorded as they read the sentences.

It was predicted that for the balanced condition, high attachment interpretations would be easier to read than low attachment interpretations due to the verb bias previously observed. For the unbalanced condition, the opposite pattern was predicted: low attachment interpretations would be easier to read than high attachment interpretations, because a prosodic break would be considered as missing on grounds of rhythmic uniformity and its absence would be construed as

a cue to low attachment of the PP to the noun. Eye movement results confirmed the predictions. The critical region was the region where the PP (du/de vélo) appeared. The region following the PP was also considered for spill-over effects. For the balanced conditions, first-pass gaze durations were longer for low attachment interpretations than for high attachment interpretations at the noun (vélo) in the PP. By contrast, for unbalanced conditions, first fixations were shorter for low attachment interpretations than for high attachment interpretations. Word skipping tendencies, which would indicate parsing easiness, also supported the predictions. Participants tended to skip the noun of the low attachment PPs more often in the unbalanced condition than the balanced condition. The opposite was observed for the high attachment PPs. Thus, it was easier for the participants to read low attachment interpretations in the unbalanced conditions. Eye movement results overall confirmed the prediction that phrase length mattered in PP attachment decisions in French.

Overall, results showed that the length of the preceding constituents (Experiment 1) or surrounding constituents (Experiments 2 and 3) affected the preferred interpretations of the ambiguous region. When there was a length explanation (uniformity) for not having a break inside a noun phrase followed by a PP, perceivers did not assume that the absence of a break was a cue to syntactic structure (low PP attachment), but when there was no length excuse, they did so.

The Pynte study confirms that constituent lengths can affect both auditory and visual sentence processing and that listeners/readers may take absence of prosodic cues as informative about the syntactic structure of a sentence if it does not provide uniform/balanced phrasing. It must be borne in mind, however, that not all languages may rank uniformity as highly as French does (and other languages such as Brazilian Portuguese and Italian). It would be of interest to see

whether comparable effects occur in English. Uniformity will be discussed in relation to Turkish in Chapter 3.

To sum up this section; it appears that speakers tend to provide balanced and eurythmic prosodic units as shown for English, Italian, Brazilian Portuguese, and French; and listeners, at least in English (Clifton et al. 2006) and French (Pynte, 2006), take the speakers' intentions for *presence* or *absence* of a prosodic break into account in making their parsing decisions. The RSH focuses on how *presence* of prosodic cues are dealt with by listeners. Namely, if a prosodic break is placed after/before a long constituent, it is taken to be less informative about the syntactic structure since the break could be justified by the length of the constituent. However, if a break is placed after/before a short constituent, the length of the constituent cannot justify the break. Thus, the prosodic break will be taken as a stronger cue towards the syntactic structure of the utterance. The Pynte study suggests that listeners, at least in French, take the uniformity of constituents into account while interpreting *absence* of prosodic boundaries. If there is a length (uniformity) explanation for not having a break inside a constituent, perceivers do not take the absence of a prosodic break as a cue to syntactic structure because the length of the preceding constituent(s) can justify it. However, if there is no length (uniformity) explanation for the absence of a break, it is taken as a cue to syntactic disambiguation.

Though not specifically mentioned in Clifton et al.'s discussion of RSH, Pynte's observations show that from a listener's perspective, eurythmic constraints such as uniformity might be taken into account in assessing the significance of a prosodic boundary. This would be very much in the spirit of RSH. If so, the logic of RSH should extend to *all* cases where a prosodic contour could be attributed to rhythmic (purely phonological) factors as opposed to/in addition to

syntactic alignment. The possibility of *any* rhythmic explanation therefore should reduce the syntactic cue value. Thus, I propose the *Extended Rational Speaker Hypothesis (ERSH)*:

Extended Rational Speaker Hypothesis (ERSH): Listeners are sensitive to the speaker's reasons for producing a prosodic phenomenon. If it could be due either to syntactic alignment or to eurythmic pressures, the possibility of the latter reduces the probability that the listener will treat it as a consequence of the syntax.

The following section will re-examine SKS, Augurzky and Schafer's findings with regard to ERSH.

2.4. Findings of Previous Studies – A Length Confound?

With these findings and ERSH in mind, we may return to consideration of the conflicting prosody conditions in the SKS, Augurzky, and Schafer et al. studies. The following illustrate the conflicting prosody conditions of Kjølgaard and Speer (1999), for which an advantage for LC syntax was observed:

- (44) a. Conflicting prosody, LC syntax: When Roger leaves || the house / it's dark.
- b. Conflicting prosody, EC syntax: When Roger leaves / the house || is dark.

One explanation considered in this dissertation is that in the conflicting prosody conditions, the parser might have resorted to a syntactic LC parsing strategy when there was a misleading prosodic cue or it is possible that LC was in play all along and it has observable effects when a competing prosody is ignored/rejected as defective (see Section 2.2 for the specific explanation proposed by SKS). The alternative explanation considered in this dissertation is related to the constituent length distribution in the SKS sentential items. Note that the misleading EC prosodic cue in the LC syntax condition in (44a) breaks the utterance into more or less equal lengths (3+2 PWds), whereas the misleading LC prosodic cue in the EC syntax condition in (44b) is placed before a short constituent and provides an unbalanced length distribution (4+1 PWds). If listeners

take constituent lengths into consideration while interpreting prosodic cues, as was found for English and French, then the EC conflicting prosodic cue in LC syntax condition (44a) might have been disregarded more easily than the LC conflicting prosodic cue in EC syntax condition (44b), given the length distribution of the constituents. These considerations could lead to an overall advantage for LC syntax for materials with phrase lengths as in (44).

Interestingly, phrase length distribution effects may have resulted in the *absence* of an LC advantage in the conflicting prosody condition in one of the experiments reported by Speer et al. (1996), which employed sentential items such as in (45).

- (45) a. Conflicting prosody, LC syntax
Because her grandmother knitted || pullovers / Kathy kept warm in the wintertime.
- b. Conflicting prosody, EC syntax
Because her grandmother knitted / pullovers || kept Kathy warm in the wintertime.

In (45a), the conflicting prosodic cue results in unbalanced length distribution (3+5 PWds); therefore it may have been difficult to ignore. However, in (45b) the conflicting prosodic boundary breaks the sentence into equal lengths (4+4 PWds) and thus might be easier to ignore. If so, then in this case the easier to ignore conflicting prosody is associated with EC syntax. Thus, the consistent LC advantage found in other SKS experiments employing sentential items such as (44) might have disappeared in this particular experiment due to the reversed constituent length distribution.

Similar observations could be made for Augurzky's findings, which also showed an overall preference for the LC structures when prosody was misleading. The following examples repeat the genitive condition where prosody and syntax are mismatched.

(46) Genitives

- a. Low Attachment prosody, High Attachment syntax (Conflicting prosody, EC syntax)
Das ist die Köchin || des Wirts / deren Pudel nervtötend winselte.
- b. High Attachment prosody, Low Attachment syntax (Conflicting prosody, LC syntax)
Das ist die Köchin / des Wirts || dessen Pudel nervtötend winselte.

These conflicting prosody conditions also had length distributions which would favor the LC (i.e., low attachment) syntax over the EC (high attachment) syntax condition. In the low attachment syntax condition, the prosodic break provides a more balanced length distribution whereas in the high attachment syntax condition, the prosodic break is placed after a short constituent. Thus the prosodic cue in (46a) might have been taken as more informative for the syntax and could therefore have been more difficult to disregard, which could account for the observed N400 (garden-path) effect, which was not observed for the low attachment syntax condition (46b).

Schafer et al., unlike SKS, observed an EC advantage although they had employed sentence materials similar to SKS. The following shows the length distributions for their conflicting prosody conditions:

- (47) a. Conflicting prosody, LC syntax:
When that moves || the square / it should land in a good spot.
- b. Conflicting prosody, EC syntax:
When that moves / the square || will encounter a cookie.

In (47a), the conflicting EC boundary is placed after a short constituent (2 PWds) and is followed by a long one (4 PWds), making the utterance unbalanced in terms of constituent length, and providing a strong cue to syntax which will be difficult for the parser to disregard. In (47b), on the other hand, the conflicting LC boundary breaks the sentence into more or less balanced portions (3+2 PWds). Thus, the conflicting prosodic boundary in the EC syntax condition in

(47b) might have been easier for the parser to disregard as it could be justified by optimal constituent lengths. This could explain the contrasting outcomes of the SKS and Schafer et al. studies.

The outcomes of the studies reviewed in this section might actually be due to the explanations offered in each of the relevant papers (e.g., topicalized reading for conflicting LC in SKS, untypical prosody in Augurzky, or truncated sentences in Schafer et al.). However, there is a possibility that these all fall under a single general explanation based on the distribution of constituent lengths in the experimental materials. The research reported in this dissertation examines this possibility. It asks whether or not constituent lengths play a role in the perceived informativeness of prosodic cues in Turkish, a language not investigated in this regard before. It will also be tested whether or not an LC advantage occurs in Turkish when prosody is uninformative. The following chapter presents two Turkish ambiguities to be employed in the study, and the specific research questions and predictions to be addressed.

CHAPTER 3. THE PRESENT STUDY: LATE/EARLY CLOSURE IN TURKISH

3.1. Syntactic Properties of the Turkish Ambiguities

3.1.1. General properties of the ambiguities and their preferred structural parsing

Two temporarily ambiguous LC/EC constructions in Turkish are tested in the study, namely a Genitive Possessive NP ambiguity and an NP Compound ambiguity as shown in (1) and (2) respectively.

(1) Genitive Possessive NP Ambiguity¹⁰

- a. LC: Ø Öğrenci-nin psikoloğ-u sev-il-di san-dı-m.
Pro student-GEN psychologist-3SG.POSS(-NOM) like-PASS-PAST think- PAST-1SG
'I thought that the psychologist of the student was liked.'
- b. EC: Ø Öğrenci-nin psikoloğ-u sev-diğ-i-ni san-dı-m.
Pro student-GEN psychologist-ACC like-FN-3SG.POSS-ACC think- PAST-1SG
'I thought that the student liked the psychologist.'

(2) NP Compound Ambiguity

- a. LC: Bayan kuaför-ü stajyer zanned-il-di.
Woman hairdresser-3SG.POSS(-NOM)¹¹ intern consider-PASS-PAST
'The women's hairdresser was considered the intern.'
- b. EC: Bayan kuaför-ü stajyer zannet-ti.
Woman(-NOM) hairdresser-ACC intern consider-PAST
'The woman considered the hairdresser the intern.'
(i.e., The woman mistook the hairdresser for the intern.)

¹⁰ Note that in Turkish, there is null morphological marking of nominative case on the subject in a main clause, a finite subordinate clause, an adverbial clause and a conditional clause (Göksel & Kerslake, 2005). In (1a), (2a), and (2b), therefore, the NOM feature is indicated in parentheses. In (1b), the GEN suffix marks the subject. This is due to the syntactic structure of the embedded clause (see details in Section 3.1.2).

¹¹ Kornfilt (1997) identifies the -(s)I morpheme in compound construction as a *nominal compound marker* since it does not indicate possession but Göksel and Kerslake (2005) identify it as a third person singular possessive marker presumably because it is identical in form to the third person singular possessive marker. Following Göksel and Kerslake and to illustrate the similarities between the two ambiguities, I use 3SG.POSS in the glosses.

In both (1) and (2) there is a temporary ambiguity in which a sentence-initial two-noun sequence can be interpreted either together as the subject (as a genitive-possessive NP in (1a) or an NP compound in (2a)) or separately as the subject and the object as in (1b) and (2b).

The two ambiguities are in essence quite similar to each other and both are due to the same two causes. The first is the ambiguous morpheme *-I*¹² on the second noun (*-u* on *psikolog* (psychologist) in (1) and *-ü* on *kuaför* in (2)); it can be interpreted as a third person singular possessive suffix *-(s)I* or as an accusative case marker *-(y)I* when attached to a noun ending in a consonant¹³. The second cause is that nominative case marking in Turkish is phonologically null (thus is indicated in parentheses in the above examples) in a main clause and a finite subordinate clause (Göksel & Kerslake, 2005). In (1a) and (2a), the first two nouns form a complex NP and the complex NP functions as the subject, which is closed late: *öğrenci-nin psikoloğ-u* (student-GEN psychologist-3SG.POSS(-NOM)) in (1a) and *bayan kuaför-ü* (woman hair dresser-3SG.POSS(-NOM)) in (2a). In (1b) and (2b), only the first noun constitutes the subject, which is closed early, ending at the genitive suffix of *öğrenci-nin* (student-GEN) in (1b) and at the null nominative suffix of *bayan* (woman(-NOM)) in (2b). In both constructions it is followed by an ACC-marked object: *psikoloğ-u* (psychologist-ACC) in (1b), and *kuaför-ü* (hair dresser-ACC) in (2b). Because nominative case is not marked overtly in these Turkish examples and because a genitive suffix

¹² Turkish is a vowel harmony language. Capital letters are used here to indicate the vowels that are phonologically underspecified for their backness and rounding features and are subject to vowel harmony rules in Turkish. Consonants assimilate to the voicing features of the preceding and following sounds. Consonants that are subject to voicing assimilation are also shown in capital letters.

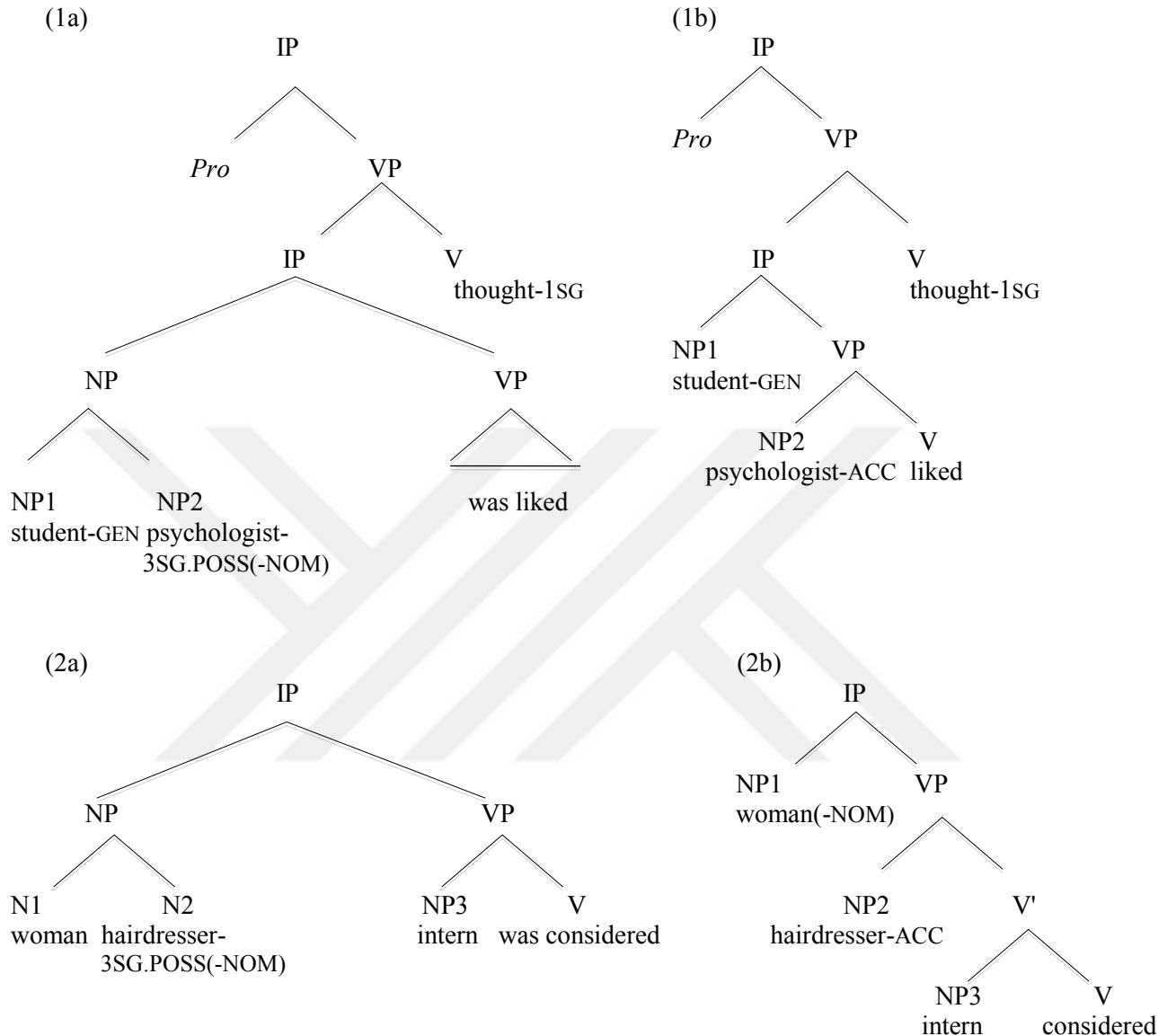
¹³ Turkish vowels cannot occur in hiatus. Therefore, if a suffix beginning with a vowel is attached to a stem ending in a vowel, either the initial vowel of the suffix is deleted, or the consonant *y* is epenthesized. The third person possessive suffix has a deletable initial *s*. The *s* in the suffix appears in order to avoid vowel sequences when the root ends in a vowel; otherwise it is deleted. The accusative case marker belongs to the second category, exhibiting an alternation *-I* versus *-(y)I*. Thus, the *y* in the accusative suffix is epenthesized only when the suffix is attached to a root ending in a vowel. In the above examples, the root nouns *psikolog* and *kuaför* end in a consonant, thus the *s* or *y* in the suffixes gets deleted and results in an ambiguous interpretation between a third person singular possessive suffix and an accusative case suffix. If the root ended in a vowel, the noun sequences would not be ambiguous. In all the experimental items the second noun ended in a consonant.

marks the subject in nominal embedded clauses as in (1b) (see more details in Section 3.1.2), the subject of these sentences remains ambiguous until the disambiguating verb (the embedded verb in (1) and the matrix verb in (2)).

In (1a), a passive verb (*sev-il-di* ‘like-PASS-PAST’) is used in the embedded clause, which takes a single argument, its subject. Thus, the first two NPs must be interpreted as a genitive-possessive structure (*öğrenci-nin psikoloğ-u* ‘student-GEN psychologist-3SG.POSS(-NOM)’) which is the subject of the passive verb in the embedded clause. In (1b), an obligatorily transitive active verb (*sev-diğ-in-i* ‘like-FN-3SG.POSS-ACC’) is used in the embedded clause, which takes two arguments. Thus the first two NPs must be interpreted as a subject (*öğrenci-nin* ‘student-GEN’) and an object (*psikoloğ-u* ‘psychologist-ACC’). Similarly, in the NP Compound ambiguity, in (2a) a passive matrix verb (*zanned-il-di* consider-PASS-PAST) takes as its subject a compound NP¹⁴ *bayan kuaför-ü* (woman hair dresser-3SG.POSS(-NOM)), while in (2b) the obligatorily transitive active verb (*zannet-ti* consider-PAST) takes both a subject (*bayan* ‘woman(-NOM)’) and a direct object (*kuaför-ü* ‘hair dresser-ACC’).

The following syntactic structures are predicted to be built for each interpretation, with English glosses and simplified here to emphasize the essential structural decision to be made by the parser.

¹⁴ Turkish has other forms of compound formation such as juxtaposed compounds as in *anneanne* (grandmother) and bare compounds as in *nylon torba* (plastic bag) in addition to *-(s)I* compounds (i.e., NP1 + NP2-POSS, as in (2a)). Among these several means of compound formation, *-(s)I* compounds have been reported to be the most productive (Göksel & Kerslake, 2005; Kornfilt, 1997).



On the basis of syntactic parsing strategies (setting prosody aside for the moment), it is predicted that (1a/2a) will be easier to process than the matched (1b/2b) due to the Late Closure strategy defined in Chapter 2¹⁵. The Late Closure strategy predicts that after processing the first NP, the parser will attach the incoming item to the phrase currently being processed and form a complex

¹⁵ Note that Minimal Attachment, defined in Chapter 2, is also relevant for parsing of the Genitive Possessive NP ambiguity because on encountering NP-GEN (i.e., before seeing/hearing NP2), it is simpler to build NP-GEN as a modifier inside a complex NP subject than to build it as the subject of a subordinate clause, which would require a more complex sentence structure. Thus, Late Closure and Minimal Attachment concur that (1a) is preferable to (1b) (see Section 3.1.2 for details).

NP *öğrenci-nin psikoloğ-u* (the student's psychologist) in (1) and *bayan kuaför-ü* (women's hairdresser) in (2), interpreting the morpheme *-I* (realized as *-u* in (1) and *-ü* in (2)) as the third person singular possessive marker. This will be appropriate for the interpretation shown in (1a/2a), with a passive verb, where the complex NP functions as the subject of the sentence and there is no object. For (1b/2b), however, the parser would discover that this analysis was incorrect when it subsequently encounters the transitive verb which needs an accusative case-marked direct object. Thus the second NP must be re-processed as the direct object of the (embedded) verb and the first NP must be re-processed as the subject of the (embedded) clause.

3.1.2. Specific structural details about each ambiguity

In this section specific aspects of each ambiguity will be examined in more detail. The Genitive Possessive ambiguity repeated below in (3) is a two-clause sentence in both versions, with the disambiguating information supplied by the embedded verb.

(3) Genitive Possessive NP Ambiguity

- a. LC: Ø Öğrenci-nin psikoloğ-**u** sev-**il-di** san-dı-m.
Pro student-GEN psychologist-3SG.POSS(-NOM) like-PASS-PAST think- PAST-1SG
 'I thought that the psychologist of the student was liked.'
- b. EC: Ø Öğrenci-nin psikoloğ-**u** sev-**diğ-i-ni** san-dı-m.
Pro student-GEN psychologist-ACC like-FN-3SG.POSS-ACC think- PAST-1SG
 'I thought that the student liked the psychologist.'

The embedded clauses in (3) are either in the form of a tensed embedded clause as in (3a), or in the form of a nominalization as in (3b) (Erguvanlı, 1984). Tensed embedded clauses such as (3a) are very similar to main clauses as they receive regular nominative case (which is null) on the subject and standard verbal endings¹⁶. In nominalized embedded clauses such as (3b), the

¹⁶ Tensed embedded clauses are used only with verbs *de-* (say), *iste-* (want) and verbs of cognition (such as think, consider and so on) (Göksel & Kerslake, 2005).

whole embedded clause is in the form of a genitive-possessive NP in which the subject NP is marked with genitive case and the embedded verb is marked with a possessive suffix after being nominalized¹⁷. This allows the first NP (*öğrenci-nin*), marked with genitive case, to be interpreted either as the first noun in a genitive-possessive NP as in (3a) or as the subject of a nominalized noun clause as in (3b).

The Minimal Attachment strategy guides the parser to choose the simplest analysis possible (Frazier, 1978, 1987) and it is relevant to the processing of the Genitive Possessive ambiguity. In (3a), the finite noun clause is indistinguishable from a main clause, structurally and morphologically, so it will presumably be parsed as a main clause until the matrix verb is encountered. This is not the case in (3b). Processing the NP1-GEN as a genitive subject entails that it is the subject of a subordinate clause and that would require the matrix clause structure and its *pro* subject to also be built at that early stage. This is a complication that would violate Minimal Attachment. Therefore, Minimal Attachment would fight against parsing NP-GEN as a subject. By contrast, in (3a) the matrix clause structure and *pro* won't be built until later, after the embedded verb is processed, by which time the GEN-POSS ambiguity has already been disambiguated, and there is nothing for Minimal Attachment to influence. Since the Minimal Attachment strategy is in agreement with the Late Closure strategy in favoring (3a) over (3b), this is not predicted to cause any complication in the experimental design but it may contribute to the greater ease of processing (3a) over (3b).

Also note that the type of ambiguity in (3) includes a null pronoun as a subject. It has been reported for Chinese that readers find it difficult to disregard the grammatical requirement that a

¹⁷ It is the subordinating suffix attached to the predicate of non-finite noun clauses that gives them a nominal structure, which can be *-DIK*, *-(y)ACAK*, *-mA*, or *-(y)Iş* (Göksel & Kerslake, 2005). Noun clauses in the form of nominalizations in Turkish can be of different types besides genitive-possessive NPs (Erguvanli, 1984; Göksel & Kerslake, 2005; Kornfilt, 1997).

pro should have an identifiable referent in the context, which could even lead to sacrificing adoption of a structurally simpler analysis (Ng & Fodor, 2011). This could apply also to Turkish sentence processing. However, in Turkish, unlike Chinese, *pro* is licensed and identified by rich agreement morphology. Unless a new referent is being introduced in the discourse or there is an intended switch of referents, pronominal subjects are generally omitted, which is facilitated by rich inflectional verbal morphology marking the relevant features of person and number (Kornfilt, 1984, 1997; Öztürk, 2002). Öztürk (2002) further claims that Turkish should be analyzed as a non-*pro*-drop language. According to her analyses, in Turkish, the VP-internal subject position (i.e., Spec VP) is occupied by the verbal agreement morphology marking the subject of the sentence (but not *pro*), whereas overt subject pronouns are base-generated in the specifier position of the topic phrase because use of overt pronouns is highly conditioned by pragmatic constraints and unless the discourse requires a topic shift, use of an overt pronoun results in ungrammaticality in Turkish. Therefore, it is predicted that use of a null subject will not result in difficulty of processing as was reported for Chinese by Ng and Fodor.

The NP Compound ambiguity, repeated below as (4), is a single-clause construction in both versions, which provides the disambiguating information for the correct structure of the sentence at the sentence-final verb, *zannet-* (think/consider).

(4) NP Compound Ambiguity

- a. LC: Bayan kuaför-**ü** stajyer **zanned-il-di.**
 Woman hairdresser-**3SG.POSS(-NOM)** intern consider-PASS-PAST
 ‘The women’s hairdresser was considered the intern.’
- b. EC: Bayan kuaför-**ü** stajyer **zannet-ti.**
 Woman(-NOM) hairdresser-**ACC** intern consider-PAST
 ‘The woman considered the hairdresser the intern.’
 (i.e., The women mistook the hairdresser for the intern.)

Verbs like *zannet-* (think/consider) are considered to be *double-object* verbs which take two internal arguments. In its active form, as in (4b), the first internal argument is the direct object with accusative case morphology, *kuaför-ü* (hairdresser-ACC); the second one is used in bare form, *stajyer* (intern), and is interpreted as the attribute of the direct object. Note that instead of a ditransitive verb such as *zannet-* which subcategorizes for two internal arguments, it is also possible to use an intransitive verb such as *ağla-* (cry) for an LC interpretation and a regular transitive verb such as *sev-* (like) for an EC interpretation. These would disambiguate the temporary ambiguity as follows:

- (5) a. LC: Bayan kuaför-ü ağla-dı.
 Woman hairdresser-3SG.POSS cry-PAST
 ‘The women’s hairdresser cried.’
- b. EC: Bayan kuaför-ü sev-di.
 Woman hairdresser-ACC like-PAST
 ‘The woman liked the hairdresser.’

However, in Turkish objects as well as subjects may be omitted in appropriate discourse contexts. Thus, use of a regular transitive verb would not exclude an interpretation in which the object of the sentence could be interpreted as null, as in (5b'). In that case the second noun (hairdresser) would be taken to be marked with possessive morphology and the subject would include both the first and second noun. Therefore, the structure would not disambiguate towards an EC interpretation.

- (5) b'. Bayan kuaför-ü Ø sev-di.
 Woman hairdresser-3SG.POSS *ec* like- PAST
 ‘The women’s hairdresser liked *ec*.’

This would pose a pragmatic violation, in the absence of any preceding context licensing the use of a null object. Gürcanlı and colleagues (Gürcanlı, Nakipoğlu, & Özyürek, 2007) present data from both adults and children, and maintain that object drop requires previous mention of the

referent in the context, unlike subject drop. Presumably this is because there is no agreement morphology that will license the null object. However, sentences presented in isolation in an experiment might be regarded by some participants as exempt from normal contextual requirements, and thus might still favor the interpretation in (5b'). Therefore, a morpho-syntactic disambiguation towards the NP-NOM NP-ACC interpretation would be more secure for experimental purposes. This is achieved by use of a double-object verb such as *zannet-* (consider)¹⁸ in which the verb takes two internal arguments. In its active form, as in (4b), the first internal argument is the direct object with accusative case morphology, *kuaför-ü* (hairdresser-ACC); the second one is used in bare form, *stajyer* (intern). Although, to my knowledge, no study on Turkish object-drop specifically considered double-object verbs such as *zannet-*, native intuition suggests that dropping the direct object but overtly mentioning the indirect object is not syntactically acceptable or pragmatically plausible. Therefore, to eliminate a possible null object interpretation, verbs such as *zannet-* that take two internal arguments will be used to disambiguate NP-compound materials in the experiments. However, if there is still such a null object interpretation with such verbs, this ambiguity construction would fail to test the hypothesis of interest in the present study, as the EC structures would not reliably have the intended disambiguation¹⁹.

¹⁸ Turkish has approximately ten other similar verbs that pattern syntactically like *zannet-*.

¹⁹ In the Genitive Possessive ambiguity no possible null object interpretation can be associated with the EC structure, resulting in an LC interpretation. This is because in the EC interpretation of the Genitive Possessive ambiguity, the subject NP (*öğrenci-nin* 'student-GEN') receives genitive case marking as in (3b), which is not the case in the LC interpretation (*öğrenci-nin psikoloğ-u* 'student-GEN psychologist-3SG.POSS) as in (3a). Thus, a null object interpretation resulting in an LC interpretation for (3b) is possible only if the second NP is *additionally* marked with the genitive suffix such as *öğrenci-nin psikoloğ-u-nun* (student-GEN psychologist-3SG.POSS-GEN) as in (3b') below. Marking the second NP with the genitive suffix would also eliminate the temporary ambiguity.

(3b') Ø Öğrenci-nin psikoloğ-u-u-**nun** Ø sev-diğ-in-i san-dı-m.
Pro student-GEN psychologist-3SGPOSS-GEN *pro* like-FN-3SG.POSS-ACC think-PAST-1SG
 'I thought (that) the student's psychologist liked *pro*.'

3.2. Prosodic Properties of the Ambiguities

Now we consider prosody. Although the sentences in (1/3a-b) and (2/4a-b) are morpho-syntactically ambiguous between an LC and EC reading until the clause-/sentence-final verb, it is possible to disambiguate them with a prosodic boundary before the disambiguating morpho-syntactic information becomes available. (As before, || indicates a prosodic boundary.) The earlier examples are repeated here in (6) and (7) with prosodic boundaries indicated.

(6) Genitive Possessive NP Ambiguity

- a. LC: Öğrencinin psikoloğu || sevildi sandım.
'I thought that the psychologist of the student was liked.'
- b. EC: Öğrencinin || psikoloğu sevdiğini sandım.
'I thought that the student liked the psychologist.'

(7) NP Compound Ambiguity

- a. LC: Bayan kuaförü || stajyer zannedildi.
'The women's hairdresser was considered the intern.'
- b. EC: Bayan || kuaförü stajyer zannetti.
'The woman considered the hairdresser the intern.'

In both (6a-b) and (7a-b), the constituents before the prosodic boundary are the subjects of the sentence and they form a separate phonological phrase (PPh) since they are specific. This is supported by the analyses provided by Özçelik and Nagai (2011).

Following upon earlier work by Kornfilt (1984), Öztürk (2005) and Çağrı (2009), Özçelik and Nagai (2011) show that in Turkish, non-specific subjects must occur in immediately pre-verbal (vP/VP internal) position and form a single PPh with the verb, whereas specific subjects raise to SpecTP and are separated from the verb by a PPh boundary, with or without other sentence

constituents in addition to the boundary (also see Kornfilt, 2011). Thus the specific subject may occur in positions other than immediately pre-verbal as shown in (9a) and (9b)²⁰.

- (9) a. Dün **adam** gel-di.
 Yesterday man come-PAST
 ‘Yesterday, **a man/the man** arrived.’
- b. **Adam** dün gel-di.
 Man yesterday come-PAST
 ‘Yesterday, **the man/*a man** arrived.’

(Özçelik & Nagai, 2011, p. 304)

In (9a), *adam* (man) could be interpreted either as specific or non-specific because it occurs immediately before the verb *geldi* (arrived). Therefore, there are two possible prosodic phrasings for (9a) as shown in (10) below.

- (10) a. [Dün]_{PPh} [adam gel-di]_{PPh}
 Yesterday man come-PAST
 ‘Yesterday, **a man** arrived.’
- b. [Dün]_{PPh} [adam]_{PPh} [gel-di]_{PPh}
 Yesterday man come-PAST
 ‘Yesterday, **the man** arrived.’

(Özçelik & Nagai, 2011, p. 307)

In (10a), the subject *adam* (man) is interpreted as non-specific because it occurs in the same PPh as the verb *geldi* (arrived). In (10b) the subject *adam* (man) is interpreted as specific because it forms a separate PPh.

In (9b) *adam* (man) can only have a specific interpretation because it does not occur in immediate pre-verbal position; therefore it must form a separate PPh as shown in (11).

²⁰ Özçelik and Nagai (2011) show similar analyses for objects also, but the discussion here is restricted to subjects only.

- (11) [Adam]_{PPh} [dün gel-di]_{PPh}
 Man yesterday come-PAST
 ‘Yesterday, **the man**/***a man** arrived.’

(Özçelik & Nagai, 2011, p. 308)

The LC/EC interpretations of the temporary ambiguities used in the present study differ with respect to what the subject of the sentence/clause is. Since on both readings of each ambiguity, the subjects are specific (they occur in sentence-initial/clause-initial positions in (6b), (7a) and (7b) or receive genitive-possessive case marking in (5a)) they would form a separate PPh and be followed by a PPh boundary.

An intonational phrase (IPh) boundary is also possible (although not obligatory) after the subject in the examples above, due to topicalization. The default topic position in Turkish is sentence-initial. Since Turkish is an SOV language, subjects typically appear at the beginning of sentences and are therefore the default or natural topic unless a different word order is used (Erguvanlı, 1984; Göksel & Kerslake, 2005; İşsever, 2003; Kornfilt, 2011)²¹. Relevant to the Genitive Possessive ambiguity, Erguvanlı (1984) mentions that it is also possible to topicalize a constituent of an embedded clause (including nominalized or finite noun clauses) by either moving it out of the clause or by placing a prosodic boundary after it in situ. A topic in Turkish is associated prosodically with an exaggerated high pitch accent, identified as a rising tone, with an optional pause following it (Kamali, 2008; Vallduví & Engdahl, 1996). Such acoustic correlates are associated with IPh boundaries by Kan (2009). Thus, a topic in Turkish apparently constitutes a separate IPh, separated from following words by a strongly marked IPh boundary, regardless of its length.

²¹ If an NP other than the subject in a sentence needs to be topicalized for pragmatic purposes, it has to be fronted to sentence/clause-initial position. Unless another NP is fronted to the sentence-initial position, the subjects of sentences are the default topics in Turkish (Göksel & Kerslake, 2005; Kornfilt, 1997), although a sentence-initial constituent does not necessarily have to be the topic (İşsever, 2003).

The experimental sentences in the current study will be uttered with an IPh boundary after the subjects to provide a clear prosodic cue to their syntactic structures.

The following pitch tracks uttered by a trained female native speaker (the author of the dissertation), illustrate the acoustic properties of the IPh boundary after the subject. Figure 3-1 and Figure 3-2 below show acoustic properties of the prosodic disambiguation for the Genitive Possessive ambiguity.

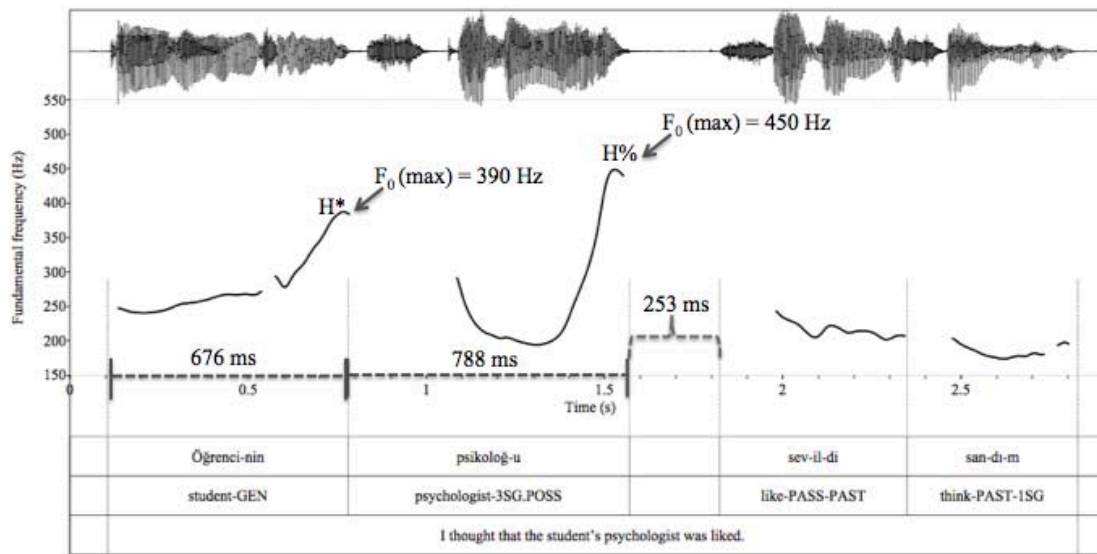


Figure 3-1 Waveform and pitch track for the Genitive Possessive ambiguity, LC interpretation, uttered by a trained female speaker of Turkish.

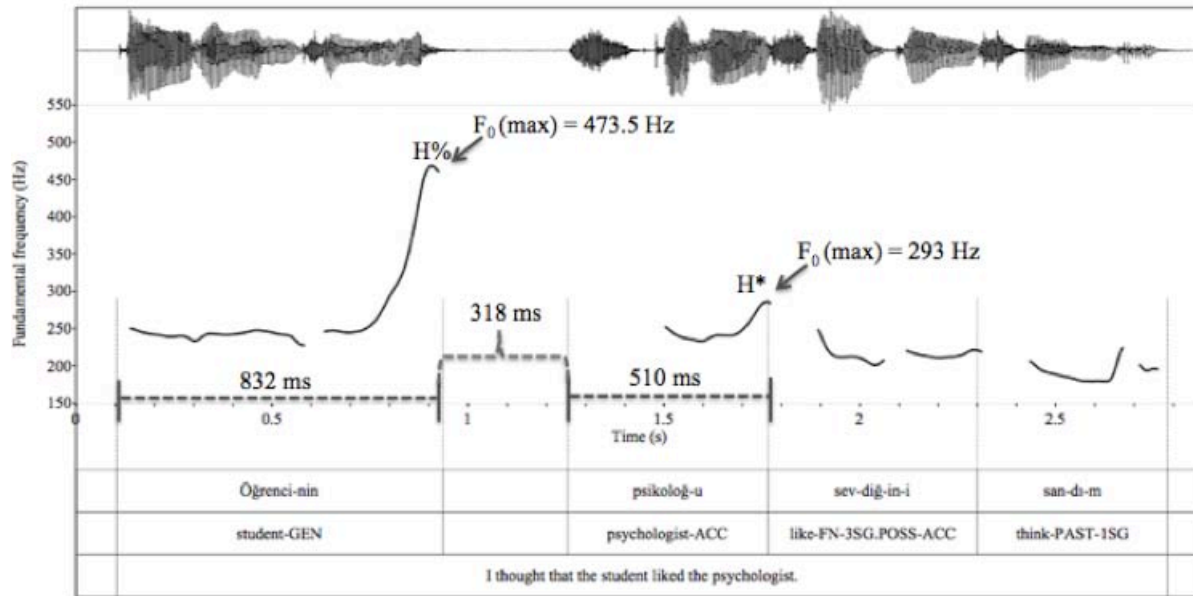


Figure 3-2 Waveform and pitch track for the Genitive Possessive ambiguity, EC interpretation, uttered by a trained female native speaker of Turkish

In Figure 3-1, presenting the pitch track for the LC version of the Genitive Possessive ambiguity, (6a), the subject of the sentence is the whole genitive possessive construction (*öğrencinin psikoloğu*). An IPh boundary after the second NP (*psikoloğu*) is realized in the form of a H% boundary tone on the second NP (maximum $F_0 = 450$ Hz) and a 253-ms silence following it. In Figure 3-2 showing the pitch track for the EC version of the Genitive Possessive, (6b), the subject of the sentence is the first NP (*öğrencinin*) only, and the IPh boundary is observed at the end of the first NP as an H% boundary tone (maximum $F_0 = 473.5$ Hz) and a 318-ms pause following it.

In addition to the H% IPh boundary tone followed by a pause, these figures also illustrate that the pre-boundary words are lengthened. In Figure 3-1, where *psikoloğu* is the pre-boundary word, it is long (788 ms) compared to the same word in Figure 3-2 (510 ms). Similarly, in Figure 3-2, *öğrencinin* is the pre-boundary word and its duration is longer (832 ms) than the same word in Figure 3-1 (676 ms).

The following figures show similar intonational patterns for the NP Compound ambiguity in (7a,b). The IPh boundaries can be observed after *kuaförü* in Figure 3-3 and after *bayan* in Figure 3-4:

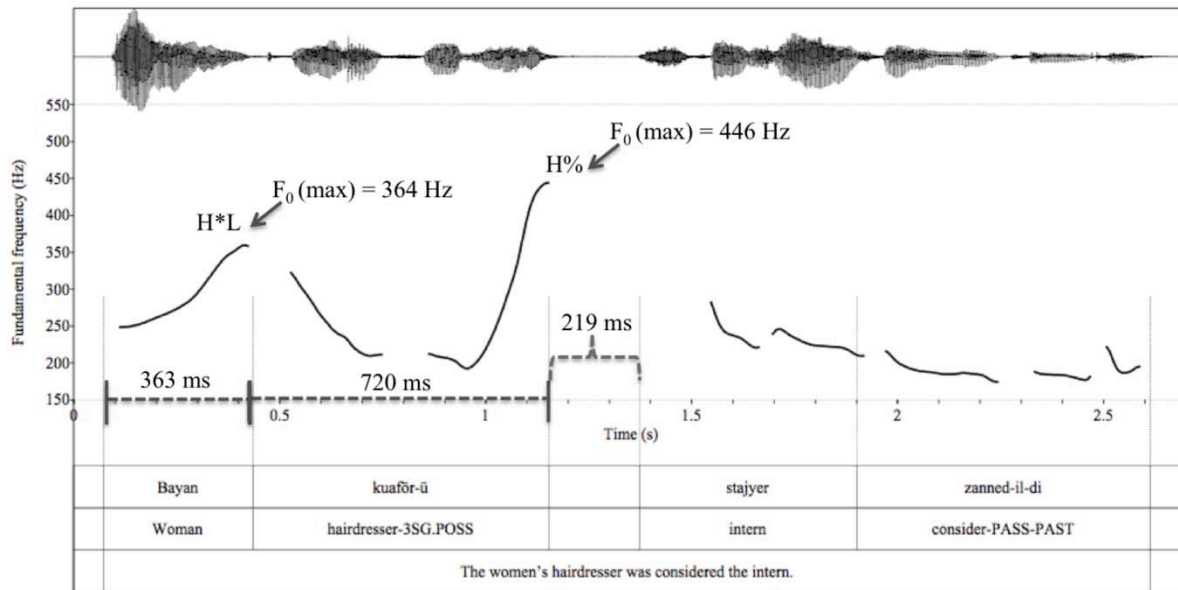


Figure 3-3 Waveform and pitch track for NP Compound ambiguity, LC interpretation, uttered by a trained female native speaker of Turkish.

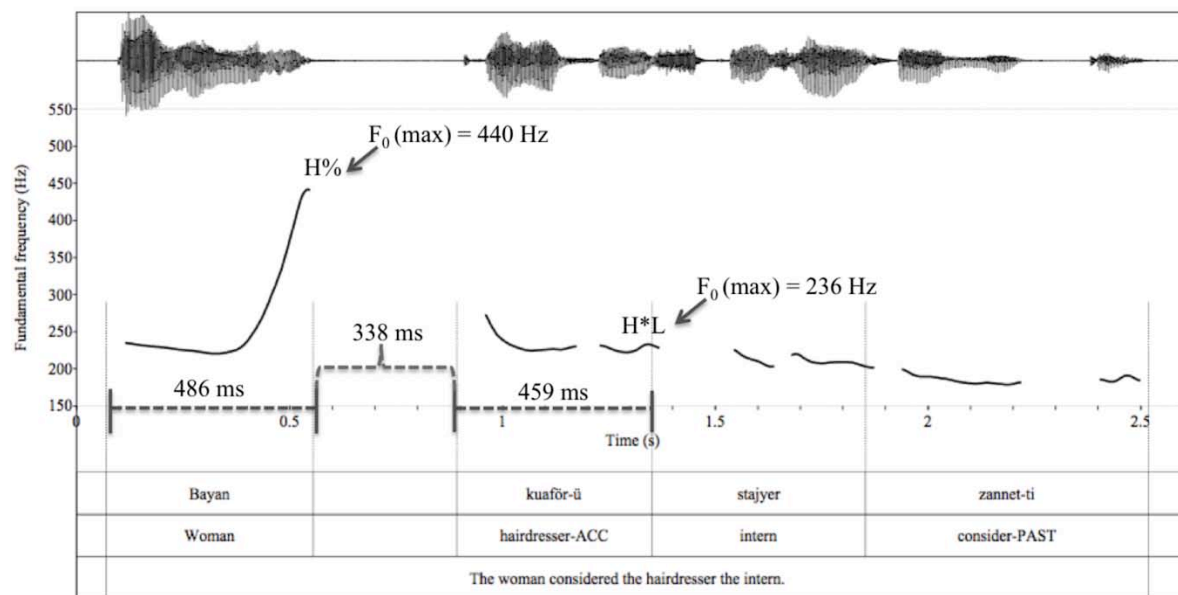


Figure 3-4 Waveform and pitch track for NP Compound ambiguity, EC interpretation, uttered by a trained female native speaker of Turkish.

In Figure 3-3, the LC sentence, the H% IPh boundary tone (maximum $F_0 = 446$ Hz) is observed on the second NP since the whole NP compound, *bayan kuaförü*, serves as the subject. It is also followed by a 219-ms silence. In Figure 3-4, the EC interpretation, the subject of the sentence is the first NP *bayan* and it is associated with an H% boundary tone (maximum $F_0 = 440$ Hz) and followed by a 338-ms pause.

Pre-boundary word lengthening can also be observed in Figure 3-3 and Figure 3-4. The word *kuaförü* is longer in Figure 3-3 (720 ms), where it is the pre-boundary word and part of the subject NP, than the same word in Figure 3-4 (459 ms). Similarly, *bayan* is longer (486 ms) in Figure 3-4, where it is the subject and pre-boundary word compared to the same word in Figure 3-3 (363 ms).

Note that the lexical prosody associated with compound NPs could potentially pose a problem for the current design (Bradley, 2011, personal communication). It has been reported for many languages including Turkish that the word-level stress pattern is affected by compound formation (Kabak & Vogel, 2001; Levi, 2002a). In compound formation the lexical stress is retained on the first noun of the compound but not on the second noun. This might appear to create a confound for the NP compound temporary ambiguity examined in the current research, since the NP compound interpretation *bayan kuaför-ü* (women's hairdresser-3SG.POSS, in (7a)) would differ prosodically from the interpretation of a succession of NP phrases as subject and object, like *bayan kuaför-ü* (woman(-NOM) hairdresser-ACC in (7b)), in terms of word-level stress, thus providing an early disambiguation cue, prior to the IPh boundary cue that follows the subject. However, this would be ruled out by a ban on tonal crowding in Turkish, as reported by Levi (2002b).

In some languages it is possible for multiple tones to link to a single tone-bearing unit (TBU), which results in the phenomenon called *tonal crowding* (Levi, 2002b). Levi (2002b) analyzed genitive possessive constructions in Turkish when spoken in isolation and in a carrier sentence. She found that in almost all cases in each production condition tonal crowding did not occur. In cases where a lexical tone (T*) competed with a PPh boundary tone (T-), the lexical tone won over the PPh boundary tone. However, in cases where a lexical tone competed with an IPh boundary tone (T%), the IPh boundary tone won. Levi proposed the following hierarchy for tone realization for Turkish in cases where there is more than one tone assigned to a single TBU:

$$T\% > T^* > T-$$

In the current materials, the prosodic disambiguation will be implemented with an IPh boundary tone (see above). Due to the ban on tonal crowding in Turkish, the NP compounds uttered in sentential contexts will be affected by the IPh boundary tone rather than by the lexical tone. Thus, in the present study, in both the NP compound and the N(-NOM) N-ACC sequence versions of the NP Compound ambiguity, the IPh prosodic boundary can signal the correct syntactic interpretation without a potential early cue from lexical prosody. The pitch track provided in Figure 3-3 above also supports this point, where the second NP in the compound receives an H% boundary tone. It can be concluded that the word-level stress pattern for compounds should not, after all, be a complication in the current design.

3.3. Research Questions, Predictions and the Methodological Design

3.3.1. Research Questions and the General Methodological Design

As noted in Chapters 1 and 2, the current study will test Turkish listeners' perception of prosodic cues in relation to the syntactic Late Closure strategy (Section 2.1) and to the ERSB (Section 2.3), in the two Turkish ambiguities outlined above. Since there have been no reported studies of

Turkish (as known at the time of these experiments) which explored the above LC/EC ambiguities in reading or listening, some more basic research questions will also be addressed. The research questions addressed in this study can be summarized as below, for reading and listening respectively:

- i. Reading:
 - a. Will Turkish speakers systematically favor an LC syntax interpretation in reading?
 - b. Or will their preferences be affected by the lengths of constituents, implying a role for prosodic phrasing in reading?
- ii. Listening:
 - a. Will overt supportive (cooperating) prosodic cues as illustrated above for the LC/EC readings of ambiguities in Turkish prevent any syntactically based garden-path effects, such as a LC-preferred interpretation?
 - b. Will such prosodic cues be strong enough to create garden-path effects when they are located in syntactically misleading positions (conflicting prosody)?
 - c. Will participants show a preference for one syntactic structure over the other that is discernible across all prosody conditions: i.e., cooperating, conflicting and neutral prosody? If so, will the preference be in accord with a syntactic LC strategy?
 - d. Will the distribution of constituent lengths in the different sentence versions interact with prosody to influence parsing preferences, as predicted by the ERSH?

Five experiments were conducted to investigate these questions. In what follows, I will briefly outline each experiment. Sections 3.2.3 and 3.3.3 will present the predictions.

Experiment 1 was a reading-aloud study which investigated whether LC or EC structures are preferred by Turkish speakers in reading. Whether constituent lengths affect these parsing preferences while reading was also tested. A *missing morpheme* task was developed for this purpose. In the missing morpheme task, participants are visually presented with sentences on a computer screen without the disambiguating morphemes, which are replaced with underscores. The participants' task was to read aloud the sentence as soon as it appeared on the screen (i.e., 'cold' reading), which required them to insert the missing morphemes, which reveal their structural analysis of the ambiguous region. There were two conditions, manipulating constituent length. (See Chapter 5 for details.)

Experiments 2A and 2B tested the interplay between constituent lengths and syntactic parsing strategies in the auditory domain, via an end-of-sentence 'got it' judgment task (Frazier, Clifton, & Randall, 1983) to establish whether and how cooperating and conflicting prosodic contours affect sentence interpretation. This methodology matches that of Kjelgaard and Speer's Experiment 2 on English LC/EC constructions. Experiments 2A and 2B in the present study differed from each other only with respect to the constituent length manipulation. (See Chapter 6 for details.)

Experiments 3A and 3B used a lexical probe version of the phoneme restoration paradigm employed by Stoyneshka et al. (2010). In the phoneme restoration paradigm, the disambiguating phonemes (in the verb, in these materials) are replaced with noise (in this study, pink noise). In the lexical probe version of the phoneme restoration paradigm (developed for this study) participants listen to the sentences and at the end of each sentence, they are presented with a visual probe (one of the disambiguating verbs, complete with all phonemes) that is congruent with, or incongruent with, or compatible with the prosody of the sentence they heard. Their task

is to respond to the visual probe as ‘yes’ (signifying ‘I heard this word in the sentence I have just listened to’) or ‘no’ (signifying ‘I didn’t hear this word’). Response time to the probe word indirectly taps which of the disambiguating morphemes on the verb the listener mentally supplies when it has been replaced by pink noise. The materials for Experiments 3A and 3B were identical to those used in Experiments 2A and 2B respectively except that the disambiguating phonemes were noise-replaced. (See Chapter 7 for details.)

The experimental sentences were longer than the examples above. They all contained 6 prosodic words (PWds) grouped into two prosodic phrases, but the groupings differed between 2+4 PWds, 3+3 PWds, and 4+2 PWds. In Turkish every lexical word is realized as a PWd (Inkelas & Orgun, 2003). The prosodic phrases in the target materials for the experiments consisted of 3+3 PWds (balanced), or 4+2 PWds (unbalanced) or 2+4 PWds (unbalanced). In deciding on the appropriate length of the constituents before/after the prosodic break, an analysis of pause frequencies provided in Nash (1973) was used. Nash asked six native speakers of Turkish to each read aloud five stories. The pause frequency data revealed that the readers paused every 4.2 words on average (with a range from 2.9 to 7.8 words), and 9.4 syllables on average (with a range from 6.8 to 13.5 syllables). Therefore, prosodic phrases in the experimental items with 2 PWds would be perceived as short, while those with 3 or 4 PWds would fall within normal range.²² To avoid an excessively short subject of just one prosodic word, a numeral modifier was added to the subject such as *seven* added to *student-GEN* (*psychologist-3SG.POSS*). Unlike an adjectival modifier or a post-positional modifier, a numeral is not ambiguous with respect to its scope.

²² It should be noted that the results of all the experiments reported here will be referenced to the distinction between balanced and unbalanced prosody but it is possible that instead they reflect the fact that the two-prosodic-word phrases were perceived as unduly short. To distinguish between these explanatory alternatives would require testing longer sentences where they can be distinguished.

To explore constituent length effects, an additional word was included in either the subject or the VP of the basic five-prosodic-word patterns. The lengthening words, such as adverbs, were words that would not introduce an additional prosodic boundary or add significantly to the meaning of the sentence. See Chapter 4 for examples.

Table 3-1 below summarizes the experimental paradigms in general.

Table 3-1 Experimental paradigms and materials used in the overall project.

	Constituent lengths comparable to SKS	Constituents lengths reversed (see below)
Missing morpheme reading task	Condition 1	Condition 2
End-of-sentence ‘got it’ task	Experiment 2A	Experiment 2B
Phoneme restoration paradigm	Experiment 3A	Experiment 3B

3.3.2. *Specific Conditions and Predictions for the Reading Experiment*

The missing morpheme reading experiment manipulated phrase lengths in two conditions. Condition 1 had an additional word inserted in the subject of the target sentences (lengthened subject) and Condition 2 had an additional word inserted in the predicate (lengthened VP). The morphemes that the participants supplied would indicate which syntactic structure they had built while parsing the initial portions of the sentences. In the lengthened subject condition, inserting LC-syntax compatible morphemes would yield an unbalanced 4+2 PWds while EC-syntax compatible morphemes would yield balanced 3+3 prosodic phrasing. In the lengthened VP condition, inserting LC-syntax compatible morphemes would result in a balanced 3+3 prosodic phrasing, whereas an EC syntax compatible morpheme would yield an unbalanced 2+4 PWds. Table 3.2 summarizes the length distributions depending on the LC/EC-syntax-compatible morphology that might be inserted by the participants.

Table 3-2 Specific conditions in the reading experiment.

Condition 1 (Lengthened Subject)	Condition 2 (Lengthened VP)
LC (4+2 PWds)	LC (3+3 PWds)
EC (3+3 PWds)	EC (2+4 PWds)

If Turkish readers favor a syntactic LC strategy no matter what the lengths of the constituents are, it is predicted that they will insert LC-compatible morphology more often than EC-compatible morphology in both length conditions²³. However, if their parsing decisions are influenced by where they insert prosodic boundaries as they read, and if their placement of prosodic boundaries is influenced by the constituent length distribution, it is predicted that the morphemes they insert will be compatible with a balanced length distribution (3+3 PWds), which would favor EC-syntax for Condition 1 and LC syntax for Condition 2. If they have both a bias for balanced constituents and a bias for LC syntax, then LC syntax-compatible morphemes will be supplied at above chance level in both conditions but would be significantly more frequent for Condition 2 (where LC syntax gives 3+3 PWds) than for Condition 1 (where LC syntax gives 4+2 PWds).

3.3.3. Specific Conditions and Predictions for the Listening Experiments

The listening experiments manipulate overt prosody (cooperating, conflicting and neutral) and syntax (LC and EC) within subjects, with phrase length patterns as a between subjects variable.

The following table presents the specific conditions in the listening experiments.

Predictions for these conditions follow beneath the table.

²³ Note that LC syntax requires insertion of passive morphology whereas EC syntax requires insertion of active morphology. This may put the LC structure at a disadvantage. However, the LC strategy can help to make passive more accessible.

Table 3-3 Specific conditions in the listening experiments.

	Cooperating Prosody	Conflicting Prosody	Neutral Prosody ²⁴
Experiments 2A and 3A	LC (4+2 PWds)	LC (3+3 PWds)	LC (4+2 PWds, syntactic)
Lengthened Subject			
(Constituent lengths similar to SKS)	EC (3+3 PWds)	EC (4+2 PWds)	EC (3+3 PWds, syntactic)
Experiments 2B and 3B	LC (3+3 PWds)	LC (2+4 PWds)	LC (3+3 PWds, syntactic)
Lengthened VP			
(Constituent lengths pattern reversed)	EC (2+4 PWds)	EC (3+3 PWds)	EC (2+4 PWds, syntactic)

The predictions for these listening experiments are grouped below under three alternative hypotheses: (i) Late Closure only; (ii) constituent length only; and (iii) both Late Closure and constituent length.

Hypothesis (i) Late Closure only: If the syntactic Late Closure strategy functions as a default parsing strategy not only when prosody is unavailable (neutral prosody) but also when it is misleading (conflicting prosody) and if it is the only determinant of parsing biases, then the results of all the listening experiments will be similar to those of SKS for English. Thus it is predicted that LC sentences will be more easily processed than EC sentences in all prosody conditions, except possibly for equal processing ease for both when they each have cooperating prosody. That is: In the cooperating prosody conditions, there may be an LC advantage due to the syntactic Late Closure strategy, or there may be no significant processing advantage for either the LC or the EC structure since the supportive prosodic cues would inform the parser about the correct syntax equally in both conditions. However, in the conflicting prosody and

²⁴ The neutral prosody condition did not have any overt prosodic boundary. The phrasing patterns given under the neutral prosody column would be due to syntactic but not prosodic boundaries.

neutral prosody conditions, there would be an LC advantage. The LC advantage in the neutral prosody condition could be attributed to the absence of prosodic cues, so that the parser will appeal to the default Late Closure syntactic parsing strategy. In the conflicting prosody condition, when the parser finds that the prosodic cues are not reliable, it will resort to the syntactic LC strategy. The following table summarizes the predictions.

Table 3-4 Hypothesis (i): Syntactic Late Closure strategy predicts processing ease (< indicates easier processing, $\leq$ indicates easier or equal ease of processing).

	All four Experiments
Late Closure Strategy	Cooperating Prosody: $LC \leq EC$
	Conflicting Prosody: $LC < EC$
	Neutral Prosody: $LC < EC$

Hypothesis (ii) Constituent Length Only: If the phrase length distribution predicts processing ease/difficulty, as outlined under the ERS in Chapter 2, Section 2.3, then the pattern of results will be different for Experiments 2A and 3A versus Experiments 2B and 3B (due to the reversed constituent length distribution in these experiments, see Table 3-3 above). The ERS makes predictions only about overt prosodic breaks. However, in the neutral prosody condition, there was no overt prosodic boundary. Thus, here, I will first outline predictions for the overt prosody conditions (cooperating and conflicting prosody). Then I will move on to the neutral prosody condition, since constituent lengths might potentially matter there too.

In Experiments 2A and 3A, in the cooperating prosody condition, there is predicted to be an LC structure advantage because the prosodic break yields unbalanced length distribution in the LC structures (4+2 PWds) and therefore it is predicted by the ERS to be treated as more informative about the syntactic structure than a prosody with balanced phrase lengths. By contrast, the cooperating EC prosodic cue gives a 3+3 PWds phrasing for which either optimal

constituent lengths or alignment with syntax could be responsible. In the conflicting prosody condition, an LC advantage is also predicted, but now for a different reason. A conflicting prosodic cue would make syntactic processing more difficult, unless the listener is able to ignore it. Because the conflicting prosody for LC syntax flanks balanced constituents (3+3 PWds), it would be easier for the parser to disregard it as a syntactic cue, by assuming that the prosodic break is due to the constituent lengths. In contrast, the EC condition is unbalanced in the conflicting condition (4+2 PWds) and therefore the motivation for the break could only be attributed to syntax, making it difficult for the parser to disregard.

For the neutral prosody condition, there is no overt prosodic break, thus ERSH would not be applicable. However, there is reason to believe that listeners mentally project missing prosodic boundaries. This is presupposed by the Boundary Deletion Hypothesis (BDH) of Pauker et al. (2011), which maintains for auditory input that “mentally deleting an overt prosodic boundary is more costly than postulating a new one” (p. 2431). In reading aloud, it is clear that readers project prosodic boundaries (even in absence of commas or other visual cue), based on syntax and phrase lengths. There is also indirect evidence that even in silent reading, readers project prosodic boundaries based on phrase lengths (cf. the Implicit Prosody Hypothesis (IPH) of Fodor (2002) and related IPH studies since.) If listeners do mentally project prosodic boundaries when they are expected but missing, then it is possible that they would favor the balanced EC structure (3+3 PWds) in Experiments 2A and 3A, following a eurhythmic uniformity principle.

In Experiments 2B and 3B, where the phrase length distribution is reversed, the ERSH would predict that the parser-preferred structures will also be reversed. In the cooperating prosody condition, the informativeness of the prosodic boundary will be stronger for the EC structure because the prosodic break is placed after a short constituent and provides unbalanced phrasing

(2+4 PWds), while the cooperative prosodic boundary may be taken less seriously as a cue to syntax in the LC condition, since that break flanks longer constituents and balances the sentence (3+3 PWds). In the conflicting prosody condition, an EC syntax advantage is predicted since the misleading prosodic cue is placed between two length-equal constituents (3+3 PWds) and so could be easier to disregard. The misleading prosodic cue for the LC structure will be perceived as more informative about syntax because it yields unbalanced phrasing (2+4 PWds) and will therefore be difficult to ignore.

In the neutral prosody condition, if listeners mentally project missing prosodic boundaries in accord with the BDH and IPH and if they follow a eurythmic uniformity principle while doing so, they will favor the LC structure which provides balanced prosodic phrasing (3+3 PWds). The table below summarizes the predictions under Hypothesis (ii).

Table 3-5 Hypothesis (ii): Constituent lengths predict processing ease (indicated by <).

	Experiments 2A and 3A	Experiments 2B and 3B
Overt Prosody	Cooperating Prosody: LC < EC	Cooperating Prosody: EC < LC
ERSH & Uniformity	Conflicting Prosody: LC < EC	Conflicting Prosody: EC < LC
Covert Prosody BDH & IPH	Neutral Prosody: EC < LC	Neutral Prosody: LC < EC

Hypothesis (iii) Both Syntactic Late Closure and Constituent Lengths: It is possible that both a syntactic Late Closure strategy and the constituent length distribution influence the way the parser interprets prosodic cues; they are not necessarily mutually exclusive. If that is the case, then the structures which are favored by both the syntactic LC and the constituent lengths will be processed most easily.

In Experiments 2A and 3A, in the cooperating prosody conditions, an LC syntax advantage is predicted because the prosodic break is placed before a short constituent (4+2 PWds), and

therefore could be perceived as strongly informative for LC-syntax, which is compatible with the subsequent morpho-syntactic information that resolves the ambiguity towards the LC interpretation. In the conflicting prosody condition, there is predicted to be an LC syntax preference too, though for a different reason: the conflicting prosodic boundary breaks the sentence into two equal length constituents (3+3 PWds) making it easy, by the ERSH, to disregard, thus reducing the conflict with the morpho-syntactic information that resolves the sentence towards an LC syntax.

In the neutral prosody condition, no significant processing difference is predicted between LC and EC structures because a prosodic balance favors the EC structure (3+3 PWds) but the syntactic Late Closure strategy favors the LC structure. It cannot be anticipated which, if either, of these factors would outweigh the other.

In Experiments 2B and 3B, in the cooperating prosody conditions, no specific prediction can be made concerning processing ease between LC and EC structures because the prosodic break is placed after a short constituent in the EC structure (2+4 PWds), making it more informative about syntax than the prosodic break in the LC structure (3+3 PWds), but the syntactic Late Closure strategy favors the LC structure. Thus, there will be a trade-off between the two forces (namely constituent length and syntactic Late Closure strategy) and it cannot be anticipated which, if either, will be stronger. In the conflicting prosody condition, the prosodic break for the EC structure balances the sentences into two equal constituents (3+3 PWds), making it easier for the parser to disregard than the misleading prosodic break in the LC structure (2+4 PWds), but the syntactic Late Closure strategy favors the LC structure, so again there may be no advantage for either structure or at most a mild residual advantage for one or the other.

Finally, in the neutral prosody condition of Experiments 2B and 3B, it is predicted that the LC structure will be favored over the EC structure because it provides both a balanced prosodic structure (3+3 PWds) and an LC syntax. Therefore the following pattern is predicted in the experiments if the constituent lengths and the syntactic Late Closure strategy act together in listeners' interpretation or projection of prosodic cues.

Table 3-6 Hypothesis (iii): Both syntactic Late Closure strategy and constituent lengths predict processing ease (< indicates easier processing, $\approx$ indicates possibility of no difference in ease of processing).

	Experiments 2A and 3A	Experiments 2B and 3B
Overt Prosody	Cooperating Prosody: LC < EC	Cooperating Prosody: EC $\approx$ LC
RSH & Uniformity	Conflicting Prosody: LC < EC	Conflicting Prosody: EC $\approx$ LC
Covert Prosody BDH & IPH	Neutral Prosody: EC $\approx$ LC	Neutral Prosody: LC < EC

Before the main experiments testing these predictions, experimental sentences were pre-tested for semantic plausibility and for their prosodic properties. Chapter 4 presents these pre-tests.

CHAPTER 4. PRE-TESTING THE EXPERIMENTAL ITEMS

A normative study was used as a pre-test to eliminate any inherent biases in the experimental sentences. Also, spoken sentences for the listening experiments were pre-tested for their prosodic properties via a pronunciation acceptability task (only the sentences in Experiments 2A and 2B) and acoustic analyses (sentences in all four listening experiments; the acoustic analyses of spoken sentences for Experiments 3A and 3B are presented in Chapter 7).

4.1. Normative Study

Noun phrase sequences which had a potentially ambiguous morphological ending on the second NP (3SG.POSS or ACC; i.e., LC or EC interpretation) were elicited from a written Turkish corpus of 17 million words (Sak, Güngör, & Saraçlar, 2008). A morphological disambiguator created by Sak et al. (2008) was used to parse the morphological structure of the NP sequences in the sentential contexts in which they occurred (i.e., whether the second NP was inflected with 3SG.POSS or ACC morphology as revealed by the further information in the sentences in which it occurred). 40 NP sequences matched for the log frequency of the alternative morphological endings of the second NP (3SG.POSS or ACC) were selected to be used in creating a pool of potential experimental sentences²⁵.

A normative study following the method in Webman Shafran (2011) was used to pretest these experimental sentences to eliminate ones that were strongly biased towards one interpretation. In the normative study, 40 sentences (with LC and EC continuations) for each ambiguity were tested in two length-versions (lengthened subject vs. lengthened VP). Recall that the lengthening

²⁵ Note that the frequency counts were based on consecutive occurrences of NP1 and NP2. However, it is possible to insert modifiers between the two NPs for both the LC and the EC interpretations of the Genitive Possessive ambiguity and before the NP2 for the EC interpretation of the NP Compound ambiguity. Such occurrences were not included in the analyses and therefore the corpus frequency match was only approximate.

words did not introduce an additional prosodic boundary or add significantly to the meaning of the sentence (see examples below). The versions were distributed across two reading lists to be judged on a 7-point Likert scale by four judges. The judges were native speakers of Turkish with a background in Linguistics: two with M.A.'s in Linguistics, one with a Ph.D. in Cognitive Science/Computational Linguistics, and one with an M.A. in Applied Linguistics.

The sentences in each length version were displayed in the format below (with normal between-word spacing and without the English glosses or titles):

(1) Genitive Possessive Ambiguity

a. Lengthened Subject (LC Unbalanced / EC Balanced)

Ambiguous segment

Ø	Yaklaşık	yedi	öğrenci-nin	psikolog-u
<i>Pro</i>	About	seven	student-GEN	psychologist-3SG.POSS/ACC

LC continuation

sev-il-di san-ıyor-uz
like- PASS-PAST
think-PROG-1PL

EC continuation

sev-diğ-i-ni san-ıyor-uz
like-FN-3SG.POSS-ACC
think- PROG-1PL

b. Lengthened VP (LC Balanced / EC Unbalanced)

Ambiguous segment

Ø	Yedi	öğrenci-nin	psikolog-u	oldukça
<i>Pro</i>	Seven	student-GEN	psychologist-3SGPOSS/ACC	much

LC continuation

sev-il-di san-ıyor-uz
like- PASS-PAST
think-PROG-1PL

EC continuation

sev-diğ-i-ni san-ıyor-uz
like-FN-3SG.POSS-ACC
think- PROG-1PL

(2) NP Compound Ambiguity

a. Lengthened Subject (LC Unbalanced / EC Balanced)

Ambiguous segment

Baş-tan ikinci bayan kuaför-ü stajyer
Beginning-ABL second woman hair dresser-3SG.POSS/ACC intern

LC continuation

zanned-il-di

consider-PASS-PAST

EC continuation

zannet-ti

consider-PAST

b. Lengthened VP (LC Balanced / EC Unbalanced)

Ambiguous segment

İkinci bayan kuaför-ü eski stajyer
Second woman hair dresser-3SG.POSS/ACC old intern

LC continuation

zanned-il-di

consider-PASS-PAST

EC continuation

zannet-ti

consider-PAST

The LC and EC interpretation presentations were counterbalanced on the right and left sides of the scale. The judges were instructed to indicate the likelihood that each of the two continuations could continue the sentence, by putting an 'X' mark in one of the boxes on the scale. If their marks were closer to one edge, it would mean that the sentence has a bias toward the interpretation on that side. Written instructions were given to the judges as to how to mark the scale. The procedure was also illustrated by five examples of possible markings. Two examples showed a single interpretation possible (unambiguous) on either side of the scale. Three examples displayed an ambiguous sentence, one with two equally possible meanings, two showing marks closer to either the LC or EC continuation side, indicating bias (on different ends

of the scale). The full list of sentences along with the instructions and examples can be found in Appendices A.1 and A.2. English translations of the instructions and examples are provided in Appendix A.3.

Each length-version of a given sentence received two scores by different judges. The scale was scored with ratings from 1 to 7. If the mark on the scale was in the middle, it was scored as 4. The LC continuation side of the scale was scored from 5-7 and the EC side was scored from 1 to 3. To qualify as acceptable, an item (a sentence pair with two length versions) had to satisfy two criteria. First, the four scores (each given by a different judge) should exhibit a difference no greater than two points on the scale. This would ensure that the judges were in general agreement on the item. This would also minimize any semantic/pragmatic differences between the different length versions as an item would not qualify as good if different versions of it differed for more than two points on the scale. Second, sentences marked at the edges (1 or 7) on the scale would result in elimination of the item since it would suggest that (at least one length version of) the sentence is not ambiguous at all. Thus, an item receiving a score of 4-4 would be optimal but an item receiving scores ranging between 2-4, 3-5, and 4-6 would also be accepted. The 24 items which best met these criteria were selected for use in the subsequent experiments (see Appendix B.1 for a full list of experimental items with English translations).

The average ratings for the selected sentences in each condition are presented in Table 4-1.

Table 4-1 Results of the normative test for the items selected for use in the main experiments: Average ratings for length-manipulated conditions.

	Lengthened Subject (LC Unbalanced/EC Balanced)	Lengthened VP (LC Balanced/EC Unbalanced)
Genitive Possessive	3.83	3.90
NP Compound	3.93	4.08

As the table shows, manipulation of length did not bias significantly towards LC or EC interpretation in the selected sentences, which was supported by pairwise comparisons: Genitive Possessive ambiguity: $t(23) = .923, p = .366$, NP Compound ambiguity: $t(23) = 1.071, p = .295$.

4.2. Pronunciation Acceptability

The 24 items selected on the basis of the normative study were read aloud and recorded by a trained native speaker (i.e., the author of the dissertation), for use in Experiments 2A and 2B (please see Chapter 7 for specific details about spoken sentences in Experiments 3A and 3B). The items were uttered in cooperating, conflicting, and neutral prosody.

All sentences with cooperating prosody had an IPh boundary after the subjects, in accord with the topicalization facts in Turkish (see Chapter 3). Instead of cross-splicing recordings to create conflicting prosody, which distorts the materials only in one condition but not the others, the conflicting prosody conditions were spoken; i.e., the speaker used LC prosody for EC sentences and EC prosody for LC sentences. Sentences with neutral prosody had no prosodic boundary in the corresponding regions of the sentence. In order for this neutral prosody to sound natural, the modifier of the sentence-initial subject received a contrastive accent, which tends to mute prosodic variation in the remainder of the sentence. This strategy is similar to the one used by Kjelgaard and Speer (1999), where they placed contrastive focus on the subject of the temporarily ambiguous first clause. Note that this baseline prosody is not argued to be neutral in some absolute sense. Rather, it will serve as a baseline condition by not providing any prosodic disambiguating cue.

The following 12 pitch tracks exemplify the cooperating, conflicting and neutral prosody conditions for the Genitive Possessive and NP Compound ambiguities, all in the lengthened

subject condition here. (See Table 4-4 below for F_0 and timing measurements across all experimental items.)

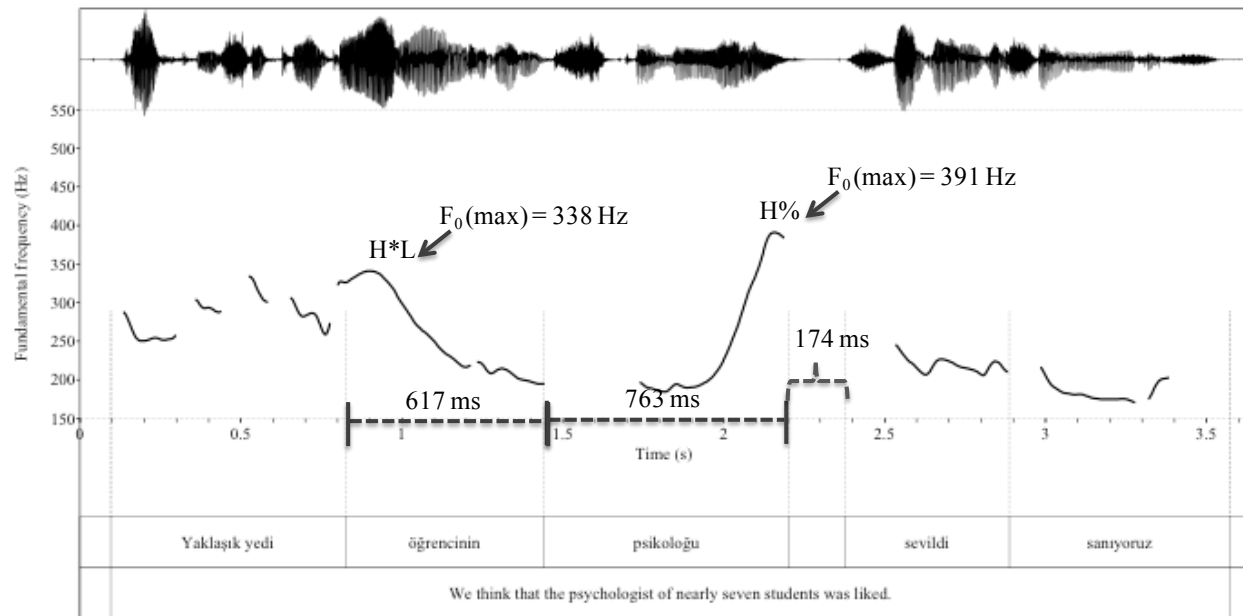


Figure 4-1 Waveform and pitch track for Genitive Possessive ambiguity LC sentence, uttered with cooperating prosody.

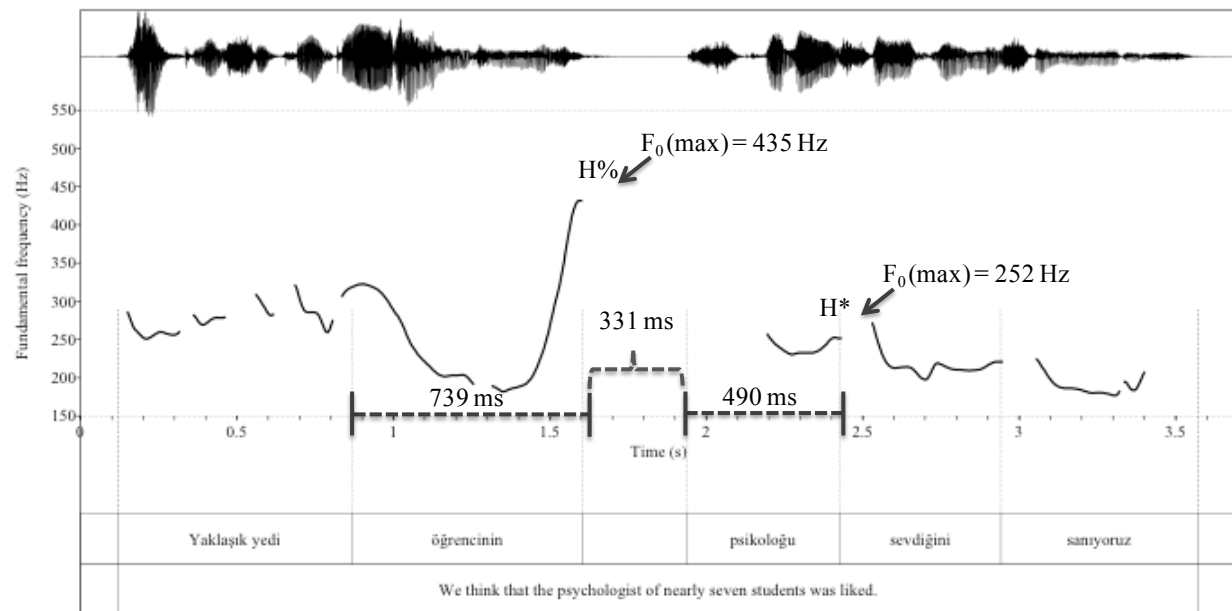


Figure 4-2 Waveform and pitch track for Genitive Possessive ambiguity EC sentence, uttered with cooperating prosody.

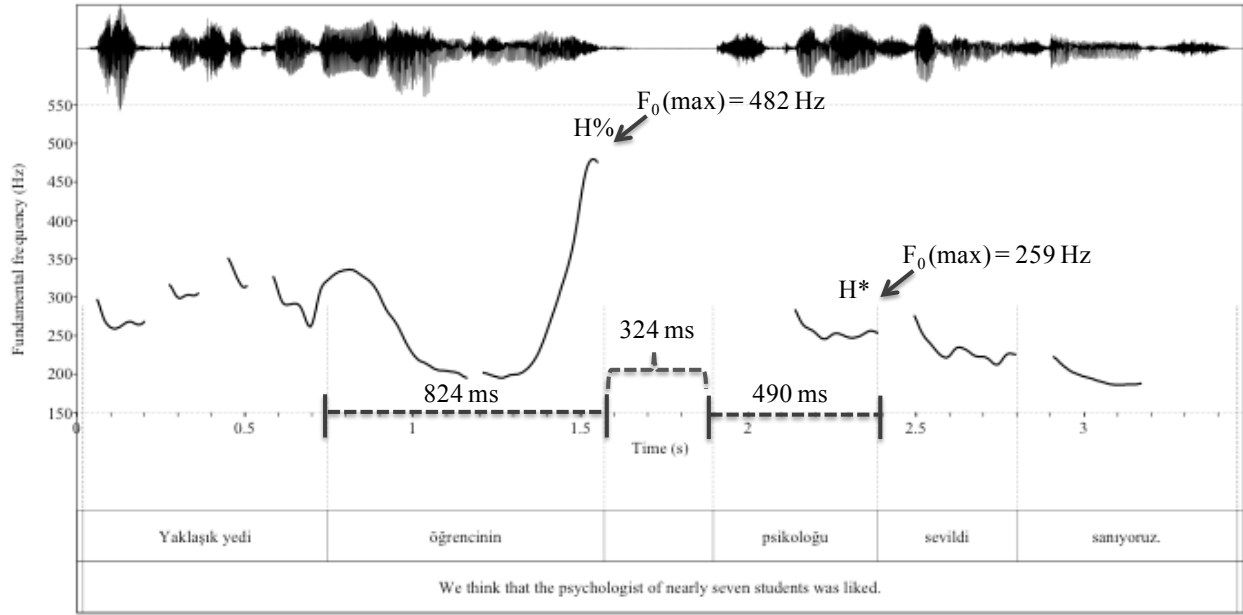


Figure 4-3 Waveform and pitch track for Genitive Possessive ambiguity LC sentence, uttered with conflicting prosody.

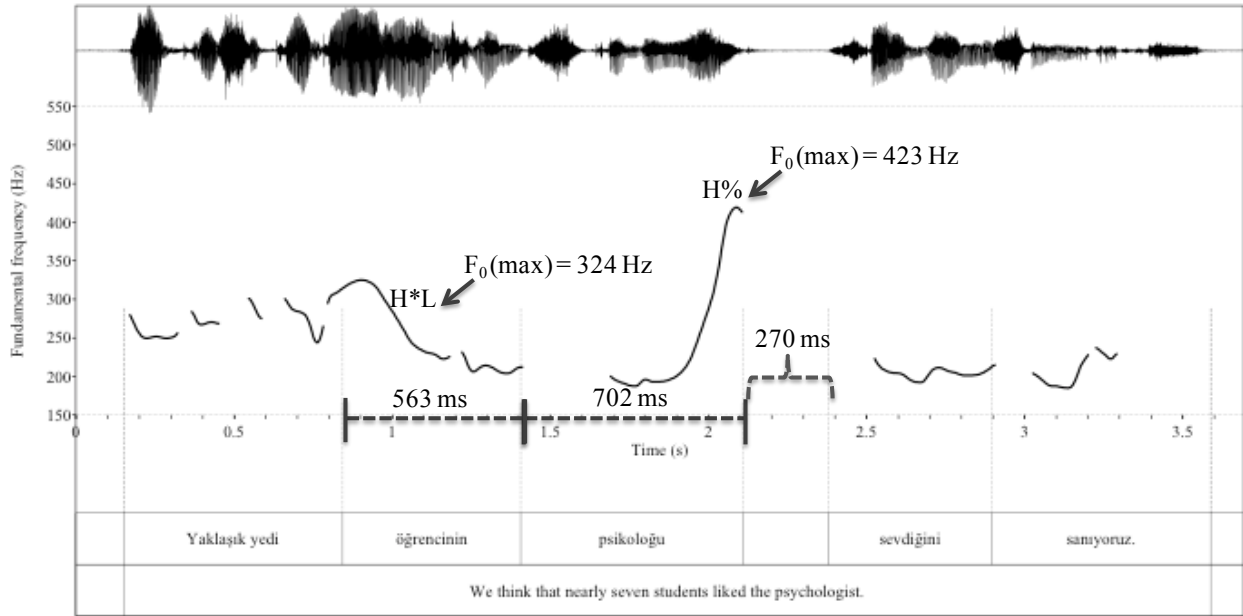


Figure 4-4 Waveform and pitch track for Genitive Possessive ambiguity EC sentence, uttered with conflicting prosody.

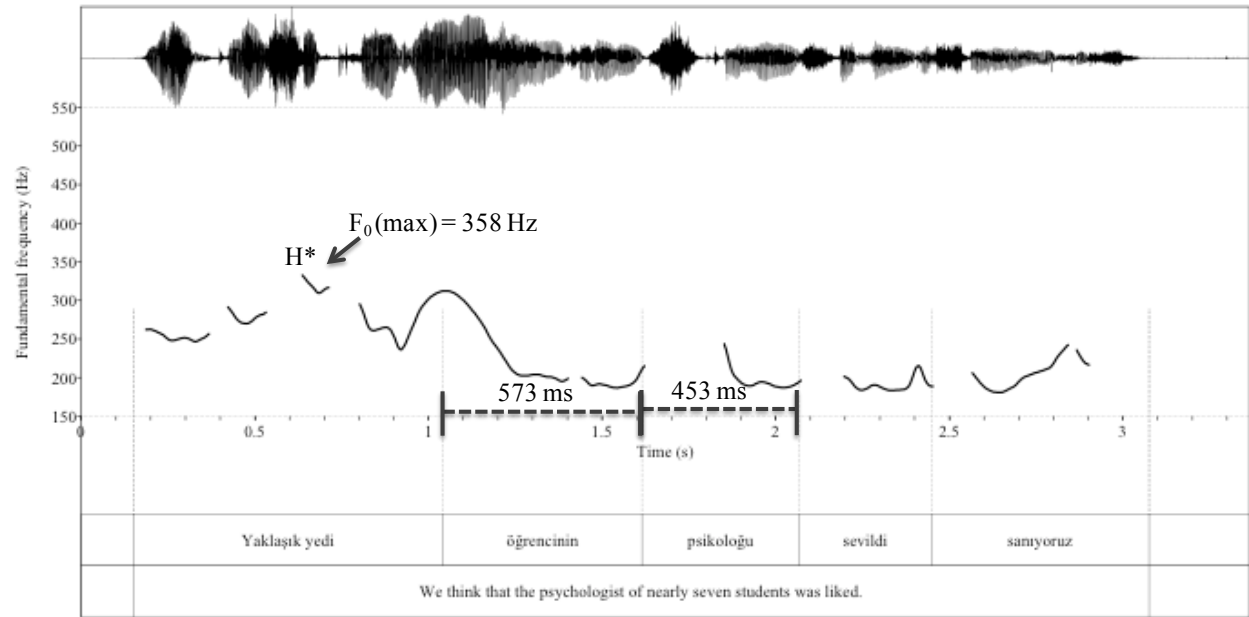


Figure 4-5 Waveform and pitch track for Genitive Possessive ambiguity LC sentence, uttered with neutral prosody.

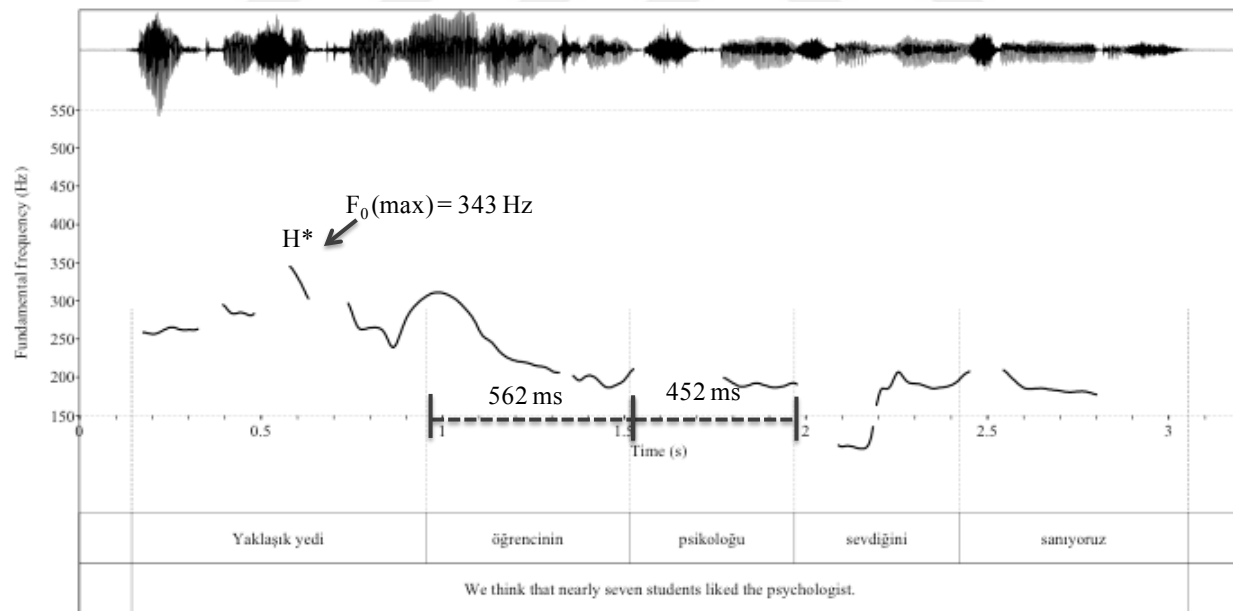


Figure 4-6 Waveform and pitch track for Genitive Possessive ambiguity EC sentence, uttered with neutral prosody.

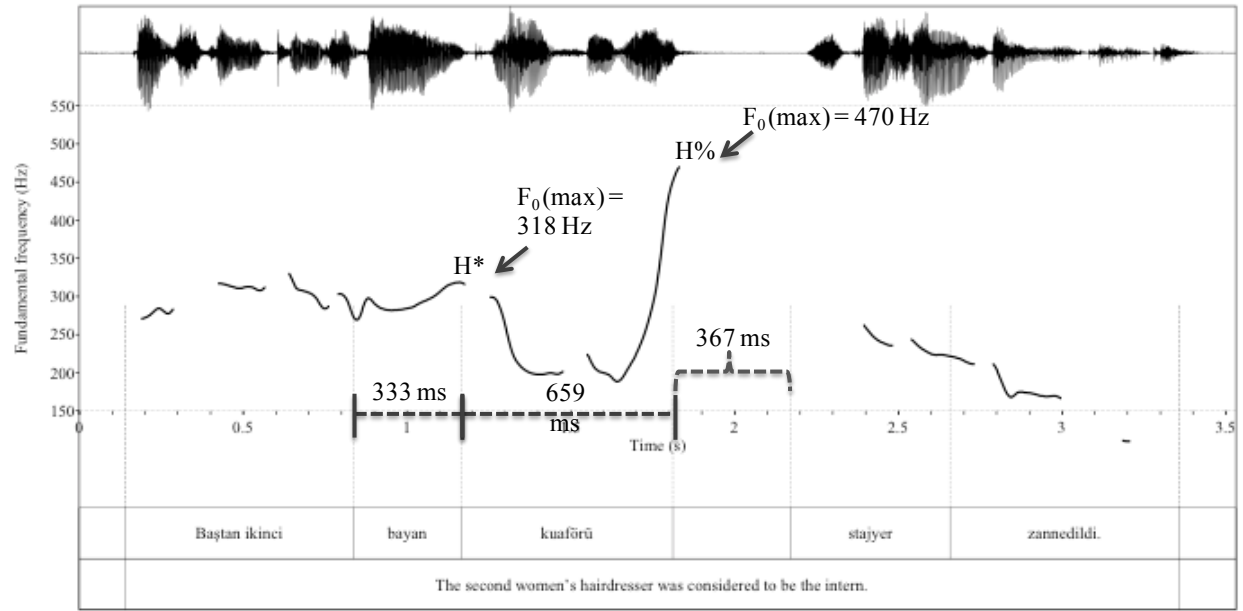


Figure 4-7 Waveform and pitch track for NP Compound ambiguity LC sentence, uttered with cooperating prosody.

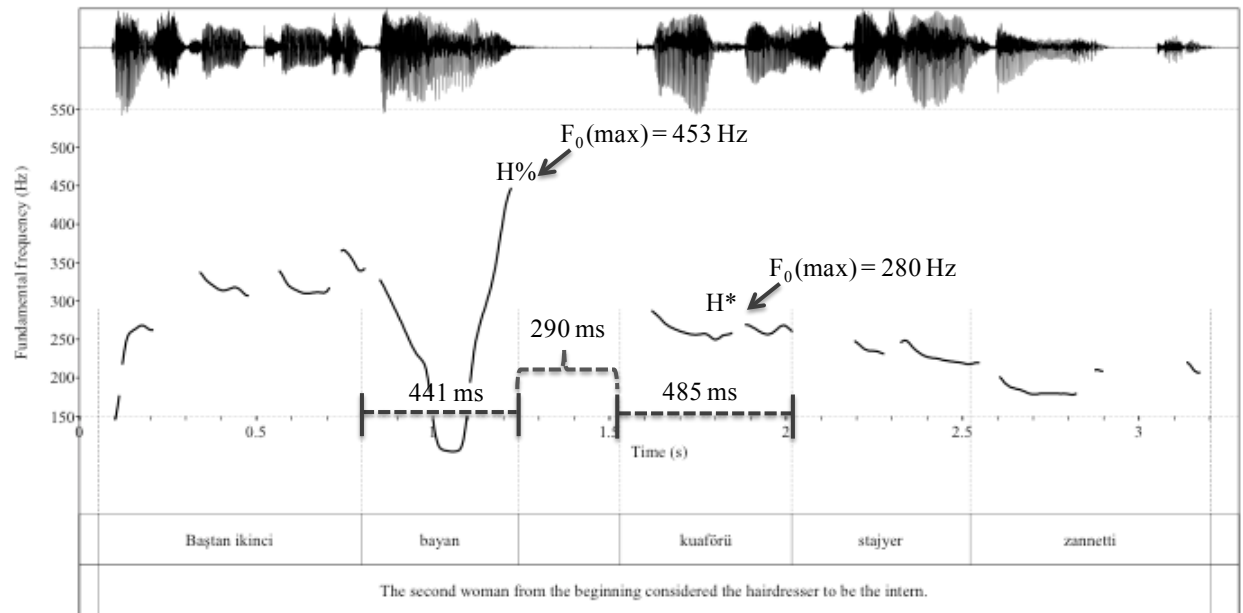


Figure 4-8 Waveform and pitch track for NP Compound ambiguity, EC sentence, uttered with cooperating prosody.

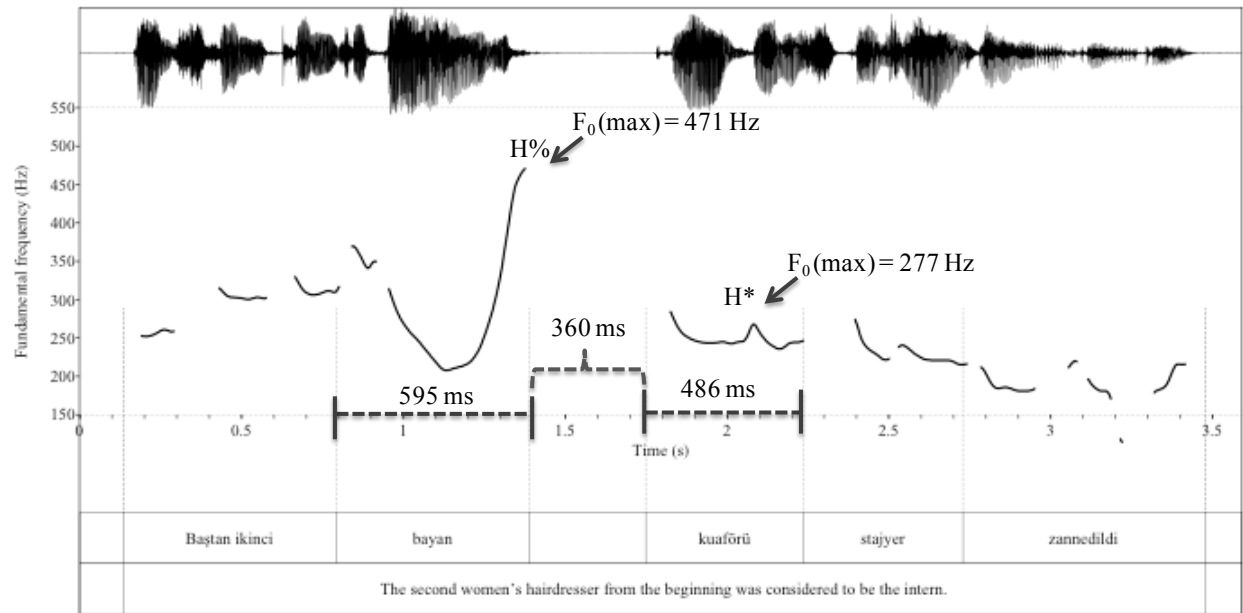


Figure 4-9 Waveform and pitch track for NP Compound ambiguity LC sentence, uttered with conflicting prosody.

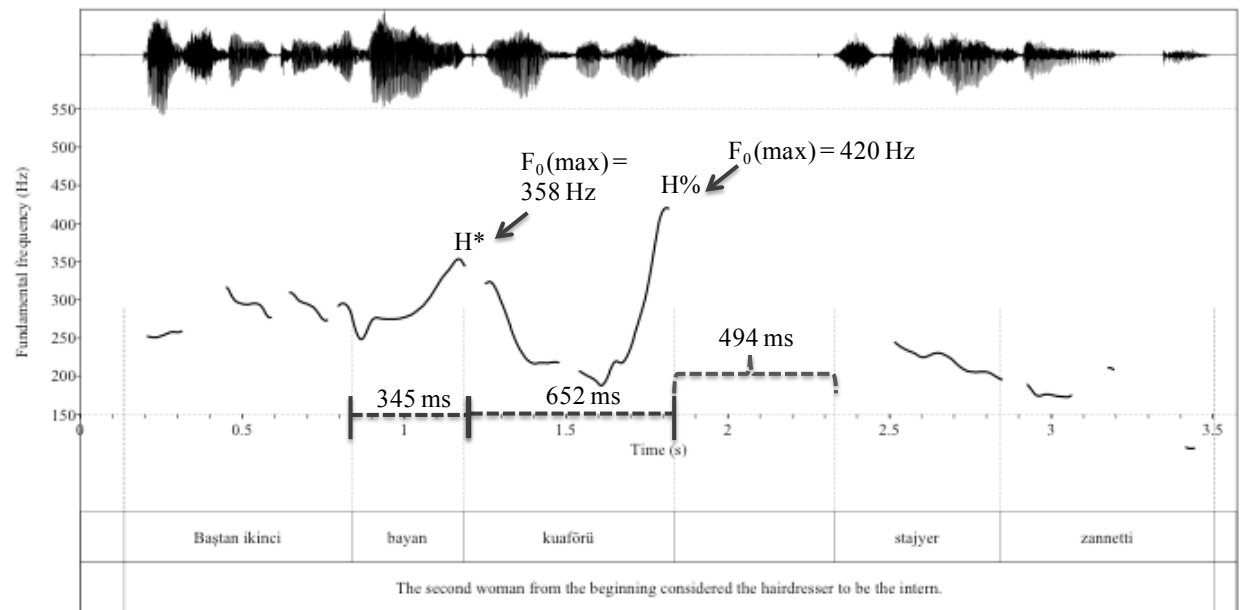


Figure 4-10 Waveform and pitch track for NP Compound ambiguity EC sentence, uttered with conflicting prosody.

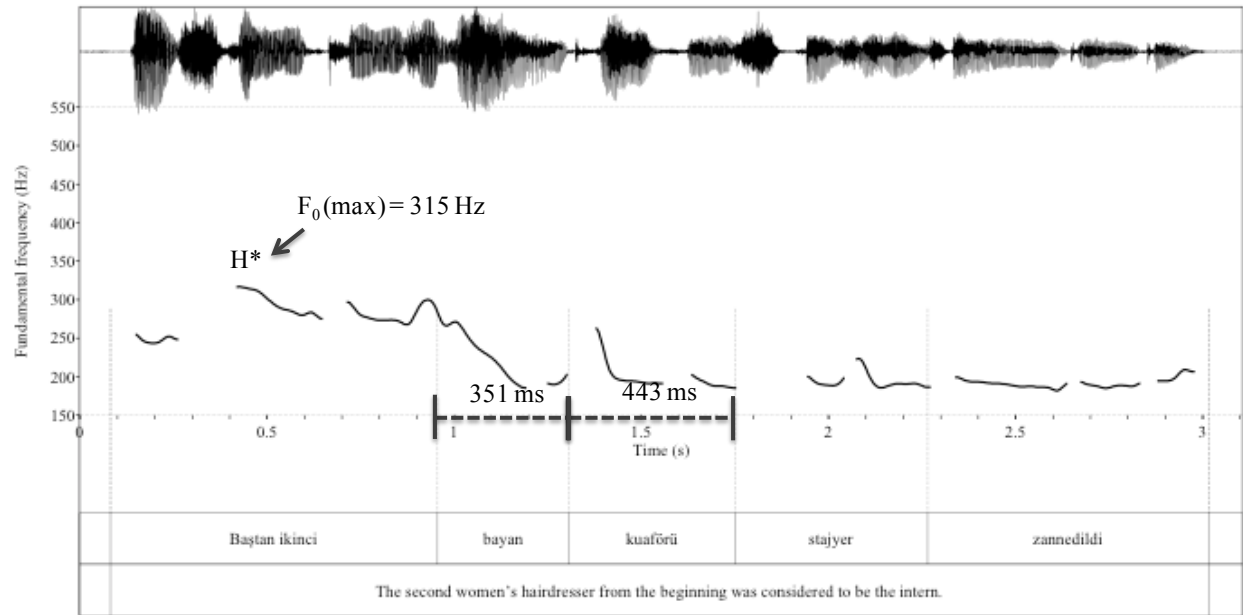


Figure 4-11 Waveform and pitch track for NP Compound ambiguity LC sentence, uttered with neutral prosody.

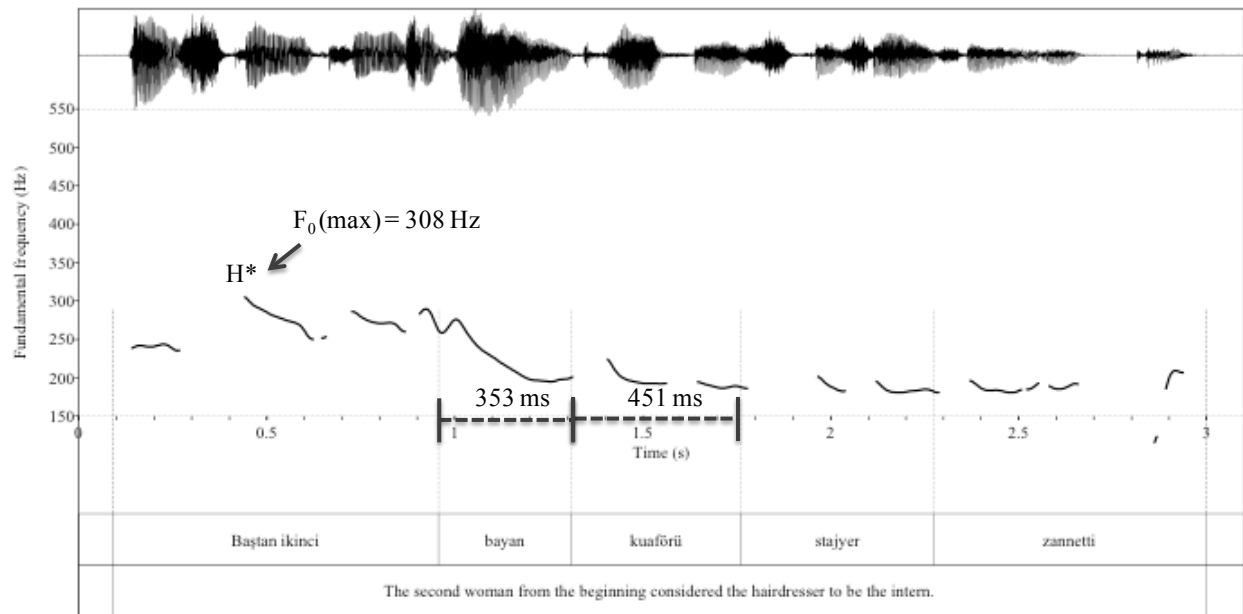


Figure 4-12 Waveform and pitch track for NP Compound ambiguity EC sentence, uttered with neutral prosody.

To ensure that the cooperating pronunciations were acceptable for each syntactic structure and that the neutral pronunciations were also perceived as comparably acceptable, a pronunciation

acceptability judgment task was carried out. Twelve linguistically informed native speakers listened to the recordings and rated the speaker's pronunciation as 'erroneous' or 'acceptable'. The judges had M.A. or Ph.D. degrees in Linguistics (N=5), Turkish Language and Linguistics (N=3) or Applied Linguistics (N=4). There were 12 versions of each sentence manipulating syntax (LC vs. EC), prosody (cooperating, conflicting, neutral) and length (lengthened subject vs. lengthened VP). Each judge heard only one version of a sentence, intermingled with prosodically and syntactically correct filler sentences (N = 24). The judges were given instructions on how to judge the sentences. If a sentence was uttered with correct prosody which is in line with the syntactic structure of the sentence, the participants would rate the sentence as 'acceptable'. If the sentence had incorrect intonation, the judges would rate it as 'erroneous'. If the sentence intonation did not support the syntactic structure but also did not conflict with it, the judges were asked to rate the sentence as 'acceptable', i.e., with the same rating as for cooperating prosody items. Each judge listened to 24 experimental and 24 filler sentences, pseudo-randomly intermingled. Items receiving 'erroneous' judgments for cooperating or neutral prosody, and 'acceptable' judgments for conflicting prosody, were re-recorded and judged again.

Table 4-2 shows the first acceptability scores for each condition. Table 4-3 shows the acceptability scores after re-recording of the sentences which were judged not to have the relevant prosodies.

Table 4-2 First acceptability ratings for pronunciation (% acceptable).

	Cooperating Prosody	Conflicting Prosody	Neutral Prosody
	LC / EC / Overall	LC / EC / Overall	LC / EC / Overall
Genitive Possessive			
Lengthened Subject	88 / 100 / 94	4 / 4 / 4	88 / 92 / 90
Lengthened VP	96 / 100 / 98	4 / 4 / 4	96 / 88 / 92
NP Compound			
Lengthened Subject	100 / 100 / 100	0 / 0 / 0	100 / 92 / 94
Lengthened VP	88 / 88 / 88	0 / 4 / 2	88 / 50 / 73

Table 4-3 Second acceptability ratings for pronunciation (% acceptable).

	Cooperating Prosody	Conflicting Prosody	Neutral Prosody
	LC / EC / Overall	LC / EC / Overall	LC / EC / Overall
Genitive Possessive			
Lengthened Subject	100 / 100 / 100	4 / 4 / 4	100 / 96 / 98
Lengthened VP	100 / 100 / 100	0 / 4 / 2	100 / 100 / 100
NP Compound			
Lengthened Subject	100 / 100 / 100	0 / 0 / 0	100 / 96 / 98
Lengthened VP	100 / 100 / 100	0 / 4 / 2	100 / 96 / 98

The expert judge ratings showed that the sentences had the prosodic properties associated with them. Cooperating prosody sentences were all rated as fully acceptable (100%) for each ambiguity in both length conditions. Neutral prosody sentences were rated as highly acceptable for each ambiguity in each length condition (mean 98% for lengthened subject condition and 100% for lengthened VP condition for the Genitive Possessive; and mean 98% for each length manipulation condition for the NP Compound ambiguity). As predicted, conflicting prosody conditions received very low acceptability ratings: mean 4% for lengthened subject and 2% for

lengthened VP for the Genitive Possessive ambiguity; and mean 0% for lengthened subject and 2% for lengthened VP for the NP Compound ambiguity.

The spoken sentences were additionally analyzed acoustically to ensure that the perceived prosodic properties were consistently realized in the signal.

4.3. Phonetic Analyses

Durational measures and fundamental frequency (F_0) analyses were conducted on the temporarily ambiguous region to confirm that the items were pronounced with the intended prosody. It was desired that the phonetic measures would indicate significant differences between the LC/EC prosody in the cooperating and conflicting prosody conditions but no difference in the LC/EC neutral prosody conditions which would serve as a baseline.

Table 4-4 shows the maximum F_0 and the duration of the NP1 and NP2 and the duration of the pause for each syntax and prosody condition.

Table 4-4 Phonetic measures of the temporarily ambiguous region: Average F₀ maximum (Hz), average word and pause duration (ms.), NA = not applicable.

	Cooperating			Conflicting			Neutral		
	Duration NP1/NP2	F ₀ max NP1/NP2	Pause NP1/NP2	Duration NP1/NP2	F ₀ max NP1/NP2	Pause NP1/NP2	Duration NP1/NP2	F ₀ max NP1/NP2	Pause NP1/NP2
Genitive Possessive									
Lengthened Subject									
LC	504/612	328/436	NA/266	666/392	451/276	376/NA	458/347	287/223	NA/NA
EC	650/390	449/275	340/NA	487/618	340/440	NA/369	459/349	289/223	NA/NA
Lengthened VP									
LC	508/618	341/432	NA/234	694/392	455/273	348/NA	469/348	314/242	NA/NA
EC	668/391	446/272	344/NA	506/635	362/433	NA/346	474/352	308/231	NA/NA
NP Compound									
Lengthened Subject									
LC	432/574	320/462	NA/329	649/353	451/269	350/NA	421/329	301/223	NA/NA
EC	625/364	456/264	390/NA	422/587	348/460	NA/424	422/335	295/220	NA/NA
Lengthened VP									
LC	445/583	337/447	NA/447	654/354	456/280	329/NA	428/343	311/239	NA/NA
EC	643/364	457/268	268/NA	440/605	348/465	NA/390	425/344	307/227	NA/NA

In acoustic terms, a prosodic boundary was characterized by a pause following the NP, and increased pitch on and lengthening of the pre-boundary word. How this was realized in each prosody condition is presented below.

Cooperating Prosody: In the cooperating prosody LC syntax conditions, there was a prosodic boundary after NP2, whereas the boundary followed NP1 in the EC syntax condition. On average, NP2 in LC syntax compared to NP2 in EC syntax was longer and had a higher pitch in both length conditions for both ambiguity types. In EC syntax conditions, on average, NP1 was longer and had higher pitch compared to NP1 in LC syntax conditions, in both length conditions for both ambiguity types. There was also a pause following NP2 in LC syntax and NP1 in EC syntax condition. Table 4-5 and Table 4-6 summarize boundary locations for the Genitive Possessive and NP Compound ambiguity respectively. The *t*-statistics showing comparisons of word duration and average maximum F_0 for NP1 and NP2 in the LC and EC syntax conditions are provided below each comparison. Pause durations (also shown in Table 4-4) are included in these tables also.

Table 4-5 Genitive Possessive ambiguity, cooperating prosody: Summary of boundary locations and comparison of word duration (ms.) and average maximum F_0 value (Hz) for NP1 and NP2 in LC and EC syntax conditions.

Length Condition	Syntax	Boundary Location	Word Duration	F0 Maximum	Pause Duration
Lengthened Subject	LC	After NP2	LC-NP2 > EC-NP2 $t(23) = 24.85, p < .001$	LC-NP2 > EC-NP2 $t(23) = 11.04, p < .001$	266 ms.
	EC	After NP1	EC-NP1 > LC-NP1 $t(23) = 19.48, p < .001$	EC-NP1 > LC-NP1 $t(23) = 15.87, p < .001$	340 ms
Lengthened VP	LC	After NP2	LC-NP2 > EC-NP2 $t(23) = 24.16, p < .001,$	LC-NP2 > EC-NP2 $t(23) = 18.20, p < .001$	234 ms
	EC	After NP1	EC-NP1 > LC-NP1 $t(23) = 21.30, p < .001$	EC-NP1 > LC-NP1 $t(23) = 25.27, p < .001$	344 ms

Table 4-6 NP Compound ambiguity, cooperating prosody: Summary of boundary locations and comparison of average maximum F₀ value (Hz) and word duration (ms.) for NP1 and NP2 in LC and EC syntax conditions.

Length Condition	Syntax	Boundary Location	Word Duration	F0 Maximum	Pause Duration
Lengthened Subject	LC	After NP2	LC-NP2 > EC-NP2 $t(23) = 29.39, p < .001$,	LC-NP2 > EC-NP2 $t(23) = 34.07, p < .001$	329 ms.
	EC	After NP1	EC-NP1 > LC-NP1 $t(23) = 17.16, p < .001$	EC-NP1 > LC-NP1 $t(23) = 33.25, p < .001$	390 ms
Lengthened VP	LC	After NP2	LC-NP2 > EC-NP2 $t(23) = 30.30, p < .001$	LC-NP2 > EC-NP2 $t(23) = 25.14, p < .001$	447 ms
	EC	After NP1	EC-NP1 > LC-NP1 $t(23) = 14.76, p < .001$	EC-NP1 > LC-NP1 $t(23) = 12.24, p < .001$	268 ms

Conflicting Prosody: In the conflicting prosody conditions, boundary location was reversed. In conflicting prosody LC syntax sentences, the pause followed NP1, and NP1 was longer and had higher pitch when compared to the same word in the conflicting prosody EC syntax condition. In conflicting prosody EC syntax conditions, the break was placed after NP2 and NP2 was longer and had higher pitch when compared to NP2 in the LC syntax condition. There was a pause following NP1 in conflicting prosody LC syntax condition and a pause following NP2 in conflicting prosody EC syntax conditions. Table 4-7 and Table 4-8 summarize the boundary locations for the Genitive Possessive and NP Compound ambiguity respectively. *t*-test results showing comparison of NP1 and NP2 on average word duration and maximum F₀ are provided below each comparison. Pause durations (also shown in Table 4-4) are also included in these tables.

Table 4-7 Genitive Possessive ambiguity, conflicting prosody: Summary of boundary locations and comparison of word duration (ms.) and average maximum F₀ value (Hz) for NP1 and NP2 in LC and EC syntax conditions.

Length Condition	Syntax	Boundary Location	Word Duration	F0 Maximum	Pause Duration
Lengthened Subject	LC	After NP1	LC-NP1 > EC-NP1 $t(23) = 22.27, p < .001$	LC-NP1 > EC-NP1 $t(23) = 8.34, p < .001$	376 ms.
	EC	After NP2	EC-NP2 > LC-NP2 $t(23) = 24.97, p < .001$	EC-NP2 > LC-NP2 $t(23) = 10.71, p < .001$	369 ms
Lengthened VP	LC	After NP1	LC-NP1 > EC-NP1 $t(23) = 17.95, p < .001$	LC-NP1 > EC-NP1 $t(23) = 9.928, p < .001$	348 ms
	EC	After NP2	EC-NP2 > LC-NP2 $t(23) = 38.97, p < .001$	EC-NP2 > LC-NP2 $t(23) = 25.27, p < .001$	346 ms

Table 4-8 NP Compound ambiguity, conflicting prosody: Summary of boundary locations and comparison of word duration (ms.) and average maximum F₀ value (Hz) for NP1 and NP2 in LC and EC syntax conditions.

Length Condition	Syntax	Boundary Location	Word Duration	F0 Maximum	Pause Duration
Lengthened Subject	LC	After NP1	LC-NP1 > EC-NP1 $t(23) = 15.85, p < .001$	LC-NP1 > EC-NP1 $t(23) = 7.37, p < .001$	350 ms.
	EC	After NP2	EC-NP2 > LC-NP2 $t(23) = 26.68, p < .001$	EC-NP2 > LC-NP2 $t(23) = 33.25, p < .001$	424 ms
Lengthened VP	LC	After NP1	LC-NP1 > EC-NP1 $t(23) = 17.57, p < .001$	LC-NP1 > EC-NP1 $t(23) = 9.45, p < .001$	329 ms
	EC	After NP2	EC-NP2 > LC-NP2 $t(23) = 30.30, p < .001$	EC-NP2 > LC-NP2 $t(23) = 25.14, p < .001$	390 ms

Neutral Prosody: In neutral prosody conditions, there was no pause after NP1 or NP2 in either LC syntax or EC syntax condition. Neither word durations nor the maximum F₀ values differed significantly for NP1 and NP2 in LC and EC syntax conditions. The following tables illustrate the comparisons and *t*-statistics.

Table 4-9 Genitive Possessive ambiguity, neutral prosody: Comparison of word duration (ms.) and average maximum F₀ value (Hz) for NP1 and NP2 in LC and EC syntax conditions.

Length Condition	Syntax	Word Duration	F0 Maximum
Lengthened Subject	LC	LC-NP2 = EC-NP2 $t(23) = .315, p = .756$	LC-NP2 = EC-NP2 $t(23) = .026, p < .979$
	EC	LC-NP2 = EC-NP2 $t(23) = .07, p = .94$	EC-NP1 = LC-NP1 $t(23) = .09, p = .929$
Lengthened VP	LC	LC-NP2 = EC-NP2 $t(23) = 1.39, p = .20$	LC-NP2 = EC-NP2 $t(23) = .717, p = .48$
	EC	EC-NP1 = LC-NP1 $t(23) = 1.07, p = .295$	EC-NP1 = LC-NP1 $t(23) = 1.12, p = .272$

Table 4-10 NP Compound ambiguity, neutral prosody: Comparison of word duration (ms.) and average maximum F₀ value (Hz) for NP1 and NP2 in LC and EC syntax conditions.

Length Condition	Syntax	Word Duration	F0 Maximum
Lengthened Subject	LC	LC-NP2 = EC-NP2 $t(23) = 1.03, p = .312$	LC-NP2 = EC-NP2 $t(23) = .81, p < .426$
	EC	LC-NP2 = EC-NP2 $t(23) = .15, p = .878$	LC-NP2 = EC-NP2 $t(23) = 1.78, p = .088$
Lengthened VP	LC	LC-NP2 = EC-NP2 $t(23) = .15, p = .875$	LC-NP2 = EC-NP2 $t(23) = 1.72, p = .980$
	EC	LC-NP2 = EC-NP2 $t(23) = .00, p = 1$	LC-NP2 = EC-NP2 $t(23) = 1.03, p = .310$

In addition to analyzing the prosodic properties of the syntactically ambiguous region, other regions were also inspected for any possible additional prosodic boundary. It has been reported that the impact of prosodic boundaries is not uniform and can show variation depending on the presence, size and location of certain other prosodic boundaries in a sentence (Carlson, et al., 2001; Carlson, Clifton, & Frazier, 2009; Frazier, et al., 2006). According to Özçelik and Nagai's (2011) analyses of prosodic properties of subjects and objects in Turkish, it is possible for the definite object of the verb marked with accusative case in EC syntax conditions to form a separate PPh. For the NP Compound ambiguity this region is the temporarily ambiguous region.

Thus, statistics for it have already been reported above, which indicate that in cooperating prosody EC syntax conditions, NP2 is not followed by a prosodic boundary. For the Genitive Possessive ambiguity, this would apply to the embedded verb in the EC syntax condition (which is marked with ACC case after being nominalized), where the disambiguating information becomes available (see examples in (1) above). Note that the disambiguating information was realized using active or passive morphology on the embedded verb, thus word duration differences would not be appropriate to use, as they would yield differences which are attributable to the unbalanced number of morphemes. However, no pause was detected after the embedded verb region indicating that no boundary in addition to the LC and EC prosodic break was attested. Thus, the sentential items were not contaminated by prosodic boundaries other than the ones that are of interest.

These pre-tests were conducted to ensure that the experimental sentences were not contaminated by any effects that were of no interest to this study. The normative study ensured that the experimental sentences were not biased toward LC or EC interpretation. The pronunciation acceptability test and acoustic analyses ensured that the spoken sentences to be used in Experiments 2A and 2B had the relevant prosodies and were free of any additional prosodic boundary. Chapters 4-7 present the main experiments.

CHAPTER 5. EXPERIMENT 1 – MISSING MORPHEME TASK

A Missing Morpheme reading task was developed for Experiment 1 in which effects of the Late Closure strategy and phrase length manipulations were investigated in the absence of prosodic cues. In this experiment, the disambiguating morphemes were replaced with length neutral underscores. Participants' task was to read aloud a sentence as soon as they saw it on the screen, providing the missing morpheme as they did so. The morphemes they inserted would show which interpretation they had computed up to that point.

5.1. Materials

The twenty-four items for each ambiguity selected in the normative study (Chapter 4) were used as experimental sentences. Each experimental sentence had two versions manipulating the length: lengthened subject and lengthened VP. In the lengthened subject condition an LC syntax would provide an unbalanced prosodic phrasing (4+2 PWds) and an EC syntax would provide a balanced prosodic phrasing (3+3 PWds) as in (1-2a). In the lengthened VP condition, an LC syntax would provide a balanced prosodic phrasing (3+3 PWds) and EC syntax would provide an unbalanced one (2+4 PWds) as in (1-2b). These are the same examples as in (1) and (2) in Chapter 4, but with the disambiguating morphemes excised.

(1) Genitive Possessive Ambiguity

a. Lengthened Subject (LC Unbalanced - EC Balanced)

Ø Yaklaşık yedi öğrenci-nin psikoloğ-u sev____ san-ıyor-uz.
Pro About seven student-GEN psychologist-3SG.POSS/ACC like- think-PROG-1PL

LC: ‘We think that the psychologist of approximately seven students was liked.’

EC: ‘We think that approximately seven students liked the psychologist.’

b. Lengthened VP (LC Balanced – EC Unbalanced)

Ø Yedi öğrenci-nin psikoloğ-u oldukça sev____ san-ıyor-uz.
Pro Seven student-GEN psychologist-3SG.POSS/ACC much like- think-PROG-1PL

LC: ‘We think that the psychologist of seven students was much liked.’

EC: ‘We think that seven students liked the psychologist much.’

(2) NP Compound Ambiguity

a. Lengthened Subject (LC Unbalanced - EC Balanced)

Baş-tan ikinci bayan kuaför-ü stajyer zanne____.
Beginning-ABL second woman hair dresser-3SG.POSS/ACC intern consider-

LC: ‘The second women’s hairdresser from the beginning was considered to be the intern.’

EC: ‘The second woman from the beginning considered the hairdresser to be the intern.’

b. Lengthened VP (LC Balanced – EC Unbalanced)

İkinci bayan kuaför-ü eski stajyer zanne____.
Second woman hair dresser-3SG.POSS/ACC old intern consider-

LC: ‘The second women’s hairdresser was considered to be the old intern.’

EC: ‘The second woman considered the hairdresser to be the old intern.’

Examples (1a) and (2a) represent conditions similar to SKS’s, where the EC interpretation is more balanced (3+3 PWds) than the LC interpretation (4+2 PWds). Sentences in (1b) and (2b) exemplify the novel length manipulation in this study where the LC interpretation is more balanced (3+3 PWds) than the EC interpretation (2+4 PWds).

There were 24 pairs of experimental sentences in total per ambiguity, which were distributed across two reading lists counterbalancing for length (lengthened subject vs. lengthened VP). In

each list, there were 24 experimental sentences per ambiguity; no participant saw more than one version of each sentence. In all the experiments reported in this dissertation, the sentences for each ambiguity served as fillers for the other one. There were an additional 48 filler sentences which did not involve any syntactic ambiguity. Twenty-four of the filler items were syntactically similar to the experimental items (12 for Genitive Possessive and 12 for NP Compound structure) and had a similar length contrast but they were unambiguous, and 24 of the filler items were of various syntactic structures comparable to the experimental items in length and complexity. Unambiguous sentences which are syntactically similar to the experimental items were included for two reasons. One was to disguise the experimental items. The second reason was to control for any biases that might influence participants' sentence completions, such as a possible bias towards using active rather than passive morphology. These filler sentences also came in pairs (i.e., same word sequence but differing morphology disambiguating active versus passive). Recall from Chapter 3 that the ambiguities in this study were possible only because the NP2s ended in a consonant. The 3SG.POSS and ACC morpheme on NP2 would be fully realized as *-sI* or *-yI*, respectively, had the NP2s ended in a vowel, which would eliminate the ambiguity. The control filler items used this as a way to provide unambiguous control sentences which would be syntactically the same as experimental sentences otherwise.²⁶ There were also 10 unambiguous practice sentences preceding the beginning of the experiment and 10 implicit 'warm-up' items, 5 at the beginning of each list and 5 half way through where participants were encouraged to take a rest break. Thus, each list following the practice session consisted of 106

²⁶ In these control filler items, the modifier added to the subject in the basic five-prosodic-word pattern before lengthening was not a numeral as in the experimental items (Section 3.3.1). However, this difference apparently had negligible effect on the outcomes (see Appendices D.2 and D.8 where control filler items show an active bias similar to the experimental items).

sentences (see Appendices B.1, B.2 and B.3 for a list of experimental items, fillers, and practice and warm-up items).

5.2. Participants, Procedure and Predictions

Sixty native speakers of Turkish took part in the experiment (mean age = 25; 22 males).

Participants were tested individually, seated comfortably in front of a computer in a quiet room.

Following informed consent procedures, the participants were given instructions by the researcher at the beginning of the experiment. Each sentence was presented on a computer screen with the disambiguating morpheme replaced with a length neutral underscore. The participants were instructed to “read aloud each sentence as soon as it appears on the screen, adding the morpheme that is missing in the verb to complete the utterance”. Participants moved from one sentence to the next by pressing a key on the keyboard. A fixation point appeared between sentences. The researcher explained the procedure to each participant individually, and answered any questions they might have before and at the end of the practice session. The researcher stayed with the participant until the end of the experiment. Participants received 15 Turkish Liras (~\$8.5 at the time of the experiments) for their participation.

The participants’ insertion of the missing morpheme was interpreted as reflecting the syntactic analysis they had computed for the sentence, thus revealing their syntactic parsing strategies and whether or not these strategies were affected by the length of the constituents. As mentioned in the predictions in Chapter 3, Section 3.3, if native speakers of Turkish have a preference for a syntactic Late Closure strategy and no sensitivity to constituent lengths, it was predicted that most of their morpheme completions would yield an LC-compatible syntax. However, if constituent length manipulation influences their judgments instead, it was predicted that their provision of the missing morphemes would balance the structures prosodically into 3+3

PWds, which would yield an EC-compatible syntax for the lengthened subject condition and an LC-compatible syntax for the lengthened VP condition. If both a syntactic Late Closure strategy and a preference for balanced length influences their morpheme insertions then LC-compatible morpheme insertions were predicted to be above chance in both conditions but significantly more frequent in the lengthened VP condition.

5.3. Data Analysis and Results

Participant inclusion criteria included a minimum of 80% grammatical responses on the target sentences, and all the participants passed this criterion. However, data from one participant was excluded from the analyses as his responses to the background questionnaire revealed that he learned Turkish after fully acquiring Kurdish as his first language. Also, data from one participant were not recorded by the computer. Thus, data from 58 participants went through analyses. Misreadings and ungrammatical responses were also excluded from analyses. These consisted of 5% of the data including missing data where participants' spoken responses were not captured due to too quick key presses.

The following graphs show the results for the Genitive Possessive and the NP Compound ambiguity respectively.

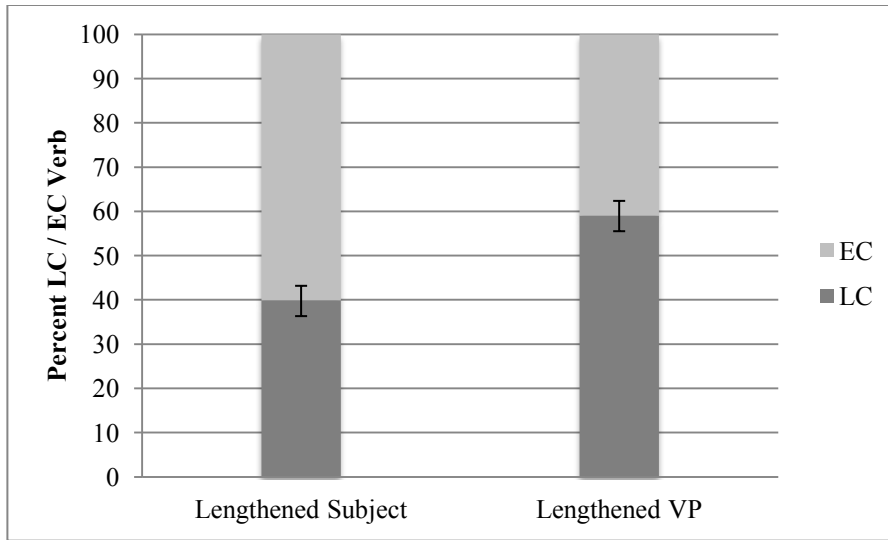


Figure 5-1 Missing morpheme task, Genitive Possessive ambiguity, percent LC and EC syntax compatible morpheme insertion for Lengthened Subject and Lengthened VP conditions.

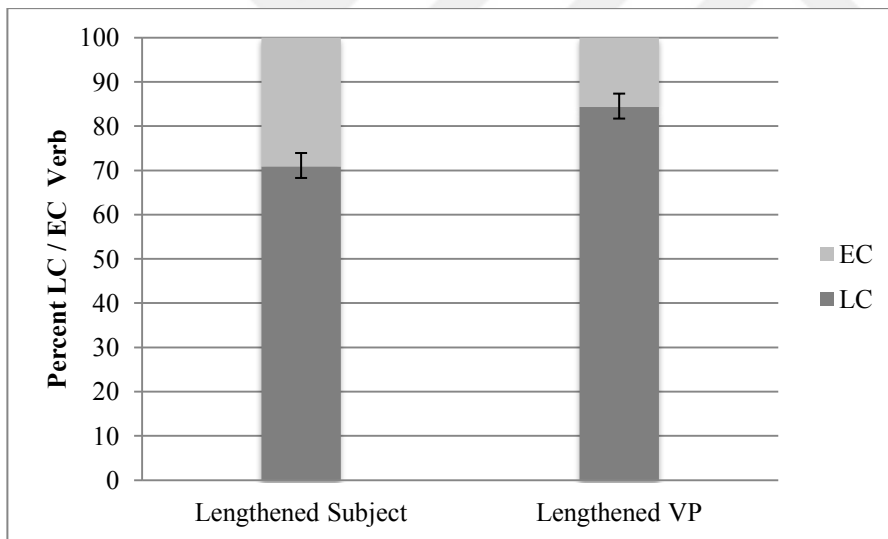


Figure 5-2 Missing morpheme task, NP Compound ambiguity, percent LC and EC syntax compatible morpheme insertion for Lengthened Subject and Lengthened VP conditions.

For the Genitive Possessive ambiguity, in the lengthened subject condition, the participants provided an LC syntax compatible morpheme 40% of the time. In the lengthened verb condition, this preference increased to 59% ($t_1(57) = -5.94, p < .001, t_2(23) = -5.96, p < .001$). The fact that the preference shifted between the length conditions, and showed no overall bias to either EC or

LC (overall LC morpheme insertion was 49.5%), provides strong support for the hypothesis that participants' syntactic processing strategies were largely guided by the lengths of the constituents, and in particular that they preferred sentence structures which were balanced into 3+3 PWds over unbalanced ones with 4+2 or 2+4 PWds. A preliminary analysis of the participants' overt prosody patterns (ear-judgments by the author of the dissertation) confirmed this preference for balanced-length constituents: they inserted an LC-prosodic break 42% of the time in the lengthened subject condition and 64% of the time in the lengthened VP condition.²⁷ There was a significant correlation between LC-compatible morpheme insertion and LC-prosody (lengthened subject: $r = .96, p < .01$, lengthened VP: $r = .89, p < .01$).

For the NP Compound ambiguity, participants completed the sentences with an LC compatible verb 70% of the time when the subject was lengthened, and this increased to 84% when the VP was lengthened ($t_1(57) = -6.53, p < .001, t_2(23) = -3.89, p = .001$). Although there was an overall LC syntax preference with the NP Compound ambiguity, the effect of length was also significant, showing that participants favored 3+3 PWd phrasing over 4+2 or 2+4 PWds. Preliminary analysis of prosodic breaks also confirmed this preference because an LC-prosodic break was inserted 71% in the lengthened subject condition, and this increased to 85% in the

²⁷ Note that a more thorough analysis of participants' placement of overt-prosody is underway. In this analysis, the specific characteristics of the prosodic boundaries (PPh or IPh boundary) will be examined and the dissertation author's ear judgments will be compared to those of another judge who will be a linguistically informed native speaker of Turkish.

lengthened VP condition. There was a significant correlation between LC-compatible morpheme insertion and LC-prosody (lengthened subject: $r = .97, p < .01$, lengthened VP: $r = .98, p < .01$)²⁸.

5.4. Discussion

The results of the Missing Morpheme task suggest that native speakers of Turkish prefer balanced phrasing (3+3 PWds) over unbalanced phrasing (4+2 or 2+4 PWds) and that this phrasing preference influenced their sentence processing routines.

For the Genitive Possessive ambiguity, the results are compatible with the Uniformity Hypothesis, which predicts that speakers prefer balanced (uniform) phrasing. Surprisingly, there was no evidence of a syntactic Late Closure strategy for this ambiguity (see results of the listening experiments in Chapter 6 and 7). This could be attributed to LC syntax requiring insertion of passive morphology in this construction, while active verb morphology creates an EC structure. Unambiguous filler items created to test whether such an effect would exist indeed showed such a bias toward active verbs. Participants inserted ungrammatical active morphology for 7% of unambiguous filler sentences whose morpho-syntax would require LC-compatible passive morphology. Ungrammatical passive morphology insertion for unambiguous filler sentences whose morpho-syntax would require EC-compatible active morphology was only 1.5%.

For the NP Compound ambiguity, there was a strong LC bias (overall LC morpheme insertion was 77%), which might reflect the syntactic Late Closure at work, in addition to a significant

²⁸ Note that Ghini's (1993) *increasing units* (see p. 78 above) maintains that "if strings with an odd number of primitive Φ s are not symmetrically parsed according to (b) (which is "strings are symmetrically parsed") Φ s on the recursive side are heavier than Φ s on the non-recursive side" (p. 56). One might consider extrapolating this to predict that 4+2 phrasing would be preferable to 2+4 in Turkish if strings are not symmetrically parsed since the recursive side is on the left in Turkish, supporting a preference for LC analysis over EC analysis. Results were in line with this for the NP Compound ambiguity, though there was also a preference for balanced lengths. For the Genitive Possessive ambiguity, readers preferred balanced lengths over 2+4 or 4+2 phrasing and there was no reliable difference between 2+4 or 4+2 phrasing.

preference for balanced prosodic phrasing. However, since LC syntax would be signaled by passive morphology for the NP Compound ambiguity, as for the Genitive Possessive ambiguity, some further explanation is required. In 25% of the LC syntax responses, participants completed the sentence with other structures such as active verbs with subject or object *pro*-drop, rather than passive verb morphology. Examples are shown in (3). It should be noted that none of these types of completions are possible for the Genitive Possessive ambiguity.

- (3) a. Active verb – subject *pro*:
 Ø Baş-tan ikinci bayan kuaför-ü || stajyer zannet-ti-m.
Pro Beginning-ABL second woman hair dresser-3SG.POSS intern consider-PAST-1SG
 LC: ‘I considered the second women’s hairdresser from the beginning to be the intern.’
- b. Active verb – object *pro*:
 Baş-tan ikinci bayan kuaför-ü || Ø stajyer zannet-ti.
 Beginning-ABL second woman hair dresser-3SG.POSS *pro* intern consider-PAST-1SG
 LC: ‘The second women’s hairdresser from the beginning considered *pro* to be the intern.’

Such constructions were included in the scoring of LC completions, subject to a stringent criterion.²⁹ The availability of these other constructions as alternatives to the passive morphosyntax that had been anticipated for the NP Compound ambiguity could be one reason why LC syntax completions were more prominent here than for the Genitive Possessive ambiguity where any syntactic Late Closure strategy would be fighting against a dispreference for passive verbs.

Chapter 6 and 7 present the listening experiments.

²⁹ The decision to code an inserted morpheme as LC-compatible was based on the prosody of the sentences and whether or not participants provided similar morphology for unambiguous control filler sentences. If the uttered experimental sentence had a clear LC prosody and if unambiguous LC syntax control filler items were produced with similar verbal morphology, then the morpheme provided for the experimental sentence was coded as LC-compatible. Otherwise, the experimental sentence was coded as either EC syntax (if EC-compatible morphology) or as ungrammatical.

CHAPTER 6. EXPERIMENTS 2A AND 2B – ‘GOT IT’ TASK

The purpose of the first pair of auditory experiments was to investigate whether or not results found in previous studies, particularly the SKS experiments on English, would replicate in Turkish with comparable methodology and a different LC/EC ambiguity, as illustrated in examples (1) and (2) in Chapter 3 above. The specific aim was to find out whether or not length of constituents would have an effect on the parser’s evaluation of prosodic breaks in addition to or instead of a syntactic Late Closure strategy.

Following the methodology of Kjølgaard & Speer (1999), a timed end-of-sentence comprehension ‘got it’ task (Frazier, et al., 1983) was used. In this task, participants are asked to indicate after hearing each sentence whether or not they have understood it, by pressing one of two keys on the keyboard as quickly as possible. This subjective judgment of successful comprehension does not tap comprehension accuracy, but participants are encouraged to take it seriously by being told that a ‘got it’ response signals their readiness to answer a comprehension question for some proportion of items at random intervals. (In the present study, 25% of items, including some target sentences and fillers, were followed by a question.) Post-sentence RT for ‘got it’ responses was taken as a measure of ease or difficulty of processing the sentence.

There were three prosody conditions (cooperating, conflicting, and neutral) and two syntax conditions (LC and EC). As described in detail in Chapter 4 Section 4.2, cooperating prosody provided a valid prosodic boundary cue to the syntactic structure, as disambiguated later in the sentence; conflicting prosody provided a misleading prosodic boundary cue to the syntactic structure, as it was disambiguated later in the sentence; neutral prosody contained no prosodic boundaries.

To test whether the pattern of findings by SKS would replicate in Turkish closure ambiguities, Experiment 2A included items similar to the SKS materials with respect to the relation between syntax and phrase lengths. Thus, sentences in Experiment 2A had a lengthened subject and were identical to those in Condition 1 in Experiment 1 (prior to deletion of the disambiguating morphemes). In the cooperating prosody conditions, the LC structures yielded unbalanced phrasing (4+2 PWds) and EC syntax yielded balanced prosodic phrase lengths (3+3 PWds). When the prosody was conflicting, the LC syntax provided balanced length (3+3 PWds) but the EC structures yielded unbalanced prosodic phrase length (4+2 PWds). In the neutral prosody conditions, the disambiguated syntactic phrasing in Experiment 2A showed the same patterns as the cooperating prosody condition (i.e., LC: 4+2 PWds; EC: 3+3 PWds) but there was no prosodic boundary signaling either the correct or incorrect structure.

If Experiment 2A yields results suggesting a preference for the LC structure, further data are required in order to establish the extent to which the lengths of constituents contribute to that outcome, as would be predicted by the Extended Rational Speaker Hypothesis. Therefore, Experiment 2B included items that reversed the phrase length balance. Thus, sentences in Experiment 2B had a lengthened VP and were identical to those in Condition 2 in Experiment 1 (except for missing morphemes). In the cooperating prosody condition, the LC syntax provided balanced prosodic phrasing (3+3 PWds) and the EC syntax provided unbalanced prosodic phrasing (2+4 PWds). When prosody was conflicting, the LC syntax provided unbalanced phrasing (2+4 PWds) and the EC syntax provided balanced phrasing (3+3 PWds). In the neutral prosody conditions the disambiguated syntactic phrasing showed the same patterns as the cooperating prosody condition (i.e., LC: 3+3 PWds; EC: 2+4 PWds) but there was no prosodic boundary signaling either the correct or incorrect structure. Table 6-1 summarizes the conditions

in Experiment 2A (lengthened subject) and Experiment 2B (lengthened VP). Example sentences are shown later in (1)-(4) in Sections 6.1 and 6.2.

Table 6-1 Conditions in Experiment 2A and 2B.

	Cooperating Prosody	Conflicting Prosody	Neutral Prosody
Experiment 2A (Lengthened Subject)	LC (4+2 PWds)	LC (3+3 PWds)	LC (4+2 PWds, syntactic)
	EC (3+3 PWds)	EC (4+2 PWds)	EC (3+3 PWds, syntactic)
Experiment 2B (Lengthened VP)	LC (3+3 PWds)	LC (2+4 PWds)	LC (3+3 PWds, syntactic)
	EC (2+4 PWds)	EC (3+3 PWds)	EC (2+4 PWds, syntactic)

The following summarizes the predictions for Experiment 2A and 2B, which were outlined in greater detail in Chapter 3, Section 3.3.

(i) If a syntactic Late Closure strategy is the default strategy when prosody is unavailable (neutral prosody) or unsupportive of syntax (conflicting prosody), it is predicted that in both Experiment 2A and 2B, the LC structure will be processed faster than the EC structure in the neutral and conflicting prosody conditions. In the cooperating prosody conditions, since the prosodic break will signal the correct syntactic structure, the LC and EC syntax conditions may be processed with equal ease. However, it is also possible that an LC advantage will still be detectable even in the case of cooperating prosody.

(ii) If listeners take into consideration the possible reasons for a prosodic break as proposed by the Extended Rational Speaker Hypothesis, it is predicted that in the cooperating prosody conditions, length unbalanced conditions (LC in Experiment 2A and EC in Experiment 2B) will be processed faster because the participants will take the boundary before/after a short constituent to be more informative of the sentence structure (4+2 PWds for LC in Experiment 2A and 2+4 PWds for EC in Experiment 2B). In the conflicting prosody conditions, however, it is

predicted that the balanced length conditions will be processed faster (3+3 PWds for LC in Experiment 2A and EC in Experiment 2B) because the conflicting prosodic cue will be easier to disregard since it could have been motivated by the constituent lengths as well as, or rather than, by the syntactic structure.

The ERSH does not make any predictions for the neutral prosody condition. However, if listeners mentally project prosodic boundaries when they are absent, as proposed by Pauker et al. (2011), and if their decisions are based on a preference for balanced constituent lengths following the Uniformity principle (as discussed in Chapter 3, Section 3.3.3), then the EC syntax will be favored in Experiment 2A and the LC syntax will be favored in Experiment 2B as they provide 3+3 PWds phrasing.

(iii) If both a default LC strategy and an ERSH sensitivity to the reasons for a prosodic break are operative, then the following can be anticipated. In the cooperating prosody conditions, there will be an LC syntax advantage in Experiment 2A as it is favored by both syntactic parsing strategies and length considerations, but this advantage will disappear in Experiment 2B, where the EC structure has a prosodic boundary after a short constituent, making the boundary more likely to be taken as informative about the syntax of the sentence. Thus, in Experiment 2A there will be an LC syntax advantage but in Experiment 2B, the LC and EC might be processed with equal ease as one is favored by syntactic parsing strategies (LC) and the other is favored by constituent length distribution (EC). The exact balance between these influences cannot be anticipated.

In the conflicting prosody conditions, there will be an advantage for the LC syntax in Experiment 2A because the conflicting prosodic cue will be easier to disregard as it breaks the sentence into two length-equal constituents (3+3 PWds) and the syntactic parsing strategy will

also favor the LC structure. However in Experiment 2B, this LC advantage will disappear because the prosodic break is placed between two length-equal constituents in the EC syntax condition. Thus, the LC and EC structures might be processed with roughly equal ease as one is favored by syntax (LC) and the other is favored due to length considerations (EC). Therefore, in the conflicting prosody conditions, in Experiment 2A there will be an advantage for the LC syntax but in Experiment 2B, both structures may be processed with equal ease.

In the neutral prosody conditions, the ERSB does not apply. However, if listeners mentally project prosodic boundaries when they are absent and if their decisions are guided by a preference for balanced length and an LC syntax, then the LC structure will be favored in Experiment 2B, where it is divided into two length equal constituents, but not in Experiment 2A, where the EC structure has equal length constituents. Thus, in the Experiment 2A neutral prosody conditions, there may not be any difference between the LC and the EC syntax conditions since under these assumptions, one is favored by syntax (LC) and the other is favored by constituent lengths (EC); however, in the Experiment 2B neutral prosody condition, there may be an LC syntax advantage since it is favored by the syntactic parsing strategy and also provides balanced length for the constituents.

6.1. Experiment 2A – ‘Got it’ – Lengthened Subject

6.1.1. Materials

The six conditions for the Genitive Possessive ambiguity are illustrated in (1). The six conditions for the NP Compound ambiguity are illustrated in (2).

(1) Genitive Possessive Ambiguity

a. Cooperating Prosody – LC Syntax – Unbalanced Length

Ø Yaklaşık yedi öğrenci-nin psikoloğ-u || / sev-il-di san-ıyor-uz.

Pro About seven student-GEN psychologist-3SG.POSS like-PASS-PAST think-PROG-1PL

‘We think that the psychologist of approximately seven students was liked.’

b. Cooperating Prosody – EC Syntax – Balanced Length

Ø Yaklaşık yedi öğrenci-nin || / psikoloğ-u sev-diğ-i-ni san-ıyor-uz.

Pro About seven student-GEN psychologist-ACC like-FN-3SG.POSS-ACC think-PROG-1PL

‘We think that approximately seven students liked the psychologist.’

c. Conflicting Prosody – LC Syntax – Balanced Length

Ø Yaklaşık yedi öğrenci-nin || psikoloğ-u / sev-il-di san-ıyor-uz.

d. Conflicting Prosody – EC Syntax – Unbalanced Length

Ø Yaklaşık yedi öğrenci-nin / psikoloğ-u || sev-diğ-i-ni san-ıyor-uz.

e. Neutral Prosody – LC Syntax – Unbalanced Length (syntactic)

Ø Yaklaşık **yedi** öğrenci-nin psikoloğ-u / sev-il-di san-ıyor-uz.

f. Neutral Prosody – EC Syntax – Balanced Length (syntactic)

Ø Yaklaşık **yedi** öğrenci-nin / psikoloğ-u sev-diğ-i-ni san-ıyor-uz.

(2) NP Compound Ambiguity

a. Cooperating Prosody – LC Syntax – Unbalanced Length

Baş-tan ikinci bayan kuaför-ü || / stajyer zanned-il-di.
Beginning-ABL second woman hair dresser-3SG.POSS intern consider-PASS-PAST.3SG
'The second women's hairdresser from the beginning was considered to be the intern.'

b. Cooperating Prosody - EC Syntax – Balanced Length

Baş-tan ikinci bayan || / kuaför-ü stajyer zannet-ti.
Beginning-ABL second woman hair dresser-ACC intern consider-PAST.3SG
'The second woman from the beginning considered the hairdresser to be the intern.'

c. Conflicting Prosody – LC Syntax – Balanced Length

Baş-tan ikinci bayan || kuaför-ü / stajyer zanned-il-di.

d. Conflicting Prosody – EC Syntax – Unbalanced Length

Baş-tan ikinci bayan / kuaför-ü || stajyer zannet-ti.

e. Neutral prosody – LC Syntax – Unbalanced Length (syntactic)

Baş-tan **ikinci** bayan kuaför-ü / stajyer zanned-il-di.

f. Neutral prosody – EC Syntax – Balanced Length (syntactic)

Baş-tan **ikinci** bayan / kuaför-ü stajyer zannet-ti.

There were a total of 144 experimental sentences for each ambiguity: 48 cooperating prosody (24 LC, 24 EC), 48 conflicting prosody (24 LC, 24 EC), and 48 neutral prosody (24 LC, 24 EC). The items were distributed across six lists counterbalancing for prosody (cooperating, conflicting, and neutral) and syntactic structure (LC vs. EC). Thus, each list included 24 experimental sentences per ambiguity. There were an additional 48 unambiguous fillers, 24 had neutral prosody and 24 had congruent prosody. In addition, there were 10 items used in a practice session prior to the beginning of the experiment and 10 implicit 'warm-up' items, 5 at the beginning of each list and 5 half way through, where participants were encouraged to take a rest break. Thus, each list following the practice session consisted of 106 sentences.

6.1.2. Participants and Procedure

Fifty-four native speakers of Turkish took part in the experiment (mean age = 25.2, 17 male).

Following informed consent procedures, a participant was seated comfortably in front of a computer in a quiet room. The sentences were presented auditorily via noise-cancelling headphones. Participants were given instructions by the researcher at the beginning of the experiment. They were told to listen to the sentences carefully and at the end of each sentence to indicate whether they had comprehended the sentence or not by pressing either the ‘yes’ or ‘no’ (written on a green and red background respectively) button on the keyboard. They were also instructed that they would be presented with comprehension questions at the end of some sentences. Thus, they needed to listen to the sentences carefully. The comprehension questions were presented in written format and appeared on the screen following the participants’ ‘understood/did not understand’ responses. The participants had to respond to the comprehension questions by pressing the ‘yes’ and ‘no’ buttons. There were 24 comprehension questions in total, which followed either experimental or filler items (8 for genitive possessive, 8 for NP compound and 8 for filler items). The practice session and implicit warm-up sentences were also followed by intermittent comprehension questions (3 in total). See Appendix B.4 for comprehension questions and their English translations. The researcher explained the procedure to each participant individually, and answered any questions they might have before and at the end of the practice session. The researcher stayed with the participant until the end of the experiment. Participants received 15 Turkish Liras (~\$8.5 at the time of the experiments) for their participation.

6.1.3. Data Analysis and Results

The criterion for inclusion in the data analysis was 85% or more accuracy on the comprehension questions. Data from one participant was excluded due to low accuracy (74%) on the comprehension questions. Some additional data were excluded from the analyses due to either failure to press a key before the time-out limit (20 seconds) or too quick key presses (before the sound file ended); together, these amounted to 1% of the data.

The data were analyzed using the R statistical computing software, version 2.15.2 (R Core Team, 2012) and *lme4* (Bates & Maechler, 2013) and *languageR* packages (Baayen, 2011). The response times (RTs) were first inspected for normal distribution. The analyses showed that the data did not distribute normally ($W = .67, p < .001, D = .20, p < .001$ for Genitive Possessive ambiguity and $W = .70, p < .001, D = .17, p < .001$ for NP Compound ambiguity) and were positively skewed (density and box and whisker plots in Appendix C.1a and C.1b). Thus, the RTs were log-transformed (Baayen & Milin, 2010; Ratcliff, 1993). The log transformations showed that the data distribution approached normality but there were still some extremes and outliers (see Appendix C.1a and C.1b for plots). Thus, any extreme or outlier data points were excluded from the overall data and from a particular subject's or item's data (Baayen, 2008). Data showed better normal distribution after exclusion of extremes and outliers ($W = .99, p < .01, D = .02, p = .48$ for Genitive Possessive ambiguity and $W = .99, p < .01, D = .03, p = .07$ for NP Compound ambiguity). This resulted in excluding 3.3% of the data for the Genitive Possessive ambiguity and 2.7% of the data for the NP Compound ambiguity.

The RTs were entered into a mixed effects model using the *lmer* function in the *lme4* package. In mixed effects modeling fixed-effects factors (factors with repeatable levels) and random effects factors (factors with levels randomly sampled from a much larger population), are

incorporated and subjects and items can be entered into the analyses together as crossed, independent random effects (Baayen, 2008; Baayen, Davidson, & Bates, 2008). This allows the model to make by-subject and by-item adjustments to the intercept. This lowers the intercept for slower subjects and increases it for faster subjects. Similarly, some items might elicit longer or shorter RTs than others. Thus, including ‘item’ as a random effects variable increases or decreases the intercept depending on item difficulty (Baayen, 2008).

Because mixed effects modeling does not require prior averaging, it allows researchers to examine effects that unfold during the course of an experiment (Baayen, 2008; Baayen, et al., 2008). For the present study, longitudinal effects of familiarization or fatigue (i.e., RTs becoming shorter in time due to familiarization or becoming longer in time due to tiredness) were examined to detect any noise they might bring into the data. Thus, following Baayen and colleagues (Baayen, 2008; Baayen, et al., 2008) the relationship between the RTs and Trial number was examined before main analyses. An analysis for the relationship between the RTs and Trial showed that the RTs became gradually shorter towards the end of the experiment ($\beta = -3.8$, $SE = .44$, $t = -8.67$, $p < .001$ for the Genitive Possessive ambiguity and $\beta = -6.24$, $SE = .64$, $t = -9.7$, $p < .001$ for the NP Compound ambiguity; see Appendix C.2a and C.2b for visual inspection of RTs as a function of Trial)³⁰. Thus, in building a model for the main analyses, Trial was included as one of the predictor variables and was adjusted to vary by-subject to control for the RTs getting shorter/longer throughout the experiment because the model with by-subject adjustment explained the data better than the one without any by-subject adjustments³¹ ($X^2(2) =$

³⁰ Note that the analyses are run in the logarithmic scale but β and SE values are back-transformed for easier interpretation of the results. t and p values are reported as they are calculated in the logarithmic scale.

³¹ Trial was centered for both ambiguities to prevent collinearity (Baayen, 2008).

17.56, $p < .001$ for Genitive Possessive ambiguity, $X^2(2) = 21.22$, $p < .001$ for NP Compound ambiguity).

The main analyses were run on the logRT and the independent variables were Prosody and Syntax. While building a model, each predictor variable was first entered into the model separately. For the Genitive Possessive ambiguity, the model for Prosody showed that sentences with conflicting prosody were processed slower than the ones with neutral prosody ($\beta = 102$, $SE = 31.35$, $t = 3.59$, $p < .001$)³². Although sentences with cooperating prosody were processed faster than those with neutral prosody, the difference did not reach statistical significance ($\beta = -15.31$, $SE = 25.71$, $t = -0.6$, $p = .95$). The model with syntax as a predictor variable showed that the LC structures were processed faster than EC structures ($\beta = -56.32$, $SE = 21.82$, $t = -2.51$, $p < .05$). For the NP Compound ambiguity, sentences with cooperating prosody were processed faster than those with neutral prosody ($\beta = -91.26$, $SE = 32.77$, $t = -2.68$, $p < .01$) and sentences with conflicting prosody were processed slower than those with neutral prosody ($\beta = 160.62$, $SE = 46.6$, $t = 3.86$, $p < .001$). There was no reliable difference between processing of the LC syntax structures and the EC syntax structures in the NP Compound ambiguity ($\beta = -7.89$, $SE = 31.43$, $t = -.025$, $p = .98$).

After analyses for main effects of each predictor variable, a more complex model including an interaction of the two predictors was built. A likelihood ratio test comparing the simple models to the complex one with interaction suggested that the model including the interaction explained

³² There are various ways of obtaining significance values for mixed effects modeling and there seems to be little agreement on which method to use (Barr, Levy, Scheepers, & Tily, 2013). Although Baayen et al. (2008) recommends using Markov Chain Monte Carlo (MCMC) sampling, it is only implemented for models with random intercepts only. The models used in the current analyses allowed for subject-specific slopes for at least one variable, and a correlation parameter between the intercept and slope for that variable. This prevented using the *pvals.fnc* function to calculate MCMC values. Thus, p -values for main effects were calculated using a t -distribution table with the given number of data points. The p -values for pairwise comparisons were elicited automatically during the comparisons.

the data better than the simpler ones for the Genitive Possessive ambiguity ($X^2(3) = 8.03, p < .05$). This interaction model also allowed for random slopes for subjects by Prosody ($X^2(7) = 19.56, p < .01$). The model including the interaction also explained the data better than the simpler ones for the NP Compound ambiguity ($X^2(3) = 14.64, p < .00$). The complex model for the NP compound ambiguity allowed for random slopes for subjects by Trial only. Thus, for both ambiguity types, the models with the interaction were retained. Please see Appendix C.3a and C.3b for model comparison tables.

The model with interaction was investigated via quantile-quantile (q-q) plots, and data points with standardized residuals below/above 2.5 standard deviations were excluded from the analyses (Baayen & Milin, 2010). Furthermore, subjects, items and individual data points were inspected to identify any overly influential subjects, items, or data points by using the *influence.ME* function (Nieuwenhuis, te Grotenhuis, & Pelzer, 2012). Both Cook's distance values and plots were used in this inspection. Two subjects, 3 items and 5 individual data points diverged from group statistics for the Genitive Possessive ambiguity, and 1 subject, 2 items, and 5 data points diverged for the NP Compound ambiguity (plots for influential subjects, items and data points can be found in Appendix C.4a and C.4b). Divergent data were excluded and the model was re-fit. The q-q plots in Appendix C.5a and C.5b show how the data fit the model for each ambiguity type after these steps.

RTs from the remaining participants and items for each ambiguity can be observed in the figures below.

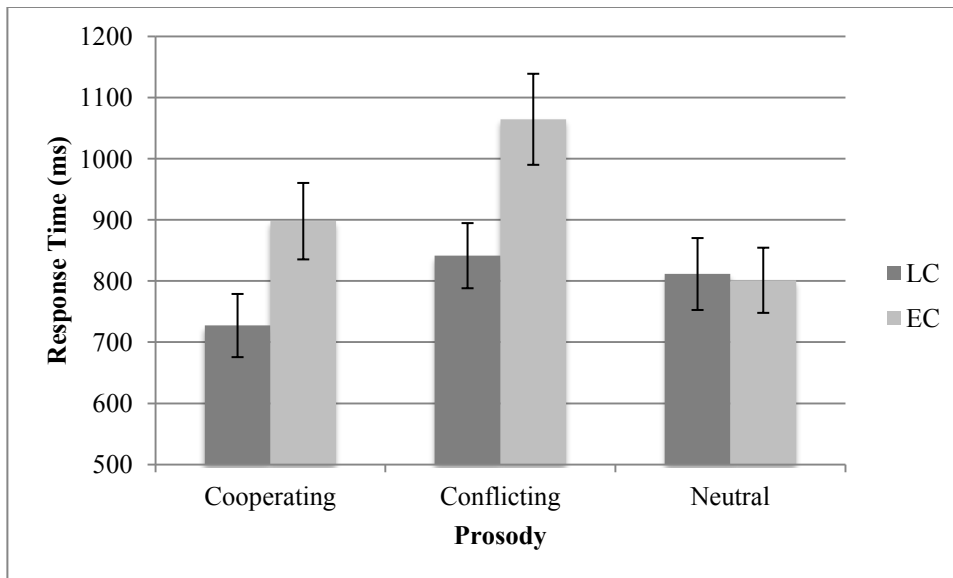


Figure 6-1 Experiment 2A, Genitive Possessive ambiguity, mean response time with standard errors for 'Understood' responses.

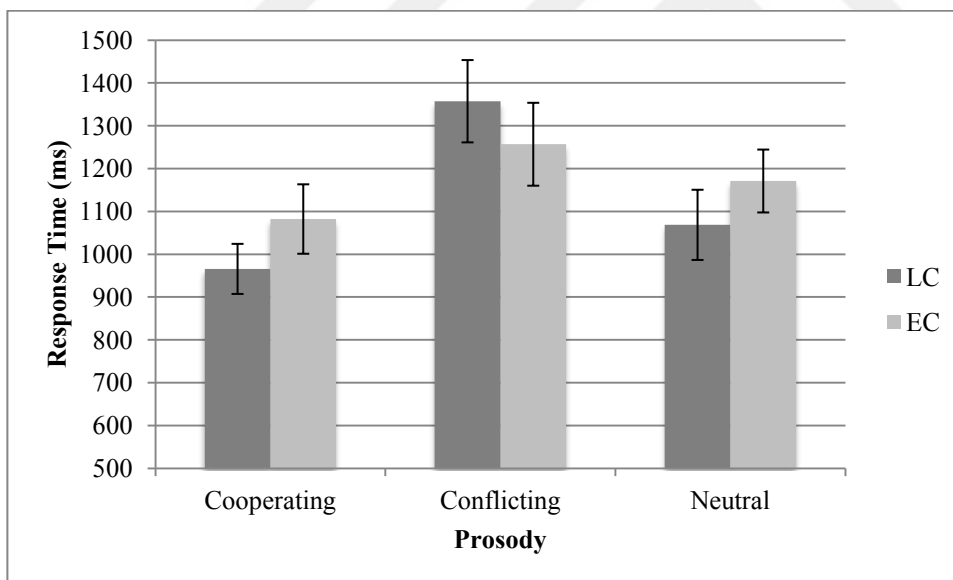


Figure 6-2 Experiment 2A, NP Compound ambiguity, mean response time with standard errors for 'Understood' responses.³³

Planned pairwise comparisons using the *glht* function showed that for the Genitive Possessive ambiguity, in cooperating and conflicting prosody conditions, structures with LC syntax were

³³ Overall, the Genitive Possessive ambiguity was processed faster than the NP Compound ambiguity. The scales for the graphs are not matched for clearer comparison of particular conditions within each ambiguity.

processed faster than those with EC syntax ($\beta = -.125$, $SE = .059$, $z = -2.10$, $p < .05$ for cooperating prosody, and $\beta = .251$, $SE = 0.062$, $z = -4.03$, $p < 0.001$ for conflicting prosody).

There was no significant difference between LC and EC syntax conditions in the neutral prosody condition ($\beta = .00007$, $SE = .062$, $z = .001$, $p = .992$). For the NP Compound ambiguity, there was an LC advantage in the neutral prosody condition ($\beta = -.162$, $SE = .062$, $z = -2.65$, $p < .01$), but the difference between the LC and EC syntax was not significant in the cooperating prosody conditions ($\beta = .007$, $SE = .060$, $z = -.124$, $p = .92$). The EC syntax sentences were processed faster than the LC syntax sentences in the conflicting prosody condition ($\beta = .13$, $SE = .064$, $z = 2.04$, $p < .05$).

The results showed the following pattern.

Table 6-2 Experiment 2A, response time data pattern. < indicates faster processing. = indicates no significant difference in processing time. All inequalities in the table are confirmed at $p < .05$ or smaller.

Ambiguity	Cooperating Prosody	Conflicting Prosody	Neutral Prosody
Genitive Possessive	LC < EC	LC < EC	LC = EC
NP Compound	LC = EC	EC < LC	LC < EC

Some tentative conclusions can be drawn from these data, in relation to the predictions outlined earlier in this chapter. For the Genitive Possessive ambiguity, there was a clear LC syntax advantage in cooperating and conflicting prosody conditions. This advantage could be due to the syntactic LC strategy but it could also be attributed to the ERSH for the reasons discussed above; results of Experiment 2B will allow us to disentangle these two possible explanations. In the Genitive Possessive neutral prosody condition, there was no advantage for either structure. The absence of an LC advantage suggests that the LC strategy did not apply here. However, it is possible that an LC bias was present but was offset by a preference for balanced

constituents, as the Uniformity Hypothesis would suggest, because in the neutral prosody condition it is the EC syntax that yields a balanced 3+3 PWds. This conclusion would rest on the assumption that listeners mentally project missing prosodic boundaries as readers do (Pauker, et al., 2011). However, a more conclusive statement can only be made after examining the results of Experiment 2B.

For the NP Compound ambiguity, there was no reliable advantage for a particular structure in the cooperating prosody condition. This is similar to SKS's findings for English: where prosodic cues correctly inform about syntax, the parser does not seem to face any greater difficulty processing EC syntax compared to LC syntax. There was an LC syntax advantage in the neutral prosody condition, which is also similar to SKS's results. This is not what was observed in the Genitive Possessive construction. Reasons for the discrepancy will be discussed in Section 6.3. In the absence of any other explanation for it in these materials it appears that the syntactic LC strategy did apply in processing of the NP compound ambiguity. There was an EC syntax advantage in the conflicting prosody condition, which is not in line with the predictions made in this study. If such an EC syntax advantage is also observed in the conflicting prosody condition in Experiment 2B, it could be due to the potential object drop interpretation that was mentioned in Chapter 3. The possibility of such a confound will be discussed after examining the data from Experiment 2B.

So far we have considered RT's to 'Understood' responses. The following graphs show the percent of 'Understood' responses in each condition for each ambiguity.

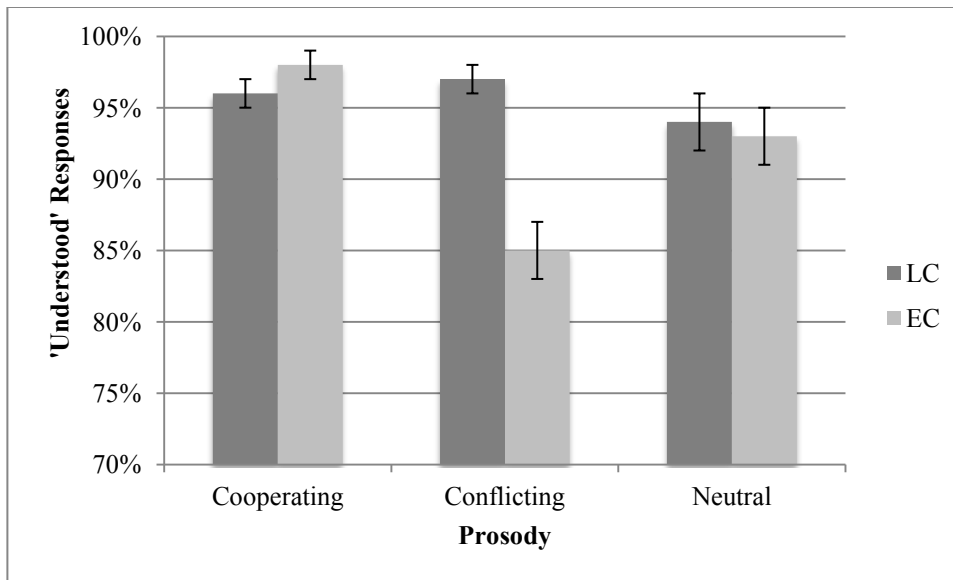


Figure 6-3 Experiment 2A: Genitive Possessive ambiguity, percent 'Understood' responses with standard errors.

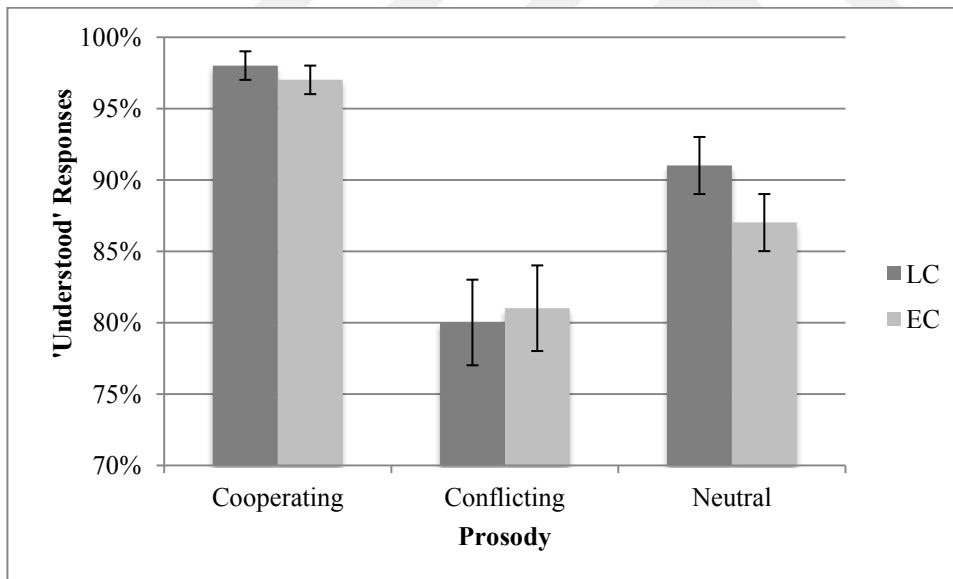


Figure 6-4 Experiment 2A: NP Compound ambiguity, percent 'Understood' responses with standard errors.

As can be seen from the graphs, the percent 'yes' responses (i.e., 'I understood the sentence') was quite high for all the conditions (>70%) for both ambiguities. For the Genitive Possessive ambiguity, when compared with the neutral prosody condition, participants' overall tendency to

respond 'yes' increased for the cooperating prosody condition (odds ratio: $\beta = 2.6$, $SE = 1.47$, $z = 2.47$, $p < .05$) and it decreased for the conflicting prosody condition though this difference was not statistically significant ($\beta = .67$, $SE = 1.35$, $z = -1.3$, $p = .18$). Participants' responses to each sub-condition (namely, LC/EC) show a similar pattern to their processing times for conflicting prosody and neutral prosody conditions. In the conflicting prosody condition, participants were more likely to give 'yes' responses in LC syntax conditions than EC syntax conditions ($\beta = 11.1$, $SE = 1.7$, $z = 4.51$, $p < .001$). In the neutral prosody condition, there was no significant difference in the probability of 'yes' responses in the LC and EC syntax conditions ($z = .45$). In the cooperating prosody condition, the participants' overall judgments for ability to understand the sentence did not differ significantly between LC and EC syntax conditions ($z = -1.61$). This does not mirror the RT data, but this could be due to the ease of comprehending both structures in these conditions since prosody and syntax match in both LC and EC syntax conditions.

For the NP Compound ambiguity, when compared to neutral prosody conditions the percent 'yes' responses increased for cooperating prosody (odds ratio: $\beta = 5.82$, $SE = 1.44$, $z = 4.75$, $p < .001$) and decreased for conflicting prosody ($\beta = .35$, $SE = 1.27$, $z = -4.19$, $p < .001$). For each sub-condition of syntactic closure (LC/EC), although the responses reflect the pattern observed for the response times for each condition, there was no significant difference between LC and EC syntax in any of the prosody conditions (z 's < 1.5).

These results for response times and 'yes' responses in Experiment 2A will be compared to those in Experiment 2B in order to understand whether constituent lengths may have had an effect here rather than or in addition to a syntactic Late Closure strategy.

6.2. Experiment 2B – ‘Got it’ – Lengthened VP

6.2.1. Materials

(3) illustrates the conditions for the Genitive Possessive ambiguity and (4) illustrates the conditions for the NP Compound ambiguity.

(3) Genitive Possessive Ambiguity

a. Cooperating Prosody – LC Syntax – Balanced Length

Ø Yedi öğrenci-nin psikoloğ-u || / oldukça sev-il-di san-ıyor-uz.
Pro Seven student-GEN psychologist-3SGPOSS much like-PASS-PAST think-PROG-1PL
‘We think that the psychologist of seven students was much liked.’

b. Cooperating Prosody – EC Syntax – Unbalanced Length

Ø Yedi öğrenci-nin || / psikoloğ-u oldukça sev-diğ-i-ni san-ıyor-uz.
Pro Seven student-GEN psychologist-ACC much like- FN-3SG.POSS-ACC think-PROG-1PL
‘We think that seven students liked the psychologist much.’

c. Conflicting Prosody – LC Syntax – Unbalanced Length

Ø Yedi öğrenci-nin || psikoloğ-u / oldukça sev-il-di san-ıyor-uz.

d. Conflicting Prosody – EC Syntax – Balanced Length

Ø Yedi öğrenci-nin / psikoloğ-u || oldukça sev-diğ-i-ni san-ıyor-uz.

e. Neutral Prosody – LC Syntax – Balanced Length (syntactic)

Ø **Yedi** öğrenci-nin psikoloğ-u / oldukça sev-il-di san-ıyor-uz.

f. Neutral Prosody – EC Syntax – Unbalanced Length (syntactic)

Ø **Yedi** öğrenci-nin / psikoloğ-u oldukça sev-diğ-i-ni san-ıyor-uz.

(4) NP Compound Ambiguity

- a. Cooperating Prosody – LC Syntax – Balanced Length
İkinci bayan kuaför-ü || / eski stajyer zanned-il-di.
Second woman hair dresser-3SG.POSS old intern consider-PASS-PAST.3SG
'The second women's hairdresser was considered to be the intern.'
- b. Cooperating Prosody – EC Syntax – Unbalanced Length
İkinci bayan || / kuaför-ü eski stajyer zannet-ti.
Second woman hair dresser-ACC old intern consider-PAST.3SG
'The second woman considered the hairdresser to be the intern.'
- c. Conflicting Prosody – LC Syntax – Unbalanced Length
İkinci bayan || kuaför-ü / eski stajyer zanned-il-di.
- d. Conflicting Prosody – EC Syntax – Balanced Length
İkinci bayan / kuaför-ü || eski stajyer zannet-ti.
- e. Neutral Prosody – LC Syntax – Balanced Length (syntactic)
İkinci bayan kuaför-ü / eski stajyer zanned-il-di.
- f. Neutral Prosody – EC Syntax – Unbalanced Length (syntactic)
İkinci bayan / kuaför-ü eski stajyer zannet-ti.

The number of experimental items, fillers, practice items and proportion of comprehension questions was the same as in Experiment 2A.

6.2.2. *Participants and Procedure*

Fifty-two native speakers of Turkish drawn from the same subject pool as Experiment 2A took part in Experiment 2B (mean age = 26.2, 14 male). The procedure was the same as for Experiment 2A. As in Experiment 2A, participants received 15 Turkish Liras (~\$8.5 at the time of the experiments) for their participation.

6.2.3. *Data Analysis and Results*

As in Experiment 2A, the data inclusion criterion was a minimum of 85% accuracy on the comprehension questions, and all participants passed this criterion. Some data were excluded

from the analyses due either to failure to press a key before the time-out limit (20 seconds) or to too quick key presses (before the sound file ended); together these comprised 1.8% of the data.

Statistical software and packages were the same as for Experiment 2A. The RTs were first inspected for normal distribution. The analyses showed that the data did not distribute normally ($W = .75, p < .001, D = .16, p < .01$ for Genitive Possessive ambiguity and $W = .74, p < .001, D = .15, p < .001$ for NP Compound ambiguity) and were positively skewed (density and box and whisker plots in Appendix C.6a and C.6b). Following the same steps as in Experiment 2A, data were log-transformed, and any extreme or outlier data points for the overall data and from a particular item or subject's data were excluded, which was approximately 1% of the data for both types of ambiguity. Data showed better normal distribution after these steps ($W = .99, p = .02, D = .02, p = .62$ for the Genitive Possessive ambiguity and $W = .99, p = .06, D = .01, p = .97$ for the NP Compound ambiguity; see Appendix C.6a and C.6b for plots for data distribution before and after log transformations and exclusion of extreme and outliers).

The RTs were entered into a mixed effects model using the *lmer* function in the *lme4* package. As in Experiment 2A, longitudinal effects of familiarization or fatigue were examined via a mixed effects model for the RTs with Trial number as the only fixed effects term. This analysis showed that the RTs became shorter towards the end of the experiment ($\beta = -4.86, SE = .48, t = -10.8, p < .001$ for the Genitive Possessive ambiguity and $\beta = -5.25, SE = .59, t = -8.83, p < .001$ for the NP Compound ambiguity; see Appendix C.7a and C.7b for visual inspection of RTs as a function of Trial). Thus, in the models for the main analyses, Trial number was included as one of the predictor variables and was adjusted to vary by subject. The models allowing for random

slopes for Trial for subjects was significantly better than those with random intercepts only³⁴ ($X^2(2) = 26.36, p < .001$ for the Genitive Possessive ambiguity, $X^2(2) = 13.66, p < .001$ for the NP Compound ambiguity).

The main analyses were run on the logRT and the independent variables were Prosody and Syntax. While building a model, each predictor variable was first entered into the model separately. For the Genitive Possessive ambiguity, the model for Prosody indicated that sentences with cooperating prosody were processed faster than those with neutral prosody ($\beta = -.52.41, SE = 25.87, t = -2, p < .05$) and sentences with conflicting prosody were processed slower than those with neutral prosody ($\beta = 138.96, SE = 33.88, t = 4.58, p < .001$). The model with Syntax as a predictor variable showed that there was not a significant difference between the LC and EC structures overall ($\beta = -17.96, SE = 23.84, t = -.76, p = .45$). For the NP Compound ambiguity, sentences with cooperating prosody were processed faster than those with neutral prosody but the difference was only marginally significant ($\beta = -59.22, SE = 31.59, t = -1.84, p = .06$) and sentences with conflicting prosody were processed slower than those with neutral prosody ($\beta = 213.67, SE = 45.58, t = 5.41, p < .001$). In the NP Compound ambiguity there was no reliable response time difference between processing of the LC syntax structures and the EC syntax structures ($\beta = -14.99, SE = 30.24, t = -.5, p = .61$).

As in Experiment 2A, after analyses for main effects of each predictor variable, a more complex model including the two predictors was built. A log likelihood test comparing the simple models to the complex one with interaction indicated that the model including both predictors explained the data better than the simpler ones for the Genitive Possessive ambiguity ($X^2(1) = .51, p = .47$ for the comparison of the simple model for Prosody vs. the complex model

³⁴ As in Experiment 2A, for the main analyses Trial was centered for both ambiguities to prevent collinearity (Baayen, 2008).

with Prosody and Syntax; $X^2(2) = 44.64, p < .001$ for the comparison of the simple model for Syntax vs. the complex model with Prosody and Syntax). This complex model also allowed for random slopes for subjects by Prosody ($X^2(7) = 16.03, p < .05$). The complex model including an interaction of Prosody and Syntax was also superior for the NP Compound ambiguity ($X^2(3) = 17.72, p < .001$). This model allowed for random slopes for centered Trial only. Thus, for both ambiguity types, the models with the interaction were retained. Please see Appendix C.8a and C.8b for model comparison tables.

Similar to Experiment 2A, during model criticism, data points with standardized residuals below/above 2.5 standard deviations were excluded from the analyses as well as overly influential subjects (4 for the Genitive Possessive ambiguity, 2 for the NP Compound ambiguity), items (4 for the Genitive Possessive ambiguity, 2 for the NP Compound ambiguity) and individual data points (3 for the Genitive Possessive ambiguity and 2 for the NP Compound ambiguity). Plots for influential subjects, items and data points are provided in Appendices C.9a and C.9b. Please see Appendices C.8a and C.8b for q-q plots to inspect how the data fit the model after these steps.

RTs from the remaining participants for each ambiguity are shown in the figures below.

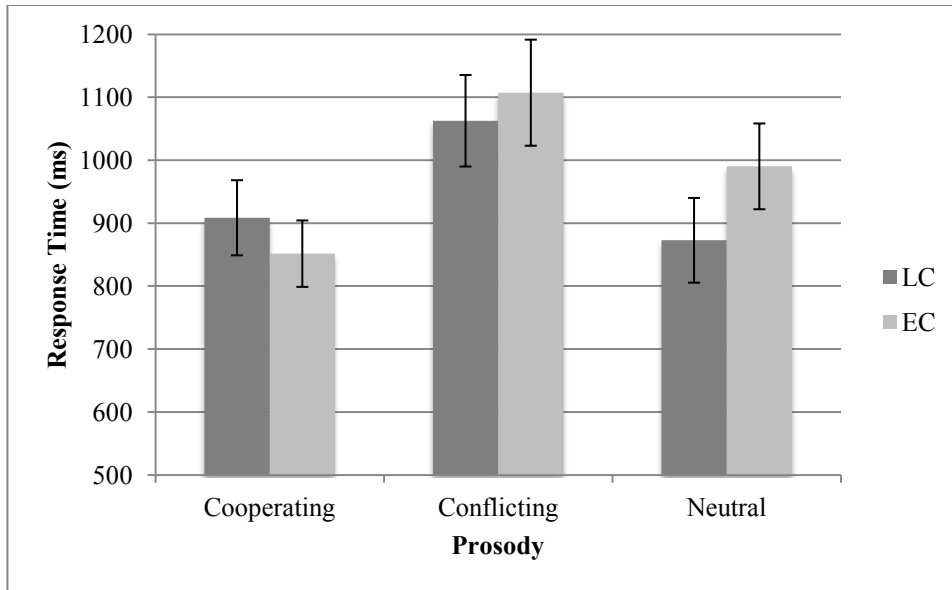


Figure 6-5 Experiment 2B, Genitive Possessive ambiguity, mean response time with standard errors for 'Understood' responses.

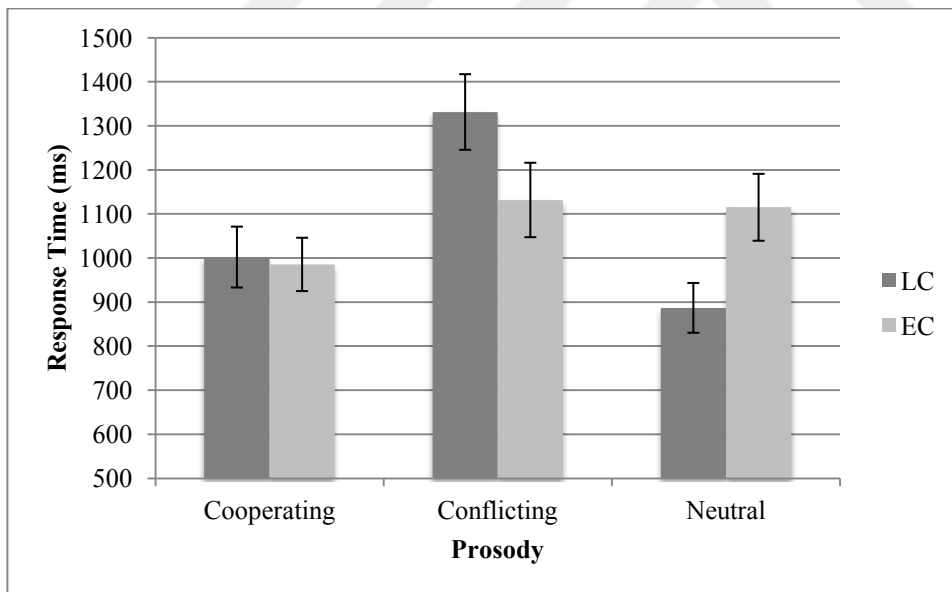


Figure 6-6 Experiment 2B, NP Compound ambiguity, mean response time with standard errors for 'Understood' responses.

Planned pairwise comparisons using the *glht* function showed that for the Genitive Possessive ambiguity, in cooperating and conflicting prosody conditions, there was no reliable difference between the LC syntax and the EC syntax structures ($\beta = 6.97$, $SE = 44.77$, $z = -.161$, $p = .87$ for

cooperating prosody, and $\beta = -2.19$, $SE = 45.08$, $z = -.05$, $p = .96$ for conflicting prosody). But for the neutral prosody condition, the LC syntax structures were processed faster than the EC syntax structures ($\beta = -86.12$, $SE = 39.63$, $z = 2.1$, $p < .05$). For the NP Compound ambiguity, there was an LC advantage in the neutral prosody condition ($\beta = -215.88$, $SE = 44.85$, $z = -4.32$, $p < .001$), and an EC syntax advantage in the conflicting prosody condition ($\beta = 155.52$, $SE = 70.25$, $z = 2.47$, $p < .05$). There was no significant difference between the LC and EC syntax in the cooperating prosody condition ($\beta = -62.84$, $SE = 52.11$, $z = 1.19$, $p = .23$).

In sum, the response time data of Experiment 2B showed the following pattern.

Table 6-3 Experiment 2B, response time data pattern. < indicates faster processing. = indicates no significant difference in processing time. All inequalities in the table are confirmed at $p < .05$ or smaller.

Ambiguity	Cooperating Prosody	Conflicting Prosody	Neutral Prosody
Genitive Possessive	LC = EC	LC = EC	LC < EC
NP Compound	LC = EC	EC < LC	LC < EC

An important finding is that for the Genitive Possessive ambiguity there was no LC advantage except in the neutral prosody condition, unlike Experiment 2A. In the cooperating and conflicting prosody conditions, the LC advantage of Experiment 2A disappeared; LC and EC syntax were processed equally easily. This implies that the LC advantage observed in Experiment 2A was not solely due to a syntactic LC strategy. However, in Experiment 2B there also was no EC advantage as would be predicted by the ERSK. This observation suggests a trade-off between a syntactic LC bias (i.e., an anti-EC bias) and the ERSK. For the neutral prosody condition, the LC advantage may suggest that the LC strategy applies when the ERSK is inapplicable. Alternatively, it may be an indication of a preference for 3+3 balance (which favors LC here) in the absence of overt prosodic phrasing. In view of the results for the cooperating and

possessive construction and the NP compound construction with respect to adjectival modification of the second NP. Example (6) shows that there can be a modifier between the two NPs in a genitive possessive NP, modifying the second NP. The ungrammaticality of (7), which is an NP compound (* indicates ungrammaticality), shows that this is not possible in the compound construction.

(6) Öğrenci-nin yeni psikolog-u
Student-GEN new psychologist-POSS
'The student's new psychologist'

(7) *Bayan yeni kuaför-ü
Woman new hairdresser
'The woman new hairdresser'

Thus, it is possible that the NP Compound ambiguity is more resistant to constituent length manipulations due to its syntactic inflexibility and that this is why it did not show any length-related effects in Experiment 2B.

Turning now to the percent 'understood' responses in Experiment 2B, figures 6-7 and 6-8 show the percent 'yes' (i.e., 'yes, I understood the sentence') responses in each condition for each ambiguity.

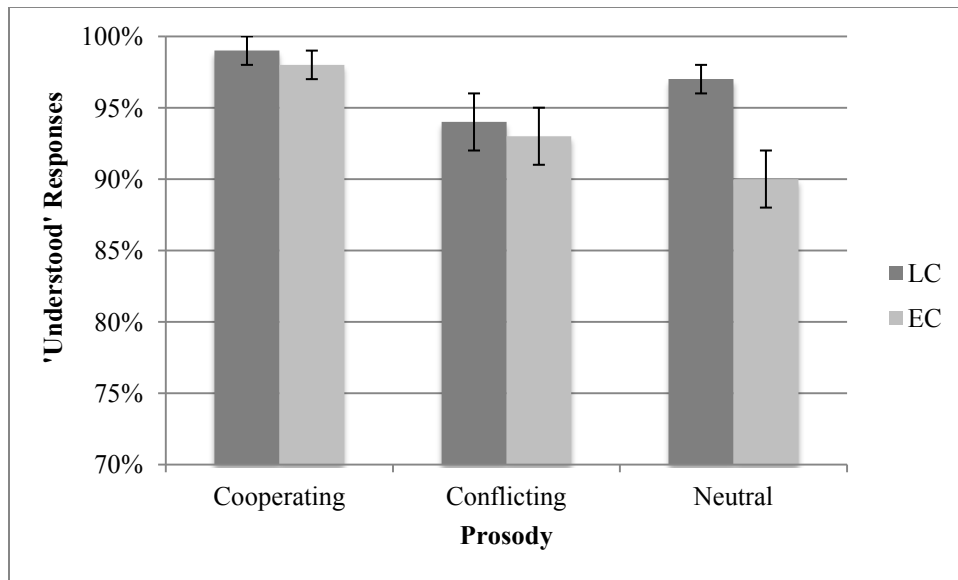


Figure 6-7 Experiment 2B: Genitive Possessive ambiguity, percent 'Understood' responses with standard errors.

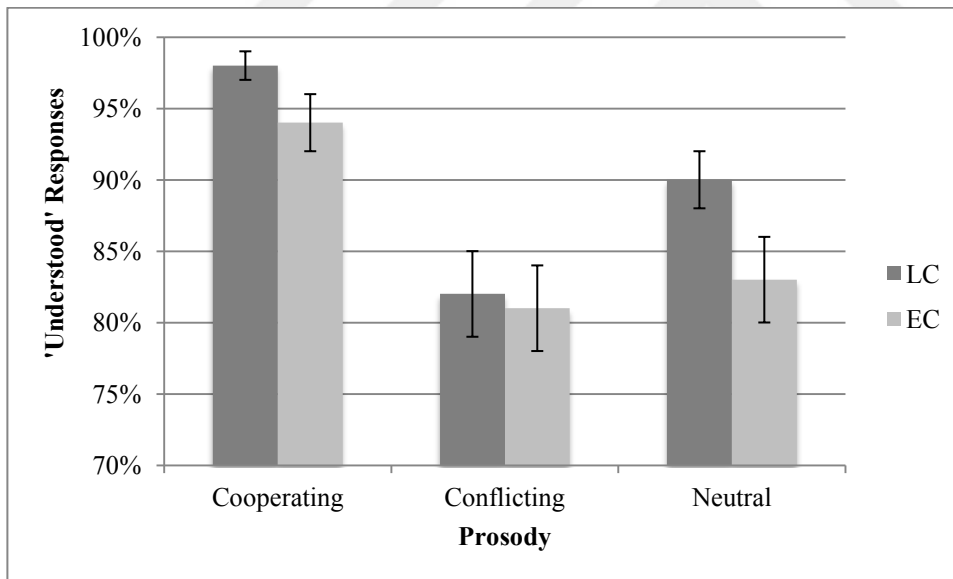


Figure 6-8 Experiment 2B: NP Compound ambiguity, percent 'Understood' responses with standard errors.

For the Genitive Possessive ambiguity, when compared to the neutral prosody condition, it was more likely for participants to respond positively in the cooperating prosody condition (odds ratio: $\beta = 6.24$, $SE = 1.67$, $z = 3.54$, $p < .001$), but the conflicting prosody condition showed no

reliable difference from the neutral prosody condition (odds ratio: $\beta = 1.04$, $SE = 1.38$, $z = .13$, $p = .89$). The specific results for each closure ambiguity condition are in accord with the response time data. Participants were more likely to indicate that they had understood the LC syntax than the EC syntax in the neutral prosody condition (odds ratio: $\beta = 4.3$, $SE = 1.68$, $z = 2.82$, $p < .05$), whereas there was no reliable response difference between LC and EC syntax in the cooperating and conflicting prosody conditions (z 's < 1.4). Thus, response data are in accord with the response time data for the Genitive Possessive ambiguity.

For the NP Compound ambiguity overall, when compared to the neutral prosody condition participants were more likely to respond positively for sentences with cooperating prosody (odds ratio: $\beta = 5.76$, $SE = 1.41$, $z = 5.05$, $p < .001$), and less likely to do so for sentences with conflicting prosody ($\beta = .53$, $SE = 1.2$, $z = -2.49$, $p < .05$). For the LC/EC structures, it was more probable for participants to give 'yes' responses for LC syntax than for EC syntax in cooperating and neutral prosody conditions ($\beta = 4.43$, $SE = 1.9$, $z = 2.23$, $p < .05$, $\beta = 2.58$, $SE = 1.4$, $z = 2.58$, $p < .05$, respectively). However, there was no significant difference between LC and EC syntax in the conflicting prosody condition ($z < .02$). Thus the LC syntax advantage in the neutral prosody response time data appeared in the response data as well. However, the EC response time advantage in the conflicting prosody condition was not paralleled by the response data.

Response time and response data in Experiments 2A and 2B support a role for both a syntactic LC strategy and constituent length effects for the Genitive Possessive ambiguity. However, the NP Compound ambiguity did not show any length effects. The following section presents a comparison of Experiment 2A and Experiment 2B outcomes.

6.3. Experiment 2A and 2B

For convenience, Table 6.4 presents the summary findings from both experiments together.

Table 6-4 Experiment 2A and 2B, response time data pattern.

Ambiguity	Experiment	Cooperating Prosody	Conflicting Prosody	Neutral Prosody
Genitive Possessive	Expt. 2A	LC < EC	LC < EC	LC = EC
	Expt. 2B	LC = EC	LC = EC	LC < EC
NP Compound	Expt. 2A	LC = EC	EC < LC	LC < EC
	Expt. 2B	LC = EC	EC < LC	LC < EC

An additional mixed effects model was run to compare data in Experiments 2A and 2B statistically. In the new mixed effects model, there was one more condition, namely Length which represented the length manipulation in each sub-experiment. As in Experiment 2A and 2B, analyses started with simpler models and gradually were built up to where Length (Experiments 2A and 2B), Prosody (cooperating, conflicting and neutral) and Syntax (LC and EC) interacted. A model including Prosody and Syntax was compared to simpler models with Prosody or Syntax as a main effect only. The complex model explained the data significantly better than simpler models for the Genitive Possessive ambiguity ($X^2(1) = 11.29, p < .001$ for the comparison of the simple model for Prosody vs. the complex model with Prosody and Syntax; $X^2(2) = 44.58, p < .001$ for the comparison of the simple model for Syntax vs. the complex model with Prosody and Syntax). The interaction model explained the data significantly better than simpler models for the NP Compound ambiguity also ($X^2(2) = 32.34, p < .001$). A second interaction model included Length as well as Prosody and Syntax. This model was compared to the simpler model including Prosody and Syntax via a likelihood ratio test. The result indicated that the interaction model with Length, Prosody and Syntax explained the data better than the simpler one for the Genitive Possessive ambiguity ($X^2(6) = 13.4, p < .05$) but not for the NP Compound ambiguity ($X^2(6) = 2.36, p = .88$).

Planned pairwise comparisons using the *glht* function showed that for the Genitive Possessive ambiguity, there was a significant difference between the two experiments only for the conflicting prosody LC syntax condition, such that the conflicting prosody LC syntax in Experiment 2B elicited longer response times than the conflicting prosody LC syntax in Experiment 2A ($\beta = 251.98$, $SE = 131.1$, $z = 2.33$, $p < .05$). Although the results of the between subjects analyses did not show significant differences in the cooperating and neutral prosody conditions, the mean RT differences were in the expected directions. For instance, sentences in the cooperating prosody LC syntax condition were processed more slowly in Experiment 2B than those in Experiment 2A ($\beta = 162$, $SE = 119.47$, $z = 1.57$, $p = .11$), and sentences in the neutral prosody EC syntax condition in Experiment 2B were processed more slowly than those in Experiment 2A ($\beta = 193.1$, $SE = 124.64$, $z = 1.83$, $p = .07$). Statistical analyses probably did not yield significant differences due to the large number of comparison conditions. With a larger population, those comparisons could also have been significant.

Since the interaction model for the NP Compound ambiguity did not appear to be a better model than simpler models, the pairwise comparisons are not reported here.

Despite the lack of significant results in the between-subjects comparisons, the data pattern for the Genitive Possessive ambiguity in Experiment 2A and 2B provided in Table 6-4 support the prediction that both the syntactic LC strategy and constituent lengths can affect listeners' perception of overt prosodic boundaries and mental projection of missing ones. The results cannot be explained by reference to either factor alone for reasons explained below. By contrast, the results for the NP Compound ambiguity show no effect of constituent length but they do offer partial support for a syntactic LC strategy which emerged presumably by default in the neutral prosody conditions. Unfortunately the results for the conflicting prosody condition are

equivocal because they are contaminated by a confounding variable. Contrary to the predictions, there was an EC syntax advantage in the conflicting prosody condition, which was probably due to a potential ‘object drop’ interpretation in the conflicting prosody EC syntax condition as discussed in Section 6.2.3. Thus, it appears that the Genitive Possessive ambiguity was a better candidate to test effects of constituent lengths, presumably due to its syntactic flexibility.

The results of the Genitive Possessive ambiguity suggest that, with overt prosodic boundaries (cooperating and conflicting prosody), a syntactic LC strategy and ERSH are both at work. In Experiment 2A, there was an LC syntax advantage in cooperating and conflicting prosody conditions. In the cooperating prosody condition, the prosodic break in the LC syntax condition yielded unbalanced lengths, providing a more informative cue to the syntactic structure of the utterance. In the conflicting prosody condition, the misleading prosody in the LC syntax structures yielded balanced lengths and thus easier to ignore as it can be attributable to constituent lengths as well as, or instead of, to the syntactic structure of the utterance. This LC advantage in cooperating and conflicting prosody in Experiment 2A was not present in Experiment 2B. In Experiment 2B, the more informative facilitatory break and the less informative misleading break were associated with EC syntax. Since no EC advantage was observed in Experiment 2B as would be predicted by ERSH, the results suggest a trade off between the syntactic LC strategy and ERSH.

In the absence of overt prosodic phrasing (neutral prosody), the only account consistent with the Genitive Possessive data in both experiments is a combination of a syntactic LC strategy plus a preference for balanced phrase lengths. It appears that listeners mentally project prosodic boundaries when they are absent in the stimulus, with a bias toward typical and/or balanced phrase lengths as well as LC syntax. This is consistent with the Uniformity (balance) effects

found in Experiment 1 (Missing Morpheme read aloud task). In that experiment, participants also had a preference for balanced phrasing which influenced their parsing decisions. However, in reading there was no additional Late Closure syntax advantage for the Genitive Possessive ambiguity. This was attributed to the task, in which participants had to supply the missing morphemes. The LC syntax would require supplying passive morphology, whose retrieval is likely to be slower compared to the active morphology in the EC syntax condition. (See Chapter 5 for discussion.)

In sum: The results of Experiment 2A and 2B for the Genitive Possessive ambiguity indicate that ERSH does indeed have powerful effects alongside the Late Closure strategy.

Experiments 3A and 3B will examine the same hypotheses with a different methodology, namely the ‘phoneme restoration’ paradigm. This has the advantage, as did the missing morpheme task, of encouraging the perceiver to select an analysis of the structure on-line, before the sentence is completed.

CHAPTER 7. EXPERIMENT 3A AND 3B - PHONEME RESTORATION TASK

Stoyneshka et al. (2010) devised a new method to investigate the use of prosodic information in ambiguity resolution processes, namely the *phoneme restoration* paradigm. The phoneme restoration paradigm builds on the phoneme restoration effect first described by Warren (1970) in which a phoneme in a spoken sentence, although replaced by a cough, was perceived as intact. That is, when asked, listeners denied that any sound was missing; they thought they had heard a complete sentence with noise overlaid on it. Listeners could not even identify where in the sentence the noise had occurred. The phoneme restoration effect has been claimed to be a true perceptual illusion, but whether that is so or not, this method serves as a natural and non-obtrusive method of gauging what analysis a listener is computing for a potentially ambiguous spoken input.

Stoyneshka et al. employed this method in an investigation of prosodic influences on NP-coordination and RC-attachment ambiguities in Bulgarian, inserting white noise in place of the phonemes that would provide disambiguating information. Listeners' identification of those phonemes revealed which reading of the ambiguity they had computed. In one version of their experiment, participants performed a post-sentence two-choice probe task, indicating which of two visually presented words they (thought they) had heard in the sentence. Results were highly sensitive to prosodic properties of the spoken sentences. Thus, phoneme restoration seems to be a promising technique for testing sensitivity to prosody in the current study. The Turkish language is well-suited for this methodology, because (like Bulgarian) its rich morphology allows us to replace just the disambiguating morphological information on the disambiguating verb, without masking the stem that carries its lexical meaning. Participants are told that the experiment concerns how well people can recognize words that are difficult to hear in noisy circumstances,

as sometimes happens in everyday life due to poor transmission, such as on a cellphone. This can help to draw listeners' attention away from the ambiguity in the materials.

In Experiments 3A and 3B, a new variant of the phoneme restoration method was used. In their Experiment 1, Stoyneva et al. (2010) asked participants 'What word did you hear?' and participants chose from two words visually presented on a screen, one corresponding to each interpretation of the preceding spoken word string, which was disambiguated only by prosody. In Experiments 3A and 3B of this dissertation study, the task was modified and participants were asked 'Did you hear this word?', i.e., a simple one-word-probe task. Yes/no responses and RTs were recorded. Thus this variant of the task (unlike the original two-word-probe task) would be less likely to draw participants' attention to the alternative possible morphological construals of the phoneme-replaced word.

The results of the 'got it' experiments showed that both syntactic Late Closure strategy and constituent lengths influenced how listeners interpret and mentally project prosodic boundaries. Experiments 3A and 3B were conducted to test whether both effects would be observed in the absence of overt morpho-syntactic information in the sentence.

The phoneme restoration experiments (Experiments 3A and 3B) tested the same sentence materials as in the 'got it' experiments (Experiments 2A and 2B, respectively) except that the disambiguating phonemes in the verb were replaced with noise. The visually presented probe word (the verb, complete with all phonemes including the disambiguating phonemes) was either congruent or incongruent with the prosody of the sentence or compatible with it (in the case of neutral prosody). The visual probe was presented at the offset of the final word of the spoken sentence, which immediately followed the phoneme-replaced word. In some filler sentences the phoneme-replaced word appeared in sentence-final position and in some it appeared in the word

before the final word. For the unambiguous filler sentences, the probe word was congruent or incongruent with the syntactic structure of the sentence. In some proportion of the filler sentences (NP Compound ambiguity, which was used as fillers in Experiment 3A and 3B), the probe word was congruent, incongruent or compatible with the prosody of the sentence (see section 7.1.1. for details). Participants were instructed to decide, as quickly as possible, whether or not the visually presented word had occurred in the sentence. Yes/no responses were taken as indicating which verb form the listeners had thought they had heard in the sentence. In case the probe word did not match that, the listener could respond ‘no’. But it is possible that participants might sometimes interpret the visually presented word as a prompt, rather than a probe. That is, they might think that it was a hint as to which word had been in the sentence, and that could lead them to reanalyze the sentence, at some cost in the response time. Thus response times were recorded and analyzed as a potential indication of perceived confirmation or conflict and possible re-analysis.

In this dissertation study, disambiguating morphemes were replaced by ‘pink’ noise instead of ‘white’ noise, a small divergence from Stoyneva et al. Pink noise was selected instead of white noise as it has equal power per octave (Bashford, Riener, & Warren, 1992; Bashford & Warren, 1987). Following Bashford et al. (1992) the noise was presented at 80dB which was approximately 15dB louder than the average amplitude of the rest of the utterance. The reason for having the noise louder than the actual speech signal was to contribute to the illusion that the missing information was indeed masked by the loud noise, not replaced by it.

The following sections provide more detailed information about the acoustic characteristics of the spoken sentence materials.

7.1. Experiment 3A– Phoneme Restoration – Lengthened Subject

7.1.1. Materials

The target sentential materials in Experiment 3 were the Genitive Possessive ambiguity constructions tested in Experiment 2. In Experiment 3A they were the same as those in Experiment 2A in terms of length distribution (i.e., lengthened subject) but the disambiguating morpho-syntactic information in the sentence was replaced with pink noise (shown as ‘’ below). LC prosody yielded unbalanced lengths (4+2 PWds) whereas EC prosody yielded balanced lengths (3+3 PWds). The neutral prosody condition did not have any overt prosodic breaks. Each sentence recording was followed by a single visual probe word whose morphology was compatible only with an LC interpretation of the sentence, or only with an EC interpretation. Participants could accept or reject the word as having been present in the sentence, presumably on the basis of how they had parsed the sentence on-line and thus what phonemes they thought they had heard. Thus, there were six presentation conditions, as illustrated in (1).

(1) Spoken Sentence

Visual Probe

LC syntax/EC syntax

a. LC Prosody

Yaklaşık yedi öğrencinin psikoloğu || sevi sanıyoruz.

sevildi / sevdiğini

b. EC Prosody

Yaklaşık yedi öğrencinin || psikoloğu sevi sanıyoruz.

sevildi / sevdiğini

c. Neutral Prosody

Yaklaşık **yedi** öğrencinin psikoloğu sevi sanıyoruz.

sevildi / sevdiğini

LC Syntax: ‘We think that the psychologist of approximately seven students was liked.’

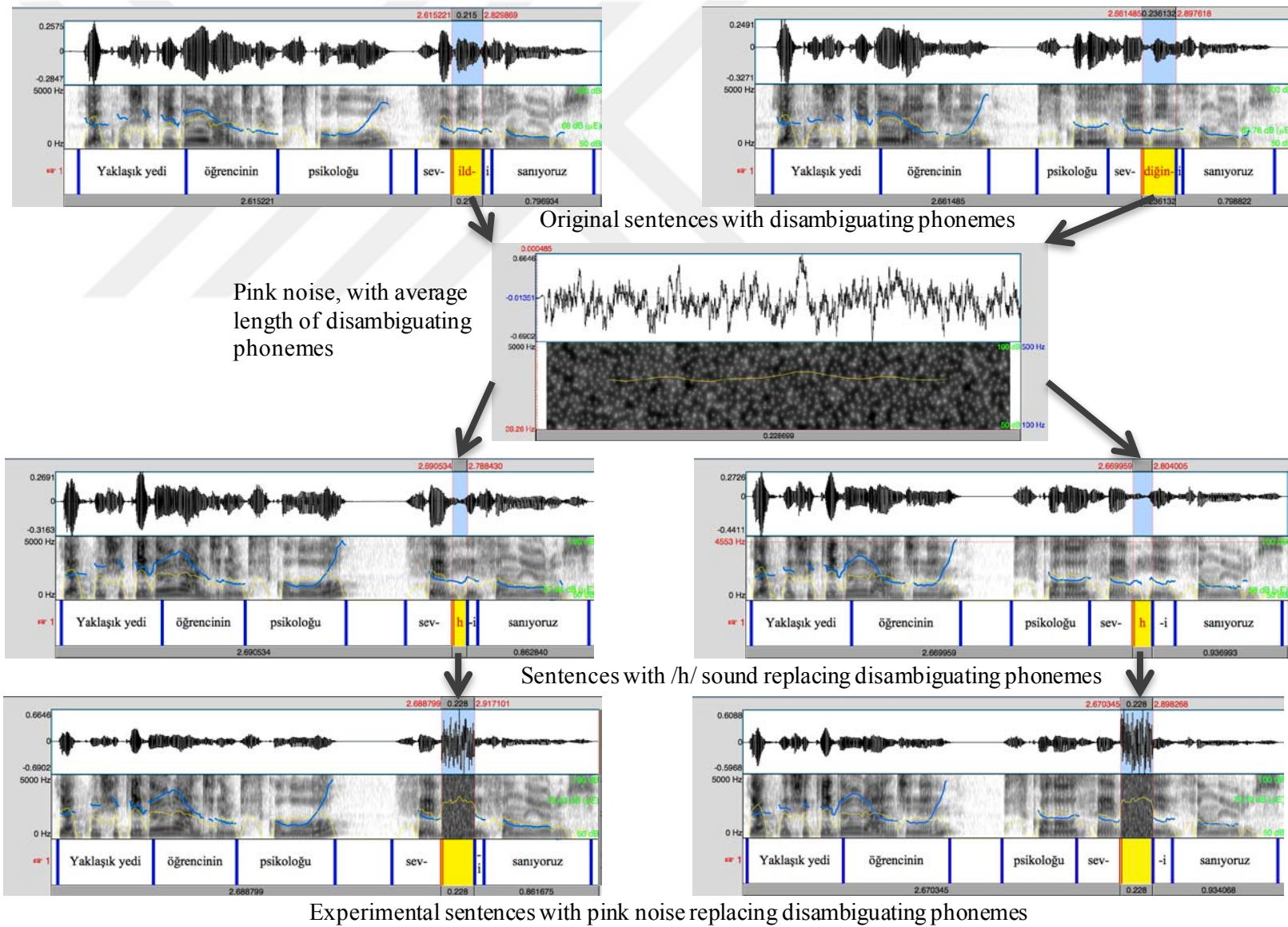
EC Syntax: ‘We think that approximately seven students liked the psychologist.’

It is known that a speech sound in continuous speech is influenced by its preceding or following sounds. Turkish, being a vowel harmony language, might actually be affected by co-

articulation more than languages that combine vowels freely. Boyce (1990) showed that speakers of Turkish and English differ with respect to their coarticulation strategies. Lip-protrusion (i.e., lip rounding) for instance seems to be non-specific for intervocalic consonants for Turkish speakers, being dictated by feature spreading from the segmental context. For English speakers, however, consonants must have some phonetic feature specification associated with lip-protrusion; i.e., the segmental context a consonant occurs in does not influence whether or not to produce it via lip rounding. The disambiguating phonemes to be spliced out of the experimental sentences have different places of articulations. Thus, even if the disambiguating phonemes are carefully spliced out, it is possible for them to leave their features in sounds preceding or following them. Co-articulatory cues have been reported to cross even syllable boundaries (Magen, 1997). Thus, even the sounds which are not immediately adjacent to the disambiguating phonemes could potentially carry some phonetic information about them. For these reasons, recordings in Experiments 2A and 2B could not be used for Experiments 3A and 3B. In order to create an acoustically neutral context for both LC and EC syntax conditions, the spoken sentences in Experiments 3A and 3B were originally uttered and recorded with the glottal fricative /h/ in place of the disambiguating morphemes to prevent any coarticulatory cues that the spliced portion of the sentences could leave in the acoustic signal. The glottal fricative /h/ is produced at the glottis and provides a neutral context, free of supralaryngeal articulation (Tunley, 1999). Warren and Sherman (1974) used a similar strategy to show that phoneme restoration is possible even when co-articulation is controlled for. They deliberately mispronounced the sounds to be noise-replaced, such as /s/ instead of /b/ or /b/ instead of /v/ (details can be found in Warren and Sherman, 1974, p.152). They showed that phoneme restoration in an English sentential context was still possible. In the current study, instead of randomly mispronouncing the to-be-

spliced-out segments, a co-articulation neutral /h/ sound was used in all sentential items, both targets and most of the fillers (see details below).

The disambiguating phonemes' average length (across LC syntax and EC syntax) was computed from the cooperating and neutral prosody items in Experiment 2A and 2B and was used to determine the length of the pink noise for each individual item. Thus, the noise length was identical for (1a) and (1b), computed by averaging the length of LC/EC phonemes in cooperating prosody items in Experiment 2A. For (1c) the average length of the LC/EC disambiguating phonemes in the neutral prosody condition of Experiment 2A was used. The following figure exemplifies how the splicing, length averaging and pink noise replacement was done.



189 Figure 7-1 Pink noise replacement procedure for Experiments 3A and 3B.

Pink noise creation and acoustic manipulation of the sentential items were all done using the Praat software (Boersma & Weenink, 2009).

The maximum threshold for the duration of the noise to permit the greatest restoration of sentence intelligibility has been reported (for English) to be 333 ms in Powers and Wilcox (1977) and 304 ms in Bashford and Warren (1987). The duration for the noise in the Turkish experimental items had a range from 184 ms to 262 ms (mean = 221 ms) falling below the threshold. Thus, the noise duration in the current experiments should allow for successful restoration.

The same procedures were applied to the filler items which were used to control for the active bias (mentioned in Chapter 4 for the missing morpheme task). Such control filler items were uttered with neutral prosody. It was predicted that in the phoneme restoration experiments, as in the missing morpheme experiments, there would be a potential bias for the EC interpretation of the sentence since it would contain an active form for the verb (or for the active form of the visual probe word), as opposed to the LC interpretation under which the verb would be in passive form. Some piloting before the main phoneme restoration experiments had confirmed this. Six native speakers of Turkish had listened to the experimental items with noise and they had been asked to write down the sentences they heard. In most cases (>70%), for both LC and EC prosody, the participants wrote down a sentence with EC structure (i.e., with a verb in active form), confirming the bias for an active verb/syntax. In order to control for this confound, additional filler items had been created. As mentioned in Chapter 4 for the Missing Morpheme task, these filler items had syntactic structure similar to the experimental items but they were not ambiguous (see Appendix B.2). The disambiguation was accomplished by using nouns ending in vowels. Recall from Chapter 3 that the ambiguity is due to the homophony between possessive

and accusative suffixes when the NP2 ends in a consonant. If it ends in a vowel (as was the case with control filler items), the possessive and accusative case endings are fully realized (*-(s)I* for possessive and *-(y)I* for accusative), thus preventing an ambiguity. When the NP2 ends in a consonant, the /s/ in the possessive suffix and the /y/ in the accusative suffix are not realized, causing the ambiguity. In control filler items all of the NP2's ended in a vowel, providing an unambiguous morpho-syntax before the embedded verb. These filler items were uttered with neutral prosody to ensure that any bias observed, over and above effects of the disambiguating morphology, could be attributed to a lexical preference not confounded with a prosodic influence. The visual probes for these fillers were either congruent or incongruent with the morpho-syntactic information. Responses and response times to these control filler items would be used to control for bias for the active verb in the target items.

As noted the NP Compound ambiguity items were treated as fillers in this experiment. For those items, the region where the noise occurred was sentence final. The sentences had LC, EC and neutral prosody conditions.

As for the unambiguous fillers of various other types, a few phonemes in the sentence-final or penultimate word (which was either the matrix or embedded verb) were replaced by pink noise. The actual lengths of the spliced-out phonemes were used to determine noise duration for these items. Such fillers all had prosody congruent with their syntactic structure. They were followed by a visual probe word which was either the noise-containing verb in full form with all its phonemes, or the stem of the noise-containing verb plus a different suffix. The noise-replaced portion of these verbs was always part of the verbal suffixes; it was never part of the verb stem.

Since the sentential items were acoustically manipulated, an ear-judgment pre-test for pronunciation acceptability was not possible for them. Thus, acoustic analyses were conducted to

ensure that all items had the relevant prosodic properties. The following table shows the average maximum F_0 and duration for NP1s and NP2s and pauses (where applicable) for the overt prosody and the no prosody conditions. t -tests confirmed that NP1 and NP2 durations and maximum F_0 's differed significantly for LC and EC prosody conditions in the predicted directions. t -test results are given beneath the cells that were compared.

Table 7-1 Acoustic properties of experimental items in Experiment 3A.

Prosody	F0 maximum (Hz)		Duration (ms)		Pause (ms)
	NP1	NP2	NP1	NP2	
LC	378	468	479	611	360 (after NP2)
EC	476	267	662	413	393 (after NP1)
	$t(23) = 8.89,$ $p < .001$	$t(23) = -46.67,$ $p < .001$	$t(23) = 30.66,$ $p < .001$	$t(23) = -24.49,$ $p < .001$	
Neutral	271	215	453	381	NA

As can be observed from the table, the pre-boundary words (NP1 for EC and NP2 for LC) were associated with higher F_0 values and longer durations. They were also followed by a pause. These cues were missing in the neutral prosody condition. Thus, the acoustic analyses confirm that the sentential items in Experiment 3A had properties associated with LC and EC prosody and neutral prosody, similar to those reported for Experiment 2A.

There were a total of 144 experimental items: 48 congruent probe (24 LC, 24 EC), 48 incongruent probe (24 LC, 24 EC), and 48 compatible probe (24 LC, 24 EC). The items were distributed across six lists counterbalancing for prosody (LC, EC and neutral) and for the visual probe (LC vs. EC). Thus, each list included 24 experimental sentences. In addition there were 192 fillers. 144 of them belonged to the NP Compound ambiguity and were distributed to six

lists for congruency and syntactic structure of the visual probe, thus 24 per list. The remaining 48 fillers were unambiguous and consisted of control fillers ($N=24$) and fillers with various structures ($N=24$). In addition, there were 10 practice items prior to the beginning of the experiment and 10 implicit ‘warm-up’ items, 5 at the beginning of each list and 5 half way through, where participants were encouraged to take a rest break. Thus, each list following the practice session consisted of 106 sentences.

7.1.2. Participants and Procedure

Forty-eight native speakers of Turkish took part in Experiment 3A (mean age = 21.4, 5 males). The participants were seated in front of a computer screen in a quiet room. They were presented with the spoken sentences via noise-cancelling head phones; at the end of each spoken sentence, a visual probe appeared on the screen. Their task was to listen to the sentence and indicate, by pressing the ‘yes’ or ‘no’ button marked on the keyboard, whether they had heard the visual probe in the spoken sentence. The researcher stayed with the participant during the practice session and answered any questions the participant might have. The task took 15-20 minutes to complete. As in the other experiments, participants received 15 Turkish Liras (~\$8.5 at the time of the experiments) for their participation.

7.1.3. Data Analysis and Results

‘Yes/no’ response data and RTs were analyzed. The former will be reported below, following discussion of the RT data.

Statistical software and packages were the same as for the ‘got it’ experiments. As in the ‘got it’ experiments, the RTs were first inspected for normal distribution. The analyses showed that the data did not distribute normally ($W = .82, p < .001, D = .15, p < .01$) and were positively skewed (density and box and whisker, and q-q plots in Appendix D.1). Following the same steps

as for the ‘got it’ experiments, the data were log-transformed, and any extreme or outlier data points for the overall data and from a particular item or subject’s data were excluded, which was approximately 1% of the data. Data showed better normal distribution after these steps. Although the normality tests still indicated violation of normality, they declined in severity ($W = .98$, $p < .001$, $D = .05$, $p = .005$) and plots showed that the data distributed much closer to normal (see Appendix D.1 for plots for data distribution before and after log transformations and exclusion of extreme and outliers).

The RTs were entered into a mixed effects model using the *lmer* function in the *lme4* package. As in the ‘got it’ experiments, longitudinal effects of familiarization or fatigue were examined via a mixed effects model for the RTs with Trial number as the only fixed effects term. This analysis showed that the RTs became shorter towards the end of the experiment ($\beta = -2.03$, $SE = .52$, $t = -3.85$, $p < .001$). Thus, the following models included Trial as an additional predictor but slopes did not vary by Trial.

Recall from Section 7.1.1. that there was a predicted bias for the EC visual probe, which is the active form for the verb. An initial inspection of RTs indicated that regardless of the prosody of the sentences (LC, EC or neutral), visual probes with EC syntax were responded to faster than the ones with LC syntax. The same pattern was observed for the unambiguous control filler items too ($\beta = 190.04$, $SE = 26.44$, $t = 7.88$, $p < .001$). This confirmed that there was a bias either for an active syntactic structure for the sentence, or for the active form of the visual probe word (see Appendix D.2 for raw RT data for ‘yes’ and ‘no’ responses for experimental items and control fillers). To check how much this trend in control fillers could predict the response times for the experimental items, the RTs for the control fillers were included in the regression model after being aggregated by subject, syntax and response (Raudenbush & Bryk, 2002; Snijders & Bosker,

2012). A model where control filler RT is a predictor for the experimental response RT suggested that the RTs for experimental items were predicted by the control filler RTs to some extent ($\beta = 54.12$, $SE = 9.3$, $t = 6.98$, $p < .001$). Thus, control filler RTs were retained in the models for the RTs for experimental items³⁵.

In this probe task the data were collected in two forms: ‘yes/no’ responses and response times. The response times were collected separately for the ‘yes’ and the ‘no’ responses, which could contribute to the RT data differentially. Whereas ‘yes’ responses could yield shorter RTs for congruent probes (and perhaps longer RTs for incongruent probes), ‘no’ responses could yield shorter RTs for incongruent probes (and perhaps longer RTs for congruent probes). Thus, the yes/no responses to the experimental items were entered into the model to check whether or not it affected the RTs. The analysis indicated that the response ‘yes’ or ‘no’ did influence the RT, where ‘yes’ responses were faster than ‘no’ responses in general ($\beta = -196.61$, $SE = 31.68$, $t = -5.83$, $p < .001$). In the main analyses, this variable actually showed a strong interaction with congruency and the syntactic structure of the visual probe ($X^2(6) = 51.59$, $p < .001$)³⁶. The post hoc comparisons indicated that although ‘yes’ and ‘no’ responses showed patterns that were meaningfully in the opposite direction (e.g., faster ‘yes’ and slower ‘no’ responses for a probe congruent with the prosody and faster ‘no’ and slower ‘yes’ responses for a probe incongruent with the prosody), pairwise comparisons using ‘yes’ responses yielded statistically reliable results (see below for post hoc comparisons for RTs of ‘no’ responses). Thus, I will first report

³⁵ Note that for the main analyses both Trial and control filler RTs were centered to prevent collinearity (Baayen, 2008).

³⁶ Note that Kjelgaard and Speer (1999) conducted response time analyses by combining ‘yes’ and ‘no’ responses in their phonosyntactic grammaticality judgment task. Given the differences between the methods used by Kjelgaard and Speer and the method in Experiments 3A and 3B of this study, as well as the observed statistical interaction of response and congruency and the syntactic structure of the visual probe, I analyzed ‘yes’ and ‘no’ responses separately.

the analyses conducted only for the RTs for 'yes' responses and then report and briefly discuss the 'no' response analyses. As with the overall RTs, control RTs and Trial were included in the analyses for the RTs for 'yes' responses as additional predictors ($\beta = -1.82$, $SE = .67$, $t = -2.68$, $p < .05$ for Trial, ($\beta = 66.58$, $SE = 22.63$, $t = 3.47$, $p < .001$ for control RT as a predictor).

The main analyses for 'yes' responses were run on Congruency of the probe word with the prosodic contour (congruent, incongruent, and compatible) and Syntactic Structure (LC and EC) implied by the visual probe, and their interaction. The model for Congruency suggested that 'yes' responses to probes compatible with the prosody (i.e., neutral prosody) were processed faster than 'yes' responses to probes congruent with the prosody of the sentence ($\beta = 81.68$, $SE = 45.3$, $t = 1.9$, $p = .06$) and also than 'yes' responses to probes incongruent with the prosody of the sentence ($\beta = 285.05$, $SE = 62.18$, $t = 5.24$, $p < .001$); the difference from the prosody-compatible probe condition was significant for the prosody-incongruent probe condition, and marginally significant for the prosody-congruent probe condition. The model with Syntactic Structure implied by the visual probe as a predictor variable showed that there was not a significant difference between the LC and EC probes ($\beta = -59.35$, $SE = 51.52$, $t = -1.15$, $p = .25$).

As in the 'got it' experiments, after analyses for main effects of each predictor variable, a more complex model including an interaction of the two predictors was built. A log-likelihood test comparing the simple models to the complex one with interaction suggested that the model with the interaction was significantly better than the simpler models ($X^2(3) = 12.07$, $p < .005$ for the comparison of the simple model for Congruency vs. a complex model for Congruency and Syntactic Structure implied by the probe, and $X^2(4) = 37.78$, $p < .001$ for the comparison of the simple model for Syntactic Structure implied by the probe vs. a complex model for Congruency and Syntactic Structure implied by the probe). Thus, the model with the interaction was kept.

Note that the models (simple or complex) allowed only for random intercepts. The models with random slopes for the variables were not significantly better than random-intercepts-only models. Whether other predictors, namely control filler RT, interacted with the Congruency and Syntactic Structure was also examined but it did not yield a reliably better model. See Appendix D.3 for model comparison tables.

During model criticism, data points with standardized residuals below/above 2.5 standard deviations were excluded from the analyses as well as overly influential subjects ($N = 2$), items ($N = 1$) and individual data points ($N = 2$). Plots for influential subjects, items and data points are provided in Appendix D.4. Please see Appendix D.5 for a q-q plot to inspect how the data fit the model after these steps.

RTs from the remaining participants and items can be observed in Figure 7-2.

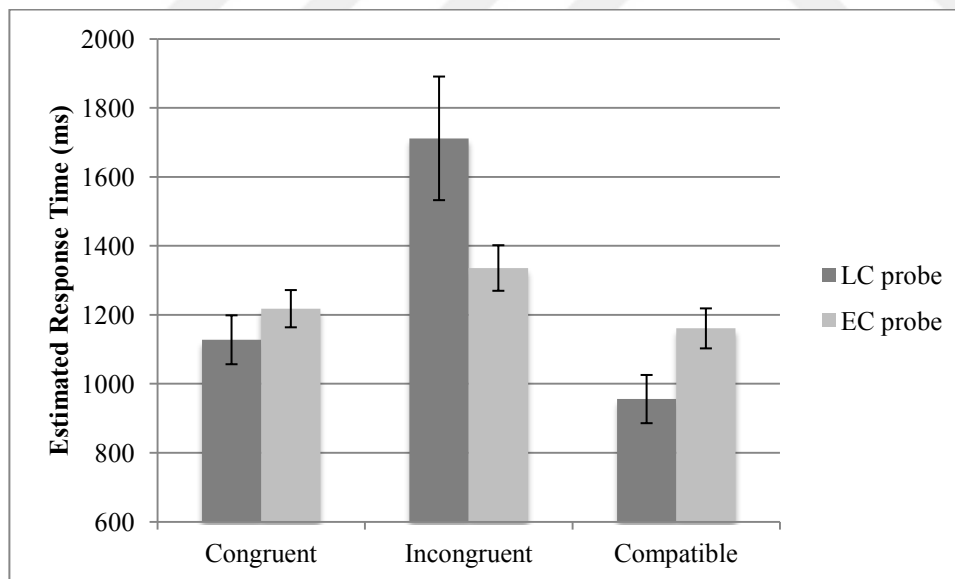


Figure 7-2 Experiment 3A: Estimated mean response time for 'yes' responses, with standard errors.³⁷

³⁷ Because the actual data were contaminated by an active bias, the graph here shows estimated RTs based on statistical analyses.

Planned pairwise comparisons using the *glht* function showed that when the probe was congruent with the prosody, there was no reliable RT difference between the LC probe and the EC probe ($\beta = -85.92$, $SE = 66.51$, $z = -1.28$, $p = .2$). Responses to EC probes were faster than to LC probes when the probe was incongruent with the prosody ($\beta = 326.66$, $SE = 159.53$, $z = 2.43$, $p < .05$). Responses to LC probes were faster than to EC probes when the prosody was neutral ($\beta = -204.95$, $SE = 69.9$, $z = -2.75$, $p < .01$).

When the prosody of a sentence and the presented visual probe were congruent with each other, no reliable difference between an LC or EC probe was observed, presumably because the parser was sensitive to both LC prosody and EC prosody in building the syntactic structure for the utterance and thereby restoring the missing phonemes. The probe word would then match the restored verb in the sentence. For probes following sentences with neutral prosody, it is possible that in absence of any overt prosodic cue, the parser would apply the syntactic parsing strategy of Late Closure and restore the missing phonemes accordingly. When the visual probe was LC, it would be easier to respond ‘yes’ to it than when it was EC, thus explaining why responses were faster to LC probes.

In the case of a probe incongruent with the prosody, it is not clear what may have caused faster responses to the combination of an EC probe with an LC prosody. An account assuming Late Closure strategy functioning as a syntactic default could not explain this. Nor could the Extended Rational Speaker Hypothesis because the LC prosody yields unbalanced phrase lengths which should have enhanced the effect of the prosody favoring LC phoneme restoration. In that case, a ‘yes’ response to EC probe would be expected to be slow. Some explanations will be discussed below in Section 7.1.4.

The response times for ‘no’ responses are shown in Figure 7-3.

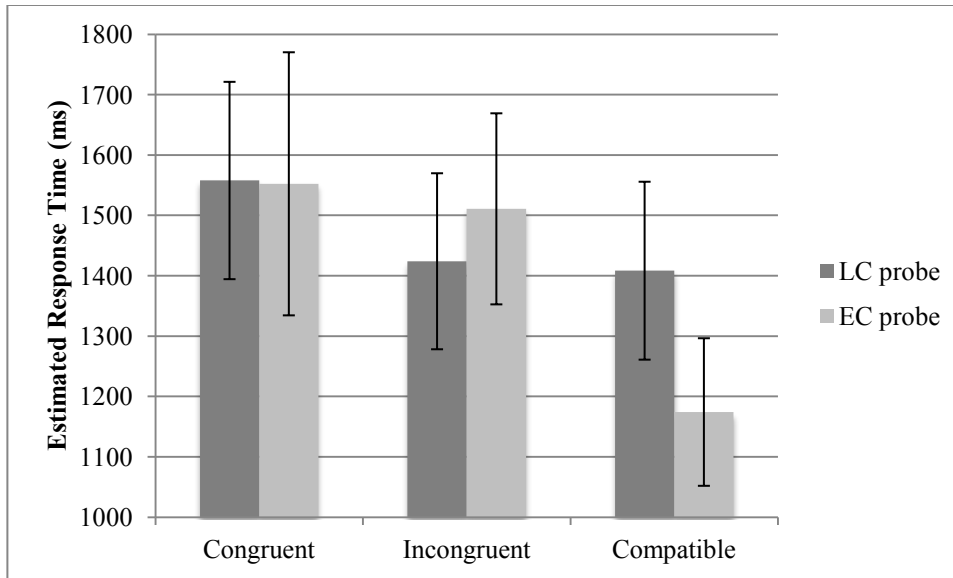


Figure 7-3 Estimated mean response time for 'no' responses, with standard errors.

RTs for 'no' responses in general showed a complementary pattern to the 'yes' response RTs. There was no reliable difference between the LC and EC probe when they were congruent with the prosody of the spoken sentence ($\beta = 4.14$, $SE = 144.05$, $z = 0.03$, $p = .97$). Participants rejected the LC probe faster than the EC probe in the incongruent condition, showing a preference for the EC probe ($\beta = -67.5$, $SE = 76.48$, $z = -.88$, $p = .37$). Though this preference was not significant, it shows a complementary pattern to the 'yes' responses where the EC probe was accepted faster than the LC probe in the incongruent condition. Similarly, in the neutral prosody condition the EC probe was rejected faster than the LC probe ($\beta = 234.18$, $SE = 147.4$, $z = 1.83$, $p = .06$), showing a preference for the LC probe as in the case of the 'yes' response RTs.

We turn now to the distribution of 'yes' responses. Procedures of active bias control as described above were also applied to these acceptance data. Please see Appendix D.6 for raw percentages of 'yes' responses for experimental and control fillers. The acceptance data were in the predicted direction. Participants were more likely to respond 'yes' to the prosody-congruent probe, followed by the prosody-compatible and then the prosody-incongruent probes (odds ratios

for congruent vs. compatible: $\beta = 2.38$, $SE = 1.22$, $z = 4.31$, $p < .001$; odds ratios for incongruent vs. compatible: $\beta = .24$, $SE = 1.21$, $z = -7.11$, $p < .001$). Figure 7-4 below shows the estimated probability of responding ‘yes’ to the probe word.

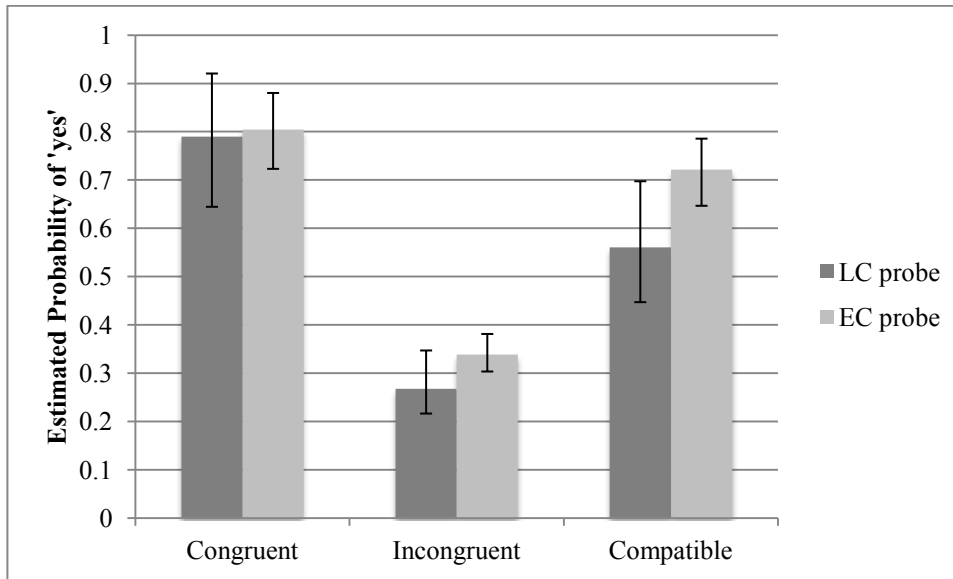


Figure 7-4 Experiment 3A: Estimated probability of ‘yes’ responses with standard errors.

The analyses confirm what Figure 7-4 shows: the participants were influenced by prosodic information in parsing the sentences, as in Experiments 2A and 2B. These data also show that the single word probe recognition method is highly sensitive to the sentential prosody.

There was no reliable difference attributable to any factor other than congruency of the probe, neither an overall LC probe/EC probe difference nor an LC probe/EC probe difference in any one of the three specific congruency conditions (z 's $< .95$).

7.1.4. Discussion

Results for the response time data here are different from what was observed in the ‘got it’ experiments. For the Genitive Possessive ambiguity in Experiment 2A, there was an LC advantage in ‘got it’ response times for the cooperating and conflicting prosody conditions and

no LC or EC advantage for the neutral prosody condition. As noted in Chapter 6, this could be attributed to either an effect of constituent lengths as per the ERSH, or a syntactic LC advantage, or both. The results of Experiment 2B showed that both a syntactic LC strategy and constituent length effects influenced the outcomes. In the present experiment, with materials parallel to those of Experiment 2A, there is an RT advantage for LC probe in the prosody-compatible probe condition only, and an RT advantage for EC probe in the LC prosody (incongruent) condition, and no advantage for LC or EC probe in the congruent probe condition. This is summarized in Table 7-2.

Table 7-2 RT data pattern in Experiment 3A compared to Experiment 2A.

	Cooperating prosody / Prosody-congruent	Conflicting prosody / Prosody-incongruent	Neutral prosody/ Prosody-compatible
Experiment 2A	LC < EC	LC < EC	LC = EC
Experiment 3A	LC = EC	LC > EC	LC < EC

Although conclusive remarks can be made only after comparison with Experiment 3B data, in Experiment 3A, there appears to be no effect of constituent lengths as there was in Experiment 2A. On the basis of the phrase lengths in the congruent and incongruent probe conditions, an LC advantage would be predicted. This was the case in Experiment 2A, but not in Experiment 3A. In fact, an LC advantage was observed in Experiment 3A only in the compatible probe condition, where ERSH does not apply, and where projection of a balanced 3+3 length pattern would have favored EC.

Absence of length effects in any of the conditions in Experiment 3A is explicable. Let us consider the congruent probe condition first. In this experiment, the missing phoneme in the embedded verb in the sentence would most likely be restored in accord with the prosody, and

thus a prosody-congruent probe word would appear to the listener to match the verb form that the listener thought s/he had heard in the sentence. This compatibility could create confidence in the listener's analysis of the sentence structure, for both LC and EC prosody, and therefore there would be little or no need to rely on lengths of constituents as an indicator of how informative the prosodic break should be taken to be.

In the neutral prosody (compatible) condition, there was no effect of constituent lengths either, whereas a preference for balanced lengths would be expected, favoring EC. This is the case in which the length-based EC preference and a syntactic LC preference could balance each other out, as in Experiment 2A. The fact that LC won out here could be due to the fact that the listener restores the missing phoneme before the ultimate length of the sentence is known, and thus before a balanced prosody could be mentally projected. This is a difference between the phoneme restoration and the 'got it' task.

In the prosody-incongruent condition in Experiment 3A an unexpected finding was the apparent EC advantage (or LC disadvantage). This was not predicted under either ERSB, or LC as syntactic default. One possibility is that it could be due to the fact that the phoneme in the embedded verb needed to be restored very soon after the prosodic boundary in the LC prosody-EC probe condition, where the LC phrase lengths were 4+2. The boundary immediately preceded the phoneme-replaced verb which in turn was followed by only one PWd prior to the presentation of the incongruent EC visual probe. In that case, the parser might be less certain of the structure of the embedded verb when subsequently confronted with a conflicting probe verb. Thus, this may have caused the EC advantage in the conflicting prosody condition in Experiment 3A. Stoyneshka et al. (2010) indeed observed a similar recency effect in their speech shadowing experiment. In the speech shadowing experiment, the participants' task was to shadow the

speaker in the stimulus recordings, by speaking the sentence aloud as they were listening to it, with as little delay as possible. It was found that for the RC attachment ambiguity, when the noise-replaced relative pronoun occurred immediately after the prosodic break (in the case of high RC-attachment), prosody-driven phoneme restorations were low (66% as compared with >80% in sentence repetition and visual probe tasks, and compared with all tasks for a temporary coordination ambiguity where the disambiguating phonemes always occurred later in the sentence). Stoyneshka et al. suggested that in that one case, there could have been too little time to integrate the disambiguating prosodic information to confidently restore the missing phonemes.

7.2. Experiment 3B: Phoneme Restoration – Lengthened VP

Experiment 3B utilized the same task as Experiment 3A with materials that reversed the phrase length balance between the subject and the VP, just as the Experiment 2B materials differed from the Experiment 2A materials. Thus, sentences in Experiment 3A had lengthened VP as opposed to lengthened subject.

7.2.1. Materials

The following examples illustrate the sentences in each prosody condition. LC prosody yielded balanced phrasing (3+3 PWds) whereas EC prosody yielded unbalanced phrasing (2+4 PWds). The neutral prosody condition did not have any overt prosodic boundary. The ‘’ symbol indicates the noise-replaced segments. As in Experiment 3A materials, there is no morphosyntax-prosody conflict in any of the sentence materials, because the verbal morphology that would determine the syntactic analysis is absent, replaced by noise. The only cue to the syntactic analysis is the prosodic phrasing. One of the visual probe words that follows the spoken sentence

is the verb form appropriate to the LC sentence and the other is the verb form appropriate to the EC analysis.

(2) **Spoken Sentence**

Visual Probe

LC syntax/EC syntax

a. LC Prosody

Yedi öğrencinin psikoloğu || oldukça sev*iii*i sanıyoruz.

sevildi / sevdiğini

b. EC Prosody

Yedi öğrencinin || psikoloğu oldukça sev*iii*i sanıyoruz.

sevildi / sevdiğini

c. Neutral Prosody

Yedi öğrencinin psikoloğu oldukça sev*iii*i sanıyoruz.

sevildi / sevdiğini

LC Syntax: ‘We think that the psychologist of seven students was much liked.’

EC Syntax: ‘We think that seven students liked the psychologist much.’

The number of experimental items, fillers, and practice items was the same as in Experiment 3A. The same procedures for noise-replacement that were used in Experiment 3A were used in Experiment 3B. The following table shows the acoustic analyses for spoken sentence materials in Experiment 3B. As in Experiment 3A, the acoustic analyses indicate that the prosodic properties relevant for disambiguation were present in the spoken signal.

Table 7-3 Acoustic properties of experimental items in Experiment 3B.

Prosody	F0 maximum (Hz)		Duration (ms)		Pause (ms)
	NP1	NP2	NP1	NP2	
LC	416	475	493	663	306 (after N2)
EC	474	271	667	403	367 (after N1)
	$t(23) = 8.18,$ $p < .001$	$t(23) = -34.97,$ $p < .001$	$t(23) = 22.68,$ $p < .001$	$t(23) = -24.79,$ $p < .001$	
Neutral	306	223	463	362	NA

7.2.2. Participants and Procedure

Forty-eight native speakers of Turkish took part in the experiment (mean age = 21.1; 4 males).

The procedure was the same as for Experiment 3A. As in the other experiments, participants received 15 Turkish Liras (~\$8.5 at the time of the experiments) for their participation.

7.2.3. Data Analysis and Results

As in previous experiments, the RTs were first inspected for normal distribution. The analyses showed that the data did not distribute normally ($W = .77, p < .001, D = .15, p < .01$) and were positively skewed (density and box and whisker plots in Appendix D.7). Hence, the data were log-transformed, and any extreme or outlier data points for the overall data and from a particular item or subject's data were excluded, which comprised approximately 1% of the data. Data showed better normal distribution after these steps ($W = .99, p < .001, D = .04, p = .04$); see Appendix D.7 for plots of data distribution before and after log transformations and exclusion of extremes and outliers.

As in the previous experiments, the RTs were initially inspected for longitudinal effects of familiarization or fatigue using Trial number as the only fixed effects term. This analysis indicated effects of familiarization, i.e., shorter RTs towards the end of the experiment ($\beta = -1.55, SE = .55, t = -2.82, p < .005$). Thus, Trial was included in the models for main analyses as an additional predictor but as in Experiment 3A, slopes did not vary by Trial.

The bias for 'yes' responses to an active verb (i.e., EC probe) was evident in this experiment too ($\beta = 391.58, SE = 22.55, t = 20.19, p < .001$); see Appendix D.8 for the experimental and control filler raw RT data. Thus, as in Experiment 3A, control filler RTs were aggregated by subject, syntactic structure of the visual probe and response and were then entered as a predictor for experimental RTs into a mixed effects model, which showed that control filler RTs explained

the experimental data to some extent ($\beta = 53.8$, $SE = 9.97$, $t = 6.5$, $p < .001$). Thus, control filler RTs were kept in model building for the RTs for experimental items³⁸.

The effect of the response (i.e., ‘yes/no’) on the RTs was also inspected. The analysis indicated that the response ‘yes’ or ‘no’ influenced the RTs, with ‘yes’ responses resulting in shorter RTs in general ($\beta = -116.61$, $SE = 32.35$, $t = -3.5$, $p < .001$). As in Experiment 3A, in the main analyses this variable showed a strong interaction with the congruency and syntactic structure of the visual probe ($X^2(6) = 20.11$, $p < .005$). As in Experiment 3A, only the RTs for ‘yes’ responses yielded reliable differences. Thus, first, the analyses for the RTs for ‘yes’ responses will be reported and discussed (see below for the analyses of ‘no’ responses). As with the overall RTs, centralized control RTs and Trial were included in the analyses for the RTs for ‘yes’ responses, as additional predictors ($\beta = -1.37$, $SE = .75$, $t = -1.78$, $p = .07$ for Trial, ($\beta = 48.62$, $SE = 13.36$, $t = 4.46$, $p < .001$ for control RT as a predictor).

The main analyses were run on the Congruency (prosody-congruent, prosody-incongruent, prosody-compatible) and the Syntactic Structure (LC/EC) implied by the visual probe, and their interaction. The model for prosody-congruency suggested that prosody-congruent probes were processed faster than prosody-compatible probes but this did not reach statistical significance ($\beta = -46.36$, $SE = 47.7$, $t = -.97$, $p = .33$). Prosody-compatible probes were processed reliably faster than prosody-incongruent probes ($\beta = 226.47$, $SE = 67.45$, $t = 3.73$, $p < .001$). The model with Syntactic Structure of the visual probe as a predictor variable showed that overall there was not a significant difference between the LC and EC visual probe although processing time was numerically faster for LC than EC ($\beta = -77.71$, $SE = 60.82$, $t = -1.27$, $p = .2$).

³⁸ As in Experiment 3A, both Trial and control filler RTs were centered to prevent collinearity.

As in the ‘got it’ experiments, after analyses for main effects of each predictor variable, a more complex model including an interaction of the two predictors was built. A log-likelihood analysis comparing the simple models to the complex one with interaction suggested that the model with interaction was significantly better than at least one of the simpler models: $X^2(3) = 2.21, p = .48$ for the comparison of the simple model for Congruency vs. a complex model for Congruency and Syntactic Structure; $X^2(4) = 23.91, p < .001$ for the comparison of the simple model for Syntactic Structure vs. a complex model for Congruency and Syntactic Structure. Thus, the model with the interaction was kept. As in Experiment 3A, the models (simple or complex) allowed only for random intercepts. The models with random slopes for the variables were not significantly better than random-intercept-only models. See Appendix D.9 for model comparison tables.

During model criticism, data points with standardized residuals below/above 2.5 standard deviations were excluded from the analyses as well as overly influential subjects ($N=4$) and data points ($N=2$). There was no overly influential item. Plots for influential subjects, items and data point analyses are provided in Appendix D.10. Please see Appendix D.11 for a q-q plot to inspect how the data fit the model after these steps.

RTs from the remaining participants can be observed in Figure 7-5.

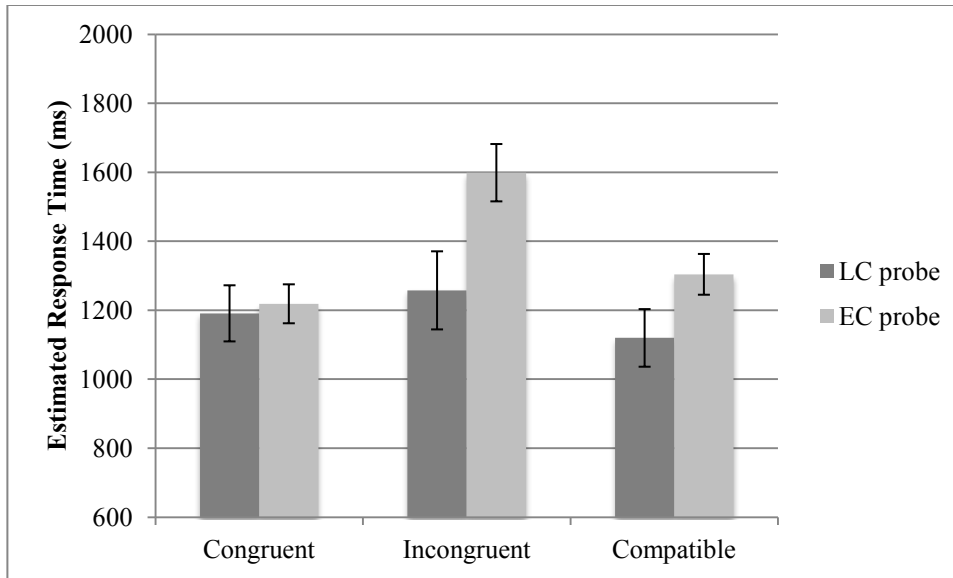


Figure 7-5 Experiment 3B: Estimated mean response time for ‘yes’ responses, with standard errors.

Planned pairwise comparisons showed that in the prosody-congruent condition, there was no reliable difference between the LC and EC probes ($\beta = -29.61$, $SE = 83.93$, $z = -.36$, $p = .7$).

There was a reliable LC advantage in the prosody-incongruent condition ($\beta = -278.3$, $SE = 94.12$, $z = -2.73$, $p < .01$) and the prosody-compatible condition ($\beta = -184.35$, $SE = 83.53$, $z = -2.11$, $p < .05$). The data show the following pattern, in which two of the three conditions show results comparable to those in Experiment 3A and would fall under the same explanations as in Section 7.1.4. The only condition that needs to be addressed, therefore, is where the probe is incongruent with the prosody. This will be discussed below, following statistical analyses confirming that *in other respects* the outcomes of Experiments 3A and 3B do not differ.

Table 7-4 RT data pattern for Experiment 3A and 3B.

	Prosody-congruent	Prosody-incongruent	Prosody-neutral
Experiment 3A	LC = EC	LC > EC	LC < EC
Experiment 3B	LC = EC	LC < EC	LC < EC

An additional mixed effects model was run on response time data to compare the results of Experiment 3A and 3B statistically to confirm that the outcomes of Experiments 3A and 3B do not differ except for the one discrepancy between them, namely in the incongruent probe condition. In the new mixed effects model, there was one more condition, namely Length, which corresponded to the constituent length manipulation in each experiment. There was no significant main effect of Length ($t = .73$) but the model which included an interaction of Length (Experiment 3A and 3B), Congruency (congruent, incongruent and compatible) and Syntactic Structure implied by the visual probe (LC, EC) was significantly better than a less complex model where only Congruency and Syntactic Structure implied by the visual probe interacted. However, the only significant difference observed in the pairwise comparisons between the two experiments was for the prosody-incongruent LC probe condition, which was processed faster in the second experiment compared to the first experiment ($p < .05$); the numerical difference between the two experiments for the prosody-incongruent EC probe condition did not reach statistical significance.

We turn now to an explanation of the one discrepancy between outcomes of Experiments 3A and 3B. Recall that in Experiment 3B, phrase lengths were reversed compared with Experiment 3A, such that LC prosody yielded 3+3 (balanced) lengths and EC prosody yielded 2+4 (unbalanced) lengths. Experiment 3A found no effects of phrase lengths on probe recognition. In the case of unbalanced prosody (LC lengths 4+2) this was explained above in terms of the prosodic boundary being too late in the LC condition for it to influence the restoration of the phoneme. This explanation does not apply in Experiment 3B where the length patterns were either 3+3 or 2+4, leaving time for integration of the prosodic boundary cue.

However, there is a natural explanation for the Experiment 3B finding for the incongruent probe. The data are RTs to the ‘yes’ responses (whereas a prosody-sensitive response would be ‘no’), so it appears likely that in these cases the parser took the probe word as a prompt to override the analysis it computed on-line for the sentence. If that is so, then the data indicate that the LC probe is more effective at triggering reanalysis than the EC probe. Given the independent evidence for an LC preference (in the neutral prosody condition in Experiment 3B, see discussion in Section 7.1.3) this can be attributed to the syntactic LC strategy. When an LC probe clashes with an on-line EC analysis, the probe would be a stronger force for reanalysis than when an EC probe clashes with an on-line LC analysis.

Thus, the analyses conducted for Experiment 3A and 3B together appear to show that unlike Experiment 2A and 2B, the phrase length manipulation did not influence processing decisions in the phoneme restoration experiments, for reasons that are explicable.

Figure 7-6 below shows the RTs for ‘no’ data.

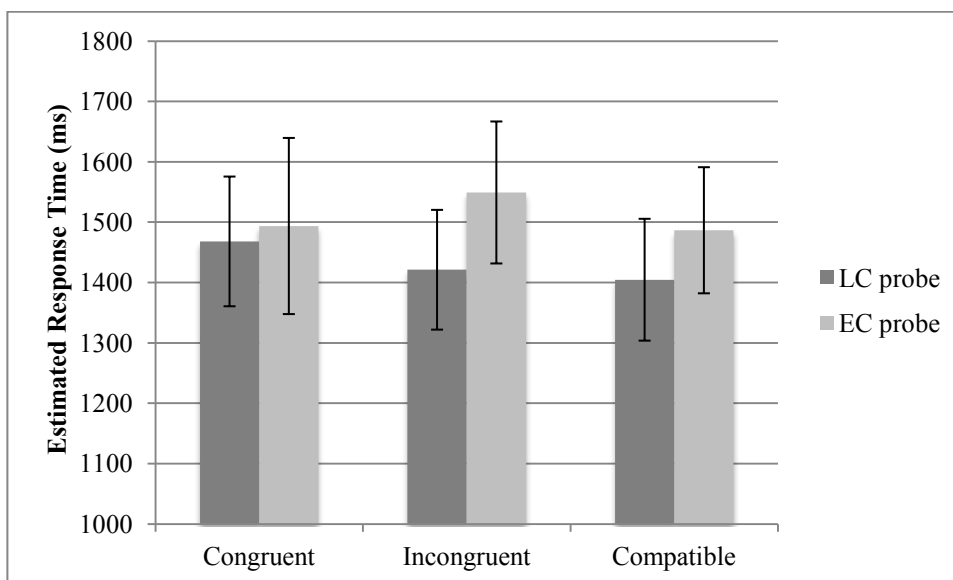


Figure 7-6 Experiment 3B: Estimated mean response time for ‘no’ responses, with standard errors.

The RTs for the ‘no’ data in Experiment 3B did not show any reliable effect. There was not any reliable difference for the LC or EC probe when the probe was congruent with the prosody of the sentence ($\beta = -25.4$, $SE = 123.7$, $z = -.21$, $p = .83$). Although the participants were slightly faster in rejecting the LC probe for incongruent and compatible probe conditions, these differences did not reach statistical significance ($\beta = -122.86$, $SE = 77.16$, $z = -1.56$, $p = .11$ for the incongruent probe and $\beta = -81.95$, $SE = 100.94$, $z = -.81$, $p = .41$ for the compatible probe). The longer RTs and wider range of RTs for ‘no’ responses could be attributed to “additional nonlinguistic checking processes” that a negative response would trigger (Kjelgaard & Speer, 1999). Thus, RTs for ‘yes’ responses may be more reliable than RTs for ‘no’ responses.

As for the acceptance data, both the raw percentages (though influenced by active bias) and the predicted probabilities (odds ratios) were in the predicted direction. Procedures of active bias control as described above were also applied to acceptance data too. Please see Appendix D.12 for raw percentages of ‘yes’ responses for experimental and control fillers. As in Experiment 3A, the acceptance data pattern was as predicted. The probability of responding ‘yes’ was the highest for the prosody-congruent condition, followed by the prosody-compatible condition, and even lower for the prosody-incongruent condition (odds ratios for prosody-congruent vs. prosody-compatible: $\beta = 1.92$, $SE = 1.19$, $z = 3.56$, $p < .001$; prosody-incongruent vs. prosody-compatible: $\beta = .39$, $SE = 1.2$, $z = -.51$, $p < .001$). The differences between the LC and EC conditions observed in the RT data are not reflected in the ‘yes/no’ response data; thus it appears that the judgment data are less sensitive than the RTs. Figure 7-7 below shows the estimated probability of responding ‘yes’ to the probe word.

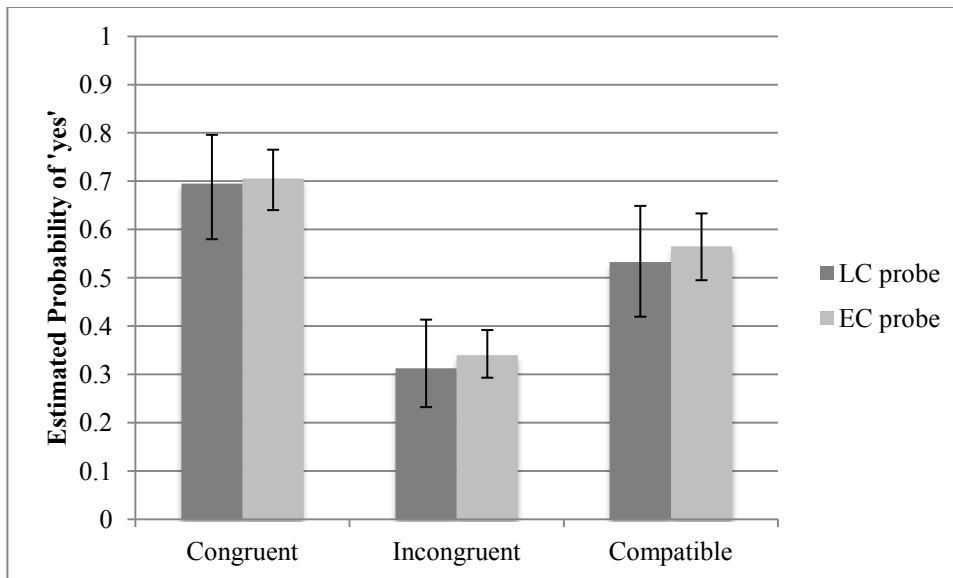


Figure 7-7 Experiment 3B: Estimated probability of ‘yes’ responses with standard errors.

The judgment data further confirm that the participants were sensitive to the prosody of the sentence they had just heard, while making their decision on the visual probe. Similar to Experiment 3A, there was no reliable difference other than congruency in the detailed comparisons of conditions (z 's < .2).

7.2.4. Discussion

As in Experiment 3A, the ‘yes/no’ data in Experiment 3B suggest that listeners are sensitive to the prosodic contour of the sentence in restoring the phonemes that are missing. This is reflected in their ‘yes’ responses to the visual probe, where they were the most likely to accept the visual probe when it was congruent with the prosody of the sentence they had listened to and presumably the syntactic analysis they had computed on the basis of the prosody. This suggests that they restored the phoneme that would match to the prosodic contour of the sentence, which contributed to the high rates of ‘yes’ responses to congruent probes, followed by lower rates of

‘yes’ responses to probes that were compatible with the analysis they computed in absence of any prosodic cue and the lowest rates of ‘yes’ responses to incongruent probes.

Table 7-5 (repeating Table 7-4) shows the pattern of results for response times observed for the visual probes in Experiments 3A and 3B:

Table 7-5 Data pattern for response times for visual probes in Experiment 3A and 3B.

	Prosody-congruent	Prosody-incongruent	Prosody-neutral
Experiment 3A	LC = EC	LC > EC	LC < EC
Experiment 3B	LC = EC	LC < EC	LC < EC

In Experiment 3A, when the visual probe was congruent with the prosody of the sentence, there wasn’t any reliable difference in the processing time of the LC and EC probes. When the visual probe was incongruent with the prosody of the sentence, the EC probe, unexpectedly, was recognized faster. When prosody was neutral, the LC probe was recognized faster. In Experiment 3B, when the visual probe and the prosody of the sentence were congruent, there was no reliable difference between LC and EC probe recognition. In the prosody incongruent condition and the prosody neutral condition the LC probe response time was faster. For comparison, Table 7-6 shows the data pattern observed for Experiments 2A and 2B.

Table 7-6 Data pattern for response times in Experiment 2A and 2B.

	Cooperating prosody	Conflicting prosody	Neutral prosody
Experiment 2A	LC < EC	LC < EC	LC = EC
Experiment 2B	LC = EC	LC = EC	LC < EC

Results of Experiment 2A and 2B had shown effects of a syntactic Late Closure strategy, and also a constituent length effects as predicted by ERSK. There was a syntactic LC advantage only when the LC syntax sentences were also favored by ERSK (informative 4+2 cooperating prosody and uninformative 3+3 conflicting prosody in Experiment 2A). When constituent lengths favored EC syntax sentences (2+4 cooperating prosody and 3+3 conflicting prosody in Experiment 2B), there was no reliable difference between the processing times of LC and EC structures suggesting that the two influences had cancelled each other out. Given the observations for cooperating and conflicting prosody conditions, it was concluded that when prosody is absent (neutral prosody condition), listeners mentally project prosodic boundaries, and in doing so they have a bias towards balanced length constituents as well as LC syntactic structure. This is in line with Fodor's Implicit Prosody Hypothesis (2002) for silent reading, and with Pauker et al.'s Boundary Deletion Hypothesis (2011), which presupposes that readers and listeners tend to mentally insert a prosodic boundary which is missing from the stimulus.

Unlike Experiment 2A and 2B, in Experiment 3A and 3B there was no evidence of a phrase length effect. While this difference between the two methodologies had not been anticipated in designing the experiments, it has a very natural explanation. In the 'got it' task, disambiguating morphology is within the sentence stimulus and it can create a conflict with the prosody, which needs to be reconciled. In deciding which factor should prevail, the parser would benefit from guidance from ERSK with respect to how seriously to take the prosodic contour; thus phrase lengths would be relevant to task performance. In the phoneme restoration paradigm, by contrast, prosody is taken to be informative about the sentence structure without contradiction by another influence. In overt (non-neutral) prosody conditions in Experiments 3A and 3B, unlike Experiments 2A and 2B, there is no potential linguistic anomaly in the sentence. So, confidence

in the computed structure is strong in both LC and EC prosody. For the congruent probe, since there is no morpho-syntactic disambiguation in the sentence, there is no need to rely on ERSH to decide how seriously to take the prosody compared with morpho-syntax. In the compatible probe condition, there is no prosodic boundary to bias the assignment of the syntactic structure. It would be expected that the parser favors Late Closure, projecting LC prosody and restoring LC-compatible phonemes more often than for EC. In fact, the LC advantage that emerged in the RT data was not evident in the ‘yes’ judgments, possibly because the judgment data are less sensitive. In the incompatible probe condition, there is still no conflict within the sentence but as noted above, the probe may prompt consideration of the alternative analysis. So, the probe word may sometimes be taken as indicating the correct syntactic analysis. Due to syntactic LC bias, when an LC probe clashes with an initial EC analysis, the probe would be a stronger force for reanalysis than when an EC probe clashes with an initial LC analysis. The faster recognition of the EC probe in Experiment 3A is not thus explained but can be attributed, as discussed above, to the noise-replaced phonemes appearing too soon after the LC prosodic boundary, which would give too little time for the listener to confidently project LC-compatible phonemes. So, there would be less conflict with the incompatible EC probe.

The next and final chapter presents a summary of the observations in all the experiments in the current study and proposes a number of ways in which this research project could be moved forward in subsequent studies.

CHAPTER 8. SUMMARY OF THE FINDINGS AND FUTURE DIRECTIONS

8.1. Summary of the Findings

The previous chapters have presented and discussed in detail a considerable amount of data from five experiments with three different methodologies. Some of the many findings were as predicted, and some were not. So in concluding this work, I would like to emphasize that all of the results are mutually compatible, and that even those which were not anticipated at the outset have found natural explanations in retrospect.

The central issue was whether constituent lengths play a role in ambiguity resolution in reading and listening via their influence on the interpretation of prosody. A secondary question was whether and how constituent length effects interact with previously documented syntactically-based parsing biases, particularly the Late Closure principle. In the absence of such data, it is imaginable that a locality constraint like Late Closure could be shown to be not syntactic in origin after all, but to be merely a reflection of prosodic phrasing influences on attachment choices in ambiguity resolution. For relative clause attachment, this is not out of the question (Fodor, 1998). Study of a wider variety of Late/Early Closure ambiguities is needed in order to settle this matter. The important work by SKS on a different Late/Early Closure ambiguity in English (*When Roger leaves the house it's/is dark*) did not entirely resolve the issue. To do so, it is necessary to *manipulate* the factors that feed into prosodic phrasing - such as phrase lengths - to determine whether and how they modulate ambiguity resolution choices.

In the research reported here, potential phrase length effects were studied in Turkish with two types of ambiguities. One ambiguity, namely the Genitive Possessive ambiguity, appeared to be a good structure to test the hypotheses and predictions. The other ambiguity, namely the NP Compound ambiguity, seemed to be contaminated by a confounding factor in the conflicting

prosody condition in listening and was not examined in the last two experiments. Thus, in this chapter, the summary of findings will be restricted to the observations made for the Genitive Possessive ambiguity.

The reading experiment (Experiment 1) employed a missing morpheme task. The specific research questions that were asked concerned whether a syntactic parsing strategy such as Late Closure, and/or constituent lengths, played a role in resolving this syntactic ambiguity in Turkish. Results indicated that constituent lengths had a significant effect on ambiguity resolution but there was no reliable effect of a syntactic LC strategy. By contrast, in the listening experiments, as was reported in Chapters 6 and 7 and will be discussed below, there was an overall LC syntax advantage. It is not straightforward why there was no LC effect in the reading experiment. Two explanations are suggested for this and both are related to the methodology being a ‘production’ rather than a ‘perception’ task.

In the reading experiment, participants were presented with sentences whose disambiguating morphology was replaced with underscores. Participants’ task was to insert the missing morphemes while reading the sentences aloud. Their insertion of an LC-compatible or EC-compatible morpheme would be taken as a measure of which syntactic analysis they had computed for the sentence. Since the LC structure required insertion of passive morphology, it could be the case that its access was more difficult than for the active verb morphology for the EC structure. Control filler sentences which unambiguously required active or passive morphology were added to the design to check for such a bias toward insertion of an active verb. The fact that participants inserted an active morphology for some proportion of control fillers which would unambiguously require insertion of a passive verb (but not vice versa) makes it a likely explanation for the absence of any apparent LC advantage. Thus, although there was an

effect of constituent lengths, any potential advantage for LC syntax may have been offset by a bias for active morphology, favoring the EC structure. This explanation implies a high proportion of cases in which LC prosody earlier in the sentence was associated with EC responses in supplying the missing morphemes in the verb. However, informal prosody analyses suggested that the prosodic boundaries matched with the morphemes that the participants provided (a high positive correlation), which may suggest that even before reaching the region of the missing morpheme participants had decided on their syntactic analysis of the structure based on the lengths of the preceding constituents. Nevertheless, there were cases where participants started with LC prosody and then read the sentence aloud *again* with EC prosody at the missing morpheme region and provided an EC morpheme. Since it was the final prosodic structure of the utterance that was taken into consideration in deciding whether the sentence was uttered with LC or EC prosody, it is indeed possible that the absence of an LC advantage in the production task is attributable to the greater ease of providing an EC (i.e., active) verb.

An alternative explanation concerns mechanisms for working memory in language production and perception. Just and Carpenter (1992) report that language production may rely on mechanisms different from language perception. It is possible that in production, the load for working memory is increased when compared to perception, due to additional processes such as phonological encoding. So, in production, upon processing 3 PWds, the readers may have opted for a phonological boundary due to memory limits, resulting in what appears to be an overall preference for balanced constituents. It would be of interest to examine the same LC/EC ambiguity with shorter sentences allowing for 2+2 balanced or 3+1 or 1+3 unbalanced lengths. Then, it may be evident whether or not the 3+3 phrasing in Experiment 1 of this study was merely due to a preference for balanced lengths independent of the LC strategy or whether the

LC strategy in this experiment may have been overridden by limited working memory in production, resulting in a preference for shorter phrases in production than in perception.

The listening experiments, namely the ‘got it’ experiments (Experiments 2A and 2B) and ‘phoneme restoration’ experiments (Experiments 3A and 3B) investigated whether or not the parser resorts to a default syntactic parsing strategy, i.e., Late Closure, when prosodic information is misleading as well as when it is uninformative, and/or whether constituent lengths influence parsing decisions via the perceived informativeness of prosodic cues (as per ERSH). The ERSH, extending the earlier Rational Speaker Hypothesis by Clifton et al. (2006), maintains that listeners are sensitive to the speaker’s reasons for producing a prosodic phenomenon. If it could be due either to syntactic alignment or to eurythmic pressures, the possibility of the latter reduces the probability that the listener will treat it as a consequence of the syntax. Thus, a prosodic break which yields unbalanced phrase lengths is taken to be more informative about the syntactic structure of the utterance than a prosodic break that yields balanced phrase lengths because the former cannot be justified by rhythmic pressures. Two pairs of listening experiments, Experiments 2A and 2B and Experiments 3A and 3B tested the ERSH relative to a Late Closure strategy. Constituent lengths were systematically manipulated in all target materials across the twinned experiments, such that the length-optimal prosodic phrasing was associated with LC in one condition, and with EC in the other.

Experiments 2A and 2B, employing a ‘got it’ task, implicated a role for both constituent lengths and syntactic LC strategy in processing sentences with overt prosodic cues. These experiments further showed that even when there is no overt prosodic disambiguation (i.e., no prosodic boundaries, in the neutral prosody condition), constituent lengths could influence parsing decisions. In such cases, there was an advantage for LC syntax only when the LC

structure favored uniform (i.e., balanced) lengths. This observation would suggest that listeners mentally project prosodic boundaries when they are absent (Pauker, et al., 2011) and that such decisions are influenced by a preference for balanced phrase lengths (Sandaló & Truckenbrodt, 2002) as well as LC syntax.

Experiments 3A and 3B, employing a ‘phoneme restoration paradigm’, confirmed that listeners are highly sensitive to the prosody of the sentence when restoring noise-replaced phonemes, as shown by their acceptance or rejection of a visual probe word congruent or incongruent with the sentential prosody. Unlike Experiments 2A and 2B, Experiments 3A and 3B did not show effects of constituent lengths in recognition of the probe word. This can be attributed to the nature of the phoneme restoration task. In restoring the noise-replaced phonemes, the parser can be expected to rely on the prosody of the sentence (Stoyneshka, et al., 2010) since there is no other source of information in the sentence which conflicts with the structure that the prosody favors. Response time data suggest that when the following probe word is congruent with the prosody-based morpho-syntactic restoration of the verb in the sentence based on on prosodic cues, the parser simply confirms its analysis with respect to the probe word, and constituent lengths would have little or no role to play.

The results of Experiments 3A and 3B further indicate that when there is no overt prosody, the parser is influenced by the LC strategy to resolve the ambiguity, replicating the previous findings for neutral prosody in the literature (e.g., Kjelgaard & Speer, 1999).

When the probe word conflicts with the analysis based on the prosody of the sentence (and therefore with the restored phoneme), Experiment 3B results suggest that the parser sometimes takes the probe word as offering an alternative analysis, and undertakes syntactic reanalysis in order to make the sentence and the probe word compatible. In this case, it is easier for the parser

to revise an EC structure (informed by the EC prosody) to an LC structure, than to revise an LC structure (informed by LC prosody) to an EC structure due to the Late Closure strategy. This was clearly not the case in Experiment 3A, since there were faster responses to the EC probe in the conflicting probe condition of Experiment 3A. As noted, this might be due to the LC prosodic boundary being detected late, shortly before the phoneme replaced verb, leaving little time for the parser to establish its initial analysis before a conflicting probe word appears.

Comparing the results of the four listening experiments, it can be concluded that ERSB applies most clearly when disambiguating morpho-syntax is present in the sentence, because then the parser needs to know how reliable the prosody is as an indicator of syntactic structure. According to the ERSB, that valuable information is derived from the lengths of prosodic phrases.

It might be questioned, then, why there was a clear effect of constituent lengths in the first experiment, i.e., the ‘missing morpheme’ experiment, in which the morpho-syntactic information was also missing. In the missing morpheme experiment, the readers do not hear the prosody that they might evaluate based on length information. They themselves produce the prosody based on optimal prosodic phrase lengths. Thus, in reading, the constituent lengths are used for projecting prosodic breaks which influence syntactic parsing decisions and therefore the morphology computed by the listeners. This is in line with previous studies which report on the interaction of constituent lengths, prosodic breaks and syntactic parsing decisions (e.g., Webman Shafran, 2011).

The research outcomes in this dissertation study shed some light on the previous findings in the psycholinguistics literature. Results suggest that constituent lengths play an important role in syntactic ambiguity resolution in both reading and listening and should be carefully controlled in

the experimental designs of psycholinguistic studies. The experiments in this study also added confirmation of the reliability of the phoneme restoration paradigm in a language other than the original Bulgarian. Responses and response times to the visual probe indicate that listeners are sensitive to sentential prosody in their restoration of missing phonemes that distinguish the syntactic structure for the utterance.

8.2. Future Directions

The three methodologies employed here complement each other in several ways, but useful contributions could be made by other methods in some follow up studies. The first experiment, a read-aloud production task, showed effects of constituent lengths as predicted; however no evidence of syntactic Late Closure strategy in addition to a preference for balanced lengths was observed in this experiment. This is attributable to the task, in interaction with particular LC/EC sentences tested here. In a production task such as reading aloud with missing morphemes to be supplied by the reader, participants may have found it easier to access and insert active morphology, which would result in an EC disambiguation of the ambiguous string, as opposed to insertion of passive morphology which would result in LC disambiguation. This bias for active morphology may have offset an LC preference. A reading study with eye-tracking is desirable in order to test whether such a disadvantage for the passive construction can be overcome in a perception task where participants would be provided with active and passive morphology; the participants would simply read sentences without having to supply any morphemes. An eye-tracking method is preferable to a more traditional self-paced reading task, so as not to disrupt any potential reader-projected prosody. It is predicted that in a reading study with eye-tracking method, an effect of syntactic LC strategy might be observed in addition to a preference for balanced lengths.

The two ‘got it’ experiments showed effects of constituent lengths confirming predictions of ERSH in listeners’ interpretation of overt prosodic cues as well as syntactic Late Closure strategy. Since the ‘got it’ methodology taps end-of-sentence comprehension, based on the results elicited in these experiments it cannot be established when each effect occurred as the sentence processing unfolded. Based on previous research (such as cross-modal naming and ERP studies reviewed in Chapter 2), it is evident that the parser uses prosodic information immediately. Thus, it is likely that at the disambiguating morpho-syntactic information, the parser confirms (in the case of cooperating prosody) or re-analyzes (in the case of conflicting prosody) its initial analysis which was based on the prosodic cues available earlier in the sentence. The constituent lengths could contribute to the parser’s confidence in its analysis or reanalysis at the end of the sentence. In the case of an informative cooperating prosodic cue (unbalanced phrase lengths) the parser would be more confident in its syntactic analysis confirmed by the morpho-syntactic disambiguating information. In the conflicting prosody condition, the parser would be more confident in its re-analysis when the conflicting prosodic cue was less informative (balanced phrase lengths) as opposed to a more informative prosodic cue (unbalanced phrase lengths). An ERP experiment, where neural responses are time-locked to the stimulus, can be used to test if this is indeed the case. CPS effects at boundary locations (Steinhauer, et al., 1999) and re-analysis effects (N400 or P600) at morpho-syntactic disambiguation in the case of conflicting prosody could confirm that re-analysis is initiated immediately at the morpho-syntactic disambiguation. The amplitude of such re-analysis effects for LC vs. EC syntax revision could inform whether or not listeners find revising from EC to LC syntax easier than revising from LC to EC syntax. End-of-sentence acceptability judgment or comprehension times might be attributable to length effects.

It would be desirable to confirm the observations and interpretation of Experiments 3A and 3B by means of a simple two-word probe choice task as employed by Stoyneshka et al. (2010) (as opposed to the single probe task used in this dissertation). In such a task, without the complication of conflict between prosody and probe, participants' selection of the probe word would reveal what syntactic analysis they had computed for the sentence and whether or how that was influenced by length manipulations.

Finally, any or all of the experiments presented here could be conducted in the future with longer sentences crafted to make it possible to distinguish whether the crucial factor in Turkish prosodic phrasing is absolute phrase lengths or balanced phrase lengths (or both).

APPENDICES

Appendix A: Normative Study Survey

A.1 – Normative Study List 1

ANKET

Değerli katılımcı,

Bu ankette size geçici muğlaklık dediğimiz, birden fazla anlam taşıyabilen cümle başlangıçları sunulacaktır. Cümle başlangıcının hemen altında bir ölçek göreceksiniz. Ölçeğin sağ ve sol tarafında o cümleyi devam ettirebilecek bir fiil veya fiil grubu sunulmuştur. Bu fiil veya fiil grupları geçici muğlaklığın bir anlamını temsil etmektedir. Sizden beklenen, ölçeğin her bir tarafındaki fiilin veya fiil grubunun muğlaklığı devam ettirme ihtimalini, ölçeğin uygun kutucuğuna koyacağınız 'X' işaretiyle belirtmeniz. Koyacağınız işaret hangi tarafa daha yakın olursa, bu, o taraftaki fiil/fiil grubunun temsil ettiği anlamın daha muhtemel olduğunu gösterecektir. Örneğin, en sağ veya en soldaki kutucuğu işaretlerseniz, bu, cümle başının muğlak olmadığını, sadece ölçeğin sağında veya solundaki yapının temsil ettiği anlamı taşıdığını gösterir. Ölçeğin ortasına koyacağınız işaret, cümle başının muğlak olduğunu ve ölçeğin her iki tarafındaki yapının da cümleyi eşit şekilde tamamlayabileceğini gösterecektir. Aşağıda, anketi cevaplandırmaya başlamadan önce incelemeniz için üç adet örnek sunulmuştur.

Katılımınız için çok teşekkürler!

ÖRNEKLER

Örnek 1

Sessiz duruşlu çocuğun annesi						
susturdular.						X
geç kalmış.						

Bu örnekte, cümle başlangıcı muğlak değildir ve sadece sağ tarafta verilen fiil ile devam ettirilebilir.

Sol taraftaki fiilin cümleyi devam ettirmesi anlamsal ve yapısal olarak uygun değildir.

Örnek 2

Geciken mektubun alıcısı merakla						
bekliyor.	X					
sunulmuşlar.						

Bu örnekte, cümle başlangıcı yine muğlak değildir ve anlamsal ve yapısal olarak sadece sol tarafta bulunan yapıyla devam ettirilmesi uygundur.

Aşağıdaki örnekte geçici muğlaklık içeren bir cümle başlangıcı vardır:

'konuşkan kasabın müşterileri' söz öbeği hep beraber bir cümlenin öznesi olarak kullanılabilir, ve sağ tarafta belirtilen etken olmayan 'eğleniyor diyorlar' fiil grubuyla devam ettirilebilir.

Aynı söz öbeğinde 'konuşkan kasap' özne, 'müşterileri' de nesne görevini üstlenebilirler.

Bu durumda, cümle etken bir fiil/fiil grubuyla devam ettirilebilir, sol tarafta gösterilen 'eğlendirdiğini söylüyorlar' fiil grubu gibi.

Örnek 3a

	Konuşkan kasabın müşterileri						
eğlendirdiğini söylüyorlar.				X			eğleniyor diyorlar.

X' işaretini yukarıdaki gibi ölçeğin ortasına koyarsanız, bu, her iki taraftaki fiil grubunun da cümleyi eşit derecede devam ettirebileceğini gösterir.

Örnek 3b

	Konuşkan kasabın müşterileri						
eğlendirdiğini söylüyorlar.		X					eğleniyor diyorlar.

Eğer işaret yukarıdaki gibi sol tarafa daha yakın olursa, bu, 'konuşkan kasabın müşterileri' söz öbeğinin özne olarak kullanılma ihtimalinin çok daha düşük olduğunu, bu yüzden cümlenin çok düşük bir ihtimalle sağ taraftaki fiil grubuyla devam ettirilebileceğini gösterir.

Örnek 3c

	Konuşkan kasabın müşterileri						
eğlendirdiğini söylüyorlar.					X		eğleniyor diyorlar.

Eğer işaret yukarıdaki gibi sağa daha yakın olursa, sağ taraftaki fiil grubunun cümleyi devam ettirme ihtimali sol taraftakinden fazladır.

ANKET CÜMLELERİ

- 1 Yeni işe başlayan kadının patronu
sevdiğini söylüyorlar.

 sevildi diyorlar.
- 2 Oldukça yetenekli grubun solisti
atıldı dediler.

 attığını duydum.
- 3 Sessiz duruşlu koruma polisi
vurulmuş.

 vurmuş.
- 4 İki jandarma müfettişi subay yardımcısı
zannetti.

 zannedildi.
- 5 Toplam iki pilot adayı subay
sanmıştı.

 sanıldı.
- 6 Toplam dokuz gazetecinin faili
bulundu sanmıştım.

 bulduğunu sanmıştım.
- 7 Üçüncü ekip personeli oldukça tecrübeli
sanıldı.

 sanmıştı.
- 8 Birinci aile danışmanı yeni müdür
zannedildi.

 zannetti.
- 9 Baştan birinci müfettiş heyeti acemi
bulmuştu.

 bulundu.
- 10 İkinci marangoz çırağı yeni kalfa
zannedildi.

 zannetti.

- 11 sevildi sanmışlar. İkinci işçinin çocuğu çok sevdiğini sanmışlar.
- 12 dövüldü zannettik. Oldukça kalabalık cemaatin imamı dövdüğünü zannettik.
- 13 sanıldı. İkinci jandarma subayı yeni asker sanmıştı.
- 14 bulmuştu. Üçüncü kedi sahibi oldukça sevimli bulundu.
- 15 dövüldü sanıyoruz. İkinci askerin esiri gece dövdüğünü sanıyoruz.
- 16 zannedilmiş. Sekiz Bulgar ajanı koruma görevlisi zannetmiş.
- 17 zannetti. Yaklaşık altı futbolcu hakemi oyuncu zannedildi.
- 18 azarlandı sandım. Dokuz adamın ekibi sabah azarladığını sandım.
- 19 kovduğunu sanıyorlar. Birinci ustanın çırağı dün kovuldu sanıyorlar.
- 20 sevildi zannettik. Oldukça eski komşunun çocuğu sevdiğini zannettik.

21	yakaladığını sanmışım.	Uzun elbiseli kadının köpeği							yakalandı sanmışım.
22	bulmuştu.	Birinci doktor heyeti biraz inatçı							bulundu.
23	yorduğunu sandım.	Yaklaşık otuz çocuğun danışmanı							yoruldu sandım.
24	öldürüldü zannettik.	Yedi sanığın mağduru gece							öldürdüğünü zannettik.
25	bulmuştu.	Sondan ikinci polis amiri yeteneksiz							bulundu.
26	kapattığını sanıyorum.	Beşinci padişahın haremi artık							kapatıldı sanıyorum.
27	zannedildi.	Sondan ikinci menajer adayı oyuncu							zannetti.
28	zannedildi.	İki avukat kızını eski sekreter							zannetti.
29	vurduğunu sanıyorlar.	Kısa etekli kızın damadı							vuruldu sanıyorlar.
30	dövdüğünü zannettik.	Birinci kalecinin rakibi sabah							dövüldü zannettik.

- 31 On sekizinci liderin pilotu
kovduğunu zannettim.

 kovuldu zannettim.
- 32 Toplam iki şirket ortağı yönetici
zannetmiş.

 zannedilmiş.
- 33 Dokuz mülteci grubu kaçak işçi
sanmıştı.

 sanıldı.
- 34 Yaklaşık dokuz polis saldırı tutuklu
zannedildi.

 zannetti.
- 35 Oldukça kalabalık ailenin köpeği
unutuldu sandım.

 unuttuğunu sandım.
- 36 İkinci bayan kuaförü eski stajyer
zannetti.

 zannedildi.
- 37 Oldukça kalabalık aşiretin lideri
vuruldu sanmışlar.

 vurduğunu sanmışlar.
- 38 Yaklaşık dokuz çiftçi çocuğu kalfa
zannetti.

 zannedildi.
- 39 Soldan birinci avukatın müvekkili
bıçakladığını sanıyorlar.

 bıçaklandı sanıyorlar.
- 40 Yedi asker düşmanı çok tehlikeli
bulmuştu.

 bulundu.

41	İki kapıcı çocuğu yeni koruma							zannetmiş.	zannedilmiş.
42	Birinci doktorun ortağı biraz							eleştirildi zannettik.	eleştirdiğini zannettik.
43	Dördüncü yazarın editörü yine							üzdüğünü sandılar.	üzüldü sandılar.
44	Birinci yönetici sekreteri temizlik işçisi							zannetti.	zannedildi.
45	Toplam iki çoban kızı hizmetçi							zannedildi.	zannetti.
46	Toplam iki katil uzmanı polis							zannedilmiş.	zannetmiş.
47	Yedi öğrencinin psikoloğu çok							sevdiğini sanıyoruz.	sevildi sanıyoruz.
48	Öndeki kadının bebeği biraz							hırpalandı zannettim.	hırpaladığını zannettim.
49	Yaklaşık altı Arnavut kadını mülteci							zannetti.	zannedildi.
50	İki takımın forveti oldukça							beğendiğini sanıyorum.	beğenildi sanıyorum.

51

Toplam sekiz avukat doktoru personel

zannedildi.

zannetti.

52

Siyah sakallı çiftçinin kızı

evlendirildi
sanıyorum.

evlendirdiğini
sanıyorum.

53

Oldukça minik bebeğin doktoru

üzdüğünü
sanıyorum.

üzüldü
sanıyorum.

54

Yaklaşık otuz milletin düşmanı

yendiğini
sandım.

yenildi
sandım.

55

Soldan üçüncü subayın askeri

azarlandı
sandım.

azarladığını
sandım.

56

Yedi polisin adamı gece

sorguladığını
sanıyoruz.

sorgulandı
sanıyoruz.

57

Dört polis çocuğu sabah sokakta

bulmuştu.

bulundu.

58

Yaklaşık yedi saldırganın doktoru

yaralandı
sanıyorlar.

yaraladığını
sanıyorlar.

59

Baştan ikinci başkan takımı başarısız

zannetti.

zannedildi.

60

Dördüncü aile hekimi çok tecrübeli

bulmuştu.

bulundu.

61	Baştan birinci mühendis ekibi başarılı							bulundu.	bulmuştu.
62	Kalabalık mafyanın avukatı gece							bıçakladığını zannettik.	bıçaklandı zannettik.
63	Sondan yedinci delege grubu karamsar							bulundu.	bulmuştu.
64	Toplam dokuz mafya elemanı ajan							sanmıştı.	sanıldı.
65	Üçüncü müdürün personeli sabah							azarladığını zannettim.	azarlandı zannettim.
66	Yirmi ikinci şubenin müdürü							sorguladığını zannettik.	sorgulandı zannettik.
67	Yedi hastanın hekimi sabah							kovuldu zannettik.	kovduğunu zannettik.
68	Yaklaşık yedi şirketin danışmanı							bekletildi zannettim.	beklettiğini zannettim.
69	Yirmi ikinci ordunun düşmanı							vurduğunu zannettik.	vuruldu zannettik.
70	Otuz personelin amiri oldukça							eleştirdiğini sanıyorlar.	eleştirildi sanıyorlar.

71	zannedildi.	Yaklaşık altı gözlemci grubu işçi							zannetti.
72	sorgulandı sanıyorum.	Üçüncü savcının sanığı sabah							sorguladığını sanıyorum.
73	yorduğunu sanıyoruz.	Baştan üçüncü bakanın sekreteri							yoruldu sanıyoruz.
74	sanıldı.	Yaklaşık otuz dağcı grubu asker							sanmıştı.
75	eleştirildi sandım.	Altı kızın avukatı biraz							eleştirdiğini sandım.
76	zannetti.	Yaklaşık yedi oğlan çocuğu çırak							zannedildi.
77	zannedildi.	Yedi doktor çocuğu yeni öğrenci							zannetti.
78	zannedilmiş.	İki köylü kadını koyun çobanı							zannetmiş.
79	sanıldı.	Yedi Amerikan casusu yeni mühendis							sanmıştı.
80	zannedilmiş.	Yaklaşık sekiz Fransız subayı ajan							zannetmiş.

81

Sekiz Alman turisti tur rehberi

zannedildi.

zannetti.

82

İkinci damadın şahidi işten

kovuldu
biliyorum.

kovduğunu
biliyorum.

83

Sağdan birinci yönetmenin kızı

kaçırıldı
sanıyorlar.

kaçırdığını
sanıyorlar.

84

Sorunlu okul öğrencileri dersten

soğutmuş.

soğumuş.

85

Onların kedileri çok

sevimli
diyorlar.

sevdiğini
bilmiyordum.

ANKET

Değerli katılımcı,

Bu ankette size geçici muğlaklık dediğimiz, birden fazla anlam taşıyabilen cümle başlangıçları sunulacaktır. Cümle başlangıcının hemen altında bir ölçek göreceksiniz. Ölçeğin sağ ve sol tarafında o cümleyi devam ettirebilecek bir fiil veya fiil grubu sunulmuştur. Bu fiil veya fiil grupları geçici muğlaklığın bir anlamını temsil etmektedir. Sizden beklenen, ölçeğin her bir tarafındaki fiilin veya fiil grubunun muğlaklığı devam ettirme ihtimalini, ölçeğin uygun kutucuğuna koyacağınız 'X' işaretiyle belirtmeniz. Koyacağınız işaret hangi tarafa daha yakın olursa, bu, o taraftaki fiil/fiil grubunun temsil ettiği anlamın daha muhtemel olduğunu gösterecektir. Örneğin, en sağ veya en soldaki kutucuğu işaretlerseniz, bu, cümle başının muğlak olmadığını, sadece ölçeğin sağında veya solundaki yapının temsil ettiği anlamı taşıdığını gösterir. Ölçeğin ortasına koyacağınız işaret, cümle başının muğlak olduğunu ve ölçeğin her iki tarafındaki yapının da cümleyi eşit şekilde tamamlayabileceğini gösterecektir. Aşağıda, anketi cevaplandırmaya başlamadan önce incelemeniz için üç adet örnek sunulmuştur.

Katılımınız için çok teşekkürler!

ÖRNEKLER

Örnek 1

		Sessiz duruşlu çocuğun annesi							
susturdular.							X		geç kalmış.

Bu örnekte, cümle başlangıcı muğlak değildir ve sadece sağ tarafta verilen fiil ile devam ettirilebilir.

Sol taraftaki fiilin cümleyi devam ettirmesi anlamsal ve yapısal olarak uygun değildir.

Örnek 2

		Geciken mektubun alıcısı merakla							
bekliyor.	X								sunulmuşlar.

Bu örnekte, cümle başlangıcı yine muğlak değildir ve anlamsal ve yapısal olarak sadece sol tarafta bulunan yapıyla devam ettirilmesi uygundur.

Aşağıdaki örnekte geçici muğlaklık içeren bir cümle başlangıcı vardır:
'konuşkan kasabın müşterileri' söz öbeği hep beraber bir cümlenin öznesi olarak kullanılabilir,
ve sağ tarafta belirtilen etken olmayan 'eğleniyor diyorlar' fiil grubuyla devam ettirilebilir.
Aynı söz öbeğinde 'konuşkan kasap' özne, 'müşterileri' de nesne görevini üstlenebilirler.
Bu durumda, cümle etken bir fiil/fiil grubuyla devam ettirilebilir,
sol tarafta gösterilen 'eğlendirdiğini söylüyorlar' fiil grubu gibi.

Örnek 3a

	Konuşkan kasabın müşterileri						
eğlendirdiğini söylüyorlar.				X			eğleniyor diyorlar.

X' işaretini yukarıdaki gibi ölçeğin ortasına koyarsanız, bu, her iki taraftaki fiil grubunun da cümleyi eşit derecede devam ettirebileceğini gösterir.

Örnek 3b

	Konuşkan kasabın müşterileri						
eğlendirdiğini söylüyorlar.		X					eğleniyor diyorlar.

Eğer işaret yukarıdaki gibi sol tarafa daha yakın olursa, bu, 'konuşkan kasabın müşterileri' söz öbeğinin özne olarak kullanılma ihtimalinin çok daha düşük olduğunu, bu yüzden cümlenin çok düşük bir ihtimalle sağ taraftaki fiil grubuyla devam ettirilebileceğini gösterir.

Örnek 3c

	Konuşkan kasabın müşterileri						
eğlendirdiğini söylüyorlar.				X			eğleniyor diyorlar.

Eğer işaret yukarıdaki gibi sağa daha yakın olursa, sağ taraftaki fiil grubunun cümleyi devam ettirme ihtimali sol taraftakinden fazladır.

Ben anket cümlelerini hazırlarken mümkün oldukça her iki anlama da eşit şekilde ağırlık vermeye çalıştım.
Bu yüzden sizin vereceğiniz puanlara göre eşit ölçüde muğlak olan cümleleri seçeceğim.
Anket cümlelerinde ölçeğin en uç taraflarını kullanmazsanız şaşırmayın, çünkü cümle başlarını mümkün olduğu kadar eşit derecede muğlak yapmaya çalıştım.

ANKET CÜMLELERİ

- 1 Yeni işe başlayan kadının patronu
sevdiğini söylüyorlar.

 sevildi diyorlar.
- 2 Oldukça yetenekli grubun solisti
atıldı dediler.

 attığını duydum.
- 3 Sessiz duruşlu koruma polisi
vurulmuş.

 vurmuş.
- 4 Toplam iki jandarma müfettişi subay
zannetti.

 zannedildi.
- 5 İki pilot adayı eski subay
sanmıştı.

 sanıldı.
- 6 Dokuz gazetecinin faili suçlu
bulundu sanmıştım.

 bulduğunu sanmıştım.
- 7 Sağdan üçüncü ekip personeli tecrübeli
sanıldı.

 sanmıştı.
- 8 Sondan birinci aile danışmanı müdür
zannedildi.

 zannetti.
- 9 Birinci müfettiş heyeti biraz acemi
bulmuştu.

 bulundu.
- 10 Baştan ikinci marangoz çırağı kalfa
zannedildi.

 zannetti.

11	sevildi sanmışlar.	Sağdan ikinci işçinin çocuğu	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								sevdiğini sanmışlar.
12	dövüldü zannettik.	Kalabalık cemaatin imamı gece	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								dövdüğünü zannettik.
13	sanıldı.	Baştan ikinci jandarma subayı asker	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								sanmıştı.
14	bulmuştu.	Sondan üçüncü kedi sahibi sevimli	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								bulundu.
15	dövüldü sanıyoruz.	Soldan ikinci askerin esiri	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								dövdüğünü sanıyoruz.
16	zannedilmiş.	Yaklaşık sekiz Bulgar ajanı görevli	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								zannetmiş.
17	zannetti.	Altı futbolcu hakemi eski oyuncu	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								zannedildi.
18	azarlandı sandım.	Toplam dokuz adamın ekibi	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								azarladığını sandım.
19	kovduğunu sanıyorlar.	Sağdan birinci ustanın çırağı	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								kovuldu sanıyorlar.
20	sevildi zannettik.	Eski komşunun çocuğu çok	<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								sevdiğini zannettik.

21	yakaladığını sanmışım.	Elbiseli kadının köpeği sabah							yakalandı sanmışım.
22	bulmuştu.	Baştan birinci doktor heyeti inatçı							bulundu.
23	yorduğunu sandım.	Otuz çocuğun danışmanı biraz							yoruldu sandım.
24	öldürüldü zannettik.	Yaklaşık yedi sanığın mağduru							öldürdüğünü zannettik.
25	bulmuştu.	İkinci polis amiri oldukça yeteneksiz							bulundu.
26	kapattığını sanıyorum.	Sondan beşinci padişahın haremı							kapatıldı sanıyorum.
27	zannedildi.	İkinci menajer adayı yeni oyuncu							zannetti.
28	zannedildi.	Toplam iki avukat kızı sekreter							zannetti.
29	vurduğunu sanıyorlar.	Etekli kızın damadı gece							vuruldu sanıyorlar.
30	dövdüğünü zannettik.	Sağdan birinci kalecinin rakibi							dövüldü zannettik.

31	kovduğunu zannettim.	Sekizinci liderin pilotu sabah							kovuldu zannettim.
32	zannetmiş.	İki şirket ortağı yeni yönetici							zannedilmiş.
33	sanmıştı.	Yaklaşık dokuz mülteci grubu işçi							sanıldı.
34	zannedildi.	Dokuz polis saldırganı eski tutuklu							zannetti.
35	unutuldu sandım.	Kalabalık ailenin köpeği dışarda							unuttuğunu sandım.
36	zannetti.	Baştan ikinci bayan kuaförü stajyer							zannedildi.
37	vuruldu sanmışlar.	Kalabalık aşiretin lideri sokakta							vurduğunu sanmışlar.
38	zannetti.	Dokuz çiftçi çocuğu yeni kalfa							zannedildi.
39	bıçakladığını sanıyorlar.	Birinci avukatın müvekkili gece							bıçaklandı sanıyorlar.
40	bulmuştu.	Toplam yedi asker düşmanı tehlikeli							bulundu.

41	zannetmiş.	Toplam iki kapıcı çocuğu koruma							zannedilmiş.
42	eleştirildi zannettik.	Sondan birinci doktorun ortağı							eleştirdiğini zannettik.
43	üzdüğünü sandılar.	Soldan dördüncü yazarın editörü							üzüldü sandılar.
44	zannetti.	Soldan birinci yönetici sekreteri temizlikçi							zannedildi.
45	zannedildi.	İki çoban kızı yeni hizmetçi							zannetti.
46	zannedilmiş.	İki katil uzmanı yeni polis							zannetmiş.
47	sevdiğini sanıyoruz.	Yaklaşık yedi öğrencinin psikoloğu							sevildi sanıyoruz.
48	hırpalandı zannettim.	En öndeki kadının bebeği							hırpaladığını zannettim.
49	zannetti.	Altı Arnavut kadını kaçak mülteci							zannedildi.
50	beğendiğini sanıyorum.	Toplam iki takımın forveti							beğenildi sanıyorum.

51	zannedildi.	Sekiz avukat doktoru şirket personeli							zannetti.
52	evlendirildi sanıyorum.	Sakallı çiftçinin kızı yazın							evlendirdiğini sanıyorum.
53	üzdüğünü sanıyorum.	Minik bebeğin doktoru yine							üzüldü sanıyorum.
54	yendiğini sandım.	Otuz milletin düşmanı sonunda							yenildi sandım.
55	azarlandı sandım.	Üçüncü subayın askeri sabah							azarladığını sandım.
56	sorguladığını sanıyoruz.	Toplam yedi polisin adamı							sorgulandı sanıyoruz.
57	bulmuştu.	Yaklaşık dört polis çocuğu sokakta							bulundu.
58	yaralandı sanıyorlar.	Yedi saldırganın doktoru akşam							yaraladığını sanıyorlar.
59	zannetti.	İkinci başkan takımı biraz başarısız							zannedildi.
60	bulmuştu.	Soldan dördüncü aile hekimi tecrübeli							bulundu.

61	bulundu.	Birinci mühendis ekibi oldukça başarılı							bulmuştu.
62	bıçakladığını zannettik.	Oldukça kalabalık mafyanın avukatı							bıçaklandı zannettik.
63	bulundu.	Yedinci delege grubu oldukça karamsar							bulmuştu.
64	sanmıştı.	Dokuz mafya elemanı polis ajanı							sanıldı.
65	azarladığını zannettim.	Baştan üçüncü müdürün personeli							azarlandı zannettim.
66	sorguladığını zannettik.	İkinci şubenin müdürü gece							sorgulandı zannettik.
67	kovuldu zannettik.	Yaklaşık yedi hastanın hekimi							kovduğunu zannettik.
68	bekletildi zannettim.	Yedi şirketin danışmanı yine							beklettiğini zannettim.
69	vurduğunu zannettik.	İkinci ordunun düşmanı gece							vuruldu zannettik.
70	eleştirdiğini sanıyorlar.	Toplam otuz personelin amiri							eleştirildi sanıyorlar.

71	zannedildi.	Altı gözlemci grubu tarla işçisi							zannetti.
72	sorgulandı sanıyorum.	Sağdan üçüncü savcının sanığı							sorguladığını sanıyorum.
73	yorduğunu sanıyoruz.	Üçüncü bakanın sekreteri çok							yoruldu sanıyoruz.
74	sanıldı.	Otuz dağcı grubu kaçak asker							sanmıştı.
75	eleştirildi sandım.	Yaklaşık altı kızın avukatı							eleştirdiğini sandım.
76	zannetti.	Yedi oğlan çocuğu tamirci çırağı							zannedildi.
77	zannedildi.	Yaklaşık yedi doktor çocuğu öğrenci							zannetti.
78	zannedilmiş.	Toplam iki köylü kadını çoban							zannetmiş.
79	sanıldı.	Yaklaşık yedi Amerikan casusu mühendis							sanmıştı.
80	zannedilmiş.	Sekiz Fransız subayı yeni ajan							zannetmiş.

81

Yaklaşık sekiz Alman turisti rehber

zannedildi.

zannetti.

82

Sondan ikinci damadın şahidi

kovuldu
biliyorum.

kovduğunu
biliyorum.

83

Birinci yönetmenin kızı sokakta

kaçırıldı
sanıyorlar.

kaçırdığını
sanıyorlar.

84

Sorunlu okul öğrencileri dersten

soğutmuş.

soğumuş.

85

Onların kedileri çok

sevimli
diyorlar.

sevdiğini
bilmiyordum.

A.3 English translations of the instructions and examples.

QUESTIONNAIRE

Dear participant,

In this questionnaire, you will be presented with temporarily ambiguous sentence beginnings (sentence beginnings which can be interpreted in two different ways). Right below the sentence beginning, you will see a scale. A verb or a verb phrase is presented on the right and left sides of the scale. Either one of these verbs/verb phrases can continue the sentence. Your task is to show the plausibility of these verbs/verb phrases to continue the temporary ambiguity by putting an 'X' mark on the appropriate box of the scale. If your mark is closer to one edge of the scale, it will mean that the verb/verb phrase on that side is more plausible to continue the sentence than the one on the other side. For example, if you put a mark on the very right or very left box, it will mean that the sentence beginning is not ambiguous and it can be continued only with the verb/verb phrase on that side of the scale. If you put a mark in the middle of the scale, it shows that the verb/verb phrase on either side of the scale can both continue the sentence, without one being a better continuation. Below are three examples for you to study before commencing to fill out the questionnaire.

Thank you for your participation!

EXAMPLES

Example 1

The quiet looking child's mother

made silenced.

						X

was late.

In this example, the sentence beginning is not ambiguous and can be continued only with the verb phrase presented at the right side of the scale.

It is grammatically and syntactically inappropriate for the verb phrase on the left side of the scale to continue the sentence.

Example 2

The recipient of the delayed letter is curiously

waiting.

X						

were presented.

In this example, the sentence beginning is again not ambiguous and can syntactically and semantically be continued only with the verb at the left side of the scale.

In the example below, there is a sentence beginning (talkative butcher-GEN customer-POSS/ACC) which is temporarily ambiguous:

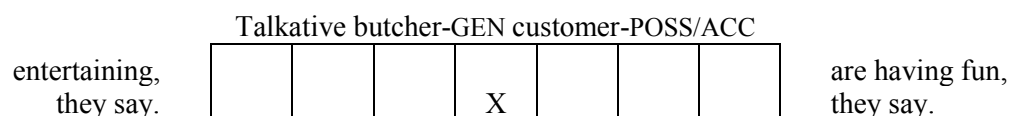
The first three nouns can function as a phrase together and be used as the subject of the sentence as ‘Talkative butcher’s customers’.

Thus, the sentence beginning can be continued with the intransitive verb phrase ‘are having fun, they say’ on the right.

In the same noun phrase sequence, ‘talkative butcher’ could be the subject and ‘the customers’ could be the object of the sentence.

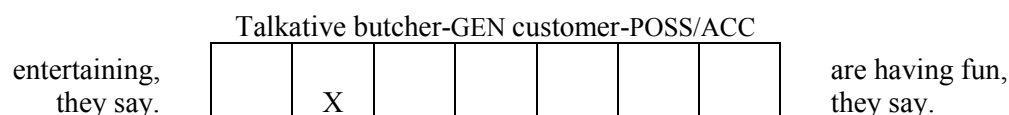
In this case, the sentence could continue with a transitive verb, such as the one on the left ‘entertaining, they say’.

Example 3a



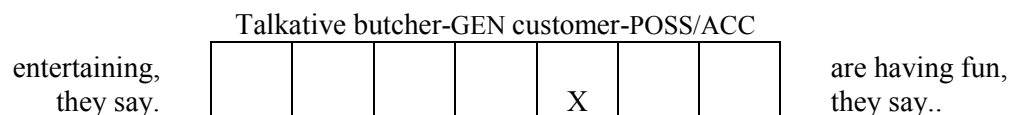
If you put the ‘X’ mark in the middle of the scale as above, this means that each continuation is equally possible.

Example 3b



If the mark is closer to the left side as above, this means that the noun phrase ‘the talkative butcher’s customers’ is very unlikely to be used the subject of the sentence and the verb phrase on the right side of the scale is unlikely to continue the sentence.

Example 3c



If the mark is closer to the right side of the scale as above, this means that it is more likely for the verb phrase on the right side to continue the sentence than the one on the left side.

When I prepared the sentences, I tried to make them as ambiguous as possible where each interpretation is equally possible. Do not be surprised if you don’t use the edges of the scales as I tried to make the sentences as ambiguous as possible.

Based on the answers you provide, I will select the ones that have little bias towards one interpretation over another.

Appendix B: Experimental Items, Fillers and Practice Sentences

B.1 Experimental Items with English Translations

	Experimental Sentences	English Translations
	Genitive Possessive Ambiguity	
1	LC (Yaklaşık) Yedi hastanın hekimi (sabah) kovuldu zannettik.	We considered that the doctor of (nearly) seven patients was kicked out (in the morning).
	EC (Yaklaşık) Yedi hastanın hekimi (sabah) kovduğunu zannettik.	We considered that (nearly) seven patients kicked the doctor out (in the morning).
2	LC (Sağdan) İkinci işçinin çocuğu (çok) sevildi sanmışlar.	They thought that the child of the second worker (from the left) was liked (much).
	EC (Sağdan) İkinci işçinin çocuğu (çok) sevdiğini sanmışlar.	They thought that the second worker (from the left) liked the child (much).
3	LC (En) Öndeki kadının bebeği (biraz) hırpalandı zannettim.	I considered that the baby of the woman in the (very) front was ill-treated (a little).
	EC (En) Öndeki kadının bebeği (biraz) hırpaladığını zannettim.	I considered that the woman in the (very) front ill-treated the baby (a little).
4	LC (Sondan) Birinci doktorun ortağı (biraz) eleştirildi zannettik.	We considered that the partner of the first doctor (from the last) was criticized (a little).
	EC (Sondan) Birinci doktorun ortağı (biraz) eleştirdiğini zannettik.	We considered that the first doctor (from the last) criticized the partner (a little).
5	LC (Sağdan) Üçüncü savcının sanığı (sabah) sorgulandı sanıyorum.	I think that the suspect of the third prosecutor (from the right) was questioned (in the morning).
	EC (Sağdan) Üçüncü savcının sanığı (sabah) sorguladığını sanıyorum.	I think that the third prosecutor (from the right) questioned the suspect (in the morning).
6	LC (Baştan) Üçüncü müdürün personeli (sabah) azarlandı zannettim.	I considered that the personnel of the third manager (from the beginning) was scolded (in the morning).
	EC (Baştan) Üçüncü müdürün personeli (sabah) azarladığını zannettim.	I considered that the third manager (from the beginning) scolded the personnel (in the morning).
7	LC (Yaklaşık) Yedi öğrencinin psikoloğu (çok) sevildi sanıyoruz.	We think that the psychologist of (nearly) seven students was (much) liked.
	EC (Yaklaşık) Yedi öğrencinin psikoloğu (çok) sevdiğini sanıyoruz.	We think that (nearly) seven students liked the psychologist (much).
8	LC (Sondan) Beşinci padişahın haremi (artık) kapatıldı sanıyorum.	I think that the harem of the fifth sultan (from the last) was closed down (already).
	EC (Sondan) Beşinci padişahın haremi (artık) kapattığını sanıyorum.	I think that the fifth sultan (from the last) closed down the harem (already).

9	LC	(Sağdan) Birinci ustanın çırağı (dün) kovuldu sanıyorlar.	They think that the the apprentice of the first master (from the right) was fired (yesterday).
	EC	(Sağdan) Birinci ustanın çırağı (dün) kovduğunu sanıyorlar.	They think that the first master (from the right) fired the apprentice (yesterday).
10	LC	(Soldan) Dördüncü yazarın editörü (yine) üzüldü sandılar.	They thought that the editor of the fourth writer (from the left) was upset (again).
	EC	(Soldan) Dördüncü yazarın editörü (yine) üzdüğünü sandılar.	They thought that the fourth writer (from the left) upset the editor (again).
11	LC	(Sondan) Üçüncü takımın forveti (oldukça) beğenildi sanıyorum.	I think that the forward player of the third team (from the bottom) was admired (much).
	EC	(Sondan) Üçüncü takımın forveti (oldukça) beğendiğini sanıyorum.	I think that the third team (from the bottom) admired the forward player (much).
12	LC	(Sağdan) Birinci kalecinin rakibi (sabah) dövüldü zannettik.	We considered that the rival of the first goal keeper (from the right) was beaten (in the morning).
	EC	(Sağdan) Birinci kalecinin rakibi (sabah) dövdüğünü zannettik.	We considered that the first goal keeper (from the right) beat the rival (in the morning).
13	LC	(Siyah) Sakallı çiftçinin kızı (yazın) evlendirildi sanıyorum.	I think that the daughter of the farmer with (black) beard got married (in the summer).
	EC	(Siyah) Sakallı çiftçinin kızı (yazın) evlendirdiğini sanıyorum.	I think that the farmer with (black) beard married off the daughter (in the summer).
14	LC	(Toplam) Dokuz gazetecinin faili (suçlu) bulundu sanmıştım.	I thought that the murderer of nine journalist (in total) was found (guilty).
	EC	(Toplam) Dokuz gazetecinin faili (suçlu) bulduğunu sanmıştım.	I thought that nine journalists (in total) found the murderer (guilty).
15	LC	(Oldukça) Kalabalık cemaatin imamı (gece) dövüldü zannettik.	We considered that the priest of the (quite) crowded sect was beaten (at night).
	EC	(Oldukça) Kalabalık cemaatin imamı (gece) dövdüğünü zannettik.	We thought that the (quite) crowded sect beat the priest (at night).
16	LC	(Sağdan) Birinci yönetmenin kızı (sokakta) kaçırıldı sanıyorlar.	They think that the daughter of the first director (from the right) was kidnapped (on the street).
	EC	(Sağdan) Birinci yönetmenin kızı (sokakta) kaçırdığını sanıyorlar.	They think that the first director (from the right) kidnapped the girl (on the street).
17	LC	(Oldukça) Kalabalık aşiretin lideri (sokakta) vuruldu sanmışlar.	They thought that the leader of the (quite) crowded tribe was shot (in the street).
	EC	(Oldukça) Kalabalık aşiretin lideri (sokakta) vurduğunu sanmışlar.	They thought that the (quite) crowded tribe shot the leader (in the street).
18	LC	(Oldukça) Eski komşunun çocuğu (çok) sevildi zannettik.	We thought that the child of the (pretty) old (i.e., former) neighbor was liked (much).
	EC	(Oldukça) Eski komşunun çocuğu (çok) sevdiğini zannettik.	We thought that the (pretty) old (i.e., former) neighbor liked the child (much).
19	LC	(Uzun) Elbiseli kadının köpeği (sabah) yakalandı sanmıştım.	I thought that the dog of the woman with a (long) dress was caught (in the morning).

	EC	(Uzun) Elbiseli kadının köpeği (sabah) yakaladığını sanmıştım.	I thought that the woman with a (long) dress caught the dog (in the morning).
20	LC	(Oldukça) Minik bebeğin doktoru (yine) üzüldü sanıyorum.	I think that the doctor of the (very) little baby was upset (again).
	EC	(Oldukça) Minik bebeğin doktoru (yine) üzdüğünü sanıyorum.	I think that the (very) little baby upset the doctor (again).
21	LC	(Soldan) Birinci avukatın müvekkili (gece) bıçaklandı sanıyorlar.	They think that the client of the first lawyer (from the left) was stabbed (at night).
	EC	(Soldan) Birinci avukatın müvekkili (gece) bıçakladığını sanıyorlar.	They think that the first lawyer (from the left) stabbed the client (at night).
22	LC	(Yaklaşık) Otuz çocuğun danışmanı (biraz) yoruldu sandım.	I thought that the counselor of (nearly) thirty children was (a little) exhausted.
	EC	(Yaklaşık) Otuz çocuğun danışmanı (biraz) yorduğunu sandım.	I thought that (nearly) thirty children exhausted the counselor (a little).
23	LC	(Baştan) Üçüncü bakanın sekreteri sabah kovuldu sanıyoruz.	We think that the secretary of the third minister (from the beginning) was fired (in the morning).
	EC	(Baştan) Üçüncü bakanın sekreteri sabah kovduğunu sanıyoruz.	We think that the third minister (from the beginning) fired the secretary (in the morning).
24	LC	(Yirmi) İkinci şubenin müdürü (gece) sorgulandı zannettik.	We considered that the manager of the (twenty-) second branch was questioned (at night).
	EC	(Yirmi) İkinci şubenin müdürü (gece) sorguladığını zannettik.	We thought that the (twenty-) second branch questioned the manager (at night).

NP Compound Ambiguity

1	LC	(Yaklaşık) Yedi Amerikan casusu (yeni) mühendis sanıldı.	(About) Seven American spies were thought to be the (new) engineers.
	EC	(Yaklaşık) Yedi Amerikan casusu (yeni) mühendis sanmıştı.	(About) Seven Americans thought the spy to be the (new) engineer.
2	LC	(Toplam) İki avukat kızı (eski) sekreter zannedildi.	Two lawyer daughters (in total) were considered to be the (old) secretary.
	EC	(Toplam) İki avukat kızı (eski) sekreter zannetti.	Two lawyers (in total) considered the girl to be the (old) secretary.
3	LC	(Baştan) İkinci jandarma subayı (yeni) asker sanıldı.	The second military police officer (from the beginning) was thought to be the (new) soldier.
	EC	(Baştan) İkinci jandarma subayı (yeni) asker sanmıştı.	The second military police (from the beginning) reportedly thought the officer to be the (new) soldier.
4	LC	(Toplam) İki köylü kadını (koyun) çoban(ı) zannedilmiş.	Two village women (in total) were reportedly considered the (sheep) shepherd.
	EC	(Toplam) İki köylü kadını (koyun) çoban(ı) zannetmiş.	Two villagers (in total) reportedly considered the woman the (sheep) shepherd.

5	LC	(Baştan) İkinci marangoz çırağı (yeni) kalfa zannedildi.	The second carpenter apprentice (from the beginning) was considered the (new) headworker.
	EC	(Baştan) İkinci marangoz çırağı (yeni) kalfa zannetti.	The second carpenter (from the beginning) reportedly considered the apprentice the (new) headworker.
6	LC	(Sondan) Birinci aile danışmanı (yeni) müdür zannedildi.	The first family counselor (from the last) was considered the (new) principal.
	EC	(Sondan) Birinci aile danışmanı (yeni) müdür zannetti.	The first family (from the last) considered the counselor the (new) principal.
7	LC	(Yaklaşık) Sekiz Bulgar ajanı (koruma) görevli(si) zannedilmiş.	(Nearly) Eight Bulgarian agents were reportedly considered the (security) employees.
	EC	(Yaklaşık) Sekiz Bulgar ajanı (koruma) görevli(si) zannetmiş.	(Nearly) Eight Bulgarians reportedly considered the agent the (security) employee.
8	LC	(Yaklaşık) Yedi doktor çocuğu (yeni) öğrenci zannedildi.	(Nearly) Seven doctor children were considered the (new) students.
	EC	(Yaklaşık) Yedi doktor çocuğu (yeni) öğrenci zannetti.	(Nearly) Seven doctors considered the child the (new) student.
9	LC	(Toplam) İki kapıcı çocuğu (yeni) koruma zannedilmiş.	Two doorman children (in total) were reportedly considered the (new) bodyguards.
	EC	(Toplam) İki kapıcı çocuğu (yeni) koruma zannetmiş.	Two doormen (in total) reportedly considered the child the (new) bodyguard.
10	LC	(Soldan) Birinci yönetici sekreteri temizlik işçisi/temizlikçi zannedildi.	The first manager secretary (from the left) was considered the cleaning lady/cleaner.
	EC	(Soldan) Birinci yönetici sekreteri temizlik işçisi/temizlikçi zannetti.	The first manager (from the left) considered the secretary the cleaning lady/cleaner.
11	LC	(Baştan) İkinci bayan kuaförü (eski) stajyer zannedildi.	The second woman hairdresser (from the beginning) was considered the (old) intern.
	EC	(Baştan) İkinci bayan kuaförü (eski) stajyer zannetti.	The second woman (from the beginning) considered the hairdresser the (old) intern.
12	LC	(Toplam) İki jandarma müfettişi subay (yardımcısı) zannedildi.	Two military police inspectors (in total) were considered military officer (assistant)s.
	EC	(Toplam) İki jandarma müfettişi subay (yardımcısı) zannetti.	Two military police officers considered the inspector the military officer (assistant).
13	LC	(Baştan) Birinci doktor heyeti (biraz) inatçı bulundu.	The first doctor commission (from the beginning) was found (a bit) stubborn.
	EC	(Baştan) Birinci doktor heyeti (biraz) inatçı bulmuştu.	The first doctor (from the beginning) reportedly found the commission (a bit) stubborn.
14	LC	(Soldan) Dördüncü aile hekimi (çok) tecrübeli bulundu.	The fourth family doctor (from the left) was found (very) experienced.
	EC	(Soldan) Dördüncü aile hekimi (çok) tecrübeli bulmuştu.	The fourth family (from the left) reportedly found the doctor (very) experienced.

15	LC	(Yaklaşık) Sekiz Fransız subayı (yeni) ajan zannedilmiş.	(Nearly) Eight French military officers were reportedly considered the (new) agents.
	EC	(Yaklaşık) Sekiz Fransız subayı (yeni) ajan zannetmiş.	(Nearly) Eight French reportedly considered the military officer the (new) agent.
16	LC	(Sondan) İkinci menajer adayı (yeni) oyuncu zannedildi.	The second manager nominee (from the last) was considered the (new) actor.
	EC	(Sondan) İkinci menajer adayı (yeni) oyuncu zannetti.	The second manager (from the last) considered the nominee the (new) actor.
17	LC	(Baştan) Birinci mühendis ekibi (oldukça) başarılı bulundu.	The first engineer team (from the beginning) was found (quite) successful.
	EC	(Baştan) Birinci mühendis ekibi (oldukça) başarılı bulmuştu.	The first engineer (from the beginning) reportedly found the team (quite) successful.
18	LC	(Toplam) İki çoban kızı (yeni) hizmetçi zannedildi.	Two shepherd girls (in total) were considered the (new) maids.
	EC	(Toplam) İki çoban kızı (yeni) hizmetçi zannetti.	Two shepherds (in total) considered the girl the (new) maid.
19	LC	(Sondan) Yedinci delege grubu (oldukça) karamsar bulundu.	The seventh delegate group (from the last) was found (rather) pessimistic.
	EC	(Sondan) Yedinci delege grubu (oldukça) karamsar bulmuştu.	The seventh delegate (from the last) found the group (rather) pessimistic.
20	LC	(Yaklaşık) Altı gözlemci grubu (tarla) işçi(s)i zannedildi.	(Nearly) Six observer groups were considered (farm) workers.
	EC	(Yaklaşık) Altı gözlemci grubu (tarla) işçi(s)i zannetti.	(Nearly) Six observers considered the group (farm) workers.
21	LC	(Yaklaşık) Otuz dağcı grubu (kaçak) asker sanıldı.	(Nearly) Thirty mountaineer groups were considered (runaway) soldiers.
	EC	(Yaklaşık) Otuz dağcı grubu (kaçak) asker sanmıştı.	(Nearly) Thirty mountaineers reportedly considered the group (runaway) soldiers.
22	LC	(Sondan) İkinci polis amiri (oldukça) yeteneksiz bulundu.	The second police chief (from the last) was found (very) untalented.
	EC	(Sondan) İkinci polis amiri (oldukça) yeteneksiz bulmuştu.	The second police (from the last) found the chief (very) untalented.
23	LC	(Toplam) İki pilot adayı (eski) subay sanıldı.	Two pilot nominees (in total) were thought to be the (old) military officers.
	EC	(Toplam) İki pilot adayı (eski) subay sanmıştı.	Two pilots (in total) thought the nominee to be the (old) military officer.
24	LC	(Yaklaşık) Yedi oğlan çocuğu (tamirci) çırak/(ğ) zannedildi.	(Nearly) Seven male kids (i.e., boys) were considered the (mechanic) apprentice(s).
	EC	(Yaklaşık) Yedi oğlan çocuğu (tamirci) çırak/(ğ) zannetti.	(Nearly) Seven boys considered the child the (mechanic) apprentice.

B.2 Filler Sentences with English Translations.

Fillers with Structures Similar to Experimental Items

Genitive Possessive Ambiguity

1	LC	Yeni (yapılan) apartmanın kapıcısı (çok) sevildi sandık.	We thought that the doorman of the new(ly built) building was (much) liked.
	EC	Yeni (gelen) komşuların kapıcıyı (çok) sevdiğini sandık.	We thought that the new(ly coming) neighbors liked the doorman (much).
2	LC	Yeni (gelen) jimnastikçinin çalıştırıcısı (oldukça) beğenildi sandım.	I thought that the coach of the new(ly joined) gymnast was (much) liked.
	EC	Genç (görünürlü) futbolcunun çalıştırıcısı (çok) beğendiğini sandım.	I thought that the young (looking) soccer player liked the coach (much).
3	LC	Yeni (yapılan) apartmanın bekçisi (gece) dövüldü sanmışlar.	They thought that the guard of the new(ly built) building was beaten (at night).
	EC	Sinirli (duran) adamın (yeni) bekçiyi dövüğünü sanmışlar.	They reportedly thought that the angry (looking) man beat the (new) guard.
4	LC	Genç (görünen) yöneticinin yardımcısı (dün) yakalandı sandılar.	They thought that the assistant of the young (looking) manager was caught (yesterday).
	EC	Yeni (başlayan) polisin yardımcısı (gece) yakaladığını sandılar.	They thought that the new(ly started) police officer caught the assistant (at night).
5	LC	(Oldukça) Yaramaz çocuğun annesi (yine) eleştirildi zannettim.	I considered that the mother of the (quite) naughty child was criticized (again).
	EC	Küçük (olan) kızın annesini (sabah) eleştirdiğini zannettim.	I considered that the little (looking) girl criticized her mother (in the morning).
6	LC	(Oldukça) Büyük kampın izcisi (uzaktan) görüldü zannettik.	We thought that the scout of the (quite) big camp was seen (from a distance).
	EC	Meraklı (duran) turistin izciyi (kampta) gördüğünü zannettik.	We considered that the curious (looking) tourist saw the scout (at the camp).

NP Compound Ambiguity

1	LC	Genç (görünen) şirket yöneticisi yeni eleman sanıldı.	The young (looking) company manager was considered the new employee.
	EC	(Oldukça) Yaşlı adam (yeni) yöneticiyi memur sanmıştı.	The (quite) old man had thought the (new) manager to be the officer.
2	LC	Çalışkan (bilinen) şirket görevlisi (yeni) patron zannedildi.	The (so-known) hardworking company employee was considered the new boss.
	EC	(Oldukça) Yaramaz çocuk (genç) görevliyi öğrenci zannetti.	The (quite) naughty child considered the (young) employee a student.
3	LC	(Oldukça) Yeni dahiliye hemşiresi (oldukça) hevesli bulundu.	The (quite) new internal medicine nurse was found (quite) enthusiastic.
	EC	Yeni (başlayan) doktor hemşireyi (biraz) tecrübesiz bulmuştu.	The new(ly-started) doctor found the nurse (a bit) inexperienced.

4	LC	Yorgun (duran) hastane nöbetçisi temizlik elemanı/temizlikçi sanıldı.	The exhausted (looking) hospital guard was thought to be the cleaning personnel/cleaner.
	EC	Yaşlı (görünen) adam nöbetçiyi (yeni) polis sanmıştı.	The old (looking) man thought the guard to be the (new) police officer.
5	LC	(Çok) Çalışkan hasta bakıcısı (biraz) sessiz bulundu.	The (very) hardworking nurse was found (a bit) quiet.
	EC	Titiz (görünürlü) adam bakıcıyı (biraz) meraklı bulmuştu.	The fussy (looking) man found the nurse (a bit) curious.
6	LC	Yeni (gelen) doktora öğrencisi editör (yardımcısı) zannedilmiş.	The new (ly joined) PhD student was considered the editor (assistant).
	EC	Genç (duruşlu) profesör öğrenciyi (yeni) asistan zannetmiş.	The young (looking) professor considered the student the (new) assistant.

Fillers with Various Structures

1	Kasabada dolanan hayaletin korkuttuğunu söylüyorlar.	They say that the ghost in the village scares.
2	Yeni derslik çok öğrenci alıyor diyorlar.	They say that the new classroom fits a lot of students.
3	Sırada bekleyen adamın kriz geçirdiğini sandık.	We thought that the man waiting in the line had a heart attack.
4	Komşular yüksek sesle müzik dinliyor diyorlar.	They say that the neighbors are listening to loud music.
5	Öğrenci geciktiği sınavı vaktinde bitirmiş sanırım.	I think the student finished the test that she was late in time.
6	Minik kediye süt verdiğimizizi sanmışlar.	They thought that we gave milk to the little cat.
7	Postada kaybolan mektup alıcısına ulaşmış diyorlar.	They say that the letter that was lost in the mail reached its recipient.
8	Sınavdan geçemeyen öğrencinin okulu bırakacağını sanıyoruz.	We think that the student who couldn't pass the test will quit school.
9	Otobüsü kaçıran yolcu biletinin parasını geri istemiş.	The passenger who missed the bus asked for a refund.
10	Dava edilen öğretmen, ifade verdi diyorlar.	They say the teacher who was sued testified.
11	Geçen hafta başlayan dizinin beğenildiğini zannetmişler.	They considered that the TV show that started last week was liked.
12	Okulda öğrendiği fıkraları herkese anlattı diyorlar.	They say that she told the jokes she learnt at school to everyone.
13	Kalabalık grup meclise doğru yürüdü zannetmişler.	They considered that the crowded group walked towards the parliament.
14	Üniversite sınavları Haziran ayında yapılacak diyorlar.	They say that the university entrance exam will be held in June.

15	Çocuk karne hediyesi olarak bisiklet istemiş.	The kid wanted a bike as a present for good grades.
16	Konuşkan öğrencinin öğretmeninden azar işittiğini sandık.	We thought that the talkative student was scolded by the teacher.
17	Annesini özleyen çocuğun kamptan kaçtığını zannediyorlar.	They are considering that the kid who missed his mother ran away from the camp.
18	Sıcaklardan bunalan vatandaş tatil arayışında diyorlar.	They say that the citizens who feel suffocated by the heat are in search for a vacation.
19	Gazete okumuyor diye gündemi takip etmiyor sanıyorlar.	They think that he doesn't follow the agenda because he doesn't read the paper.
20	Pencereler kurşun geçirmez camla yapılmış diyorlar.	They say that the windows are made with bullet-proof glass.
21	Ünlü sanatçının kendine limuzin aldığını sanıyoruz.	We think that the famous artist bought himself/herself a limousine.
22	Düzenli egzersiz pek çok rahatsızlığı önlemiş.	It is said that regular exercise can prevent lots of illnesses.
23	Boğazda tekne turuna katılan turist çok mutlu diyorlar.	They say that the tourist who had a boat tour at the Bosphorous was very happy.
24	Sessiz duran çocuk birinci oldu zannettik.	We considered that the kid who looked quiet got the first place.

B.3 Practice/Warm Up Sentences

Practice/Warm Up Sentences

1	Grubun temsilcisi sorusunu yöneltti sanıyoruz.	We think that the representative of the group asked his/her question.
2	Derbi maçının trafiği tıkadığını söylüyorlar.	They say that the big derby jammed the traffic.
3	Meraklı turist herşeyin fotoğrafını çekiyormuş.	The curious tourist is (reportedly) taking a photo of everything.
4	Sevimli köpek sahibinin peşini bırakmıyor diyorlar.	They say that the cute puppy follows its owner to everywhere.
5	Arabanın kızına doğum günü hediyesi olduğunu söylüyorlar.	They say that the car is a birthday gift to his/her daughter.
6	Çalışkan öğrenci oldukça sevildi dediler.	They said that the hardworking student was very much liked.
7	Hareketsiz duran kedinin oyun yaptığını sanmışım.	I had thought that the motionless cat was playing tricks.
8	Aldığı kitabı beğenmeyen kadın iade etmiş.	The woman who didn't like the book she bought (reportedly) returned it.
9	Çoktandır beklediğim sınav sonuçları açıklandı zannettim.	I thought that the exam results that I have been waiting for a long time were announced.
10	Karısından boşanan adam depresyon tedavisi görüyormuş.	The man who divorced his wife is reportedly receiving depression treatment.
11	Ünlü oyuncu kimsesiz çocuklar için gösteri yapacak diyorlar.	They say that the famous actor will have shows for orphans.
12	Çocuğun şiiriyle öğretmenini sevindirdiğini sanıyoruz.	We think that the child made his/her teacher happy with his/her poem.
13	Yeni sistemin internet hızını arttıracığını düşünüyorlar.	They think that the new system will excellerate the internet speed.
14	Suçsuz olduğu ispatlanan gazeteci serbest bırakılmış.	The journalist who was found innocent was released.
15	Futbol oynayan çocuk düşüp dizini incitmiş.	The kid playing football (reportedly) fell and hurt his knee.
16	Çocuğun kız kardeşini çok sevdiğini söylüyorlar.	They say that the child likes his sister very much.
17	Büyükannesi onun çoktan uyuduğunu zannetmiş.	His/her grandmother thought he/she was fast asleep.
18	Genç ve yetenekli patron sürekli çalışıyor diyorlar.	They say that the young and talented boss works all the time.
19	Cezaevinde çıkan yangın kontrol altına alınmış.	The fire at the prison was (reportedly) taken under control.
20	Minik çocuk markette annesini kaybetmiş.	The little kid lost his/her mother at the grocery store.

B.4 Comprehension Questions in Experiment 2A and 2B.

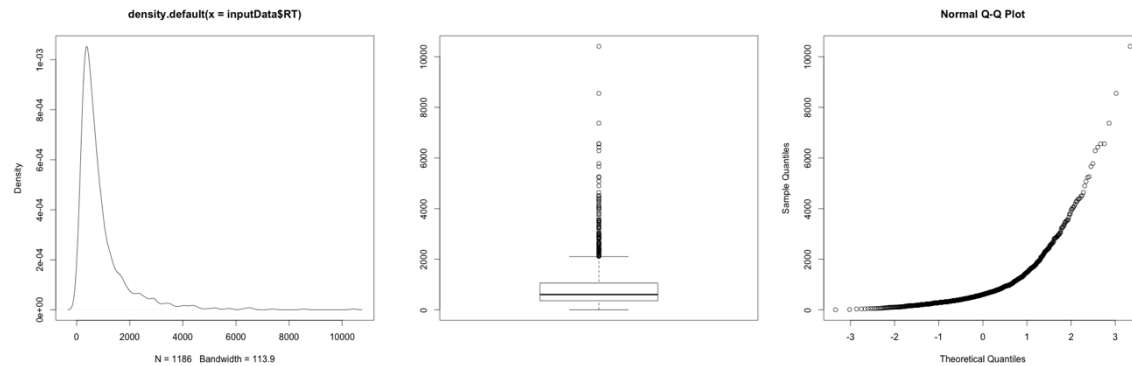
Comprehension Questions were addressed after each version of the items (syntactic and prosodic) numbered below.

	Questions	English Translations	Response
Genitive Possessive Ambiguity			
1	Cümlede 'hasta' kelimesi geçti mi?	Did the sentence contain the word 'patient'?	Yes
3	Cümlede 'kadın' kelimesi geçti mi?	Did the sentence contain the word 'woman'?	Yes
4	Cümlede 'hemşire' kelimesi geçti mi?	Did the sentence contain the word 'nurse'?	No
5	Cümlede 'avukat' kelimesi geçti mi?	Did the sentence contain the word 'lawyer'?	No
10	Cümlede 'yazar' kelimesi geçti mi?	Did the sentence contain the word 'writer'?	Yes
16	Cümlede 'oyuncu' kelimesi geçti mi?	Did the sentence contain the word 'actor'?	No
18	Cümlede 'çocuk' kelimesi geçti mi?	Did the sentence contain the word 'child'?	Yes
23	Cümlede 'milletvekili' kelimesi geçti mi?	Did the sentence contain the word 'senator'?	No
NP Compound Ambiguity			
1	Cümlede 'ajan' kelimesi geçti mi?	Did the sentence contain the word 'agent'?	No
3	Cümlede 'komutan' kelimesi geçti mi?	Did the sentence contain the word 'commander'?	No
4	Cümlede 'çoban' kelimesi geçti mi?	Did the sentence contain the word 'shepherd'?	Yes
5	Cümlede 'marangoz' kelimesi geçti mi?	Did the sentence contain the word 'carpenter'?	Yes
10	Cümlede 'patron' kelimesi geçti mi?	Did the sentence contain the word 'boss'?	No
16	Cümlede 'menajer' kelimesi geçti mi?	Did the sentence contain the word 'manager'?	Yes
18	Cümlede 'uşak' kelimesi geçti mi?	Did the sentence contain the word 'servant'?	No
23	Cümlede 'subay' kelimesi geçti mi?	Did the sentence contain the word 'military officer'?	Yes
Fillers with Structures Similar to the Experimental Items			
Genitive Possessive			
3-LC	Cümlede 'polis' kelimesi geçti mi?	Did the sentence contain the word 'police'?	No
3-EC	Cümlede 'apartman' kelimesi geçti mi?	Did the sentence contain the word 'building'?	Yes
NP Compound			
1-LC	Cümlede 'ofis' kelimesi geçti mi?	Did the sentence contain the word 'office'?	No
1-EC	Cümlede 'yaşlı' kelimesi geçti mi?	Did the sentence contain the word 'old'?	Yes
Fillers with Various Structures			
1	Cümlede 'hayalet' kelimesi geçti mi?	Did the sentence contain the word 'ghost'?	Yes
5	Cümlede 'öğretmen' kelimesi geçti mi?	Did the sentence contain the word 'teacher'?	No
10	Cümlede 'dava' kelimesi geçti mi?	Did the sentence contain the word 'sue'?	Yes
23	Cümlede 'feribot' kelimesi geçti mi?	Did the sentence contain the word 'ferry'?	No

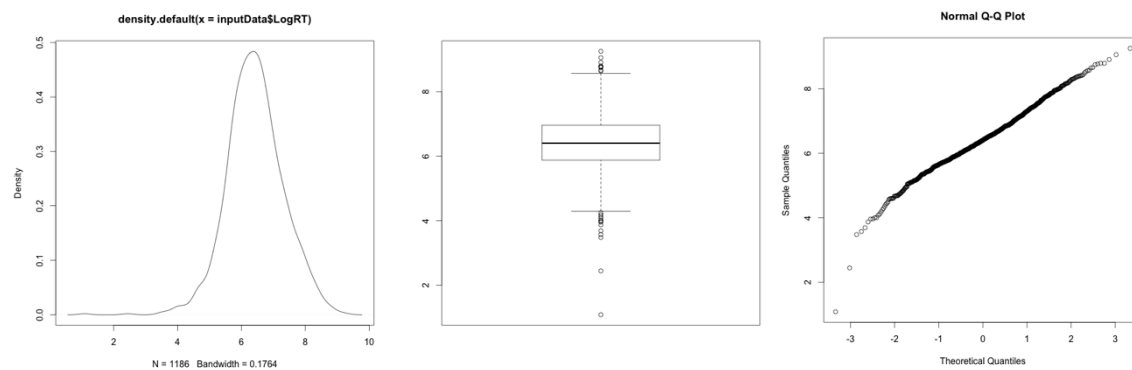
Appendix C: Additional Statistical Data Plots for ‘Got It’ Experiments

C.1a Experiment 2A: Data Distribution Plots for Genitive Possessive Ambiguity.

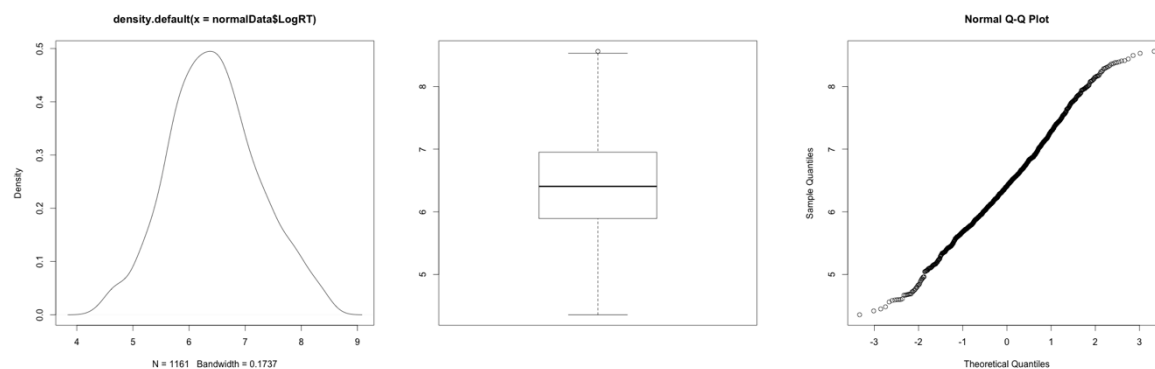
Density, Box and Whisker and Q-Q plots illustrating raw data distribution.



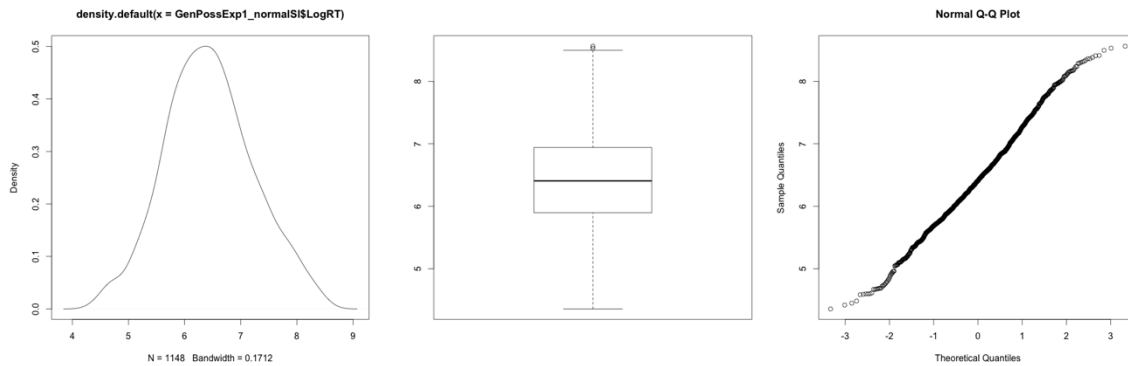
Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution.



Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points.

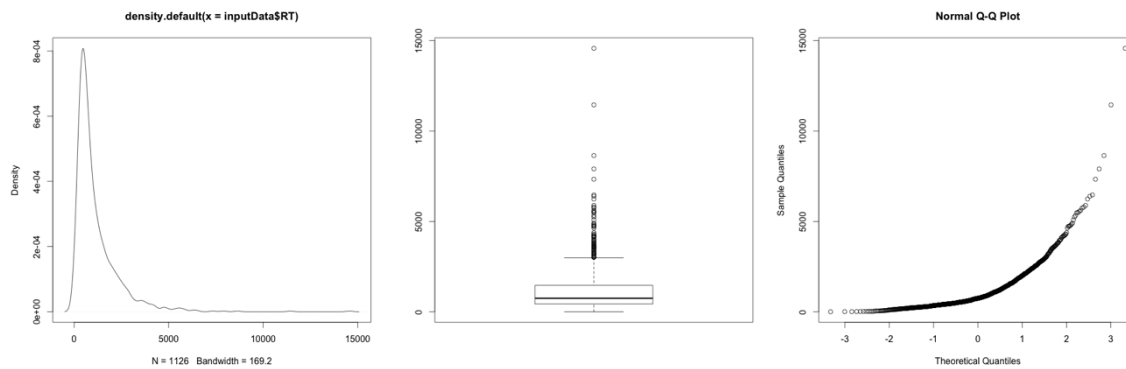


Density and Box and Whisker plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points for individual subjects and items.

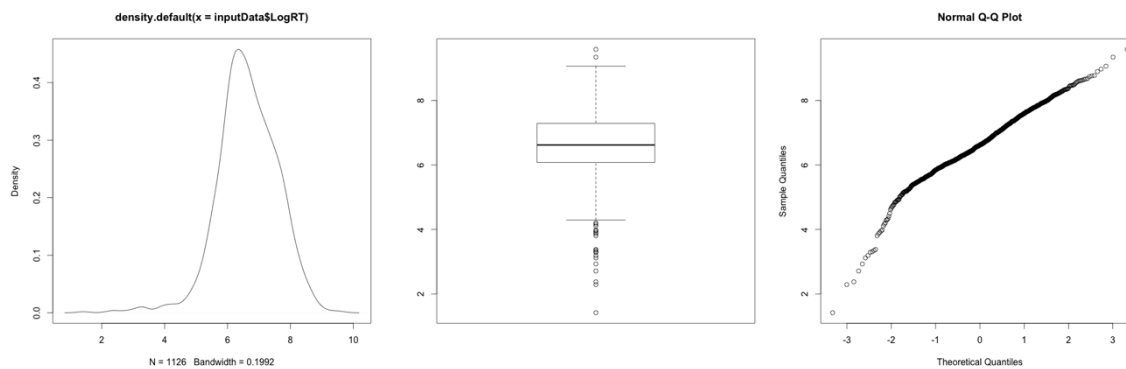


C.1b Experiment 2B: Data Distribution Plots for NP Compound Ambiguity.

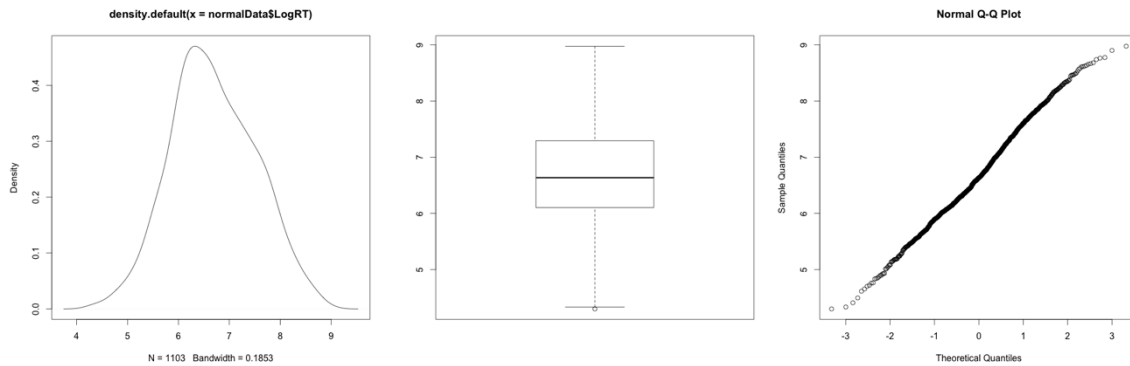
Density, Box and Whisker and Q-Q plots illustrating raw data distribution.



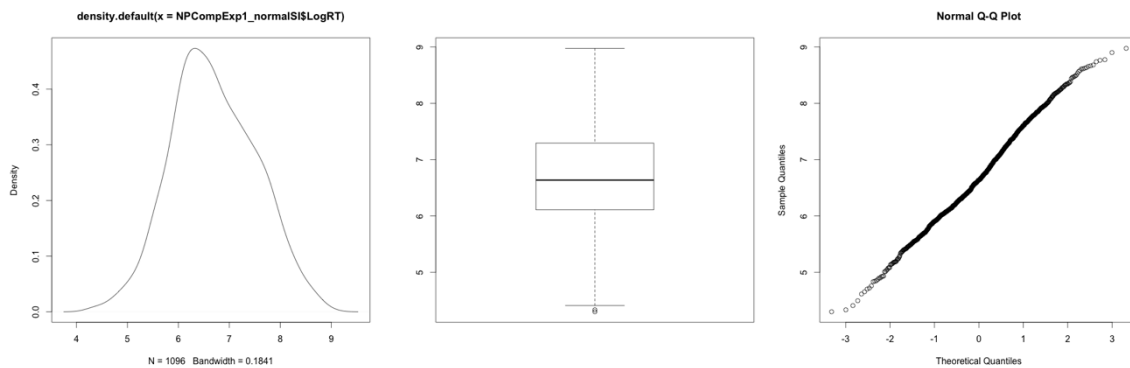
Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution.



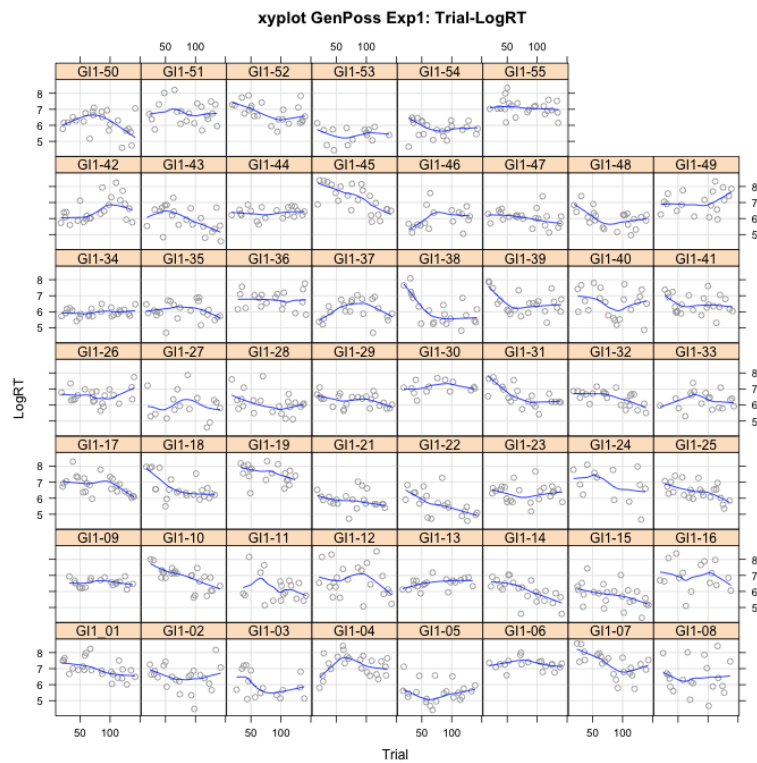
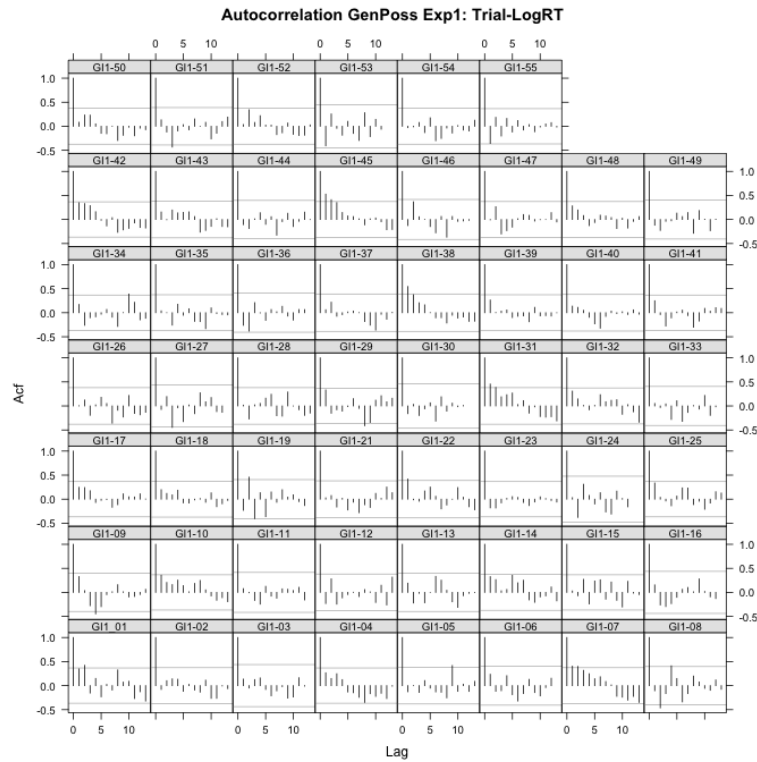
Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points.



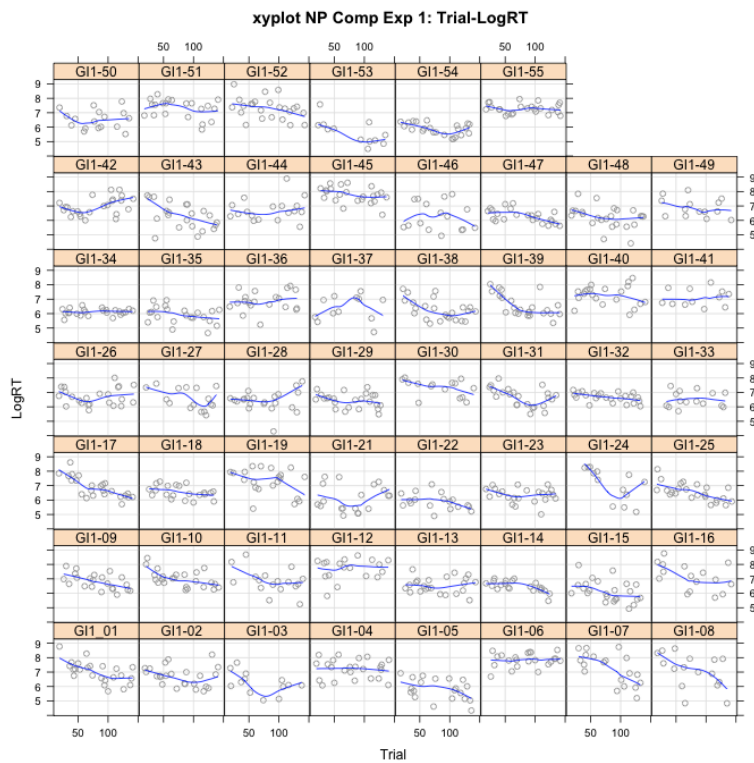
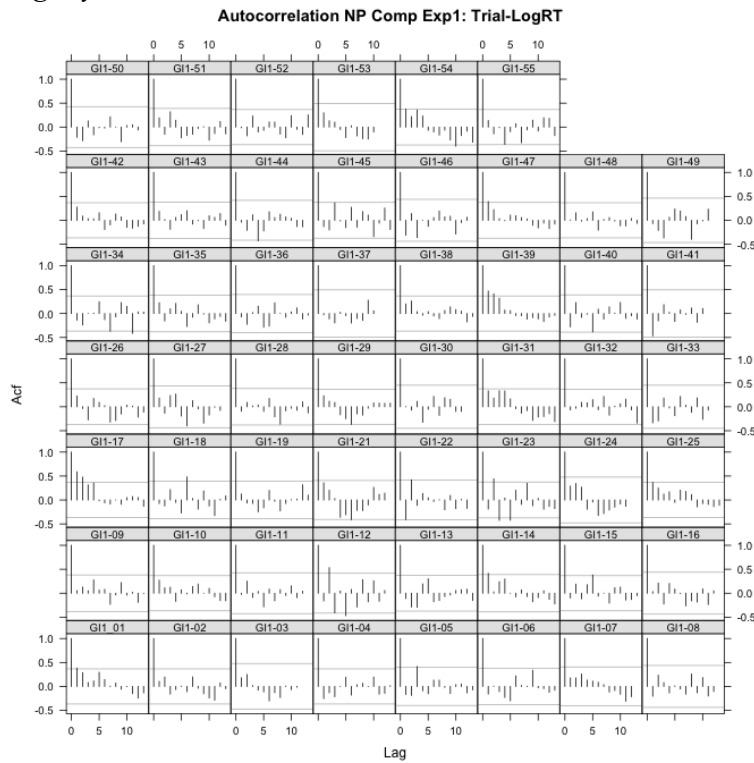
Density and Box and Whisker plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points for individual subjects and items.



C.2a Experiment 2A: Autocorrelation and trellis graphs for RTs and Trials for Genitive Possessive Ambiguity.



C.2b Experiment 2A: Autocorrelation and trellis graphs for RTs and Trials for NP Compound Ambiguity.



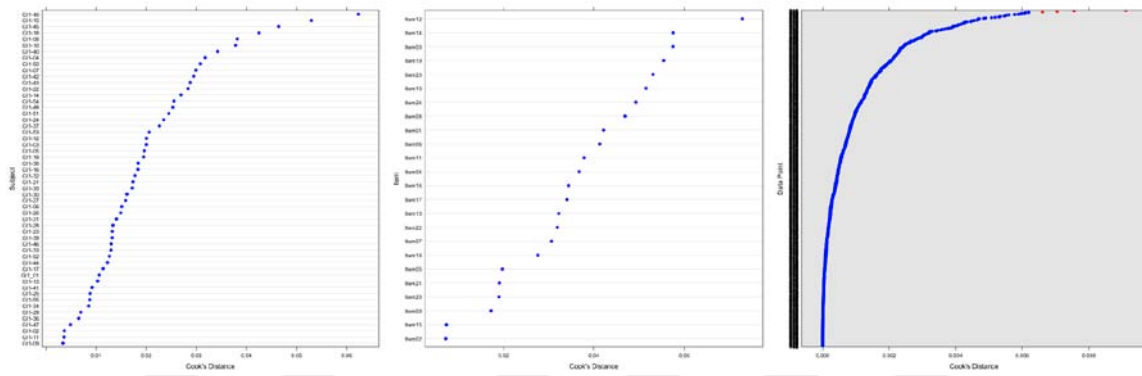
C.3a Experiment 2A: Genitive Possessive Ambiguity, model comparison table

Model	Fixed effects	df	Deviance	AIC	LR test			
					BIC	Comparison	X ² (df)	p
mod1	Trial, Prosody (re: subject)	9	2264	2282	2328	–	–	–
mod2	Trial, Syntax (re: subject)	8	2278	2294	2335	–	–	–
mod3	Trial, Prosody, Syntax (re: Trial, subject)	10	2257	2307	2357	mod1–mod3 mod2–mod3	7.4(1) 21.54(2)	<.01 <.001
mod4	Trial, ProsodyXSyntax (re: Trial, subject)	12	2249	2273	2333	mod3–mod4	8.03(3)	<.05

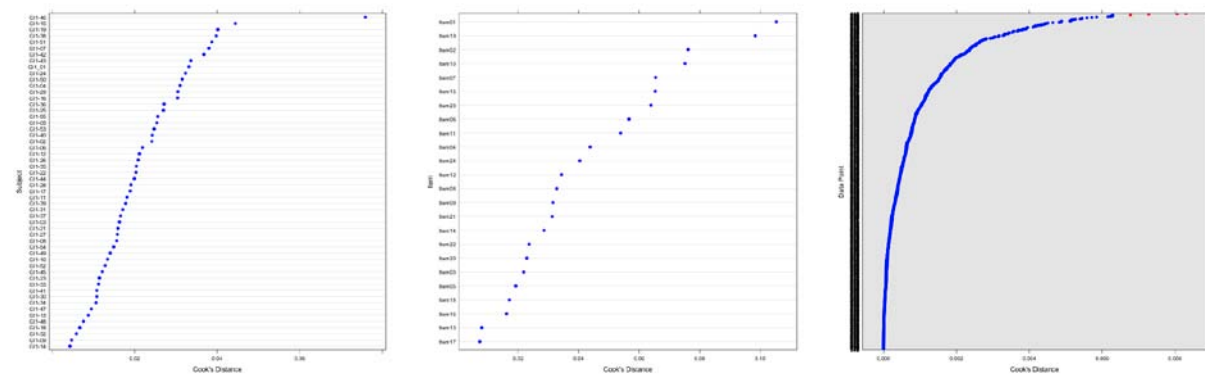
C.3b Experiment 2A: NP Compound Ambiguity, model comparison table

Model	Fixed effects	df	Deviance	AIC	LR test			
					BIC	Comparison	X ² (df)	p
mod1	Trial, Prosody (re: subject)	9	2240	2258	2303	–	–	–
mod2	Trial, Syntax (re: subject)	8	2228	2298	2338	–	–	–
mod3	Trial, Prosody, Syntax (re: Trial, subject)	10	2240	2260	2310	mod1–mod3 mod2–mod3	.04(1) 41.46(2)	=.82 <.001
mod4	Trial, ProsodyXSyntax (re: Trial, subject)	12	2225	2249	2309	mod3–mod4	14.59(3)	<.001

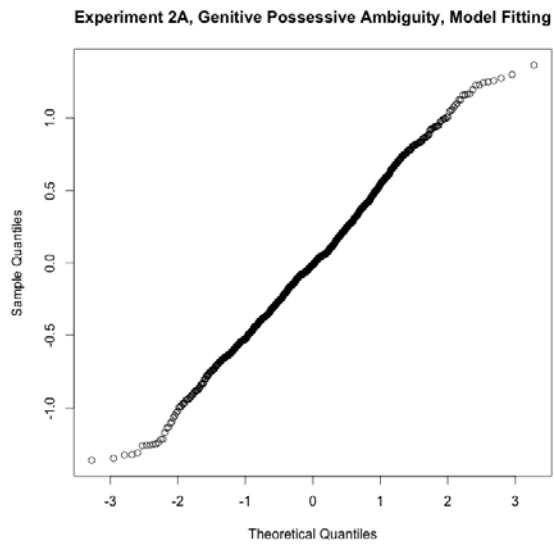
C.4a Experiment 2A, Genitive Possessive Ambiguity, Data plots for Influential Subjects, Items and Data Points



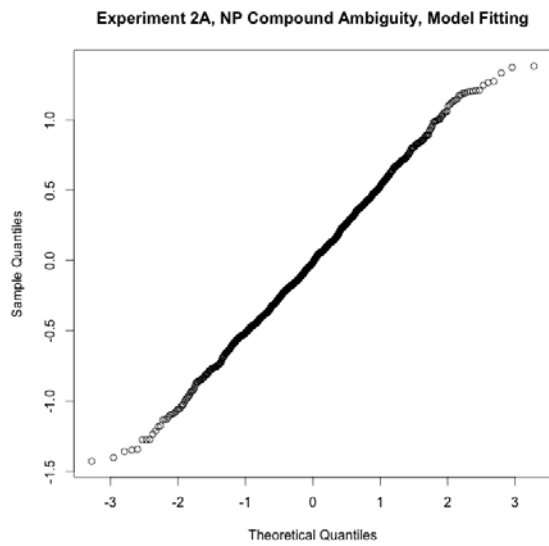
C.4b Experiment 2A, NP Compound Ambiguity, Data plots for Influential Subjects, Items and Data Points



C.5a Experiment 2A, Genitive Possessive Ambiguity, Q-Q Plots for Model Fitting

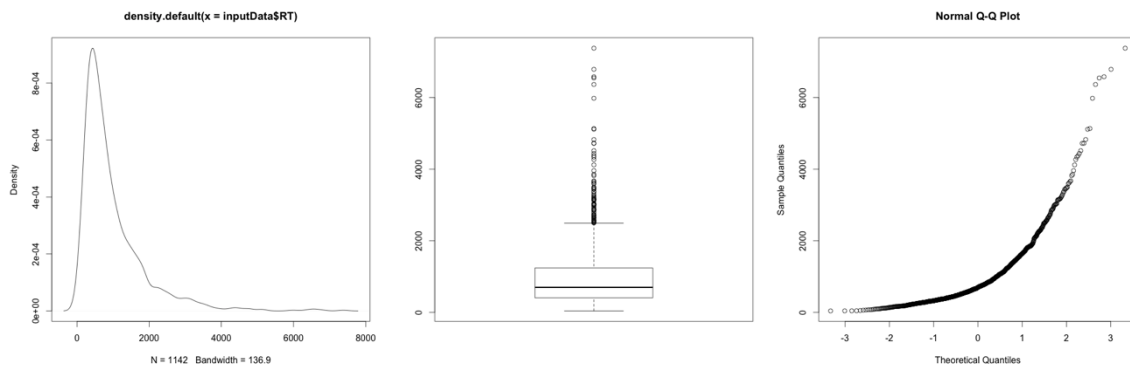


C.5b Experiment 2A, NP Compound Ambiguity, Q-Q Plots for Model Fitting

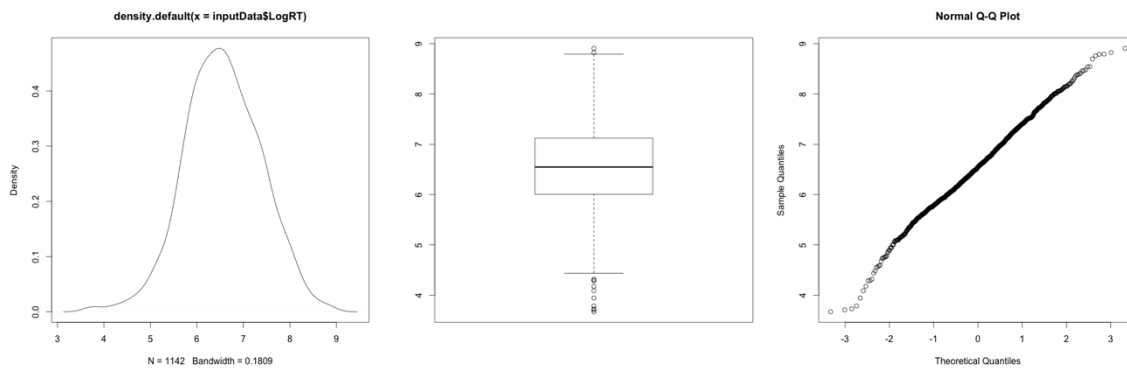


C.6a Experiment 2B: Data Distribution Plots for Genitive Possessive Ambiguity

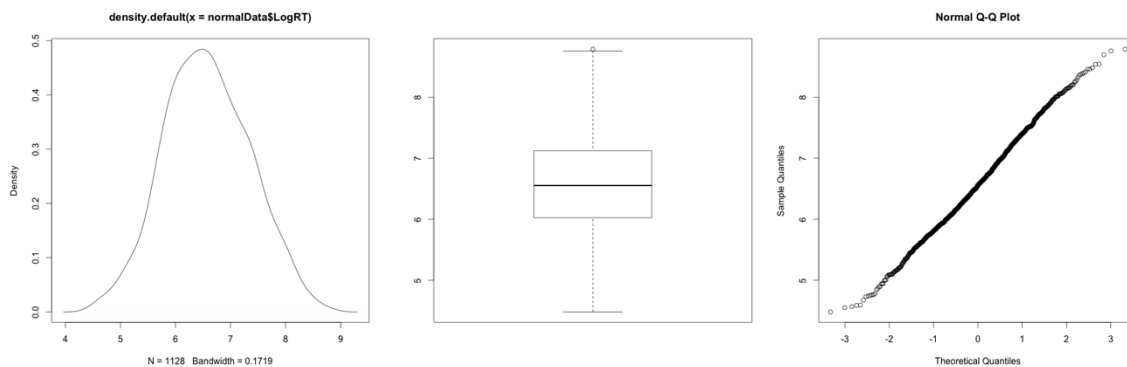
Density, Box and Whisker and Q-Q plots illustrating raw data distribution.



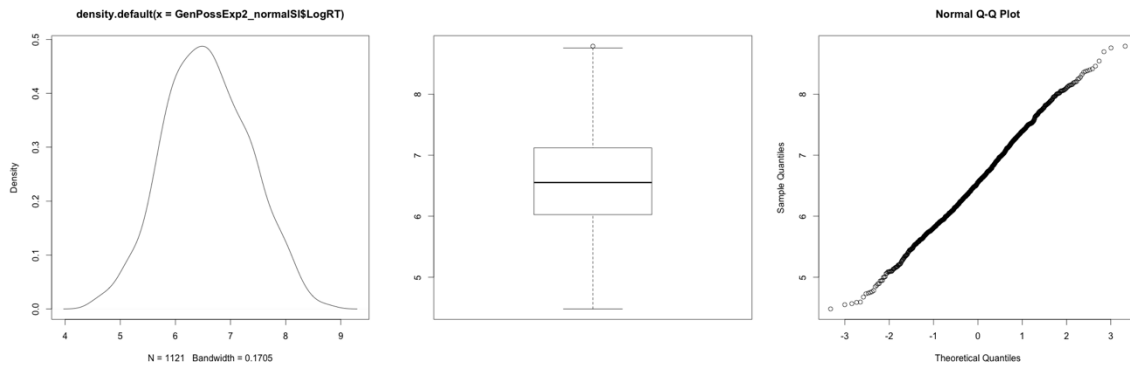
Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution.



Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points.

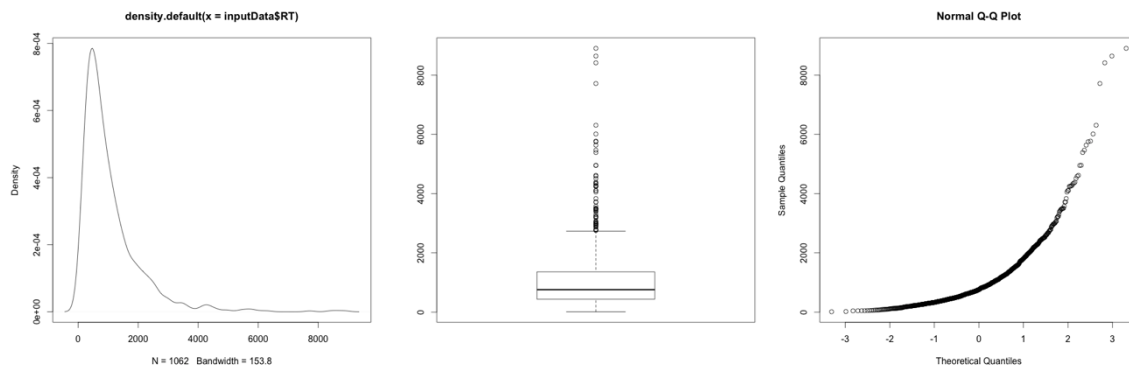


Genitive Possessive Ambiguity, Density and Box and Whisker plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points for individual subjects and items.

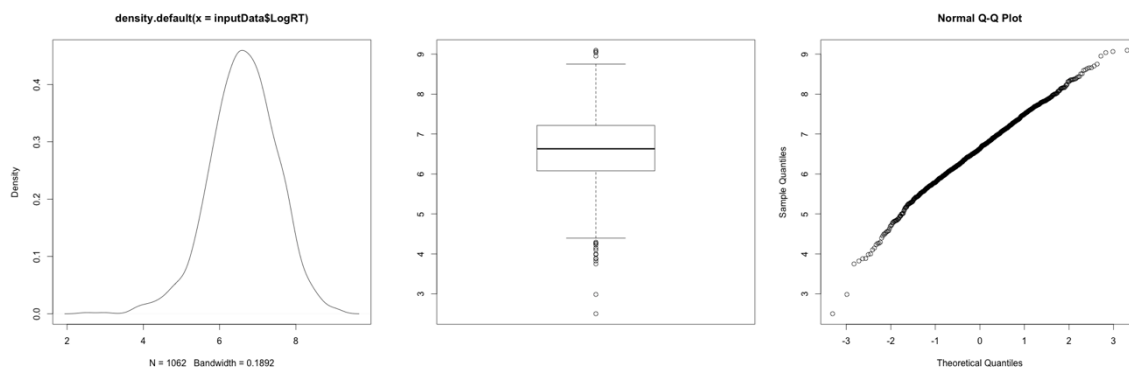


C.6b Experiment 2B: Data Distribution Plots for NP Compound Ambiguity

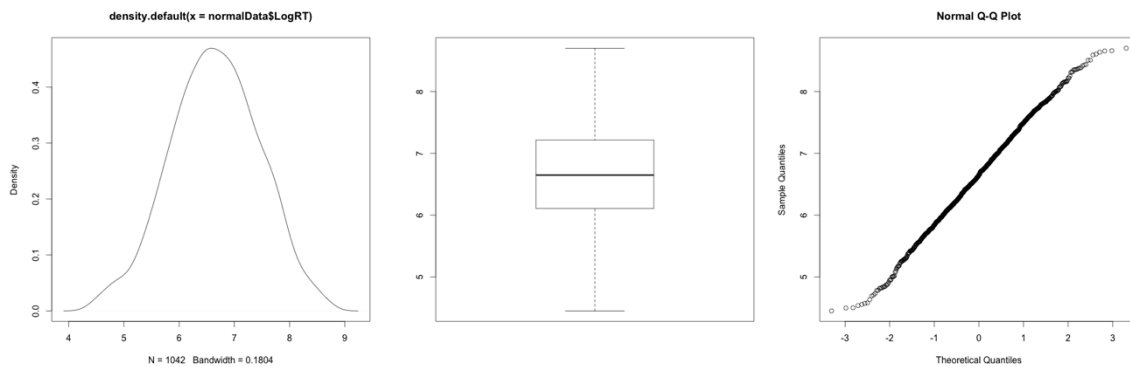
Density, Box and Whisker and Q-Q plots illustrating raw data distribution.



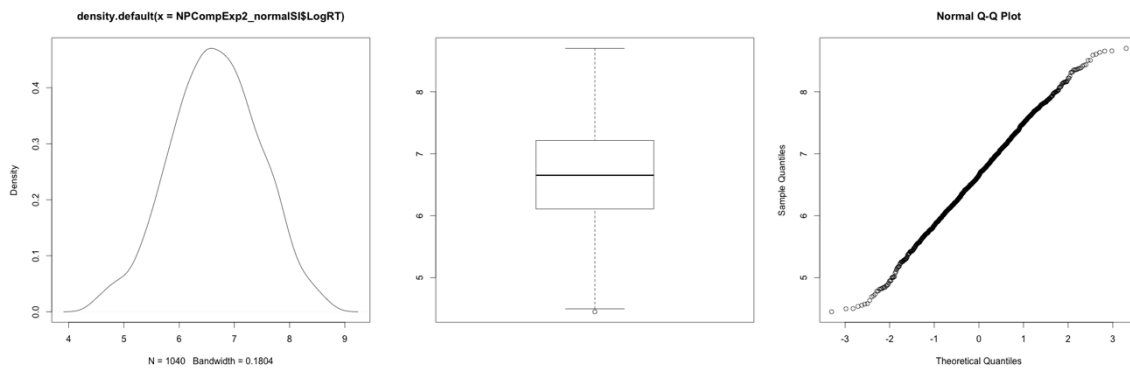
Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution.



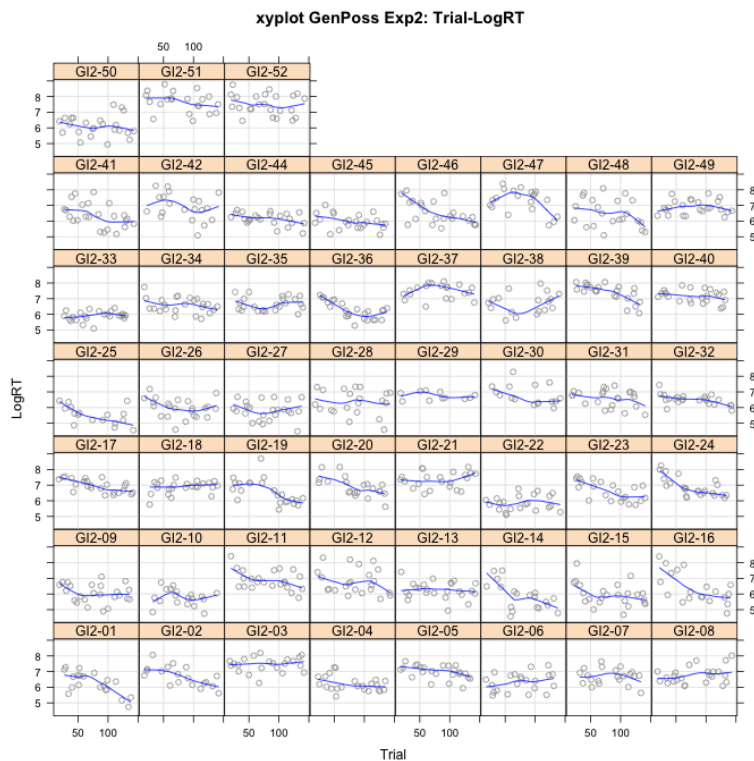
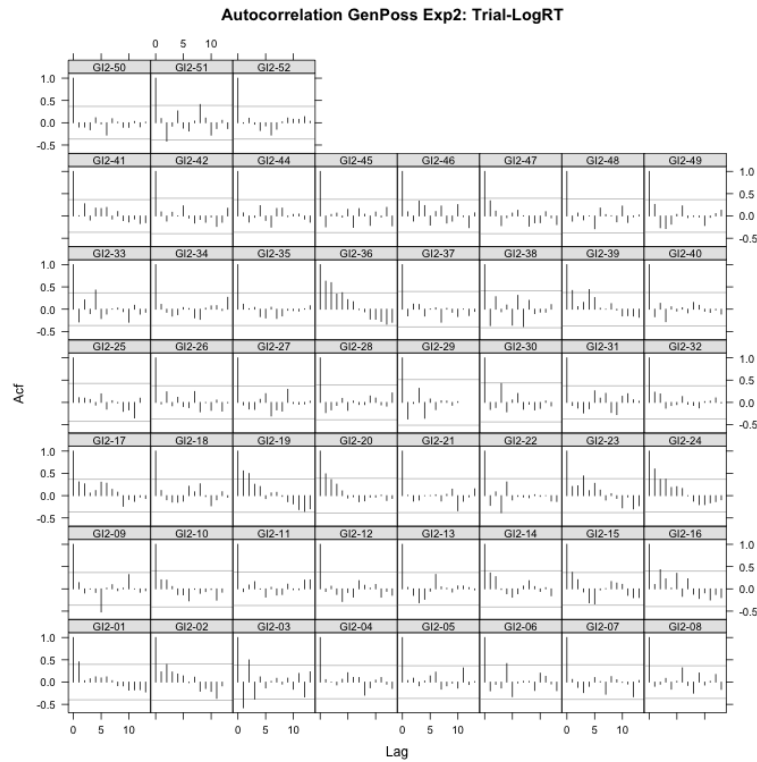
Density and Box and Whisker and Q-Q plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points.



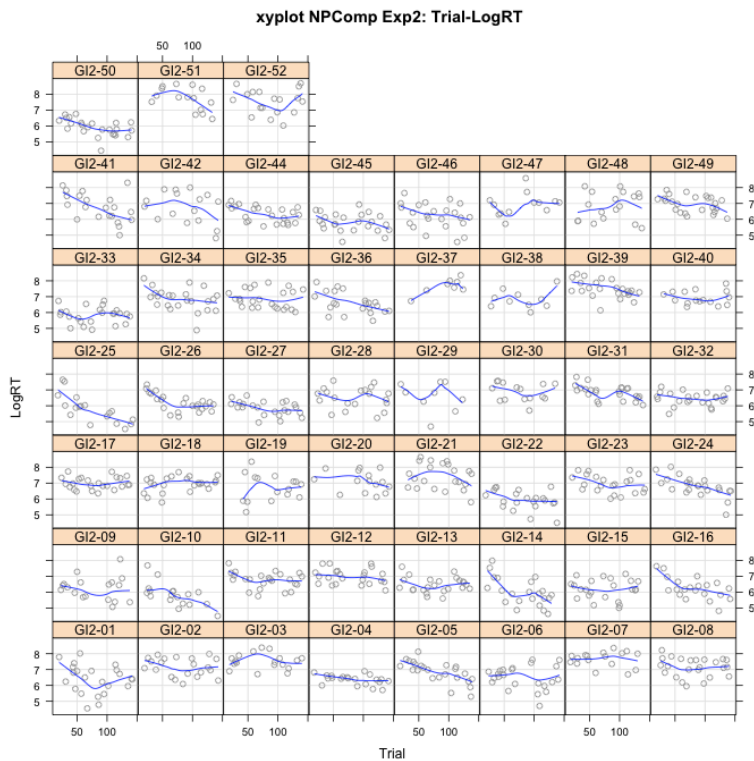
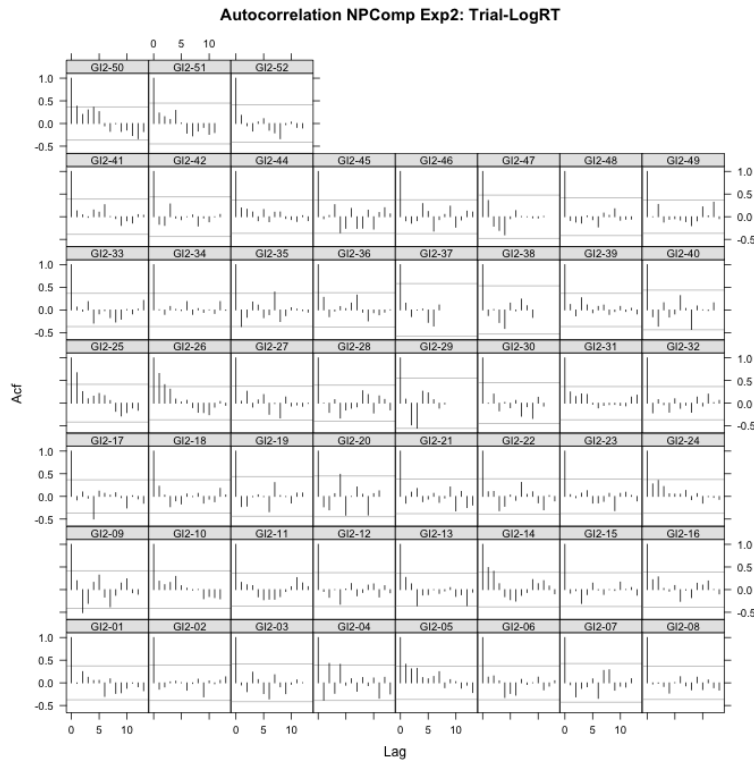
Density and Box and Whisker plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points for individual subjects and items.



C.7a Experiment 2B Autocorrelation and trellis graphs for RTs and Trials for Genitive Possessive Ambiguity.



C.7b Experiment 2B: Autocorrelation and trellis graphs for RTs and Trials for NP Compound Ambiguity.



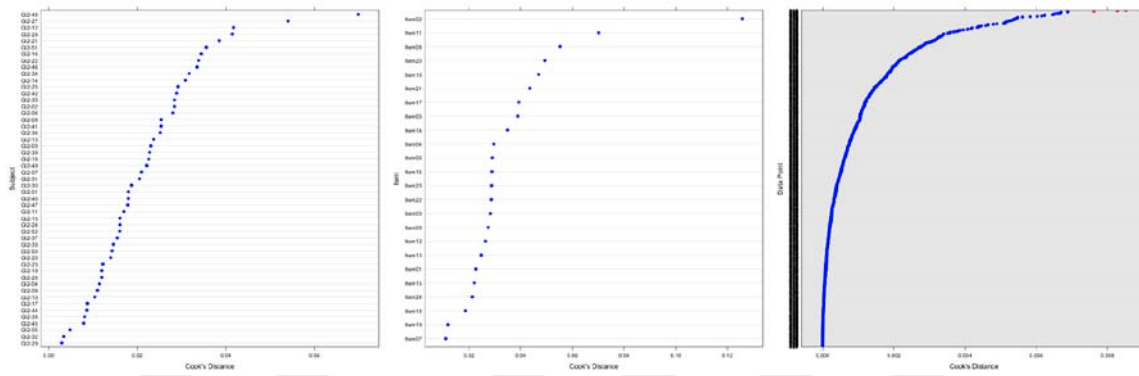
C.8a Experiment 2B: Genitive Possessive Ambiguity, model comparison table

Model	Fixed effects	df	Deviance	AIC	BIC	LR test		
						Comparison	X ² (df)	p
mod1	Trial, Prosody (re: subject)	9	2005	2023	2068	–	–	–
mod2	Trial, Syntax (re: subject)	8	2049	2105	2338	–	–	–
mod3	Trial, Prosody, Syntax (re: Trial, subject)	10	2004	2024	2074	mod1–mod3 mod2–mod3	.51(1) 44.64(2)	=.47 <.001
mod4	Trial, ProsodyXSyntax (re: Trial, subject)	12	2004	2028	2088	mod3–mod4	.24(3)	=.88

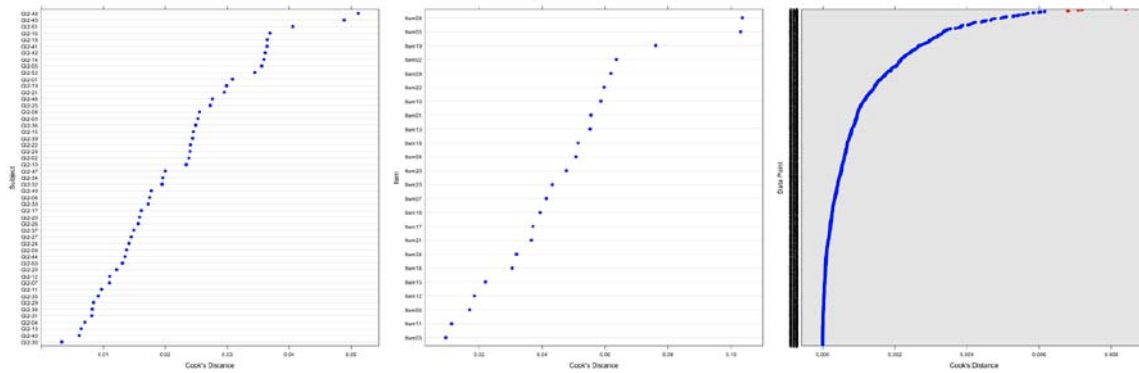
C.8.b Experiment 2B: NP Compound Ambiguity, model comparison table

Model	Fixed effects	df	Deviance	AIC	BIC	LR test		
						Comparison	X ² (df)	p
mod1	Trial, Prosody (re: subject)	9	2005	2023	2068	–	–	–
mod2	Trial, Syntax (re: subject)	8	2060	2076	2115	–	–	–
mod3	Trial, Prosody, Syntax (re: Trial, subject)	10	2005	2025	2074	mod1–mod3 mod2–mod3	.22(1) 54.88(2)	=.63 <.001
mod4	Trial, ProsodyXSyntax (re: Trial, subject)	12	1987	2011	2071	mod3–mod4	17.72(3)	<.001

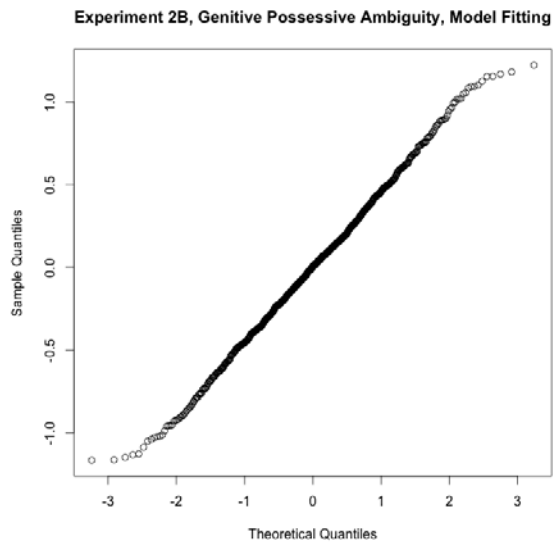
C.9a Experiment 2B, Gentive Possessive Ambiguity, Data plots for Influential Subjects, Items and Data Points



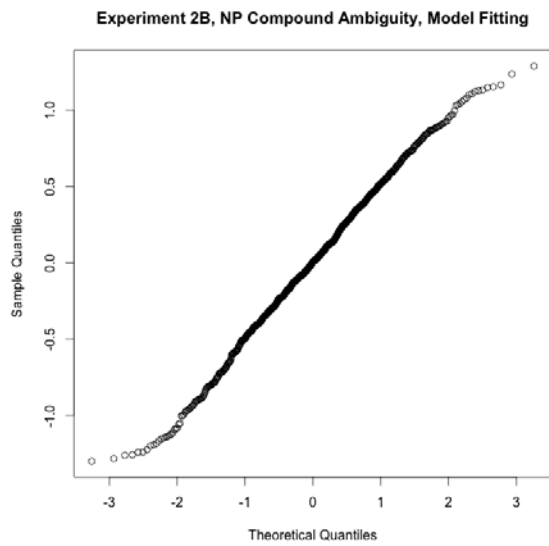
C.9b Experiment 2B, NP Compound Ambiguity, Data plots for Influential Subjects, Items and Data Points



C.10a Experiment 2B, Genitive Possessive Ambiguity, Q-Q Plots for Model Fitting



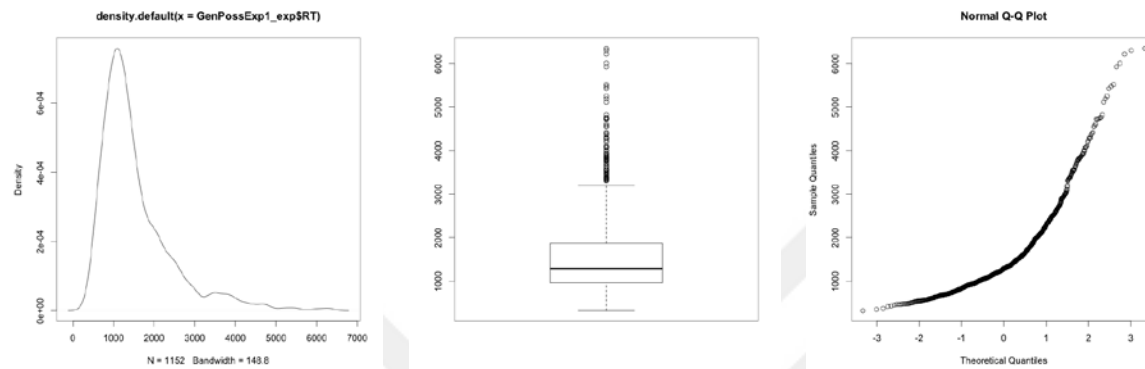
C.10b Experiment 2B, NP Compound Ambiguity, Q-Q Plots for Model Fitting



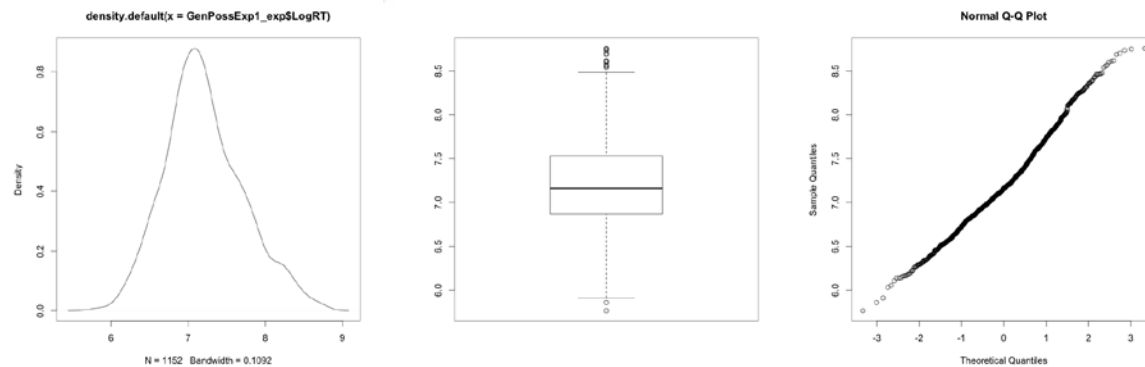
Appendix D: Additional Statistical Data Plots for Phoneme Restoration Experiments

D.1 Experiment 3A: Data Distribution Plots

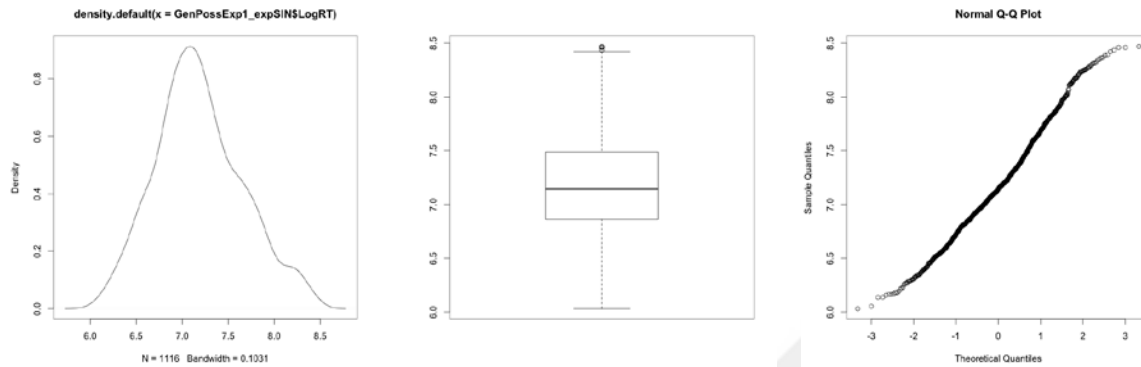
Density, Box and Whisker and Q-Q Plots illustrating raw data distribution.



Density, Box and Whisker and Q-Q Plots illustrating Log-transformed data distribution.

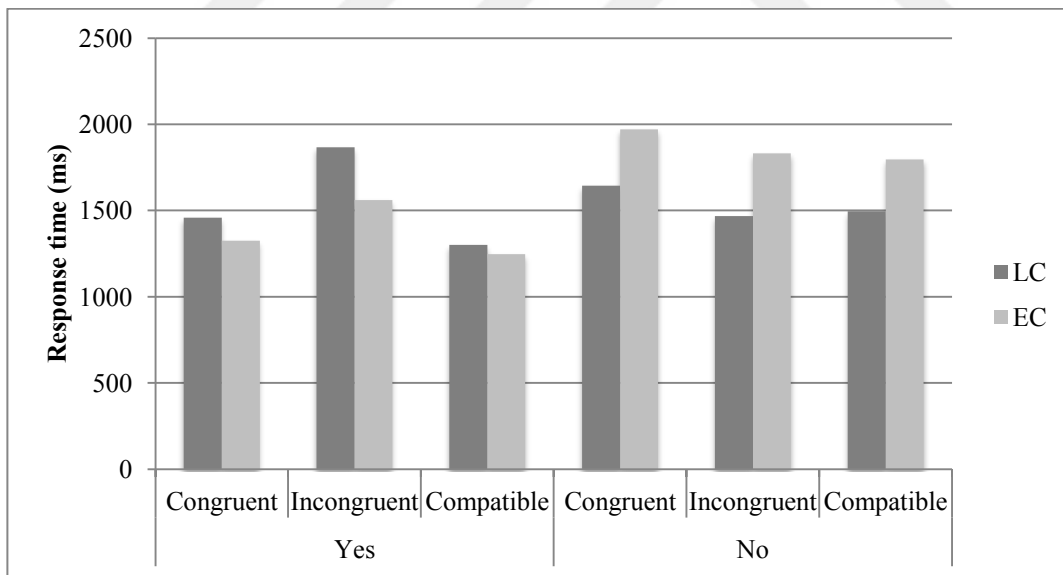


Density, Box and Whisker and Q-Q Plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points.

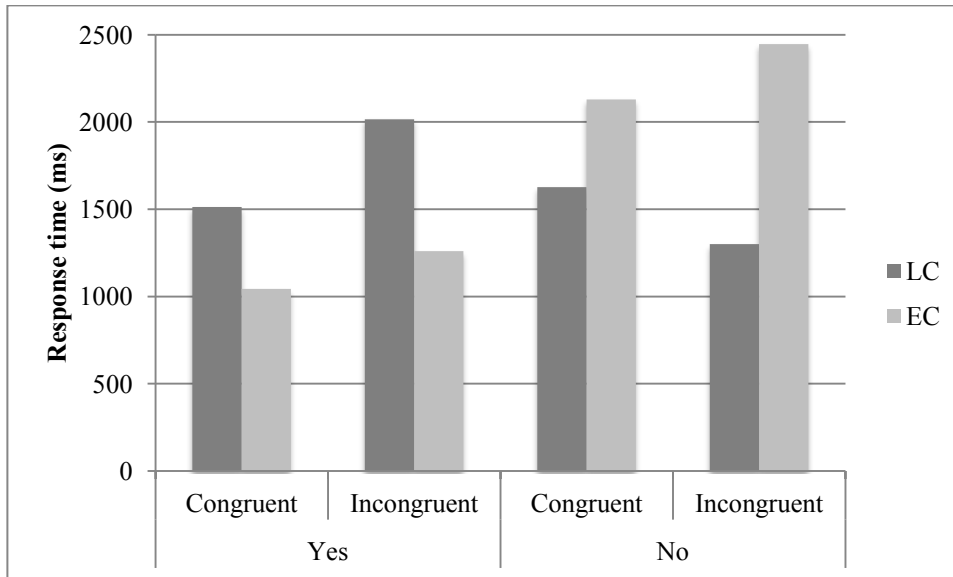


D.2 Experiment 3A: Experimental and Control Filler raw RTs, illustrating the EC ('active') bias in the data.

Experimental sentences raw RTs for congruent, incongruent or compatible probe with 'yes' and 'no' responses.



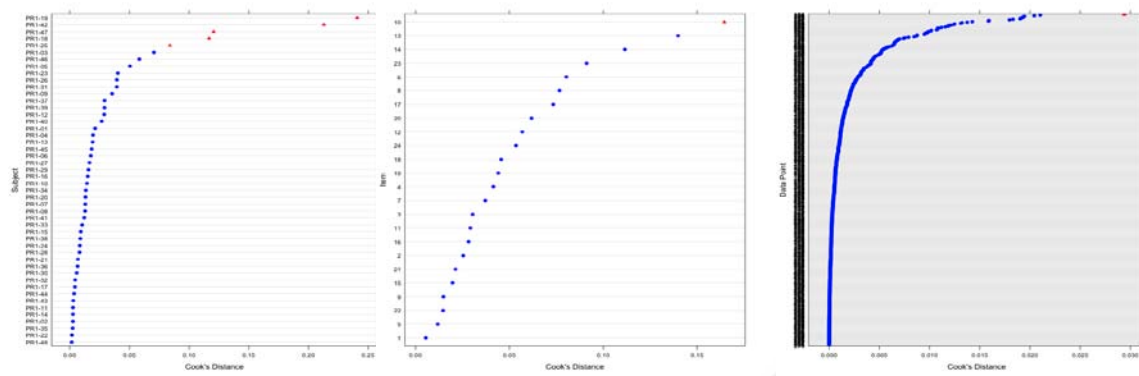
Control filler sentences raw RTs for congruent or incongruent probe with ‘yes’ and ‘no’ responses.



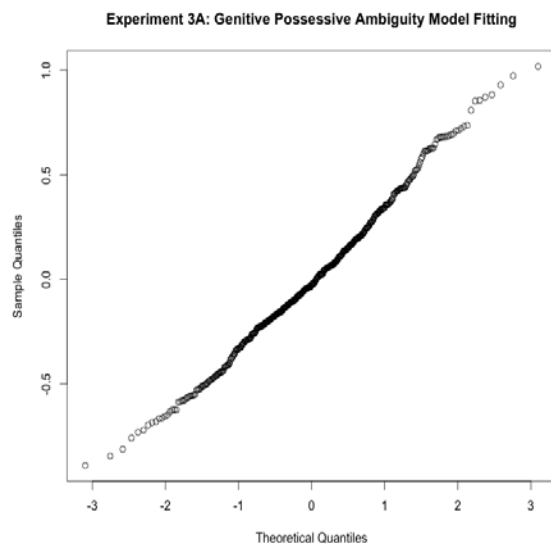
D.3 Experiment 3A: Model Comparison Table for RTs for ‘yes’ responses

Model	Fixed effects	df	Deviance	AIC	LR test			
					BIC	Comparison	$\chi^2(df)$	<i>p</i>
mod1	Trial, Control RT, Prosody (re: subject)	8	625	641	676	–	–	–
mod2	Trial, Control RT, Syntax (re: subject)	7	651	665	695	–	–	–
mod3	Trial, Control RT, Prosody, Syntax (re: subject)	9	624	642	681	mod1–mod3 mod2–mod3	1.13(3) 26.84(4)	=.28 <.001
mod4	Trial, Control RT, ProsodyXSyntax (re: subject)	11	613	635	683	mod3–mod4	10.94(4)	<.005

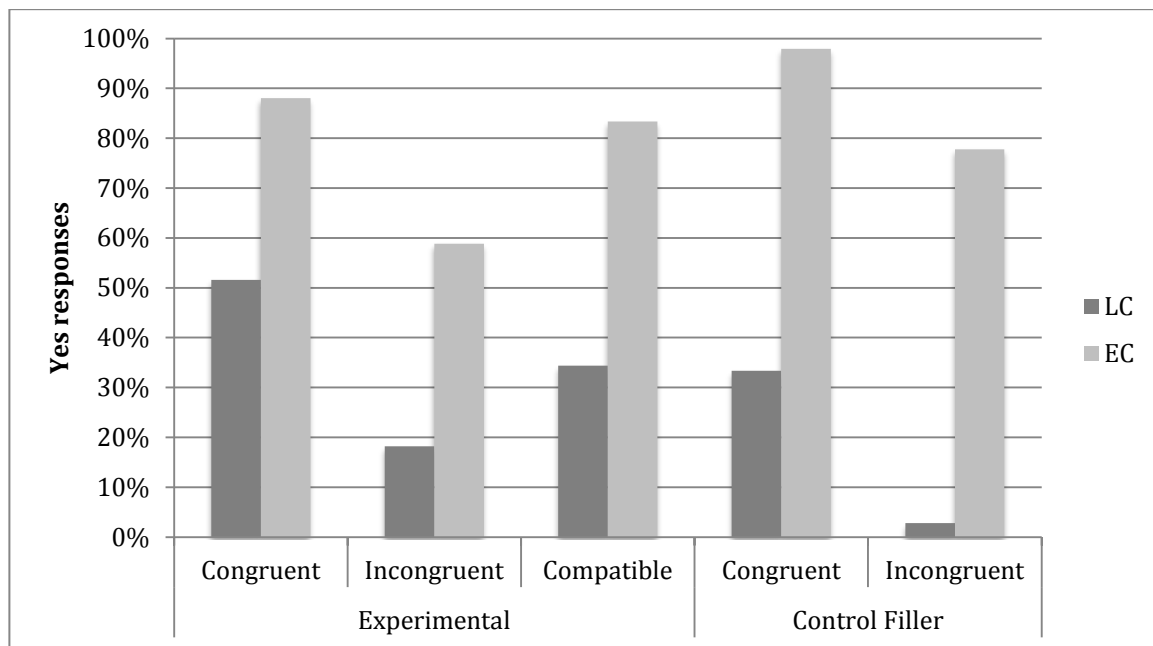
D.4 Experiment 3A: Data plots for influential subjects, items and data points.



D.5 Experiment 3A, Q-Q plot for model fitting.

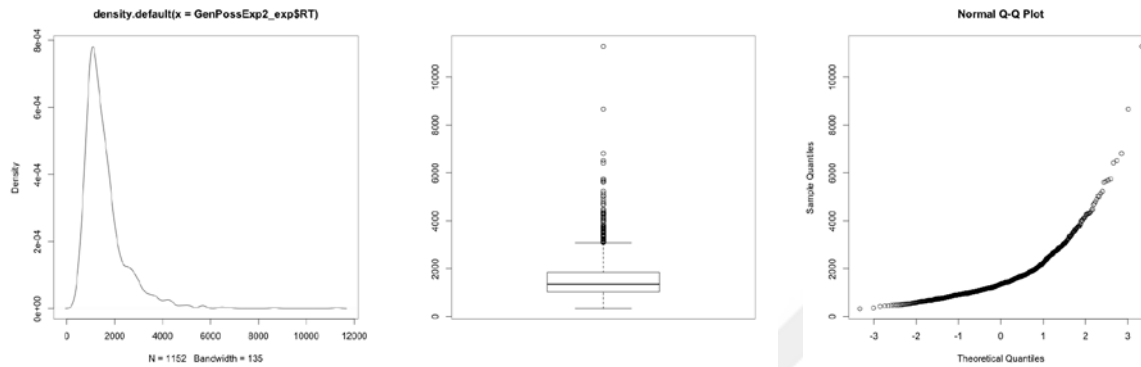


D.6 Experiment 3A: Raw percent ‘yes’ responses for control fillers and experimental sentences when the probe was congruent incongruent or compatible with the sentential prosody.

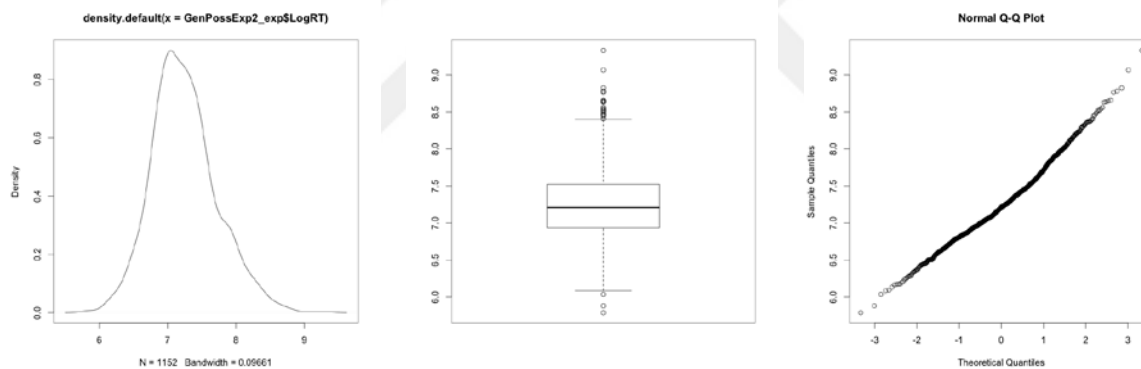


D.7 Experiment 3B: Data Distribution Plots

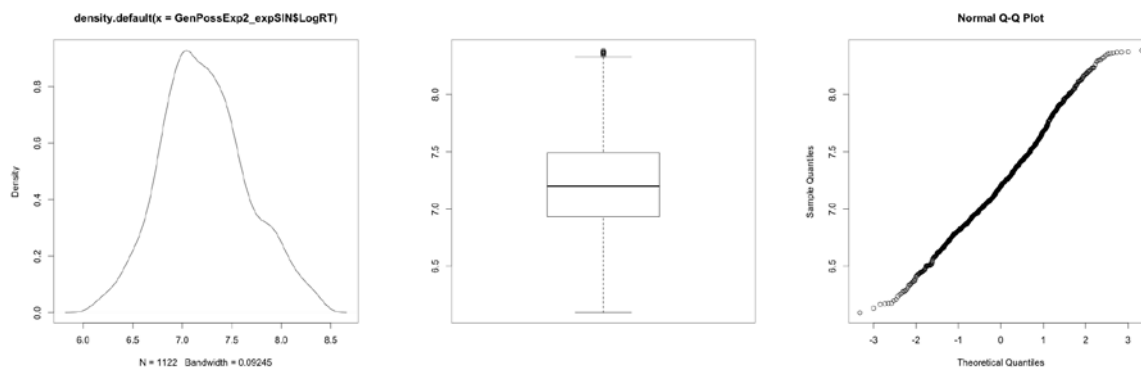
Density, Box and Whisker and Q-Q Plots illustrating raw data distribution.



Density, Box and Whisker and Q-Q Plots illustrating Log-transformed data distribution.

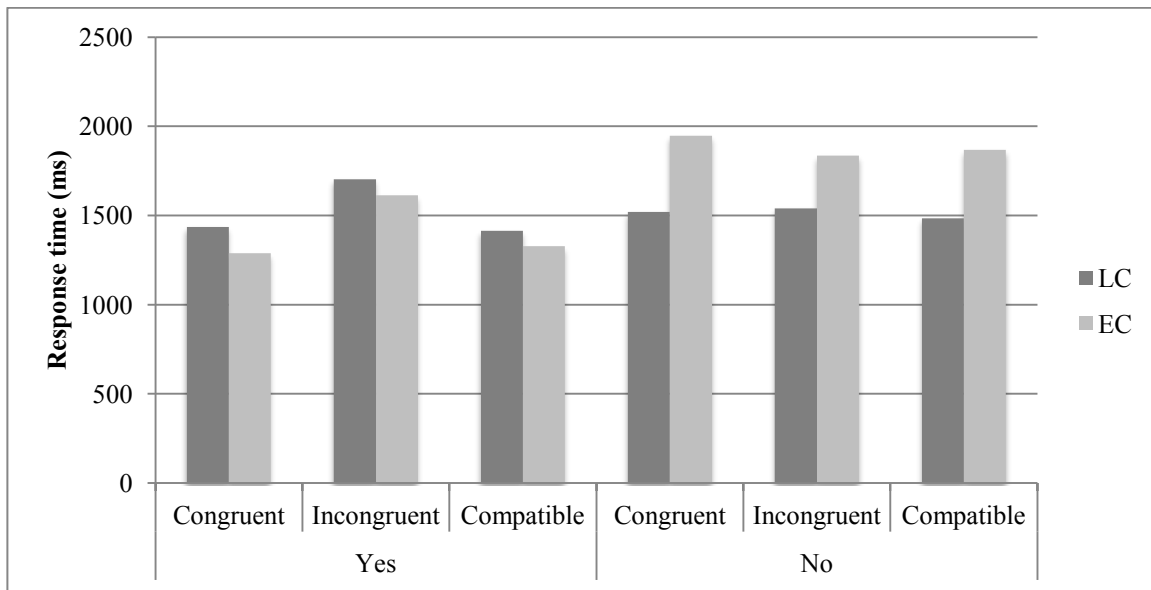


Density, Box and Whisker and Q-Q Plots illustrating Log-transformed data distribution, after deleting extreme and outlier data points.

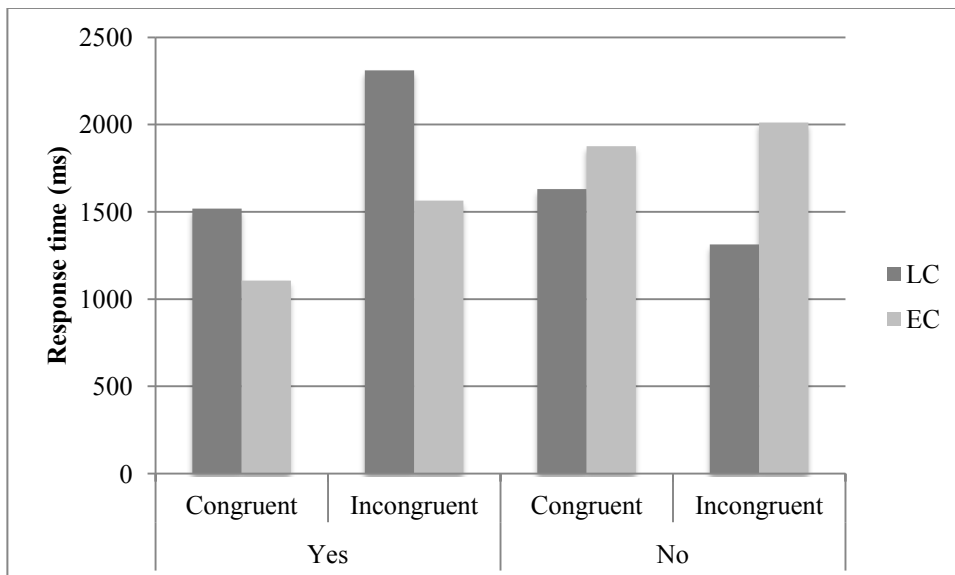


D.8 Experiment 3B: Experimental and Control Filler raw RTs, illustrating the EC ('active') bias in the data.

Experimental sentences raw RTs for congruent, incongruent or compatible probe with 'yes' and 'no' responses.



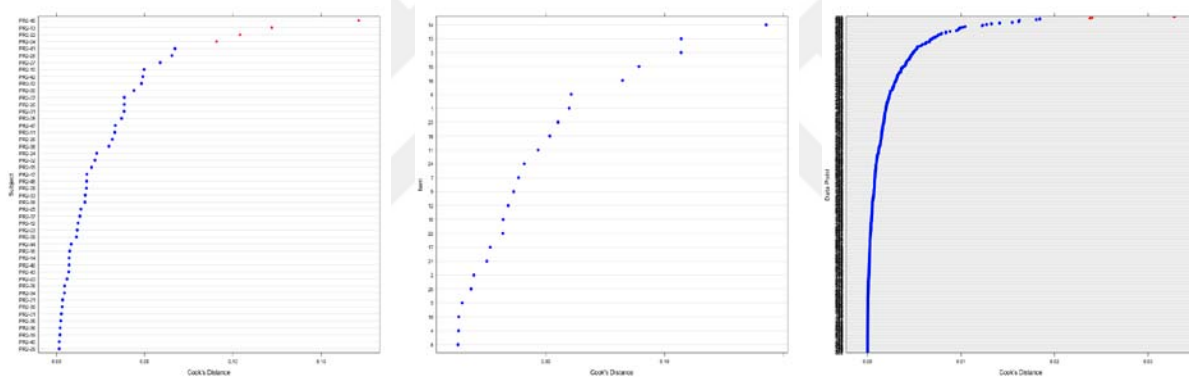
Control filler sentences raw RTs for congruent or incongruent probe with 'yes' and 'no' responses.



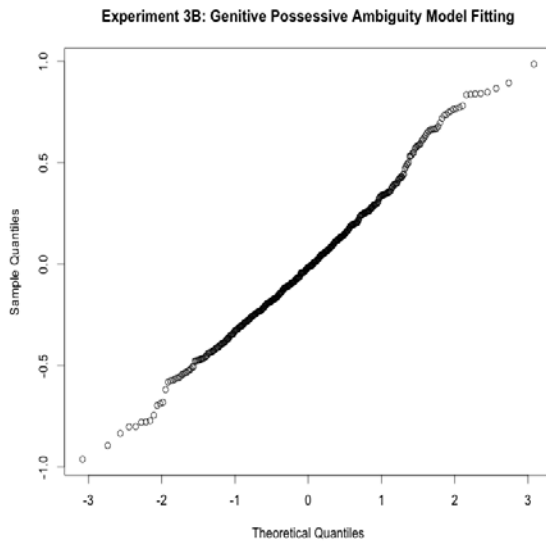
D.9 Experiment 3B: Model Comparison Table for RTs for ‘yes’ responses

Model	Fixed effects	df	Deviance	AIC	BIC	LR test		
						Comparison	$X^2(df)$	p
mod1	Trial, Control RT, Prosody (re: subject)	8	586	602	636	–	–	–
mod2	Trial, Control RT, Syntax (re: subject)	7	607	621	651	–	–	–
mod3	Trial, Control RT, Prosody, Syntax (re: subject)	9	585	603	641	mod1–mod3 mod2–mod3	0(1) 0(2)	=1 =1
mod4	Trial, Control RT, ProsodyXSyntax (re: subject)	11	613	635	683	mod3–mod4	40.63(2)	<.001

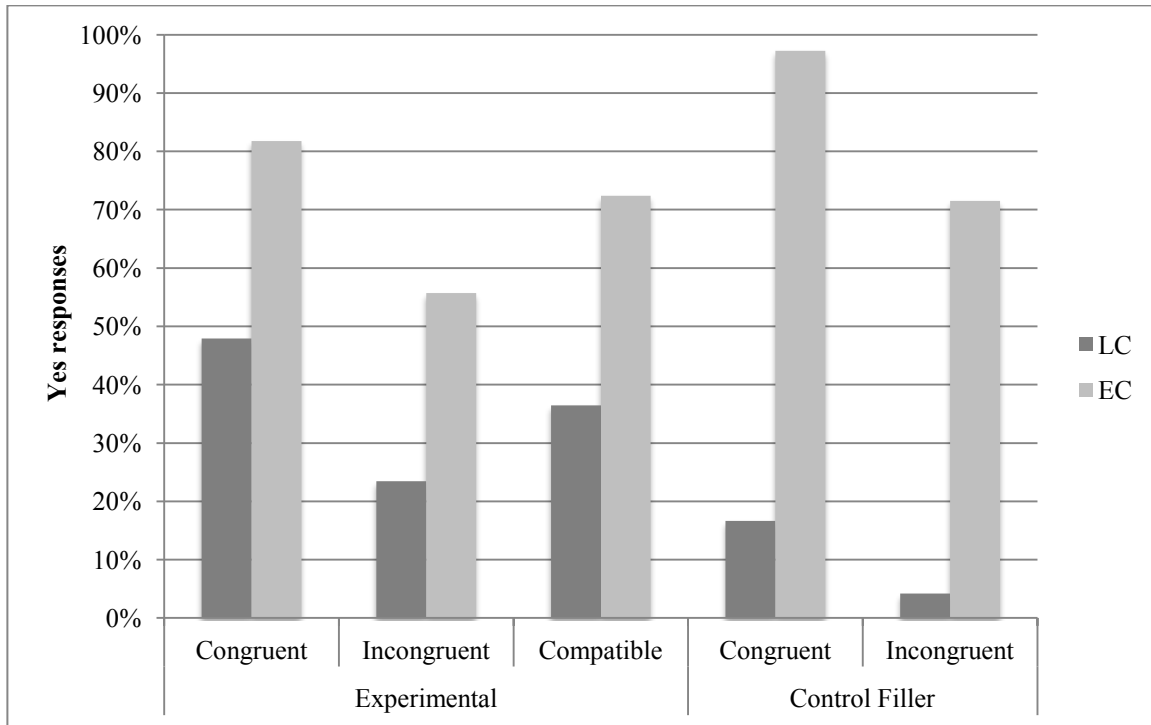
D.10 Experiment 3B, Data plots for influential subjects, items and data points.



D.11 Experiment 3B, Q-Q plot for model fitting



D.12 Experiment 3B: Raw percent 'yes' responses for control fillers and experimental sentences when the probe was congruent incongruent or compatible with the sentential prosody.



REFERENCES

- Altmann, G. T. M., van Nice, K. Y., Garnham, A., & Henstra, J. A. (1998). Late closure in context. *Journal of Memory and Language*, 38(4), 459-484. doi: 10.1006/jmla.1997.2562
- Augurzky, P. (2006). *Attaching relative clauses in German: The role of implicit and explicit prosody in sentence processing*. MPI Series in Human Cognitive and Brain Sciences (Vol. 77). Leipzig.
- Baayen, R. H. (2008). *Analyzing linguistic data: A practical introduction to statistics using R*. Cambridge: Cambridge University Press.
- Baayen, R. H. (2011). LanguageR: Data sets and functions with “Analyzing Linguistic data: A practical introduction to statistics”. R package version 1.4 (available at <http://cran.r-project.org/web/packages/languageR/languageR.pdf>).
- Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, 59, 390-412.
- Baayen, R. H., & Milin, P. (2010). Analyzing reaction times. *International Journal of Psychological Research*, 3(2), 12-28.
- Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, 68(3), 255-278. doi: <http://dx.doi.org/10.1016/j.jml.2012.11.001>
- Bashford, J., Riener, K., & Warren, R. (1992). Increasing the intelligibility of speech through multiple phonemic restorations. *Perception & Psychophysics*, 51(3), 211-217. doi: 10.3758/bf03212247
- Bashford, J., & Warren, R. (1987). Multiple phonemic restorations follow the rules for auditory induction. *Attention, Perception, & Psychophysics*, 42(2), 114-121. doi: 10.3758/bf03210499
- Bates, D., & Maechler, M. (2013). Linear mixed-effects models using S4 classes. R package version 0.999999-2 (available at <http://cran.r-project.org/web/packages/lme4/lme4.pdf>).
- Boersma, P., & Weenink, D. (2009). *Praat: doing phonetics by computer (Version 5.1.05)*. [Computer program]. Retrieved June 11, 2010, from <http://www.praat.org/>.
- Boyce, S. (1990). Coarticulatory organization for lip-rounding in Turkish and English. *Haskins Laboratories Status Report on Speech Research*, 99/100, 1-18.
- Breen, M., & Clifton, C. (2013). Stress matters revisited: A boundary change experiment. *Quarterly Journal of Experimental Psychology*, 66(10), 1896-1909.

- Cagri, I. M. (2009). Arguing against subject incorporation in Turkish relative clauses. *Lingua*, 119(2), 359-373. doi: <http://dx.doi.org/10.1016/j.lingua.2007.10.019>
- Carlson, K., Clifton, C., & Frazier, L. (2001). Prosodic boundaries in adjunct attachment. *Journal of Memory and Language*, 45(1), 58-81. doi: 10.1006/jmla.2000.2762
- Carlson, K., Clifton, C., & Frazier, L. (2009). Nonlocal effects of prosodic boundaries. *Memory & Cognition*, 37(7), 1014-1025. doi: 10.3758/mc.37.7.1014
- Clifton, C., Carlson, K., & Frazier, L. (2002). Informative prosodic boundaries. *Language and Speech*, 45(2), 87-114. doi: 10.1177/00238309020450020101
- Clifton, C., Carlson, K., & Frazier, L. (2006). Tracking the what and why of speakers' choices: Prosodic boundaries and the length of constituents. *Psychonomic Bulletin & Review*, 13(5), 854-861.
- Coulson, S., King, J. W., & Kutas, M. (1998). Expect the unexpected: Event-related brain response to morphosyntactic violations. *Language and Cognitive Processes*, 13(1), 21 - 58.
- Cuetos, F., & Mitchell, D. C. (1988). Cross-linguistic differences in parsing: Restrictions on the use of the Late Closure strategy in Spanish. *Cognition*, 30(1), 73-105. doi: 10.1016/0010-0277(88)90004-2
- De Vincenzi, M. (1991). *Syntactic parsing strategies in Italian*. Dordrecht: Kluwer Academic Publishers.
- Eckstein, K., & Friederici, A. D. (2006). It's early: Event-related potential evidence for initial interaction of syntax and prosody in speech comprehension. *Journal of Cognitive Neuroscience*, 18(10), 1696-1711. doi: 10.1162/jocn.2006.18.10.1696
- Erguvanli, E. E. (1984). *The function of word order in Turkish grammar*. Berkeley, CA: University of California Press.
- Ferreira, F., Anes, M. D., & Horine, M. D. (1996). Exploring the use of prosody during language comprehension using the auditory moving window technique. *Journal of Psycholinguistic Research*, 25(2), 273-290. doi: 10.1007/bf01708574
- Fodor, J. D. (1998). Learning to parse? *Journal of Psycholinguistic Research*, 27(2), 285-319. doi: 10.1023/a:1023258301588
- Fodor, J. D. (2002). Prosodic disambiguation in silent reading. In M. Hirotani (Ed.), *NELS 32* (pp. 112-132). Amherst, MA: GLSA Publications.
- Frazier, L. (1978). *On comprehending sentences: Syntactic parsing strategies*. (Unpublished doctoral dissertation). University of Connecticut.

- Frazier, L. (1987). Sentence processing: A tutorial review. In M. Colthart (Ed.), *Attention and performance XII: The psychology of reading*. Hillsdale, N.J.: Lawrence Erlbaum Associates.
- Frazier, L., Carlson, K., & Clifton, J. C. (2006). Prosodic phrasing is central to language comprehension. *Trends in Cognitive Sciences*, 10(6), 244-249. doi: 10.1016/j.tics.2006.04.002
- Frazier, L., Clifton, C., & Randall, J. (1983). Filling gaps: Decision principles and structure in sentence comprehension. *Cognition*, 13(2), 187-222. doi: 10.1016/0010-0277(83)90022-7
- Frazier, L., & Fodor, J. D. (1978). The sausage machine: A new two-stage parsing model. *Cognition*, 6(4), 291-325. doi: 10.1016/0010-0277(78)90002-1
- Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, 14(2), 178-210. doi: 10.1016/0010-0285(82)90008-1
- Frazier, L., & Rayner, K. (1987). Resolution of syntactic category ambiguities: Eye movements in parsing lexically ambiguous sentences. *Journal of Memory and Language*, 26(5), 505-526. doi: 10.1016/0749-596X(87)90137-9
- Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences*, 6(2), 78-84. doi: 10.1016/S1364-6613(00)01839-8
- Gee, J. P., & Grosjean, F. (1983). Performance structures: A psycholinguistic and linguistic appraisal. *Cognitive Psychology*, 15(4), 411-458. doi: 10.1016/0010-0285(83)90014-2
- Ghini, M. (1993). Ø-formation in Italian: A new proposal. In C. Dyck (Ed.), *Toronto Working Papers in Linguistics* (Vol. 12 (2), pp. 41-78): Department of Linguistics, University of Toronto.
- Gilboy, E., Sopena, J.-M., Clifton, C., & Frazier, L. (1995). Argument structure and association preferences in Spanish and English complex NPs. *Cognition*, 54(2), 131-167. doi: 10.1016/0010-0277(94)00636-y
- Göksel, A., & Kerslake, C. (2005). *Turkish: A comprehensive grammar*. New York: Routledge.
- Gürcanlı, Ö., Nakipoğlu, M., & Özyürek, A. (2007) Shared information and argument omission in Turkish. *Proceedings of the 31st Annual Boston University Conference on Language Development*. Somerville, MA: Cascadilla Press.
- Inkelas, S., & Orgun, C. O. (2003). Turkish stress: A review. *Phonology*, 20(1), 139-161.
- İşsever, S. (2003). Information structure in Turkish: The word order-prosody interface. *Lingua*, 113(11), 1025-1053. doi: 10.1016/s0024-3841(03)00012-3

- Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*, 99(1), 122-149. doi: 10.1037/0033-295X.99.1.122
- Kabak, B., & Vogel, I. (2001). The phonological word and stress assignment in Turkish. *Phonology*, 18(3), 315-360.
- Kamali, B. (2008). Scope of negation and phonological phrasing in Turkish *Paper presented at Mediterranean Syntax Meeting II (MSM-II)*. Boğaziçi University.
- Kan, S. (2009). *Prosodic domains and syntax prosody mapping in Turkish*. (Unpublished master's thesis). Boğaziçi University, Istanbul.
- Kimball, J. (1973). Seven principles of surface structure parsing in natural language. *Cognition*, 2(1), 15-47. doi: 10.1016/0010-0277(72)90028-5
- Kjelgaard, M. M., & Speer, S. R. (1999). Prosodic facilitation and interference in the resolution of temporary syntactic closure ambiguity. *Journal of Memory and Language*, 40(2), 153-194. doi: 10.1006/jmla.1998.2620
- Kornfilt, J. (1984). *Case marking, agreement, and empty categories in Turkish*. Unpublished Ph.D. Dissertation, Harvard University.
- Kornfilt, J. (1997). *Turkish*. New York, NY: Routledge.
- Kornfilt, J. (2011). The sentential subject constraint/CED as a left-dislocation constraint in Turkish. *Proceedings of the 7th Workshop on Altaic Formal Linguistics (WAFL 7)* 203-219.
- Kraljic, T., & Brennan, S. E. (2005). Prosodic disambiguation of syntactic structure: For the speaker or for the addressee? *Cognitive Psychology*, 50(2), 194-231. doi: <http://dx.doi.org/10.1016/j.cogpsych.2004.08.002>
- Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: brain potentials reflect semantic incongruity. *Science*, 207, 203-205.
- Lehiste, I. (1973). Phonetic disambiguation of syntactic ambiguity. *Glossa*, 7, 107-122.
- Levi, S. V. (2002a). *Intonation in Turkish: the realization of noun compounds and genitive possessive NPs*. . Unpublished manuscript, University of Washington.
- Levi, S. V. (2002b). Limitations on tonal crowding in Turkish. In *Phonologica: 9th international phonology conference*.
- Lovrić, N. (2003). *Implicit prosody in silent reading: Relative clause attachment in Croatian*. Doctoral dissertation. City University of New York, NY.

- Magen, H. S. (1997). The extent of vowel-to-vowel coarticulation in English. *Journal of Phonetics*, 25(2), 187-205. doi: <http://dx.doi.org/10.1006/jpho.1996.0041>
- Marslen-Wilson, W. D., Tyler, L. K., Warren, P., Grenier, P., & Lee, C. S. (1992). Prosodic effects in minimal attachment. *The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, 45(1), 73 - 87.
- Nagel, H. N., Shapiro, L. P., Tuller, B., & Nawy, R. (1996). Prosodic influences on the resolution of temporary ambiguity during on-line sentence processing. *Journal of Psycholinguistic Research*, 25(2), 319-344. doi: 10.1007/bf01708576
- Nash, R. (1973). *Turkish intonation*. Paris: Mouton, the Hague.
- Ng, S., & Fodor, J. D. (2011). Use your headedness: an exercise in psycholinguistic exploitation. In H. Yamashita, Y. Hirose & J. L. Packard (Eds.), *Processing and producing head-final structures*. London, New York: Springer Science+Business Media B. V. .
- Nieuwenhuis, R., te Grotenhuis, M., & Pelzer, B. (2012). influence.ME: Tools for detecting influential data in mixed effects models. *The R Journal*, 4(2), 38-47.
- Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language*, 31(6), 785-806. doi: 10.1016/0749-596X(92)90039-Z
- Özçelik, Ö., & Nagai, M. (2011). Multiple subject positions: A case of perfect match between syntax and prosody. In M. B. Washburn, K. McKinney-Bock, E. Varis, A. Sawyer & B. Tomaszewicz (Eds.), *Proceedings of the 28th West Coast Conference on Formal Linguistics* (pp. 303-312). Somerville, MA: Cascadia Proceedings Project.
- Öztürk, B. (2002). Turkish as a non-pro-drop language. In E. E. Taylan (Ed.), *The verb in Turkish* (pp. 239-259). Philadelphia, PA, USA: John Benjamins Publishing Company.
- Öztürk, B. (2005). *Case, referentiality and phrase structure*. Amsterdam: John Benjamins.
- Pauker, E., Itzhak, I., Baum, S. R., & Steinhauer, K. (2011). Effects of cooperating and conflicting prosody in spoken English garden path sentences: ERP evidence for the Boundary Deletion Hypothesis. *Journal of Cognitive Neuroscience*, 23(10), 2731-2751. doi: 10.1162/jocn.2011.21610
- Powers, G. L., & Wilcox, J. C. (1977). Intelligibility of temporally interrupted speech with and without intervening noise. *The Journal of the Acoustical Society of America*, 61(1), 195-199. doi: <http://dx.doi.org/10.1121/1.381255>
- Price, P. J., Ostendorf, M., Shattuck-Hufnagel, S., & Fong, C. (1991). The use of prosody in syntactic disambiguation. *The Journal of the Acoustical Society of America*, 90(6), 2956-2970.

- Pynte, J. (2006). Phrasing effects in comprehending PP constructions. *Journal of Psycholinguistic Research*, 35(3), 245-265. doi: 10.1007/s10936-006-9014-y
- R Core Team. (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.
- Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin*, 114(3), 510-532.
- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods (2nd ed.)*. Thousand Oaks, CA: Sage Publications.
- Rayner, K., & Frazier, L. (1987). Parsing temporarily ambiguous complements. *The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, 39(4), 657 - 673.
- Sak, H., Güngör, T., & Saraçlar, M. (2008). Turkish language resources: Morphological parser, morphological disambiguator and web corpus. *GoTAL*, 5221, 417-427.
- Sandalo, F., & Truckenbrodt, H. (2002). Some notes on phonological phrasing in Brazilian Portuguese. *MIT Working Papers in Linguistics*, 42, 285-310.
- Schafer, A. J., Speer, S. R., Warren, P., & White, S. D. (2000). Intonational disambiguation in sentence production and comprehension. *Journal of Psycholinguistic Research*, 29(2), 169-182.
- Selkirk, E. (1984). *Phonology and syntax: The relation between sound and structure*. Cambridge: MIT Press.
- Selkirk, E. (2000). The interaction of constraints on prosodic phrasing. In M. Horne (Ed.), *Prosody: theory and experiment* (pp. 231-262). Dordrecht: Kluwer Academic Publishing.
- Selkirk, E. (2011). The syntax-phonology interface. In J. Goldsmith, J. Riggle & A. Yu (Eds.), *The Handbook of phonological theory*. Oxford: Blackwell.
- Snedeker, J., & Trueswell, J. (2003). Using prosody to avoid ambiguity: Effects of speaker awareness and referential context. *Journal of Memory and Language*, 48(1), 103-130. doi: [http://dx.doi.org/10.1016/S0749-596X\(02\)00519-3](http://dx.doi.org/10.1016/S0749-596X(02)00519-3)
- Snijders, T. A. B., & Bosker, R. J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling (2nd ed.)*. Los Angeles: Sage.
- Speer, S. R., Kjelgaard, M. M., & Dobroth, K. M. (1996). The influence of prosodic structure on the resolution of temporary syntactic closure ambiguities. *Journal of Psycholinguistic Research*, 25(2), 249-271. doi: 10.1007/bf01708573

- Steinhauer, K., Alter, K., & Friederici, A. D. (1998). Don't blame it (all) on the pause: Further ERP evidence for a prosody-induced garden path in running speech. *Proceedings of the 5th International Conference on Spoken Language Processing* (Vol. 5, pp. 2187–2190). Canberra: Australian Speech Science and Technology Association (ASSTA).
- Steinhauer, K., Alter, K., & Friederici, A. D. (1999). Brain responses indicate immediate use of prosodic cues in natural speech processing. *Nature Neuroscience*, 2, 191-196.
- Steinhauer, K., & Friederici, A. D. (2001). Prosodic boundaries, comma rules, and brain responses: The closure positive shift in ERPs as a universal marker for prosodic phrasing in listeners and readers. *Journal of Psycholinguistic Research*, 30(3), 267-295. doi: 10.1023/a:1010443001646
- Stoyneshka, I., Fodor, J. D., & Fernández, E. M. (2010). Phoneme restoration methods for investigating prosodic influences on syntactic processing. *Language and Cognitive Processes*, 25(7), 1265-1293.
- Swinney, D., Ford, M., Frauenfelder, U. H., & Bresnan, J. (1988). On the temporal course of gap-filling and antecedent assignment during sentence comprehension. In B. Grosz., R. Kaplan, M. Macken & I. Sag (Eds.), *Language structure and processing*. Stanford, CA: CSLI.
- Tanenhaus, M. K., Garnsey, S. M., & Boland, J. (1990). Combinatory lexical information and language comprehension. In G. Altmann (Ed.), *Cognitive models of speech processing: Computational and psycholinguistic perspectives* (pp. 383-408). Cambridge, MA: MIT Press.
- Truckenbrodt, H. (1995). *Phonological phrases: Their relation to syntax, focus and prominence*. Unpublished doctoral dissertation. MIT. Cambridge, MA.
- Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language*, 33(3), 285-318. doi: 10.1006/jmla.1994.1014
- Tunley, A. (1999). *Coarticulatory influences of liquids on vowels in English*. Unpublished Ph.D. Dissertation. King's College, University of Cambridge. Cambridge.
- Vallduví, E., & Engdahl, E. (1996). The linguistic realization of information packaging. *Linguistics*, 34(3), 459-519.
- Warren, R. (1970). Perceptual restoration of missing speech sounds. *Science*, 167(3917), 392-393.
- Warren, R., & Sherman, G. (1974). Phonemic restorations based on subsequent context. *Attention, Perception, & Psychophysics*, 16(1), 150-156. doi: 10.3758/bf03203268

- Watson, D., & Gibson, E. (2004). The relationship between intonational phrasing and syntactic structure in language production. *Language & Cognitive Processes*, 19(6), 713-755.
- Watt, S. M., & Murray, W. S. (1996). Prosodic form and parsing commitments. *Journal of Psycholinguistic Research*, 25(2), 291-318. doi: 10.1007/bf01708575
- Webman Shafran, R. (2011). *Prosody and parsing in a double PP construction in Hebrew*. Ph.D. 3491137, City University of New York, United States -- New York. Retrieved from <http://ezproxy.gc.cuny.edu/login?url=http://search.proquest.com/docview/918686869?accountid=7287> Dissertations & Theses @ City University of New York Graduate Center; ProQuest Dissertations & Theses (PQDT) database.

