# PHONEME RESTORATION METHODS REVEAL PROSODIC INFLUENCES ON SYNTACTIC PARSING: DATA FROM BULGARIAN

by

IGLIKA STOYNESHKA-RALEVA

A dissertation submitted to the Graduate Faculty in Linguistics in partial fulfillment
of the requirements for the degree of Doctor of Philosophy,

The City University of New York

2013

This manuscript has been read and accepted for the
Graduate Faculty in Linguistics in satisfaction of the
dissertation requirement for the degree of Doctor of Philosophy.

Janet Dean Fodor

Date

Chair of Examining Committee

Gita Martohardjono

Date

Executive Officer

Eva M. Fernández

Irina A. Sekerina

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

## ABSTRACT

# PHONEME RESTORATION METHODS REVEAL PROSODIC INFLUENCES ON SYNTACTIC PARSING: DATA FROM BULGARIAN

by

Iglika Stoyneshka-Raleva

Adviser: Professor Janet Dean Fodor

This dissertation implements and evaluates a new methodology for studying aspects of human language processing and the factors to which it is sensitive. It makes use of the phoneme restoration illusion (Warren, 1970): listeners are convinced that they are hearing an uninterrupted speech stream even though a portion of it is actually replaced by noise. Phoneme restoration is used here to explore the role of prosodic phrasing, specifically the location of a major prosodic break on the interpretation of a sentence where no other type of disambiguation remains.

Two target constructions in Bulgarian are investigated in a series of experiments, using the same basic materials: NP/S coordination in (1) and RC attachment in (2). The target items are originally disambiguated by morphological agreement: number agreement between subject and verb in (1) and gender agreement between the head noun and the relative pronoun in (2). Each pair of sentences differs in one word where the morphological disambiguation is encoded.

(1) a.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Ani | **‖** | i | Ivan | i | Mimi | **biaha** | vav vaztorg. |
| In the end | meet-past-1p.pl | Ani | | and | Ivan | and | Mimi | were | in ecstasy |

‘In the end, we met Ani and Ivan and Mimi were in ecstasy.’

b.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Ani | i | Ivan | \|\| | I | Mimi | **beše** | vav vaztorg. |
| In the end | meet-past-1p.pl | Ani | and | Ivan | | and | Mimi | was | in ecstasy |

'In the end, we met <u>Ani and Ivan</u> and Mimi was in ecstasy.'

(2) a.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Podtseniha | advokata \|\| | na | pevitsata | **koiato** | kupi | imenieto. |
| underestimate-past | lawyer-m | of | singer-f | who-f | buy-past | estate-det |

'(They) underestimated the lawyer of the singer who$_{=N2}$ bought the estate.'

b.

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata | na | pevitsata \|\| | **kojto** | kupi | imenieto. |
| underestimate-past | lawyer-m | Of | singer-f | who-m | buy-past | estate-det |

'(They) underestimated the lawyer of the singer who$_{=N1}$ bought the estate.'

In addition to morphological agreement, the alternative structures for both (1) and (2) are also disambiguated by the location of a major prosodic break. For the NP/S coordination the prosodic boundary coincides with the end of the first clause, so that a boundary after the first noun (1a) signals that only that noun (*Ani*) belongs in the first clause as an object of the first clause verb, while the other two nouns (*Ivan & Mimi*) form a coordinate subject in the second clause, whereas a boundary after the second noun (1b) signals that the first two nouns (*Ani & Ivan*) form a coordinate object in the first clause (1b) and the third noun (*Mimi*) is the subject of the second clause. For the RC attachment, placing a boundary after the first noun (2a) indicates that the RC modifies the second noun ('singer'), whereas placing a boundary after the second noun (2b) indicates that it should modify the first noun ('lawyer').

The morphological disambiguation is removed from the stimuli by replacing the phonemes that encode the morphological agreement and parts of the surrounding phonemes with white noise. Each pair of sentences becomes segmentally identical (and thus globally ambiguous). However, the distinct prosodic contour for each is preserved and is now the only cue to the intended structure. What phonemes are restored by participants indicates the structure they have assigned to the sentence by the agreement features assigned on the noise-containing word. The advantage of the PR method is that it is completely natural and unobtrusive, like normal listening, drawing no attention to the presence of ambiguity. Participants concentrate on hearing the sentence despite the occasional noise, just as in everyday situations.

Three different response tasks are employed: a visual word choice task in which participants indicate which of two words they have ‘heard’ in the stimulus sentence (Experiments 1a-c), a sentence repetition task in which participants repeat back the sentence after hearing it (Experiment 2a-b), and a sentence shadowing tasks in which participants repeat back the sentence as they are listening to it (Experiments 3a-b). In each, the phoneme restoration data obtained indicated that prosodic boundary location provided viable disambiguation of syntactic structure. However, the effect of prosody differed for the two constructions. Both prosodic contours disambiguated NP/S coordination equally well, but a break after the first noun was a stronger structural cue for RC attachment than a break after the second noun. The data on Bulgarian comported well with findings of prosodic effects in coordination and RC attachment interpretation in other languages.

The same target constructions are investigated further, using visual (written) stimuli identical to the auditory stimuli with an ‘ink blot’ obliterating morphological agreement. Different visual presentations are used to mimic the prosodic phrasing in speech and two tasks are employed: silent reading with visual word choice (Experiments 4a-b) and silent reading with sentence repetition (Experiments 5a-b). Visual grouping disambiguated NP/S coordination quite effectively, but had little impact on RC attachment interpretation.

**ACKNOWLEDGEMENTS**

I would like to thank first and foremost my dissertation adviser, Dr. Janet Dean Fodor who provided insightful guidance and support through the long process of conducting my research and writing the dissertation. I am truly appreciative of her endless patience and her constant encouragement.

She generously shared her vast knowledge and expertise and was a source of ideas and inspiration at every stage. She gave me advice and positive attitude, and she even gave me the right words sometimes. She always listened and she gave me opportunities to share my work.

I am deeply grateful to the members of my committee, who took valuable time from their busy schedules to offer advice and help. I am indebted to Dr. Eva Fernández for teaching me about experimental design and helping me in my first attempts. Without her I would not have been able to prepare my experiments and she was extremely nice helping me sense of the data I have collected. I am thankful to Dr. Irina Sekerina for her positive impact on my writing. Her helpful suggestions and constructive criticism incited me to reorganize and streamline the dissertation.

I am also grateful to other members of the faculty at the Linguistics program of the CUNY Graduate Center, in particular Dr. Gita Martohardjono, who as the Executive officer gave me an opportunity to finish this dissertation.

Finally, I would like to thank my family for being there for me: my husband who gave me his love and support when I was struggling through and our two beautiful children who were a constant distraction but ultimately an inspiration to go on.

**TABLE OF CONTENTS**

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER 1
# AMBIGUITY RESOLUTION AND THE ROLE OF PROSODY

## 1.1. Syntactic ambiguity resolution

One of the central areas of interest in psycholinguistics and sentence processing research in particular is ambiguity resolution, i.e. what happens when more than one possible interpretation can be assigned to incoming linguistic material, and why a particular interpretation takes precedence over the other possible one. Different specific versions of these two broad questions (e.g. whether incoming words tend to be attached high or low in the syntactic tree; what determines these preferences) have fueled prolific research. Answering them can bring us closer to understanding how the human mind is able to comprehend the complex structures of natural languages.

Empirical data on which is the initially preferred interpretation of an ambiguous string of words can indicate which structures the human sentence processing mechanism finds easy and which ones difficult, thereby allowing psycholinguists to generate hypotheses about its architecture and mode of operation. For example, the sentence in (1) below is temporarily ambiguous, i.e. the structure is ambiguous up to a certain point (*italicised*) but is disambiguated by a word (bold font) encountered at a later point in the string. The sentence in (2) is globally ambiguous, i.e. two distinct interpretations of the entire string are possible.

(1) While Mary was reading *the letter* **fell** on the floor.

(2) He saw the girl *with the binoculars*.

a. He saw the girl by using the binoculars.
b. He saw the girl who had the binoculars.

In (1), when the noun phrase ‘the letter’ is encountered, it can be interpreted as the object of the verb ‘reading’ (which is optionally transitive). But if this interpretation is maintained, the second clause will lack a subject which will make it ungrammatical in English, a language that requires an overt subject. Experiments on the resolution of this ambiguity have shown that indeed the post-verbal noun phrase in sentences like (1) is typically initially interpreted as a direct object of the first-clause verb, as is revealed by increased processing difficulty when the disambiguating second-clause verb (in this case ‘fell’) is encountered.

The sentence in (2), on the other hand does not involve recovery or reanalysis, because it can legitimately be interpreted as either (a) or (b). In the first case the prepositional phrase (PP) ‘with the binoculars’ is taken to modify the verb ‘saw’ which can take an instrumental adjunct headed by ‘with’, in the second case it is taken to modify the noun phrase (NP) headed by ‘the girl’. However, the VP attachment (2a) seems to be preferred.

Different explanations of such data have been proposed, based on different assumptions about the human language processing mechanism. In the Garden-path Model of sentence processing (Frazier and Fodor, 1978) these findings are viewed as instantiations of two basic structural principles: Late Closure and Minimal Attachment.

**Late Closure** was formulated by Frazier (1987) as follows “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: 562)

**Minimal Attachment** was first proposed in Frazier & Fodor (1978) to stipulate that “each lexical item (or other node) is to be attached into the phrase marker with the fewest possible number of nonterminal nodes linking it with the nodes which are already present.” (Frazier & Fodor, 1978: 320).

Late Closure correctly predicts that the ambiguity in (1) will incur processing difficulties (a ‘garden path’ effect). Minimal Attachment predicts a preference for the simpler structure in a sentence like (2), since it has the fewest phrasal nodes. (Adding a PP modifier to the NP requires an additional nominal node, so analyzing the PP as a nominal modifier (2b) will be non-minimal attachment).

These on-line preference principles are embedded in the Garden-path Model’s depiction of sentence processing as incremental (i.e. each new word in an input string is combined with the preceding material as it is encountered), and as serial (i.e. only one structural interpretation is computed even if others would be equally acceptable grammatically), with the result that reanalysis may be required if that structure later proves to be incorrect. The strong underlying assumption is that the human parsing mechanism is universal and therefore presumed innate, and that parsing preferences are primarily based on a set of structurally-based strategies, even if there are additional influences from other factors such as semantic plausibility, structural frequency, etc.

Note that although some syntactic structures give rise to ambiguity, ambiguity is not inherent to those structures per se. For example, the sentence in (2) is globally ambiguous, because the verb falls in a specific category that can take an instrument adjunct and because PP (and the NP within it) can fill that role. If the verb has different categorization (e.g. ‘meet’ instead of ‘see’), the sentence is no longer ambiguous. If the PP contains a non-instrumental NP (e.g. ‘with red hair’ instead of ‘with the binoculars’) the sentence will not be ambiguous. As an extension, although ambiguity is universally present in human language, a specific structure is not necessarily universally ambiguous. For example, the ambiguity in (2) has an exact parallel in Bulgarian, which is the language under investigation in this dissertation. However, an ambiguity like (3) below does not have an equivalent in Bulgarian, for several reasons. The pronoun morphology is more diverse and the possessive and accusative forms differ, nouns are not typically attributively used and the goal is usually introduced with a preposition.

(3) He fed *her* dog biscuits.

a. He fed her biscuits intended for dogs to eat.

b. He fed biscuits to the dog which belongs to her.

Bulgarian: a. nahrani ia (‘fed her’) s kučeški biskviti (‘with dog biscuits’)
b. nahrani kučeto i (‘fed her dog’) s biskviti (‘with biscuits’)

For comparison, the sentence in (1) is temporarily ambiguous in English, but a parallel Bulgarian sentence in (4) below is globally ambiguous, although it is ambiguous for the same reason (optional transitivity of ‘read’). In (4) the ambiguity is not resolved later in the sentence (at the second-clause verb), because Bulgarian allows null subjects and the sentence remains ambiguous between the two interpretations given.

(4) Dokato četeše pismoto padna na poda.
While read-past-imp letter-det fall-past on floor-det

a. PRO was reading and at the same time the letter fell on the floor.
b. PRO was reading the letter and at the same time PRO fell on the floor.

A seemingly similar sentence in (5) is ambiguous like (1) in English, but in this case its Bulgarian equivalent in (6) is unambiguous, because the verb ‘sviria’ (play) can express the meaning of ‘play an instrument’ only with the preposition ‘na’ (on), otherwise it means ‘produce a tune or melody’.

(5) While Mary was playing the violin fell on the floor.

(6) Bulgarian
Dokato (Maria) svireše tsigulkata padna na poda.
While (Mary) play-past violin-det fall-past on floor-det.

In short, the same construction can be ambiguous or not, depending on the features of its lexical elements, and for similar reasons the same construction can be ambiguous in one language but not in another, or may manifest as a different type of ambiguity. Therefore, it is important that sentence processing be investigated for a variety of structures and in a variety of languages in order to achieve a better understanding of how the parser operates. Parsing principles like Late Closure and Minimal Attachment are assumed in the Garden path model[1] to apply to the initial structuring of a sentence in general (regardless of the presence of ambiguity) and have been demonstrated in a number of languages. They provide a heuristic for efficient structural decisions. However, they cannot encompass the whole process of ambiguity resolution, because the ultimate interpretation of a sentence can be and often is influenced by a variety of other linguistic and non-linguistic factors, among others the selection restrictions and semantic plausibility discussed above, or the broader context in which the sentence is embedded or even pragmatic considerations. For example, the sentence in (3) may be preceded by a statement like “Mary asked Tom to feed her dog.” consistent with the interpretation in (3b) or by a statement like “Tom cannot be trusted to take care of his daughter.” consistent with the interpretation in (3a) and that context would influence the ultimate interpretation of the sentence.

In order to establish which factors drive or facilitate syntactic interpretation in general, as well as when the different cues become accessible to the processing routines and when/how they interact with each other, the effects of different factors need to be isolated.  Studying ambiguity can be a useful tool to achieve that understanding, besides being an indicator of how language processing proceeds in general (e.g. which of two alternative structures is assigned initially). By systematically manipulating a particular factor in an experimental setting, researchers can the use

---

[1]Also the Minimal Chain Principle (De Vincenzi, 1991)

ambiguity resolution preferences that are established as a measure of its effect on parsing decisions and a means to investigate when and to what extent different factors affect the operations of the human parser.

One factor that has increasingly come into focus in sentence processing research is prosody, roughly definable as the intonation and rhythmic structure of a sentence. It was demonstrated decades ago (e.g. Lehiste, 1973) that prosodic phrasing can bias listeners toward a particular syntactic structure for an ambiguous string of words. Since then, there has been a wealth of research on the prosodic characteristics of spoken sentences and their role in ambiguity resolution. Some of the relevant studies will be discussed in the next section.

### 1.2. Prosody and ambiguity resolution

Traditionally, beginning in the 1960's, sentence processing research associated with linguistic models of generative grammar was mostly conducted with visually presented materials, since the technology for successfully creating and manipulating auditory materials was not sufficiently advanced or convenient to use. As the technical limitations were overcome, researchers increasingly began to turn to spoken language, which is evolutionarily the primary means of communication, and thereby gained a new perspective on the factors that influence the human parsing mechanism. As prosody is an inalienable part of spoken language in natural conditions, the role of prosodic cues in sentence processing is of considerable current interest to researchers. A series of studies spanning several decades have established that prosodic properties of spoken sentences, such as prosodic phrasing, implemented in terms of timing (rhythm) and intonation (pitch), play a guiding role in syntactic parsing.

The early studies aimed primarily to demonstrate that prosody can disambiguate spoken sentences, and to establish which ambiguities are more sensitive to prosodic cues than others. Lehiste (1973) found that ambiguity that lies in alternative syntactic bracketing, could be successfully disambiguated by prosody, but that was not the case for syntactic category ambiguities. She elicited prosodically distinct productions of the alternative interpretation[2] of different ambiguous sentences, including an ambiguous structure like (2) then used them in a listening study. Lehiste (1973) found that for such sentences (syntactic bracketing ambiguities), listeners in the second part of her study (a forced choice paraphrase task) were able to identify the intended meaning of the speakers in the first part of her study, especially for the consciously disambiguated utterances. She also found that the items whose meaning was reliably distinguished differed in prosodic phrasing from their counterparts and identified acoustic properties, such as durational differences at the relevant syntactic boundaries that speakers might have been using, and listeners might have been sensitive to.

Lehiste (1973)'s findings were confirmed in a subsequent study by Lehiste, Olive, & Streeter (1976), who used a subset of the same materials. They found that the durational characteristics associated with a prosodic phrase boundary can disambiguate sentences with structural ambiguities, but that duration is not a good cue in sentences with only lexical ambiguities in the same syntactic structure. This was important early evidence that prosodic phrasing is primarily associated with syntactic phrase structure. (However, see below for discussion of other factors, such as phrase length, which interact/interfere with the prosodic mapping of syntactic phrase structure.)

2 Participants first read the sentence aloud, then were informed of the ambiguity and asked which meaning they intended and finally asked to produce two distinct token of the sentence conveying the two alternative interpretations.

Following Lehiste, an experimental study by Price, Ostendorf, Shattuck-Hufnagel, and Fong (1991) used a similar production-perception paradigm to investigate prosodic disambiguation for several classes of syntactic ambiguities. In this study, however, the sentences were produced in disambiguating contexts by trained speakers, and listeners then had to identify which context the sentence came from. As in Lehiste's research, it was found that utterances which were successfully identified showed systematic differences in the location or strength of prosodic boundaries at points of syntactic ambiguity.

Later research has investigated whether and to what extent prosodic phrasing determines the initial syntactic parse of a sentence, not just its ultimate interpretation. Experimental outcomes have shown that prosody can actually overcome parsing biases such as Minimal Attachment and Late Closure which otherwise can create garden path effects. For example, Marslen-Wilson, Tyler, Warren, Grenier & Lee (1992) investigate the online effects of prosodic cues in sentences with nominal vs. clausal complements like (7). The phrase 'the last offer from the management' in (7a) is the direct object of the verb 'considered' and thus requires only an NP node (minmal attachment), whereas in (7b) it is the subject of a complement clause, which requires an additional sentence node (non-minimal attachment).

(7)

a. The workers considered *the last offer from the management* of the factory.

b. The workers considered *the last offer from the management* was a real insult.

Prior research on the same type of structure (Frazier and Rayner, 1982) found evidence of processing difficulty for sentential complement sentences compared (longer reading times compared to nominal complement sentences). Marslen-Wilson et al. (1992) and found that response times were affected by the prosodic contour of the utterance indicating the structure in (7a) or (7b) even though the sentences had been cut before the pint of disambiguation. The finding is interpreted as demonstrating that prosodic information can be used online to resolve structural ambiguities.

Systematic research of prosodic effects on parsing could not be conducted without an underlying theory of prosodic representations and a system of formally describing the prosodic properties of an utterance. Many researchers have adopted for that purpose the Autosegmental-Metrical model of intonational phonology (e.g. Pierrehumbert 1980, Beckman and Pierrehumbert, 1986; Beckman& Hirschberg, 1994) and use the conventions of the Tones and Break Indices (ToBI) system (Beckman & Elam, 1997) as a means of representing prosodic features (such as pauses, accentual and tonal properties) of spoken sentences. A major assumption is that prosody has a structure of its own and this structure is not fully determined by, although it may be significantly constrained by, syntactic structure. This system assumes a prosodic hierarchy, such that the elements of one level compose the elements of the next level. Thus, an utterance is composed of one or more intonational phrases (IPh), each of which in turn is composed of one or more intermediate phrases (ip) defined by (at least one) pitch accent. Intonational phrase edges are marked by a high (H%) or low(L%) boundary tone and the edges of intermediate phrases by a high(H-), low (L-) or a downstepped high (!H-) phrase accent.

Prosodic breaks can occur at the edges of both IPh and ip phrases and are similarly classified depending how they are realized phonetically, not just on the grounds of greater acoustic prominence: an IPh break occurs at the edge of an intonational phrase and is marked by a boundary tone, whereas an ip break occurs at the edge of an intermediate phrase.

Kjelgaard and Speer (1999) adopt these distinctions in their investigation of the role of prosodic break location in disambiguating early/late closure sentences like those in (8) below. They used several experiments which provide both off-line and on-line measures of prosodic effects. (Note: The symbol || here marks a prosodic boundary and will be used for this purpose elsewhere in this dissertation.)

(8) a. Whenever Roger leaves || *the house* is dark. EARLY CLOSURE

b. Whenever Roger leaves *the house* || it's dark. LATE CLOSURE

In silent reading (8b) had been found to be processed faster, while (8a) provokes a garden path. This would follow from the Late Closure parsing principle, which would favor the analysis on which the NP (*the house*) that follows the verb (*leaves*) is initially interpreted as its object. Kjelgaard and Speer (1999) used spoken stimuli with early closure (8a) or late closure (8b) syntax and had a distinct prosodic contour. In the cooperating prosody condition the utterance contained a prosodic break after the verb for the early closure sentence as shown in (8a) and after the NP in the late closure sentence as shown in (8b), i.e. the location of the prosodic break coincided with the syntactic boundary. In the conflicting prosody condition, the prosodic break was not aligned with the syntactic boundary, in the sentence and was in fact located at the syntactic boundary for the alternative structure: after the verb in the late closure sentences and after the noun in the early closure sentences. Kjelgaard and Speer (1999) also included a baseline prosody condition, i.e. stimuli with phonetically neutralized properties at the potential prosodic boundary positions. They found that a prosodic break after the subordinate verb in auditory presentation of early closure sentences (cooperating prosody), eliminated the processing disadvantage of such structures that was observed in the baseline and conflicting prosody conditions and standardly found in studies with visually presented materials. Both early and late closure sentences were processed more quickly with cooperating prosody compared to baseline prosody, which indicated that a prosodic boundary coinciding with syntactic boundary can significantly facilitate a particular interpretation compared to a baseline condition where no prosodic break was present. The prosodic boundaries in the stimuli for the three experiments were IPh type boundaries, but the effects were replicated with phonological phrase (ip) boundaries in Experiment 4.

Carlson, Clifton and Frazier (2001) used the same boundary type distinction in an investigation on prosodic disambiguation of the structure illustrated in (9) below where the phrase ‘after Bill visited’ can modify either the subordinate clause verb ‘telephoned’ (low attachment) or the matrix clause verb ‘learned’ (high attachment).

(9) Susie learned || that John telephoned || after Bill visited.

Carlson et al. (2001) explore why particular prosodic boundaries produce an effect on interpretation. They first investigate whether mere acoustic prominence determines a prosodic boundary’s effect on parsing decisions (Experiment 2) by comparing stimuli with durational differences in the realization of the ip break before the ambiguously attached phrase and did not find any effects. Next, they employ various combinations of IPh and ip prosodic breaks at the two points in the utterance marked by || in (9) to test whether a prosodic boundary’s effect is determined relative to other relevant prosodic boundaries in the utterance (Experiment 3). Their results support that hypothesis: the effect of a same-category break before the ambiguous adjunct is modulated by the category (or size) of the earlier break. They call a later boundary that differs in size from an earlier one ‘informative’ and explore the notion further by systematically contrasting a smaller earlier boundary (0 or ip) with a larger later one (ip or IPh) (Experiment 4). Their data indicate that a phrasing where the later of the two breaks is larger (regardless of its category) promotes more high attachment compared to a phrasing where the two breaks are equal in size. Carlson et al. (2001) argue that a prosodic break is not simply a local cue that facilitate structural decision and its effects are not invariant or simply functions of boundary type, but rather "the interpretation of one prosodic boundary depends on the existence and relative size of other prosodic boundaries in the sentence" (p75). The informative boundary hypothesis is extended to utterances with a single prosodic break by treating it as an instantiation of the strongest contrast in prosodic break size size (0-IPh or IPh-0) (Experiment 5).

The language of investigation in above cited studies was English but their assumptions potentially apply to other languages and some have been tested empirically in other languages. Nespor & Vogel (1986) were among the first to expand the scope of research on prosodic disambiguation beyond English. Similar to Lehiste (1973) they used a forced-choice paraphrase selection task to test prosodic effects in Italian and found that listeners did well on ambiguous sentences where the alternative syntactic structures correlated with prosodic phrasing differences, but not on sentences with lexical ambiguities that did not entail syntactic phrasing differences. Current psycholinguistic research is turning more and more toward other languages with diverse phonological and syntactic structures from which psycholinguists can gain a better understanding of how the human parsing mechanism works in general and how prosodic information is integrated in particular. A variety of constructions in different languages have been studied in experiments with prosodic manipulations. (e.g. Cutler & Clifton, 2000; De Vincenzi & Lombardo, 2000; Hemforth & Konieczny, 2000; Kang and Speer, 2004). Some of that research is particularly relevant to this dissertation and will be discussed further in Chapter 2.

To sum up, different aspects of prosodic disambiguation of structural ambiguities have emerged from prior experimental results, as exemplified, though far from comprehensively, in the discussion above. While prosodic effects on syntactic parsing decisions are indisputable, the exact mechanism by which they are realized is unclear and have given rise to different theories, some of which are concerned with the processing aspect of the prosody-syntax relations, while others are focused on the grammar aspect of how syntactic constituents are mapped onto prosodic constituents.

The lack of one-to-one correspondence between syntactic structure and prosodic contour makes the study of prosody even more intricate, because often a particular prosodic contour can favor one interpretation of an ambiguous string but also allow the alternative interpretation. To capture the partial dependency of prosody on syntactic structure, Selkirk (2000, and elsewhere) proposed a set of a set of constraints, formulated in the framework of Optimality theory (Prince and Smolensky, 1993).

The syntactic alignment constraint AlignXP concerns the relationship between the boundaries of syntactic constituents and prosodic constituents. It requires that every maximal syntactic projection be aligned with a prosodic phrase boundary at its edge and is parameterized as Left or Right oriented in different languages. For example, a right edge alignment has been proposed for English by Selkirk (2000) as follows:

Align $XP_R$ (XP, R; MaP, R)

“The right edge of any XP in syntactic structure must be aligned with the right edge of a MaP in prosodic structure.” (Selkirk, 2000: 232)

The phonological length constraint BinMaP is concerned with the well-formedness (optimal length) of prosodic phrases. It is actually a merger of two opposing constraints BinMin (postulating that a major phrase must consist of <u>at least two</u> minor phrases) and BinMax (postulating that a major phrase must consist of <u>at most two</u> minor phrases), which are treated as a single binary constraint in Selkirk (2000) since there is no evidence from English to differentiate them.

(i) Binary Maximum (MaP)
A major phrase may consist of at most two minor / accentual phrases.

(ii) Binary Minimum (MaP)
A major phrase may consist of at least two minor / accentual phrases.

(iii) Binary (MaP)
A major phrase may consist of just two minor / accentual phrases.
(Selkirk, 2000: 244)

In addition to the alignment and optimal size constraints, Selkirk adopts the Wrap constraint (Truckenbrodt, 1995) which requires that a morphosyntactic constituent not be split into distinct prosodic constituents, formulated as follows:

Wrap XP (XP; MaP)

"The elements of an input morphosyntactic constituent of type XP must be contained within a prosodic constituent of type MaP in output representation."

The constraints are assumed to be universal i.e. they operate in all languages and they interact in all languages but their language specific ranking determines the outcome. Importantly, all constraints are violable and ultimately not all of them need to be satisfied in a well-formed phrase. The number of violations incurred and the ranking of the constraints that are violated determines the acceptability of a prosodic structure. For example, AlignR XP and Wrap XP are inherently opposed and satisfying one incurs violation of the other. Since the two may be ranked differently across languages, violating either the former or the latter may be permissible yielding different types of prosodic phrasing in different languages.

For English, the interface constraints $AlignXP_R$ and WrapXP appear to be of equal rank and higher ranked than the size constraint(s) BinMaP (Selkirk, 2000). However, the ranking of constraints in a language is not self-evident and is sometimes hard to establish, since unlike for syntax, there are no clear criteria of well-formedness of prosodic contours and other constraints on prosodic representations may exist that have not surfaced in the languages explored and may also come into play.

The exact mapping of syntax and prosody is thus not clear cut and the effects of prosody on parsing cannot always be not straightforwardly explained by the grammar constraints until or unless the influences of other contributing factors have been identified. Not surprisingly, therefore, different theories have been developed - not altogether incompatible with each other - concerning the role of prosodic characteristics (in particular, prosodic boundary location and strength) in resolving syntactic attachment ambiguities. Some are discussed briefly below.

Schafer (1997) proposed a **Prosodic Visibility Hypothesis** which assumes that "the input to the syntax is not simply a string of words, but rather those words structured into a prosodic representation" (Schafer, 1997, p.43) and phonological phrasing of an utterance determines the *visibility* of syntactic nodes, which is gradient across multiple phonological phrases with the nodes within the phonological phrase currently being processed being more visible than nodes outside of that phonological phrase. It further states that attachment to a node with high visibility is less costly in terms of processing/attentional resources than attachment to a node with low visibility, thus phonological phrasing can indirectly influence syntactic processing.

Schafer's experiment on PP attachment using sentences like (10) where the PP 'with a mean look' could be attached either to the verb 'angered' or to the noun 'rider' served as one test case for the prosodic visibility hypothesis. Previous research on the same type of construction has established a preference for VP attachment that can be accounted for by the fewer necessary nodes (minimal attachment). Schafer considered different available well-formed prosodic contours for the utterance in (10), given below with the inner brackets indicating ip phrases:

(10) The bus driver angered the rider with a mean look.

a. ((The bus driver angered the rider ) (with a mean look ))$_{IPh}$

b. ((The bus driver angered ) (the rider with a mean look ))$_{IPh}$

c. ((The bus driver angered the rider with a mean look ) )$_{IPh}$

d. ((The bus driver) (angered ) (the rider ) (with a mean look ) )$_{IPh}$

Her data confirmed the prediction that NP attachment will be preferred with the pre-NP boundary in (10b) where the NP is inside the current prosodic phrase and the verb is not, compared to the other conditions. She also observed less VP attachment responses with a phrasing like (10d) where the verb is separated from the ambiguous PP by two phrases and the NP by only one compared to (10a) and (10c) where the verb and the noun are in the same phrase. Based on her data Schafer (1997) claims that phonological phrases boundaries are sufficient to cause effects on interpretation and that these boundaries need not be located at the point of syntactic ambiguity. Prosodic Visibility is able to account for such non-local effects by seeing prosody as a structure instead of a sequence of cues.

Another hypothesis that in a way builds on a similar assumption that not individual cues, but the overall / global prosodic structure of the sentence determines structural interpretation is the **Informative Boundary Hypothesis** proposed by Carlson et al. (2001) and Clifton et al. (2002) and briefly discussed in section 1.2. The Informative Boundary Hypothesis proposes that the effectiveness of a prosodic boundary as structural disambiguator is dependent on its size relative to other prosodic boundaries at relevant points in the same utterance, i.e. prosodic boundaries are interpreted in context-dependent fashion. While assuming that listeners use their grammar (including prosodic constraints) to assign structure to a sentence, the Informative boundary hypothesis is concerned with how speakers and listeners exploit the options allowed by the grammar and listeners respond to the pattern of prosodic choices made by the speaker on the assumption that speakers are rational (i.e. consistent) in those choices. Subsequently, the same group of researchers expanded this view of how prosodic information affects interpretation with the **Rational Speaker Hypothesis** (Clifton et al. 2002, 2006) which claims that speakers are self-consistent, employing intonation in a manner consistent with their intended message and proposes that listeners interpret the significance of prosodic breaks in light of the presumed intentions or causal influences on the speaker. This hypothesis will be discussed further in Chapter 3.

Watson and Gibson (2005) propose the **Anti-Attachment Hypothesis**, which states that ”Listeners prefer not to attach an incoming word to a lexical head that is immediately followed by an intonational boundary.” (p. 285). For example, in a sentence like (11) below, which contains the same PP-attachment ambiguity as (2), a boundary after the noun (*spy*) as in (11a) will signal to the listener not to attach the PP to it, but rather to the verb (*saw*), while a boundary after the verb as in (11b) will discourage attachment to the verb and thus favor attachment to the noun.

(11)

a. The cop saw the spy || with the telescope.

b. The cop saw || the spy with the telescope.

In contrast to the Prosodic Visibility and Informative boundary hypotheses where phonological boundaries are assumed to influence attachment decisions, the Anti-Attachment Hypothesis assumes that only intonational prosodic boundaries (IPh) affect interpretation. The Anti-Attachment hypothesis regards the function of prosodic breaks differently: it assumes that intonational boundaries are meant to force constituents apart during the parsing process, not group relevant constituents together, i.e. a prosodic break after a constituent signals that it receives no upcoming attachments.

The **Implicit Prosody Hypothesis** (IPH, Fodor 2002), which will be discussed further in Chapter 2, takes an even broader view of prosodic influences in parsing, applying to silent reading as well as to the overt production and perception of speech. It claims that: "in silent reading, a default prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, the parser favors the syntactic analysis associated with the most natural (default) prosodic contour for the construction."

Unlike the above-mentioned hypotheses, IPH is not committed to any particular prosody-syntax mapping, but claims that whatever syntax-prosody relations hold for overt prosody in speech also obtain for implicit prosody in silent reading. The appeal of a prosodic account of silent reading data is that it has the potential to handle both cross-linguistic variation and within-language variation (e.g. constituent length effects) with respect to syntactic parsing preferences, and possibly also between-subject and between-item variation found in reading experiments.

### 1.3. Methods currently in use for studying prosodic effects in sentence processing

A variety of methods are currently in use for establishing the preferred reading of an ambiguity, and the possible role of prosody in influencing it. These range from simple tasks to more complex ones. Some have been adapted from older silent reading research paradigms;

others have been developed specifically for use with auditory materials. There are procedures that require very little equipment and are suitable for field work, as well as procedures that make use of sophisticated technology so they can only be conducted in a specialized laboratory. Some of the more prevalent ones are discussed briefly below.

### 1.3.1. Post-sentence comprehension questions

Post-sentence comprehension questions, e.g. *Who had the binoculars?* for the ambiguity in (2) has been the traditional method of ambiguity resolution research in silent reading, typically followed by the two alternative answers from which participants had to choose one. This method has been used successfully also in studies with auditory materials. In fact, the procedure used by Lehiste (1973) was similar to those comprehension questions, but in a more general form, asking participants what the sentence means and giving the two paraphrases. Other researches have used sentence-specific comprehension questions. For example, Schafer et al. (1996) used auditory materials with a comprehension question to examine the effect of focus (realized prosodically through pitch accent) on interpreting an ambiguously attached relative clause. Investigating the same construction in Croatian, Lovrić (2003) used written comprehension questions in combination with auditory stimuli in his Experiment 5 to investigate how overt prosody affects ambiguity resolution. Carlson et al. combined an auditory presentation with a visually presented question in their investigation of the interpretation of prosodic breaks in an utterance as a function of their relative size (see section 1.2.) and Fernández (2007) used a similar procedure (visually-displayed comprehension question following an auditory stimulus) to establish the effect of explicit prosody (location of prosodic break) on RC-attachment interpretation in English.

While still a very useful method for compiling ambiguity-resolution preference data, the questionnaire has a major drawback for studies concerned with prosody. It typically introduces a whole additional sentence (the comprehension question) for processing in order to elicit participants' interpretation of the stimulus sentence. This creates a distance in time between the stimulus and the reaction to it. In addition the comprehension question comes with its own set of semantic and pragmatic characteristics which sometimes create a bias toward a particular interpretation of the stimulus sentence. The question also has its own prosody which may over-ride or blur the prosodic representation of the stimulus sentence in working memory – potentially a crucial flaw in a study of prosodic influences on parsing.

#### 1.3.2. Post-sentence well-formedness / acceptability judgments

This technique is also adapted from earlier silent reading studies to studies with auditory materials. A variant of this task was used for example by Igoa and Teira (2003) who investigated the role of prosody in RC-attachment. In their experiment, RC-attachment was lexically disambiguated by morphology (number agreement) and the materials contained a prosodic break after N1 or after N2. They used a well-formedness judgement task and found that incongruent (conflicting) prosody was costly as shown by a greater percentage of errors and longer reaction times on those items compared to items where congruent prosody facilitated interpretation. A different variety of this task was used by Frazier, Clifton, & Carlson (2004) to investigate the role of several principles in determining the preferred intonation of a sentence. Specifically, they used two prosodic acceptability ranking tasks. In Experiments 1 and 3 participants had to rate the rhythm and melody of a recorded stimulus on a scale from 1 to 5, while in Experiments 2 and 4 participants had to decide which of two recorded versions of a stimulus (heard in sequence) was better in terms of rhythm and melody.

Post-sentence acceptability judgments can provide valuable insights into what makes a prosodic contour natural and effective. On the other hand, such a task by nature explicitly directs participants' attention to the phenomenon which is the focus of the experiment and requires meta-linguistic evaluation, which is not part of normal sentence processing. Thus it may not be well suited for investigating the role of prosodic cues in ambiguity resolution in more ecologically natural use of language.

#### 1.3.3. Self-paced listening / Auditory moving window

Ferreira, Anes and Horine (1996) developed a self-paced listening paradigm known as Auditory Moving Window to study speech perception. It is parallel to standard self-paced reading paradigms, but uses auditory stimuli. The recordings are broken up into a series of segments, and listeners have to pace themselves through the sentence by pushing a button and thus prompting successive presentation of the segments.

Self-paced listening methods like the Auditory Moving Window technique have the advantage of giving online temporal measures of sentence processing and allow reaction-time measures at multiple points on-line, unlike other techniques. The disadvantage is that the stimulus is cut at multiple points, possibly disrupting the natural prosodic contour. Also, as in self-paced reading, in order to obtain valid results in such a task, it is important to prevent participants from rapidly calling up the segments until the end of the sentence without fully processing them.

#### 1.3.4. Cross-modal naming

Another technique is cross-modal naming, where the participants have to name (pronounce) a visually presented word following a syntactically ambiguous spoken sentence fragment, e.g., *Flying planes ARE/IS*. The assumption is that naming times for the visually presented word show how easily it is integrated into the phrase structure being computed by the listener, i.e. faster naming times indicate that the word is compatible with that structure and longer naming times indicate it is not.

Marslen-Wilson, Tyler, Warren, Grenier, & Lee (1992) used this technique, combined with a rating task for the word as an appropriate continuation, to investigate whether prosodic phrasing affects parsing of sentences with a nominal vs. clausal complement to the verb and whether prosodic cues can facilitate the dispreferred clausal complement structure (see section 1.2.). They found that naming times for words consistent with the clausal continuation (e.g., *was*) following a syntactically ambiguous fragment with clausal-complement prosody were were shorter than following a fragment with NP-complement prosody and were comparable to following a fragment with clausal-complement prosody and an overt complementizer.

Kjelgaard & Speer (1999) used the cross-modal naming task along with a speeded grammaticality judgment task, end-of-sentence comprehension task in their research on the effect of facilitating or conflicting prosody on early/late closure sentences, as discussed above (section 1.2.). The cross-modal naming task is implemented in two experiments as a means of collecting online data and is used with stimuli containing IPh prosodic breaks (Experiment 3) and yielded comparable results with stimuli containing ip prosodic breaks (Experiment 4), proving to be a sensitive measure of prosodic effects.

More recently, Blodgett (2004) employed this technique to investigate the interaction prosodic phrasing for the same structure (early / late closure ambiguity) with verb bias (transitive-bias / equi-bias / intransitive bias) and plausibility. She also explored the effects of IPh breaks and  ip breaks and found that IPh boundary location can determine the initial syntactic structure for these closure ambiguities regardless of verb bias (which is taken as evidence that IPh boundaries trigger both semantic and syntactic wrap-up), whereas ip boundaries and verb bias seem to contribute to the initial parse cumulatively.

In all, cross-modal naming has been used successfully to elicit the effects of spoken prosodic contours on listeners' interpretive decisions for several different syntactic ambiguities. This technique has the advantage of probing directly at the point of interest, making the information it provides more immediate compared to post-sentence tasks. Its drawbacks are that it uses sentence fragments, so the prosodic representation is possibly disrupted, and that it employs a sentence-medial lexical-decision task that requires integrating material across modalities, making it quite different from sentence processing in natural conditions.

#### 1.3.5. Event-related potentials

Event-related potentials (ERP), measures of electrical activity in the brain, have been used as a tool for studying sentence-processing in both normally-functioning and language-impaired populations. Recent studies have established the closure-positive shift (CPS) as a reliable ERP correlate of prosodic effects in processing (Steinhauer, Alter, & Friederici, 1999), and have shown that prosodic effects occur very early on-line. With regard to prosodic processing, ERP methods are employed to track the perception of prosodic breaks, and to assess sensitivity to prosodic anomalies (e.g. Steinhauer et al., 1999; Augurzky, 2006; Eckstein & Friederici, 2006), as well as to evaluate the impact of prosodic cues on sentence processing.

ERP measures provide fine-grained data on the time-course of processing, including prosodic effects, and have the potential to answer questions that are impossible to investigate with other methods. Although most research to date has been conducted with materials containing IPh boundaries, at least one study (Li and Yang, 2009) reports similar effects of phonological phrases. ERP studies are thus indisputably a valuable tool for online investigations of sentence processing. However, ERP methods also have certain disadvantages. Namely, most ERP studies of prosody-syntax alignment by necessity use mis-matched or ungrammatical materials, because they measure brain reaction to violations, although that is not necessary in studies that aim to detect neural effects of the prosody itself. Also, for the moment, ERP studies require special (and expensive) equipment that is not available in all psycholinguistic laboratories and is not easily transportable, which means that experiments can only be carried out in certain locations and involve participants who speak the languages spoken there.

#### 1.3.6. Scripted discourse

In order to investigate whether prosodic disambiguation effects could also be observed in somewhat spontaneously produced speech Schafer, Speer, Warren, and White (2000) developed an interactive board-game where participants had to negotiate moves of game pieces to goals another using the scripted sentences (a constrained set of possible sentence structures) that were provided by the experimenters. Participants were not explicitly informed of the ambiguity and had control on what piece to move and which sentences to use. This set-up allowed experimenters to elicit utterances with naturally produced prosody, but still control the content of participants' production. The experimenters themselves did not produce any of the scripted sentences and no punctuation was present in the script, so as not to bias participants to a particular prosody.

The game resembles a real discourse situation, since participant pairs have goals that can only be achieved by cooperation, but it is designed to elicit production of a variety of ambiguities, including the early/late closure ambiguity, illustrated below:

(12) a. When that moves || the square will encounter a cookie. (EC)

b. When that moves the square || it should land in a good spot. (LC)

Schafer et al. found “strong evidence of prosodic disambiguation” (p.175). Phonological analyses of the production data (both of the full sentences and sentence truncated before the disambiguating material) that speakers consistently produced a stronger boundary after *moves* as compared to after *square* in the early closure sentences (91%), and the other way around in the late closure sentences (96%). This categorization was confirmed by durational measures.

In a follow up perception experiment, listeners were able to use those patterns to interpret sentence fragments correctly, confirming experimentally the role of prosody in what is a closer approximation to real discourse than in most experimental paradigms.

The scripted discourse game developed by Schafer et al. (2000) is an innovative method of placing participants in a situation that to some extent simulates real-life discourse, making it possible to draw some at least tentative conclusions about real-life sentence processing. One disadvantage, however, is that the researcher has to create a constrained situation with a very limited number of possible meanings from which the participants could pick, thus limiting the range of linguistic and prosodic phenomena that can be explored. It is also highly likely that the participants become aware, over the course of the experiment, of the contrasting prosodic renditions of the small set of sentential forms they are forced to employ.

#### 1.3.7. Eye tracking / Visual world

In the Visual World paradigm, participants’ eye movements over a carefully constructed visual display are monitored as they listen to auditory stimuli and gaze fixation on a visually presented array of potential referents is used as a measure in order to draw conclusions about linguistic processing.

It can provide a highly sensitive and continuous measure of on-line language processing phenomena, including ambiguity resolution. With spoken input, it provides finely timed data about when potential referents or actions are evoked in the minds of listeners, since the gaze tends unconsciously to follow the interpretation. This method has been used for example to study the role of prosodic phrasing information in prepositional phrase attachment as in *Tap the frog with the flower* (Snedeker & Trueswell, 2003). It has also been employed successfully to investigate other prosodic phenomena such as the interpretive consequences of contrastive pitch accents (Ito & Speer, 2005; Watson, Gunlogson, & Tanenhaus, 2006).

The Visual World paradigm represents a leap forward in obtaining rich data on sentence processing in a simulated real-life interaction using natural speech input (i.e. uninterrupted, no fragments, no splicing). However, similarly to the discourse-elicitation board game protocol, not all ambiguities are equally suited for implementation in a visual world setting. Choice of this method depends in part on how the different interpretations of an ambiguous sentence can be distinguished visually. This is quite easy for an ambiguity such as in (2) above, but more challenging for an ambiguity such as the early/late closure sentences in (8) or the matrix/subordinate sentences in (9).

To sum up, all of the methods described in this section are useful tools for studying the role of prosody in parsing, including ambiguity resolution. However, each of the techniques currently in use also has its disadvantages or limitations. That is why, despite all these options, sentence processing research may benefit from yet another method, one that would satisfy some important criteria of naturalness and unobtrusiveness in addition to sensitivity to prosodic influences on ambiguity resolution in syntactic parsing. Ideally this would be a method that is less likely to draw participants' attention to the syntactic ambiguity, as post-sentence comprehension questions tend to do. It would also avoid drawing attention to the significance of the prosody, as is inevitable when participants are asked to judge prosodic acceptability, or when syntactic constructions are presented with conflicting prosody as is common in ERP studies. Finally, the optimal experimental task would be one in which participants' responses are spontaneous and non-deliberative, because their attention is focused elsewhere than on the phenomenon actually under investigation. The Visual World paradigm clearly meets these criteria (see Watson, Gunlogson, & Tanenhaus, 2006), but it remains to be seen how adaptable it will prove to be for other syntactic ambiguities.

## 1.4. Proposed new method

### 1.4.1. Advantages of proposed method

The primary purpose of the experiments reported in this dissertation is to explore a new methodology for use in sentence processing research in general, and in particular for studying the role of prosodic information in ambiguity resolution. In contrast to existing methods described above, this method relies on lexical disambiguation, similar to the cross-modal task employed by Marslen-Wilson, Tyler, Warren, Grenier, and Lee (1992), but with an important difference: it does not require use of incomplete sentences, which may create artifacts if hearers tend to construe a sentence fragment as a phrase.

Instead, the method proposed here uses complete utterances with a natural prosodic contour, in which the morphological/lexical disambiguation has been eliminated but can be restored by the listener. It takes advantage of the phoneme restoration effect (Warren, 1970), an auditory illusion that arises when part of an utterance is replaced by an extraneous sound such as a cough or white noise, but listeners apparently fill in (restore) the missing phoneme in perception and report that they heard the complete utterance. Later, the restoration effect has been used to examine the extent to which lexical and higher-level representations can influence speech perception (Samuel, 1981, 1996). The original experiment on phoneme restoration (Warren, 1970) and relevant following research are presented in more detail below. In the experiments on Bulgarian reported here, phoneme restoration is used as a tool to elicit responses which reveal ambiguity resolution, using several different behavioral tasks described in detail in Chapters 3 and 4.

1.4.2. The phoneme restoration effect: background

The phoneme restoration effect was first described by Warren (1970) on the basis of a very small-scale experiment, with the single item shown in (12) below. Note: The symbol ▓ indicates the location where one or more phonemes have been replaced.

(12) The state governors met with their respective legi▓latures in the capital city.

The sentence was recorded and then the *s* in *legislatures* was replaced by a cough before presentation to listeners.[3] Participants were given a printout and asked to circle the exact position at which the cough occurred and whether or not the cough replaced the circled portion completely. Warren reported that 19 out of 20 listeners did not realize that any speech sound was missing and the one person who suspected a missing sound guessed a wrong one. He noted that even the research team members who were aware of how the stimulus had been created 'heard' the missing phoneme and so did participants when they listened to the stimulus again after they were told that a speech sound was in fact missing. Also, none of the participants could correctly identify the position of the cough in the sentence. The effect was replicated with a 1000Hz tone

3For an auditory demonstration, see Warren, 2008, and accompanying sound files.

(equal to the peak intensity of the cough.) It could not be replicated, however, when the excised portion of the stimulus was replaced with silence.

Warren's first experiment was replicated with the whole syllable *gis* in *legislatures* replaced by noise, showing that the restoration effect was not disrupted by stretches of noise up to a few hundred milliseconds (Warren & Warren, 1970). Warren and colleagues (e.g., Bashford & Warren 1979; Sherman 1971) and other researchers since (e.g. Samuel 1981, 1996) describe this effect as a genuine perceptual illusion, in which listeners are convinced that they are hearing an uninterrupted speech stream even though in fact a portion of it is absent and has been replaced by noise. Many more stringent tests followed (for a review, see Samuel, 1996). Some focused on the nature of the replacing sound and how psychoacoustic properties of the replacement sound (e.g., amplitude, spectrum and quality of the replacing noise) affected the probability of detecting the missing phoneme (Warren & Obusek, 1971). To briefly summarize their results: They generally found that the illusion was most effective when the noise was loud enough that it could have masked the speech sound had it been present. The strength of the illusion also depended on the acoustic properties of the excised phoneme, as well as on factors such as word/non-word status, word length, and position of the noise in the word.

Most relevant for present purposes is the effect of sentential context on phoneme restoration. Early work by Sherman (1971) and Warren & Sherman (1974) had found that the noise was typically 'heard' as a phoneme that made a word congruent with the rest of the sentence, even when the relevant context occurred *after* the critical word (e.g., the word with noise in *The ▓eel is on the shoe* was heard as *heel* rather than as *meal* or *wheel*). In later work Samuel (1981) noted that participants tended to report *battle* in the context of *soldier* in (13a) and *batter* in the context of *pitcher* in (13b). Note that the restored phoneme in (13) reveals a semantic (or at least associative) influence on lexical ambiguity resolution. The same is true of the sentential materials used by Sherman (1971).

(13) a. The soldier’s thoughts of the dangerous bat▓ made him very nervous.
b. The pitcher’s thoughts of the dangerous bat▓ made him very nervous.

Samuel developed a discrimination paradigm to investigate the role of different factors on phoneme restoration: participants had to determine whether the stimulus item they received was noise-replaced (i.e. the speech sound was missing) or noise-added (i.e. the speech sound was masked). How well participants were able to discriminate between the two was the measure of phoneme restoration[4]. Samuel (1981) compared the restoration rates on words and segments from the same words (Experiment 1) and found much better discriminability on segments, indicating that even though the acoustic information was available, lexical context promoted phoneme restoration, which was confirmed by the lower discriminability in words vs. non-words with identical procedure (Experiment 2). When the targets were multiply restorable words in sentences, such as (13) above (Experiment 3) participants were able to discriminate better in predictable context than unpredictable context (i.e. ‘soldier’ vs. ‘pitcher’ for ‘battle’) but at the same time predictable words were judged to be intact more often than less predictable ones, indicating that sentential context creates a bias in both the discrimination and the following word-judgment task, similar to the sentence context effects reported in Sherman (1971).

[4] Discriminability and restoration are in inverse relation: lower discriminability between versions indicates phoneme restoration, “the inference is that they sound alike because the missing phoneme is being restored in the replaced version.”

### 1.4.3. How phoneme restoration was used in the current research

The goal in the experiments described here was to test whether a restored phoneme can reveal a prosodic influence on syntactic ambiguity resolution. Neither prosody nor syntactic ambiguity has been previously examined using phoneme restoration. Samuel's paired target sentences as in (13) were evidently intended to have the same prosodic contour (though recorded separately; Samuel, 1981, p. 487), so they did not allow assessment of prosodic effects. The sentential materials tested by Sherman (1971) and Samuel (1981) were lexically but not structurally ambiguous, and they were disambiguated only by semantic-pragmatic biases.

The language of investigation is Bulgarian, which allows concurrent morphological and prosodic disambiguation. A series of experiments on two ambiguities in Bulgarian provide new data confirming the influence of prosody on resolution of structural ambiguities. In order to assess a possible prosodic influence on syntactic ambiguity resolution, target sentence pairs were created that contain a temporary syntactic ambiguity resolved by morphological agreement. The sentences in a pair are minimally different in their phonemic sequence and designed to meet specific syntactic and morphological criteria, described in Chapter 3. The two sentences in each pair were recorded (by the author, a native speaker of Bulgarian) with appropriate prosody. Then, as in the original phoneme restoration studies, a portion of the speech signal was removed and replaced by white noise. In target sentences this noise-replacement manipulation was applied specifically to the disambiguating phoneme(s), thereby eliminating the morphological /lexical disambiguation cues, while at the same time it did not disrupt the prosodic contour of the sentence and in particular did not affect the disambiguating prosodic break which came before the noise-replaced region. As a result, the pair of sentences became fully identical segmentally, but provided contrasting prosodic cues to the intended structure of the sentence. In effect, the noise replacement turned the temporarily ambiguous sentences into two versions of a globally ambiguous item with distinct prosodic contours. How a listener restored the missing sounds, i.e. what morpho-lexical markers were assigned to the noise-containing word, would indicate which syntactic structure s/he had imposed on the word string. If the prosodic phrasing is taken into account by listeners, the phonemes that are 'perceived' should represent morphological agreement that would create a syntactic structure congruent with the prosodic phrasing (henceforth 'prosody-congruent restorations').

### 1.5. Outline of the dissertation

The primary purpose of the research reported in this dissertation was to test and validate a novel method for studying ambiguity resolution. This method is based on the phoneme restoration illusion discussed in the previous section and is implemented in the current research as a means for investigating the role of prosody in syntactic ambiguity resolution. In addition, since the experiments conducted for this research were conducted in Bulgarian, a language which has not been widely studied in psycholinguistics and which is very different from English with respect to its reliance on morphological disambiguation, the results provide original data concerning prosodic effects on syntactic ambiguity resolution in that language.

Using prosody-congruent phoneme restorations as a measure of prosodic effects on ambiguity resolution has some advantages. First, the target stimuli will be grammatical sentences with well-formed prosodic contour. The noise will only substitute segmental information and should not interfere with the global prosodic representation unless the noise-replacement is performed at a point where relevant prosodic features are realized, such as at a prosodic boundary. This is surely a desirable characteristic for stimuli in a study of prosodic effects.

Moreover, since similar noise does co-occur with speech in normal everyday situations, the stimuli will sound completely natural to participants. Actually, an experimenter can make sure that participants are attending to the prosody of the stimulus without explicitly directing their attention to it by telling them in advance that the stimuli are going to be ‘noise’ at times and need to focus in order to hear well.

Secondly, in a phoneme restoration experiment the ambiguity resolution response is essentially brought down to a lexical choice which can be formalized as a choice or elicited in another way. Asking participants to indicate what they heard rather than what the sentence means eliminates some drawbacks of comprehension questions that were pointed out in section 1.3.1, namely the need to process an additional sentence that distances the response from the stimulus and may potentially bias the response through its semantic, pragmatic or prosodic characteristics. Thus, a phoneme restoration forced choice protocol should minimize participants’ awareness of the ambiguity and collect more immediate responses, which at the same time would be very similar to the responses on a comprehension question. These features make it an attractive choice in an investigation of prosodic effects on ambiguity resolution.

Furthermore, phoneme restoration responses on ambiguity resolution are by no means limited to forced choice between alternatives. The auditory stimuli for phoneme restoration can potentially be implemented in different response tasks, depending on the experimenter’s needs. Importantly, there is no inherent need to use a sentence-medial task, just as there is no need to use sentence fragments or cross-spliced versions, although all of these can be incorporated in a phoneme restoration experiment.

Finally, the range of ambiguities that can be explored in a phoneme restoration experiment are not limited by requirements for a visual display, as it is for the Visual World paradigm, although admittedly, it is limited by the need to create minimally different sentence pairs. Ideally, the words that differentiate the two sentences should be function words, but that is not always possible to achieve.

The dissertation is organized as follows.

*Chapter 2* introduces the two constructions that are used together as test cases for prosodic effects on phoneme restoration in the main experiments reported in this dissertation: a coordination ambiguity and a relative clause ambiguity. Previous research on prosodic effects on resolving each of the two structural ambiguities is discussed. The findings for other languages reported in the processing literature indicate that these two constructions are sensitive to prosodic disambiguation and therefore are suitable candidates for validating a novel methodology. It is anticipated that the outcomes will be compatible with those of previous studies of these constructions in other languages with other methods, but may possibly show greater sensitivity.

*Chapter 3* reports on the process of creating the experimental stimuli. The three related experiments presented in Chapter 3 used a word-choice task to investigate the role of prosody in resolving both types of ambiguity in Bulgarian. Experiment 1a focuses on the impact of prosodic boundary location on ambiguity resolution. It confirms that prosodic information can successfully disambiguate both constructions in Bulgarian. Experiment 1b introduces an additional variable in the design, crossing prosodic boundary location and length of constituents. Experiment 1c uses stimuli with an unnaturally flat prosody which contained no discernible boundaries.

*Chapter 4* presents four additional experiments, implementing the phoneme restoration method in two production-perception tasks: sentence repetition (Experiments 2a and 2b) and sentence shadowing (Experiments 3a and 3b). The same auditory stimuli as the short version items in the experiments of Chapter 3 are employed. The results of the Chapter 3 experiments are largely replicated, with some task-specific differences.

*Chapter 5* provides a comparison of the three response tasks used to elicit phoneme restorations. It presents participants' feedback on their perception of the phoneme-replaced materials and a brief assessment of the production data collected in Experiments 2 and 3, specifically the indication of prosodic break at the relevant position in participants' utterances.

*Chapter 6* presents two experiments with visual stimuli that parallel the auditory experiments; the critical graphemes are replaced by a visual 'blot'. The same sentence materials as in the previous experiments are used in written form in a word-choice and an elicited production task. The data show that in some cases prosodic-like effects can be induced by the format of a visual presentation of a sentence.

Finally, *Chapter 7* provides a summary of the findings of the main experiments on prosodic and visual grouping effects for the two ambiguities that were used to validate the efficacy of the new methodology. It also presents a pilot experiment on prosodic disambiguation of several other constructions in Bulgarian, some of which have not been studied before in any language with respect to prosody, and discusses the implications of the findings. This final chapter also raises some issues related to the current experiments and possible future research employing the phoneme restoration paradigm.

A summary of the experiments reported in the dissertation is given in Table 1 below.

**Table 1-1**. Summary of experiments in dissertation

Phoneme restoration experiments

| | | | |
|---|---|---|---|
| Materials | | Recorded sentences in which noise replaced the portion of the lexical item that provides morphological disambiguation | |
| Prosody | | Natural prosody with informative breaks | Unnatural prosody with no breaks |
| TASK | Visual word choice | Experiment 1a | |
| | | Experiment 1b + length contrast | Experiment 1c + length contrast |
| | Sentence repetition | Experiment 2a | Experiment 2b |
| | Sentence shadowing | Experiment 3a | Experiment 3b |

Grapheme restoration experiments

| | | | |
|---|---|---|---|
| Materials | | Typed sentences in which an ink blot replaced the portion of the lexical item that provides morphological disambiguation | |
| Presentation | | Two-screen, with sentence split in the location of a prosodic break | One screen |
| TASK | Silent reading with visual word choice | Experiment 4a + length contrast | Experiment 4b + length contrast |
| | Silent reading with sentence repetition | Experiment 5a | Experiment 5b |

# CHAPTER 2
# THE TWO TARGET CONSTRUCTIONS AND THEIR PROPERTIES IN BULGARIAN

This chapter introduces the two constructions that are the focus of investigation: the NP/S coordination ambiguity and the RC attachment ambiguity. Previous research on these constructions in other languages is discussed in Section 2.2., in particular studies concerned with the role of prosodic phrasing or showing possible prosodic effects. The syntactic structure and prosody of these constructions in Bulgarian and some details on related structures that may be relevant are discussed in Section 2.3. A previous study on RC attachment in Bulgarian (Sekerina, Fernández and Petrova, 2003) is discussed in Section 2.3.5.

## 2.1. The two ambiguities selected for investigation

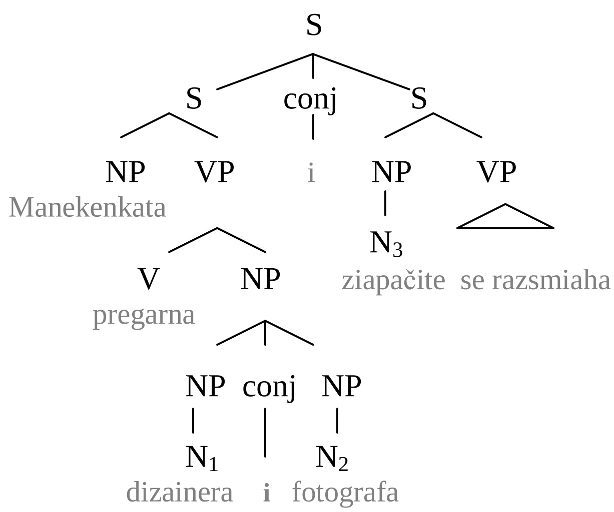
When piloting a new experimental method, it is essential that the data obtained can be compared to data from previous experiments using different experimental tools. In the present case, this means it is necessary to pick syntactic ambiguities that have already been studied, ideally in the same language and preferably investigated in more than one study and through a variety of experimental techniques. The two constructions presented in (1) and (2) below fit most (1) or all (2) of these pre-requisites. Also, since the proposed new method will be used in this research as a tool to investigate the role of prosody in sentence processing, it was important that the ambiguities be sensitive to prosodic disambiguation. There is evidence in the literature that this is indeed the case for both constructions. Some relevant studies are discussed in Section 2.2.1.

The sentence in (1) is ambiguous as to where the NP coordination is parsed, as illustrated in the syntactic trees below. In (a) the first noun (‘designer’) and the second noun (‘photographer’) are grouped together as the object of the first clause verb (‘embrace’) while in

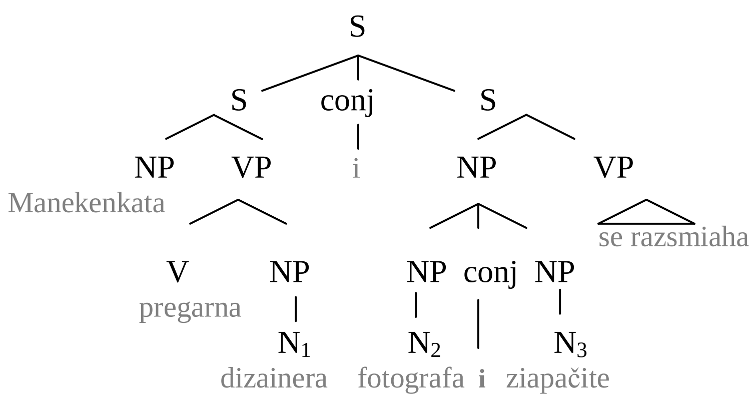
(b) the second noun ('photographer') and the third one ('onlookers') are grouped together as a coordinated NP that is the subject of the second clause.

(1) Manekenkata pregarna dizainera **i** fotografa **i** ziapačite se razsmiaha.
Model-det embrace-past designer-det and photographer-det and onlookers-det. refl laughed-past
*The model embraced the designer and the photographer and the onlookers laughed*

a. FIRST-CLAUSE OBJECT NP-COORDINATION



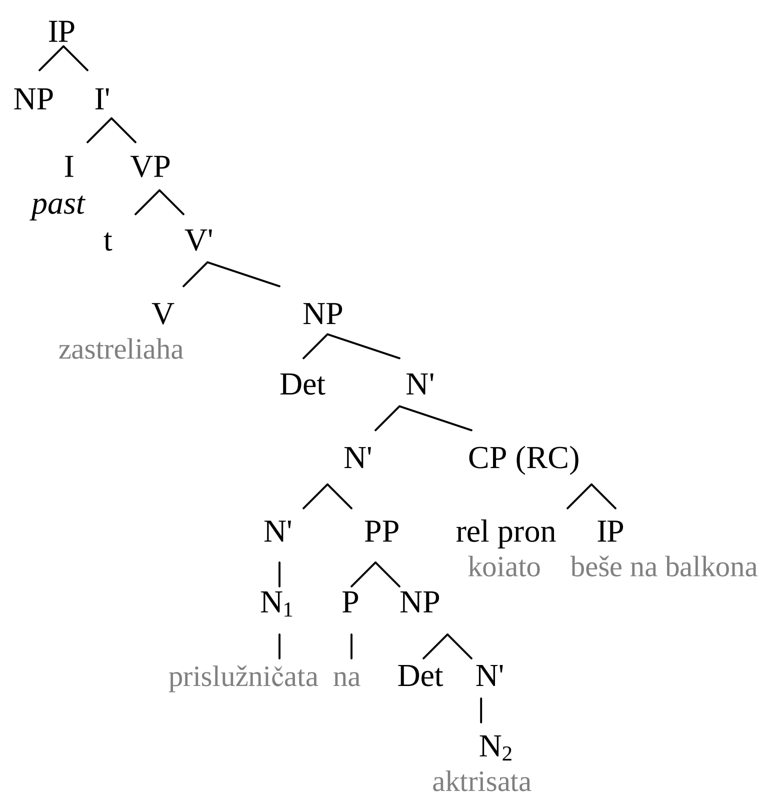

b. SECOND CLAUSE SUBJECT NP-COORDINATION



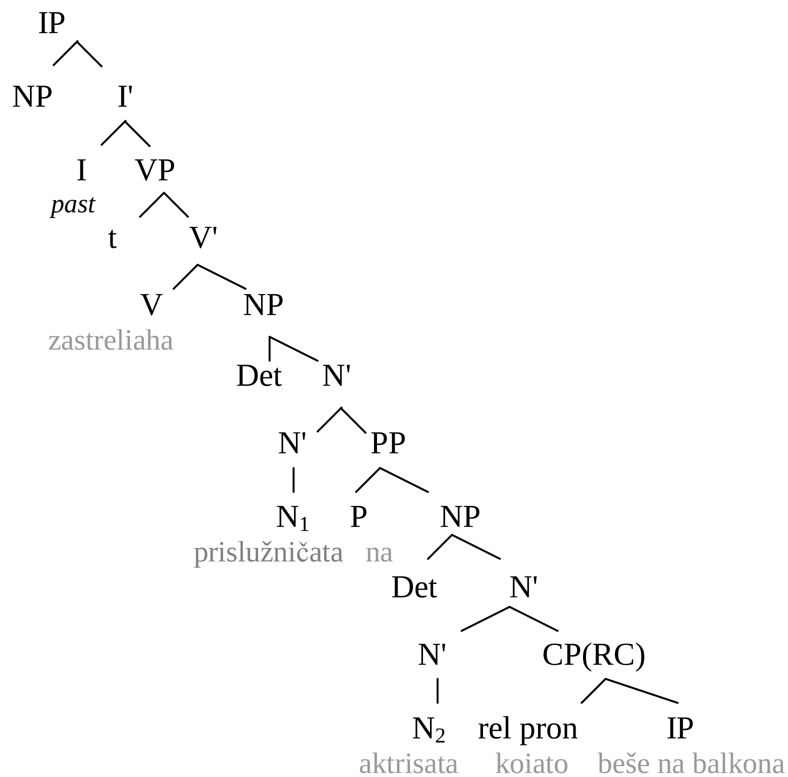

Other than the location of the NP coordination, the two alternative interpretations illustrated in the syntactic trees for (1) are quite similar with respect to global sentence structure: both (1a) and (1b) consist of two conjoined clauses; the first clause in both contains a transitive verb with nominal argument; the second clause in both contains an intransitive verb (reflexive in Bulgarian). Since the NP coordination is in a different clause in (a) and (b), we can expect a correlation of each interpretation with the location of a major prosodic boundary: after the second noun in (a) or after the first noun in (b). The prosodic characteristics of this type of sentence in Bulgarian will be discussed in more detail in Section 2.3.1. This ambiguity will henceforth be referred to as NP/S coordination, since the choice point in the parse arises at ‘i fotografa’ which may be attached as part of an NP coordination in object position, or as the beginning of a new clause conjoined with the first clause.

(2) Zastreliaha prislužničata na aktrisata, koiato beše na balkona.
Shoot$_{3p\text{-}pl\text{-}past}$ servant$_{fem\text{-}det}$ of actress$_{fem\text{-}det}$ who$_{fem}$ be$_{3p\text{-}sg\text{-}past}$ on balcony$_{det}$.
*(They) shot the servant of the actress who was on the balcony.*

a. HIGH RC ATTACHMENT



b. LOW RC-ATTACHMENT




The example in (2) illustrates the relative clause (RC) attachment ambiguity. The sentence contains a relative clause that can potentially modify either the whole complex NP (‘servant of the actress’) or only the second noun (‘actress’) which immediately precedes the RC; see the syntactic tree structures below. The former is known in the literature as high attachment of RC and the latter as low attachment.

Research on RC attachment in various languages has shown that this construction is sensitive to prosodic disambiguation; details in Section 2.2.2. Note that the high RC attachment structure in (a) has a structural discontinuity preceding the RC, which may be marked by a prosodic boundary, whereas the low RC attachment structure in (b) has no such discontinuity.

Importantly for present purposes, there is a published study on this particular ambiguity in Bulgarian (Sekerina, Fernández and Petrova, 2003) which used both written and auditory materials. Although it did not specifically examine the role of prosody in syntactic/semantic processing, the RC-attachment ambiguity resolution preferences they report can be compared with the data from the current experiments.

To sum up, both NP/S coordination (1) and RC attachment (2) can be globally ambiguous in Bulgarian and are good candidates for an experiment that aims to validate a new methodology, because ambiguity resolution preferences for these constructions have been investigated in a number of studies using established methodologies, so that the results obtained in the current research can be compared with findings on other languages (for both constructions) and also with existing data on Bulgarian (for RC attachment). The following section presents existing research on these two ambiguities and related structures in other languages.

## 2.2. Previous research on the processing of NP/S coordination and RC attachment ambiguities and other ambiguities relevant to the current experiments.

### 2.2.1. Studies on NP/S coordination and other coordination structures.

The Bulgarian example (1) is related to an experimental item from a study on Dutch (Hoeks, Vonk and Schriefers, 2002), shown in (3). The Dutch sentences in (3) contain a temporary ambiguity at the point of integrating the noun following the conjunction word ‘en’, which is resolved by the end-of-sentence phrase (in bold in the examples) which in (3a)[5] is a PP modifying the verb ‘embraced’ and in (3b) a verb which takes ‘photographer’ as its subject.

---

[5] The PP refers to the action in (3a) because it is sentence final; otherwise it can also refer to the noun (e.g. ‘the photographer at the party laughed’).

(3) a. De mannequin omhelsde de ontwerper *en de fotograaf* **op het feest**.
The model embraced the designer and the photographer at the party.

b. De mannequin omhelsde de ontwerper *en de fotograaf* **lachte**.
The model embraced the designer and the photographer laughed.

Although partly similar, the temporary ambiguity in Dutch (3) differs from the Bulgarian example in (1) in an important way. As noted above, in the Bulgarian example in (1) alternative structures (1a) and (1b) are equal in overall complexity, but that is not the case in the Dutch sentences in (3). The Dutch NP coordination sentence (3a) has a simpler syntactic structure than the Dutch S coordination sentence (3b). The noun ‘photographer’ can be parsed in the currently open clause, in which case it is interpreted as one conjunct within the direct object of the verb ‘embrace’, as in (3a), or as starting a new conjoined clause of which it is the subject, as in (3b).

This type of temporary ambiguity in Dutch was previously investigated in a self-paced reading experiment (Frazier, 1987) and a preference for NP coordination over S coordination was found, measured by reading times for the last (disambiguating) segment of the sentences, which was interpreted as a manifestation of the Minimal Attachment principle. Hoeks et al. (2002) explored alternative explanations for the processing difficulty associated with the temporarily ambiguous NP (‘the photographer’ in the example) in S coordination sentences is preference in their study. Their hypothesis is that readers “*disprefer* S-coordination when this involves having to complicate the assumed topic–comment structure by having to accommodate the ambiguous NP as a second topic” (p.101) with *topic* defined as the element referring to an entity about which information is given.

Hoeks et al. (2002) used several different tasks to explore the effect of discourse context (topic structure) on the interpretation of this type of ambiguity. Experiment 1 used a gated completion task in which sentence fragments were presented either in isolation or in contexts biasing toward one of the interpretations and the fragments were cut at various points: after the conjunction, after the definite article, or after the second noun. Participants had to provide a continuation that made a grammatical and plausible sentence. For fragments presented in isolation, they found a preference for NP coordination over S coordination. However, when the preceding context indicated possible S coordination, that interpretation was frequently adopted. Experiment 2 employed self-paced reading and found evidence for greater processing difficulty of S coordination sentences in a neutral context, which was eliminated in biasing contexts. Experiment 3, combined self-paced reading with eye-tracking and obtained similar results. Hoeks et al. explain their findings in terms of a principle of minimal topic structure[6], although they do not exclude a Minimal Attachment account of the data. This principle of minimal topic structure dictates a preference for the simplest topic structure unless there is evidence to the contrary. This principle is satisfied in the NP coordination sentence (3a) which has a simple one topic structure known as *topic-comment*[7], whereas it is not satisfied in the S coordination sentence (3b) on its own, since it requires two topics. The data in Hoeks et al. (2002) show that the larger context in which an ambiguous sentence appears has an effect on parsing preferences. In particular, preceding context can indicate the possibility of a more complex topic structure (by introducing the two referents) and thus reduce the processing difficulty which a temporarily ambiguous sentence with S coordination causes when presented in isolation or with non-biased context[8].

[6] "In the absence of explicit contextual or syntactic cues regarding the topic-structure of a sentence, assume the simplest topic-structure possible."(p.101)

[7] This type of topic structure is also the most common.

[8] Hoeks, Hendriks, Vonk, Brown and Hagoort (2006) report that although thematic information was used rapidly it did not completely neutralize processing difficulty.

Hoeks et al. (2002) also included as a control condition a contrast between a comma and no comma after the first noun in Experiments 2 and 3. They consider the comma a pragmatic marker of S coordination, because in that position it disallows NP conjunction, but it is possible that the comma induces a prosodic-type break in silent reading that contributes to the finding of reduced processing difficulty. It can be anticipated that a prosodic break after the first noun (before the conjunction) in a spoken rendering of a sentence like (3b) would also promote the S coordination interpretation compared to no break at that location.

To summarize, the NP/S coordination experiments on Dutch confirmed a preference in silent reading for NP coordination over S coordination and showed that this preference can be shifted by pragmatic context. The possibility of prosodic disambiguation of this construction was not investigated by Hoeks et al. (2002, 2006) but cannot be ruled out. Such an explanation is proposed for the auditory experiments on the Bulgarian ambiguity in (1).

Coordination ambiguities in general have been shown to be sensitive to disambiguation by insertion of a prosodic phrase break at one or another position in the sequence of conjuncts. This type of structural ambiguity and its prosodic disambiguation have been the focus of a number of investigations of the relationship between prosody and syntax, dating back to seminal work by Lehiste (1973), which included items with coordination ambiguities like the ones in (4). In (4a) the adjective can modify just the first noun in the coordination structure or the coordinate ‘N and N’ sequence. In (4b) the three nouns can be grouped in different ways: (Steve) or (Sam and Bob) vs. (Steve or Sam) and (Bob).

(4)

a. The old men and women stayed home.

b. Steve or Sam and Bob will come.

Lehiste (1973) reports a production and a perception study. In the production part, speakers first read aloud sentences without being informed of the existence of an ambiguity, then they had to identify the meaning they had intended and produce disambiguating versions for each interpretation. The three versions of the sentences were used in a subsequent listening task with paraphrase choice. The perception data showed that listeners were on average able to judge the intended meaning correctly for the deliberately disambiguated stimuli and to a lesser extent for the original productions. The different versions of the sentences where intended structure was interpreted correctly by listeners showed differences in prosodic phrasing. In a subsequent study with some of the same materials Lehiste, Olive, and Streeter (1976) found that listeners can distinguish between different bracketing in the sentence (4a) on the basis of durational cues other than pauses. More recently, a variant of the coordination ambiguity has been featured in assessment instruments designed to detect expressive and perceptive prosody deficits in children (Peppé & McCann, 2003; Peppé, McCann, Gibbon, O'Hare, & Rutherford, 2007). Their Chunking Input and Output task included items with a sequence of three color adjectives that could be grouped differently, such as: 'pink&black and green socks' versus 'pink and black&green socks'.

A coordination ambiguity similar to (4b) was investigated by Clifton, Frazier, and Carlson (2006) with respect to how well it can be disambiguated by prosodic break location. They used an auditory questionnaire with a forced-choice paraphrase task, as shown in (5) below, with a systematic manipulation of prosodic boundary placement and constituent length. Their findings are relevant to the current research, because of an important similarity between the Bulgarian NP/S coordination presented in (1) and their experimental materials illustrated in

(5). Both coordination constructions involve a series of three nominal conjuncts that can be grouped differently, resulting indifferent interpretations of the sentence.

(5) a. Pat or Jay and Lee convinced the bank president to extend the mortgage.

b. Who convinced the bank president?

c. Pat, or (Jay + Lee) (1 or 2 people) (Pat or Jay) + Lee (2 people)

The ambiguity in English (5a) is due to scope. In one case the disjunction has scope over the conjunction, so the interpretation is 'either Pat did X or Jay and Lee together did X'. In the other case, the conjunction scopes over the disjunction and the interpretation is 'either Pat or Jay did X together with Lee'. The auditorily presented sentences had a prosodic break either early, after the first noun ('*Pat'*), or late, after the second noun ('*Jay'*). Participants read a comprehension question, such as in (5b) following each sentence, and selected one of two visually presented answers, as illustrated in (5c).

Clifton et al. (2006) established that the prosodic phrasing manipulation robustly affected listeners' syntactic/semantic analysis of the ambiguity. With an early break the second and third nouns were most often grouped together syntactically and the first interpretation (1 or 2 people) was inferred; with a late break the first and second nouns were most often grouped together syntactically and the alternative interpretation (2 people) was constructed. In a follow-up experiment they replicated those findings with common nouns with determiners. An additional contrast in their study that also had an effect on interpretation preferences was constituent length; this will be discussed in more detail in Chapter 3.

It should be noted that the NP/S coordination ambiguity in (1) to be investigated in Bulgarian combines characteristics of the two ambiguities discussed in this section: different grouping of three nominal conjuncts comparable to that used in English by Clifton et al. (2006), and a NP that can be parsed as object NP coordination in the current clause or can open a new clause in a S coordination structure, similar to the ambiguity in Dutch used in Hoeks et al. (2002, 2006).

2.2.2. Previous research on the processing of the RC attachment ambiguity

The sentence in (2) is based on an experimental item from Cuetos and Mitchell (1988), the study which spurred a debate on cross-linguistic differences in language processing and prompted an interest in RC attachment preferences in different languages. Cuetos and Mitchell (1988) conducted a silent reading questionnaire study on RC attachment in Spanish (Experiment 1A) and on close translations of the same materials into English (Experiment 1B) ("literal English translations of the 24 sentences used in Experiment 1A" p.80), as illustrated in (6).

(6)

a. Alguien disparó contra la criada de la actriz que estaba en el balcón con su marido.
b. Someone shot the servant of the actress who was on the balcony with her husband.

The 'NP of NP RC' sentences in (6) are ambiguous in both languages, because as already discussed for (2), the relative clause can modify either the complex 'NP of NP' phrase ('la criada de la actriz' / 'the servant of the actress') or only the second NP ('la actriz' / 'the actress'). The Late Closure principle predicts that the RC will preferentially be attached to the second noun. Yet, the silent reading questionnaires with parallel materials (Cuetos and Mitchell, 1988) showed opposing preferences in the two languages: English speakers generally tended to interpret the relative clause as referring to the lower NP (in keeping with Late Closure), while Spanish speakers tended to prefer high-attachment to the whole 'NP of NP' complex (contrary to Late

Closure). Cuetos and Mitchell (1988) report three additional silent reading experiments in Spanish, which used experimental items with RC attachment forced low by an additional clause disambiguating by pragmatics or gender agreement and different types of control items[9]. The experimental and control items were presented as a sequence of visual displays and reading times for the final display were compared. All three experiments revealed processing difficulty in the experimental items compared to the controls, contrary to what would be predicted based on Late Closure.

The observation of different preferences with parallel materials in English and Spanish and in particular, the Spanish speakers' preference for high attachment found by Cuetos and Mitchell (1988) contrary to the prediction of Late Closure, is problematic for a theory of sentence processing based on the assumption of a universal parser, such as the Garden Path model of Frazier (1978). An explanation was therefore needed for the cross-linguistic variation in ambiguity resolution preferences for this construction. For that reason Cuetos and Mitchell (1988)'s seminal study on RC attachment in English and Spanish prompted extensive research on this ambiguity in other languages. The literature is extensive. See the appendix to this chapter for a summary of data and proposed explanations for RC attachment preference differences cross-linguistically, much of which concerns silent reading.

In a related line of research, a number of studies in the last decade have explored the possible role of overt prosody in influencing the interpretation of the RC attachment ambiguity, using auditory materials. The findings most relevant to the current research are briefly summarized below.

---

[9] The control items were similar to the experimental items in content, but did not force low-attachment interpretation, because they had one NP only (Experiment 2), one NP /conjoined NPs (Experiment 3) or two NPs did not differ in gender (Experiment 4).

In English, the role of prosody in disambiguating the NP of NP RC construction was investigated with respect to contrastive accent[10] by Schafer, Carter, Clifton and Frazier (1996) and Maynell (1999, 2001). Both found that a pitch accent on one of the two nouns shifts the attachment preference to the accented host[11]. Maynell (1999, 2001) also established that an IPh boundary between the complex nominal and the relative clause creates an overall preference for high RC attachment contrasting with the low attachment preference observed without a prosodic break in that position.

Subsequently, Clifton, Carlson and Frazier (2002) investigated how the interpretation of RC attachment (and of several other ambiguities) was affected by the presence of a prosodic boundary after N1 and its size[12] relative to the boundary after N2 as shown in (7) below affected. They found a significant difference in attachment interpretations, especially between the two phrasings in (a) and (c) and conclude that a prosodic boundary preceding a constituent which is larger relative to an earlier boundary promotes more high attachment interpretations[13].

(7) I met the daughter || of the colonel || who was on the balcony.

| | | |
|---|---|---|
| a. | 0 | ip |
| b. | ip | ip |
| c. | IPh | ip |

Fernández (2007) conducted a listening comprehension experiment as part of her investigation on the RC-attachment construction in English in which she compared three types of prosodic contour (a break after N1, a break after N2, and no break). She observed a general

[10] For example contrastive stress on 'propeller' or on 'plane' in the sentence "The sun sparkled on the <u>propeller</u> of the <u>plane</u> that the mechanic was so carefully examining."
[11] The data provide support for their Focus Attraction Hypothesis
[12] The difference in size of the boundary after N1 was manifested in lengthening of N1 as well as F0 modulation.
[13] Supporting their Informative Prosodic Boundary hypothesis first formulated in Carlson, Clifton and Frazier (2001) for adjunct attachment (e.g. Susie learned that Bill telephoned late last night / after John visited.)

preference toward low RC attachment in her experiment. However, compared to the no break condition a break after N2 produced a small but reliable increase in high attachment interpretations, whereas a break after N1 substantially decreased high RC attachment responses. The length of the relative clause modulated the effect of the early break (after N1) but not the late break (after N2).

The findings for English thus show that a prosodic break in a particular position can give a boost to one interpretation over the alternative. The presence/absence of an IPh boundary was found to be a salient cue for attaching the RC predominantly high or low respectively in other languages besides English. For example, Jun (2003) found effects of boundary placement on RC attachment in several languages (English, Greek, Spanish, French, Farsi, Japanese and Korean).

In Spanish, for which high attachment preferences for this construction were first reported, Igoa and Teira (2004) explored the role of prosodic facilitation on RC attachment with unambiguous materials: RC attachment was disambiguated by number agreement (N1 and N2 were mismatched in number and the RC verb disambiguated to one or the other) and the prosodic break location either reinforced the morphological disambiguation (congruent prosody) or counteracted it (incongruent prosody)[14]. They found prosodic effects in all tasks (questionnaire, grammaticality judgement, anomaly detection and cross-modal naming), particularly in the sentences with RC attachment forced low. In addition, they report asymmetric effects of the two prosodies on RC attachment interpretation, as were observed for English by Fernández (2007), namely a greater effect of a break after N1.

---

[14]In a subsequent study, Teira and Igoa (2007) established that the durational features played the essential part in prosodic disambiguation of this structure in Spanish. Durational cues may be expected to also play a part in Bulgarian.

Such asymmetry in the magnitude of the alternative prosodic boundaries' effect on RC attachment interpretation has been reported for other languages, such as Croatian. Lovrić (2003) explored the effects of different prosodic phrasing in Croatian (Zagreb dialect) where two alternative forms of the NP of NP RC construction, illustrated in (8), exist in free variation: one has an overt non-thematic preposition 'od' before the second (genitive) noun, the other does not.

(8)

a. Nazvali smo klijenticu || (*od*) odvjetnice što puši cigare.
b. Nazvali smo klijenticu (*od*) odvjetnice || što puši cigare.
"We phoned the client of the lawyer that smokes cigars"

Lovrić (2003) established that the presence of the preposition reduced high RC attachment interpretations in silent reading. The phrasing patterns in a subsequent production study showed that the presence of 'od' increased the likelihood of a prosodic break after N1 (even when it was not consistent with the RC disambiguation by number) and eliminated or weakened the probability of a break before a relative clause (i.e., after N2) which is otherwise common in Croatian. Finally, the two prosodic patterns (a break after N1 vs. a break after N2) were contrasted in an auditory questionnaire study with ambiguous materials RC attachment like (8). Lovrić (2003) reports that regardless of the presence of the preposition the break after N1 produced a very low rate of high RC-attachment interpretations, whereas a break after N2 produced a steady, but more moderate high RC attachment preference. The Croatian data thus confirms that overt prosodic phrasing may cause a shift in attachment preference for the relative clause and show a stronger effect of N1 break compared to N2 break.

Similar findings were reported in Augurzky (2006) who used different methods, including ERPs, to explore extensively the same ambiguity in German, which also has an optional non-thematic preposition (‘von’). She found an effect of overt preposition on RC attachment interpretation in silent reading not just with ‘von’, but also with a thematic preposition (‘bei’) and confirmed in a production study that the presence of a preposition increases the probability of a prosodic break between N1 and N2. In a listening questionnaire ERP study Augurzky (2006) found immediate effects of the prosodic break, as well as different CPS patterns elicited by the different prosodic phrasings.

Shaked (2009) investigated the RC-attachment ambiguity in Hebrew free state and construct state ‘NP of NP’ constructions, which have the same meaning but differ in syntactic structure and morpho-phonological characteristics. Her elicited production data show that participants produce a prosodic break between N2 and RC more often when the sentence is disambiguated toward high RC attachment than when the sentence is disambiguated toward low RC attachment, but the proportion of breaks is also influenced by RC length. Her listening experiment with ambiguous materials confirms the effect of prosodic information in RC attachment interpretation.

The findings of prosodic effects on RC attachment interpretation in different languages are relevant to the present research in two ways. First, they indicate that the presence of a prosodic break at a relevant point in the structure can disambiguate RC attachment or at least bias toward a specific interpretation of the RC consistent with it. This gives grounds to including the RC attachment ambiguity as a test case for disambiguation by prosodic break location in Bulgarian. Secondly, in view of the observed asymmetry in the effects of a prosodic break after N1 vs. after N2 in Croatian (Lovrić, 2003), Spanish (Igoa and Teira, 2004) and English (Fernández, 2007) a similar finding may be expected for Bulgarian.

There is some data on RC-attachment in Bulgarian. It was investigated with written and auditory materials by Sekerina et al. (2003). They found a 59% high attachment preference in silent reading using a standard questionnaire task, similar to the high attachment preference found for Russian (Sekerina, 1997). However, the opposite preference emerged for both written and spoken input with novel sentence materials describing geometric shapes arranged in a visual presentation. These psycholinguistic experiments on Bulgarian will be discussed in more detail in section 2.3.5. The next section provides some linguistic details on the two ambiguities in Bulgarian, with respect to syntactic structure and prosodic phrasing.

## 2.3. Linguistic details of the two constructions in Bulgarian

### 2.3.1. The NP/S coordination ambiguity in Bulgarian: syntax and morphology

The overall structure for NP coordination and S coordination in Bulgarian is not different from that of their English or Dutch counterparts which were discussed earlier. The Bulgarian sentences in (9a-b) below are the equivalents of the Dutch examples in (3) above. The Bulgarian equivalents of the Dutch examples are given below: NP coordination in (9a) and S coordination in (9b); the sentence in (9c) repeats the Bulgarian example with global ambiguity given in (1). As already discussed, the difference between the two interpretations for (9c) is that the two possible locations of the NP-coordination change the complexity of each clause, but not the overall structural complexity of the sentence. This is important to note, because it eliminates the factor of differential global syntactic complexity for the competing interpretations of this construction.

(9) **a. NP coordination**

Manekenkata pregarna dizainera I fotografa po vreme na partito.
Model-det embrace-past [designer-det and photographer-det] at time of party
*The model embraced the designer and the photographer at the party.*

**b. S (clause) coordination**

Manekenkata pregarna dizainera **i** fotografa se razsmia.
[Model-det embrace-past designer-det] and [photographer-det refl laughed-past
*The model embraced the designer and the photographer laughed.*

**c. combined NP and S coordination (globally ambiguous)**

Manekenkata pregarna dizainera **i** fotografa **i** ziapačite se razsmiaha.
Model-det embrace-past designer-det and photographer-det and onlookers-det refl laughed-past-pl
*The model embraced the designer and the photographer and the onlookers laughed*

The two additional examples in (10) show that in Bulgarian this type of sentence, combining NP and S coordination can also be temporarily ambiguous. As is the case of (9c), the overall structure of the sentences in (10a) and (10b) is parallel, i.e. each consists of two coordinated clauses connected by the conjunction 'and', the first clause with a [S-V-O] structure and the second one structured as [S-VP]. As in (9c), at the point where the second noun ('photographer') is encountered in (10a-b), both interpretation are available. However, the two sentences in (10) are only temporarily ambiguous because Bulgarian has obligatory subject verb-agreement, reflected in morphological markers for person and number. In this case the morphological form of the verb in the second clause disambiguates the temporarily ambiguous sentences via number agreement.

(10)

**a. combined: NP coordination followed by clause coordination**

Manekenkata pregarna dizainera **i** fotografa **i** pomošnikat mu **se razsmia**.
[Model-det embrace-past [designer-det and photographer-det]] and [assistent his refl laughed-past-sg]
*The model embraced the designer and the photographer and his assistant laughed.*

**b. combined: NP coordination following clause coordination**

Manekenkata pregarna dizainera **i** fotografa **i** pomošnikat mu **se razsmiaha**.
[Model-det embrace-past designer-det] and [[photographer-det and assistent his] refl laughed-past-pl]
*The model embraced the designer and the photographer and his assistant laughed.*

In (10a) the second clause verb ('laugh') is singular, so it can only refer to the singular third NP ('his assistant') and therefore only allows the syntactic structure shown in (1a), whereas in (10b) the verb ('laugh') is plural, so it has to refer to the coordinate NP ('the photographer and his assistant') and therefore mandates the syntactic structure shown above in (1b). The sentence in (10c) is globally ambiguous, because the plural verb can refer to either the third NP which is plural in this case or to a coordination of singular NPs.

The Bulgarian sentences in (9c) and (10a-b) also in some way resemble the coordination ambiguity given in (5) which was investigated for English by Clifton et al. (2006). Both constructions involve different grouping of three nominal conjuncts that correspond to alternative interpretation of the sentence. But there is an important difference. In the materials illustrated in (5), a differently configured coordinate NP fills the subject position of the main clause (always at the beginning of the sentence), whereas the three nouns in the temporarily ambiguous Bulgarian NP/S coordination construction in (10) and the globally ambiguous one in (9c) fill two syntactic positions in two coordinated clauses (object of the first clause and subject of the second clause). So while both ambiguities are related to which conjunct is in a higher syntactic node than the other, the alternative NP grouping in the NP/S coordination construction does not involve multiple layers of NP coordination with scopal ambiguity as the ambiguity (due to alternating 'and' and 'or') in (5) and may thus be a cleaner test case for prosodic grouping effects.

In the NP/S coordination in (10) the same conjunction 'i' (*and*) is used both for NP coordination and clause coordination. The conjunction 'i' is the most common in coordinating structures in Bulgarian and unlike others can be used with all types of conjuncts[15]. In Bulgarian, as in other languages, the syntactic role of the coordinated elements is typically the same, although their internal structure does not have to be identical. For example, NP conjuncts are not restricted in type, structure and number of modifiers, although an extreme disbalance between the conjuncts in terms of complexity (e.g., coordination of a single noun with a complex NP containing multiple modifiers of different types) is not typical in stylistically neutral speech.

When more than two constructions are linked together in a coordination structure, the conjunction 'i' is typically only used before the last one and the conjuncts that are not preceded by 'i' are separated by a comma in writing, e.g. 'manekenkata, dizainera, fotografa i pomošnikat mu'. Repeating the conjunction in same-type phrase coordination is possible, but it is not stylistically neutral. For example, (11a) only conveys a piece of information and is stylistically neutral, while (11b) conveys also attitude, a difference which will be reflected in the phrasing of the utterance[16] and in punctuation by the comma before 'I'.

(11)
a. Maria dovede brat si, saprugata mu i trite im detsa.
Maria brought-3p brother own wife-det his and three their children
*Maria brought her brother, his wife and their three children.*

b. Maria dovede brat si i saprugata mu, i trite im detsa.
Maria brought-3p brother own and wife-det his and three their children
*Maria brought her brother and his wife and their three children.*

However, when different levels of coordination are combined, multiple instances of the conjunction 'i' are possible and are stylistically neutral. This is the case in the target construction that combine NP/S coordination shown in (10) which combines NP and clause coordination.

[15] The other conjunction that can be used in NP coordination is 'ili' (or) and there are conjunctions that are used to form VP/S coordination structures that express contrast, such as 'no' (but) and 'a' (while).
[16] In (11b) each NP will typically be placed in a separate prosodic phrase

With the two instances of ‘i’ in (10) there is no comma in writing to indicate the location of the prosodic break, because in Bulgarian comma is not placed before the conjunction ‘i’ when between two syntactically-equivalent conjuncts[17].

2.3.2. Prosodic disambiguation of the NP/S coordination ambiguity and typical prosody of coordination constructions in Bulgarian

In addition to overt morphological agreement marking, the NP/S coordination construction in (10) is disambiguated in Bulgarian by a clausal prosodic (IPh) boundary in normal speech at the end of the first clause in the complex sentence. For the object NP coordination sentence in (10a) the IPh boundary will fall after the second noun ‘fotografa’ (*the photographer*). Such a break will prosodically group the first two nouns together and show they are a constituent intended to fill the object position in the first clause as a coordinated NP. The subject position of the second clause will then be filled by the third NP, ‘pomošnikat mu’ (*his assistant*), in conformity with the singular form of the verb in the second clause. For the subordinate subject NP coordination structure in sentence (10b) the IPh boundary will be located after the first noun, ‘dizainera’ (*the designer*), showing that it is intended to stand on its own as the object of the first clause verb. The second and third noun will now be grouped together prosodically and form a conjoined subject for the second clause, which is in agreement with the plural form of the verb. Importantly, the location of the prosodic break in the globally ambiguous sentence (9c) can indicate the intended structure, even in the absence of morphological agreement cues. A break after the second noun will group the first two nouns in object NP

[17] A comma is generally not used before ‘i’ in Bulgarian, unless for emphatic reasons. It is obligatorily used, however, before disjunction with ‘no’ (but) and ‘a’ (but/while).

coordination, while a break after the first noun will signal second clause subject NP coordination. This is also the case in the current research: the prosodic boundary location was the sole disambiguator of the intended structure in the stimuli after morphological disambiguation was removed by noise substitution.

In Bulgarian, IPh type prosodic breaks are produced by default in normally paced, stylistically neutral speech at the end (right edge) of a sentence or a clause in a complex sentence. Thus, the IPh break at the end of the first clause in a S coordination may be taken as an instantiation of a general syntax-prosody alignment constraint in Bulgarian of the type formalized by Selkirk as Align $XP_R$ (see Chapter 1 above.) This alignment constraint was formulated for English, where prosodic boundaries have been shown to align with the right edge of syntactic constituents. Its direction in any language is a language-specific parameter setting, though there appears to be a trend for prosodic edge alignment to coincide with the syntactic branching direction of a language. The fact that in coordination structures in Bulgarian, the legitimate location of a prosodic boundary is between a conjunct word and the material preceding it, not between the conjunct word and the following conjunct, supports the assumption that Bulgarian is also an $Align_R$ XP parameter setting language. (Note: This assumption may or may not be broadly applicable; only nominal and clausal edges are addressed here.)

The IPh break is realized through both tonal and durational means. The common durational marker of a right-clause-edge IPh break is pre-boundary lengthening, often accompanied by a pause, but the size of both depends on factors such as speech rate and intensity. (Misheva & Nikov, 1998; Tilkov, 1981). The boundary tone can be high or low as in English, with a continuation rise being more typical in a non sentence-final clause.

Another observation about prosodic phrasing in Bulgarian possibly relevant for the current research is that as a general rule, two phrases that form one syntactic constituent or a syntactic complex will in the default case (i.e. in stylistically neutral speech) be produced in Bulgarian in one prosodic phrase, unless they are inordinately long and/or complex in structure. That is, a prosodic break will generally not occur between a head and its modifier or between sister nodes in the tree. Tilkov (1981) specifically lists the following cases where separation should not normally occur inside a combination of: a lexical word and clitic(s) (i.e. within a prosodic word); nouns in apposition (e.g. 'zamestnic-direktor' **vice principal**)[18]; an attributive adjective and a noun (e.g. 'goliama kašta' *big house*)[19]; two adverbs if one modifies the other (e.g. 'mnogo barzo' *very fast*); single-word subject and verb-form (e.g. 'vlakat dojde' *the train came*); single word verb-form and direct object or adverbial (e.g. 'četa kniga' *read a book*; 'varvia barzo' *walk fast*); idiomatic expressions (e.g. 'ot igla do konets' *from beginning to end*)

This list indicates that besides the $\text{Align}_R$ XP constraint, it is likely that another type of constraint also operates in Bulgarian and is of relatively high rank: perhaps a Wrap-type constraint that requires both edges of XP and MaP to align or a semantic constraint like Selkirk's (1984) *Sense Unit Condition*, which predicts that a boundary will not occur within a constituent formed by a head and any number of its modifiers and/or arguments.

In the case of NP coordination structures, this means that the two nominal elements that form a NP coordination will typically also form a single prosodic phrase. The requirement to keep the NP coordination prosodically 'tight' (as a sense unti) does not interfere with the requirement to insert an IPh break at the clause boundary, so both constraints can be satisfied in

[18]Also when a first and last name are used (e.g. Ivan Petrov), so this applies to the long NP/S coordination items with proper names.

[19] This concerns the long items for both NP/S coordination and RC attachment.

(10). However, another type of constraint on prosodic phrasing that has been shown to operate in English (Selkirk, 2000) and other languages like Hebrew (Shaked, 2009) may be relevant to the current research, namely a constraint on optimal phrase length. For example, in (12) below, the two noun phrases, 'my brother' and 'his wife' will be phrased together when grouped in a coordinate subject (12a). However, if one conjuncts is long, as in (12b-c) this may not be the case. The two coordinate NPs may still be grouped together together prosodically, but they will likely separated into two smaller phrases, especially in (12c) where the first conjunct is long. The presence and size of this optional boundary depends on various factors such as speech rate[20].

(12)
a. <u>Brat mi i saprugata mu</u> šte ni gostuvat prez uikenda.
Brother my and wife-det his will us visit-pl during weekend
*My brother and his wife will visit us this weekend.*

b. <u>Brat mi i neveroiatno pretencioznata mu sapruga</u> šte ni gostuvat prez uikenda.
Brother my and unbelievably pretentious-det his wife will us visit-pl during weekend
*My brother and u*nbelievably pretentious *his wife will visit us this weekend.*

c. <u>Neveroiatno pretenciozniat mi brat i saprugata mu</u> šte ni gostuvat prez uikenda.
Unbelievably pretentious-det my brother and wife-det his will us visit-pl during weekend
*My unbelievably pretentious brother and his wife will visit us this weekend.*

Thus, a well-formedness (optimal length) constraint is also in play in Bulgarian. Some of the items listed by Tilkov (1981) as phrases that cannot be divided by a break include a length restriction. (For example, subject and verb have to be phrased together **only** if both are single-word phrases). This distinction also implies the existence of well-formedness constraints like BinMaP in Bulgarian and also that perhaps the minimum phrase length requirement BinMin is ranked higher than its counterpart BinMax. It is important to note that prosodic breaks in

[20]The break inside the coordination structure will not be an IPh break, at least in stylistically neutral speech. Its presence may also be modulated by where the NP coordination appears in a sentence.

Bulgarian can be a reflex of constituent length, because constituent length is one of the variables manipulated in some of the experiments reported in this dissertation (Experiments 1b and 1c).

Note, however, that the NP-length contrast in (12) is between a short NP and a very long one, so the length constraints may not apply in the same fashion to the sentence materials for the experiments reported here, in which the NPs are all short or long. In principle, there is no constraint on the length of the coordinated components in Bulgarian either in absolute terms or relative to each other. However, a phrase with same-size coordinate components will in general sound more mellifluous to speakers of the language. Conceivably, there may be a (probably low ranking) balance constraint in the language, which favors same-size phrases, such as the Same Size sister constraint (Fodor, 1998).

### 2.3.3. The RC-attachment ambiguity in Bulgarian: syntax and morphology

The NP of NP RC construction in Bulgarian illustrated in (2) and repeated as (13a) below is globally ambiguous, as is its counterpart in English and Spanish given in (6). The Bulgarian sentence in (13a) also has in general the same syntactic structure as its counterpart in English / Spanish in (6). As shown in the syntactic trees for (2), above, the overall syntactic structure of the sentence for the alternative RC attachments differs in an important way: the high (N1) RC attachment sentence in (13b) has a structural discontinuity in the syntactic tree which is not present in the low (N2) RC attachment sentence in (13c), which is fully right-branching.

The two additional examples given in (13b) and (13c) show that in Bulgarian this type of structure can contain merely a temporary ambiguity that is resolved by means of overt morphological agreement[21], just as in the case of the NP/S coordination ambiguity.

(13)

a. ambiguous RC attachment

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Zastreliaha | prislužničata | na | aktrisata, | koiato | beše | na | balkona |
| Shoot$_{\text{3p-pl-past}}$ | servant$_{\text{fem-det}}$ | of | actress$_{\text{fem-det}}$ | who-fem | be$_{\text{3p-sg-past}}$ | on | balcony$_{\text{det}}$. |

*(They) shot the servant(fem) of the actress(fem) who(fem) was on the balcony.*

b. disambiguated to N1 (high) RC attachment

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Zastreliaha | prislužnika | na | aktrisata, | kojto | beše | na | balkona |
| Shoot$_{\text{3p-pl-past}}$ | servant$_{\text{masc-det}}$ | of | actress$_{\text{fem-det}}$ | who-masc | be$_{\text{3p-sg-past}}$ | on | balcony$_{\text{det}}$. |

*(They) shot the servant(masc) of the actress(fem) who(masc) was on the balcony.*

c. disambiguated to N2 (low) RC attachment

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Zastreliaha | prislužnika | na | aktrisata, | koiato | beše | na | balkona |
| Shoot$_{\text{3p-pl-past}}$ | servant$_{\text{masc-det}}$ | of | actress$_{\text{fem-det}}$ | who-fem | be$_{\text{3p-sg-past}}$ | on | balcony$_{\text{det}}$. |

*(They) shot the servant(masc) of the actress(fem) who(fem) was on the balcony.*

d. unambiguous RC attachment

| | | | | | |
|---|---|---|---|---|---|
| Zastreliaha | aktrisata, | koiato | beše | na | balkona |
| Shoot$_{\text{3p-pl-past}}$ | actress$_{\text{fem-det}}$ | who-fem | be$_{\text{3p-sg-past}}$ | on | balcony$_{\text{det}}$. |

*(They) shot the actress(fem) who(fem) was on the balcony.*

Although an alternative relativizer does exist[22], relative clauses in Bulgarian are typically introduced by a relative pronoun that is morphologically marked for gender (masculine, feminine

[21]Morphological disambiguation is also possible in Spanish through verb agreement and may be achieved in English through agreement with reflexives, but in Bulgarian it involves the relative pronoun as well (which is an obligatory element of any relative clause).

[22] RCs can be introduced by 'što' and 'deto' which do not change in form, but both are rarely used at present, unlike in Croatian where the non-inflected form is frequently used (Lovrić 2003).

or neuter) and/or number[23] as are all pronominal elements in Bulgarian. Sometimes the relative pronoun is preceded by a ‘pied-piped’ preposition, which is part of the relative clause. The relative pronoun in Bulgarian obligatorily agrees in gender/number with the head of the RC. Therefore, when the two nouns that can be modified by the RC differ in gender as in (13b) and (13c), the gender of the relative pronoun indicates the intended RC attachment. In (13b) the relative pronoun is masculine ‘kojto’, therefore the RC has to refer to the first noun ‘prislužnika’ (*servant*) which is masculine. In contrast, the relative pronoun in (13c) is feminine ‘koiato’, therefore the RC has to modify the second noun ‘aktrisata’ (actress) which is also feminine. The relative pronoun in the unambiguous sentence (13d) is the feminine ‘koiato’ because it has to agree in gender with the only possible head for the RC to modify, ‘aktrisata’ (*actress*). In the globally ambiguous sentence in (13a) the relative pronoun does not disambiguate, because the two nouns which the RC can modify are of the same gender. Number agreement can also disambiguate RC attachment in Bulgarian. If one of the possible host nouns in a ‘NP of NP’ complex is singular and the other plural, e.g. ‘prislužnitsite na aktrisata’ (*servants of the actress*), the relative pronoun will disambiguate through agreement by number (or combined number and gender). In general, Bulgarian verb forms obligatorily agree with the subject in person, number and in some cases gender[24] and consequently within a subject-extracted RC the verb agrees with the relative pronoun, so it may provide additional disambiguation, but that was not used in the current experiments.

The NP in Bulgarian has a different internal structure than in English. The definite/indefinite articles are bound morphemes that attach to (the right edge of) the noun or one

[23] Only the singular forms are differentiated for gender, the plural form is the same.
[24] Some verb forms (e.g. participles) have a masc-fem-neuter third person singular paradigm.

of its modifiers, e.g. ‘prisluzniča’ (servant-fem), prisluzničata (servant-fem-def). Bulgarian NPs also differ in syntactic/semantic properties from their counterparts in English, but that will not be relevant in this research[25].

What is most relevant for present purposes is that the NP in Bulgarian is overtly marked for gender, as well as number. All nouns belong to one of three grammatical genders: masculine, feminine and neuter. For nouns denoting an animate entity, masculine/feminine grammatical gender typically coincides with natural gender. For example, the nouns ‘sin’ (son), ‘bašta’ (father) and ‘brat’ (brother) are masculine and the nouns ‘dašteria’ (daughter), ‘maika’ (mother) and ‘sestra’ (sister) are feminine. Unlike other languages, Bulgarian neuter is not restricted to inanimate entities, but the neuter animate nouns such as ‘kote’ (kitten) ‘dete’ (child) and ‘bebe’ (baby) seem to have a semantic nuance of ‘not defined by natural gender’ (i.e. natural gender is not an essential characteristic of this entity), unlike masculine and feminine. Gender marking may be used to form cognate words for animate nouns where a natural gender distinction is required by semantics, such as ‘lav’ (lion) – ‘lavitsa’ (lioness) or ‘saprug’ (husband) – ‘sapruga’ (wife) or where the distinction follows from pragmatic considerations, for example for nouns denoting professions, such as ‘lekar’ (doctor-masculine) and ‘lekarka’ (doctor-feminine). In the latter case, however, when cognate words exist[26], the masculine (unmarked) form is typically the more generic term. Thus, for example the sentence in (14a) is felicitous, but the sentence in (14b) is not.

(14) a. Tia e lekar.
She is doctor-masc.

---

[25] For example, Bulgarian does not express the same mass/count distinction as in English. Also, unlike English, the definite form is used to express generalizations.

[26] Not all nouns denoting professions have a feminine form that will be recognized. For example, there is no standard feminine form in use for ‘astronavt’ (astronaut) or ‘požarnikar’ (firefighter), although in principle a feminine cognate could be made.

b. *Toj e lekarka.
He is doctor-fem.

In general, Bulgarian exhibits overt morphological agreement of subject and complement, a violation of which renders the sentence ungrammatical. However, a violation of morphological agreement in gender may be permitted by the semantics/pragmatics of the sentence as in (14a) where ‘lekar’ is used generically, unlike in (14b) where ‘lekarka’ does not have the broader semantic category connotations.

Because such cognates are used in the RC attachment materials, that semantic difference was taken into account and order of the masculine and feminine noun in the NP of NP in the target items was counterbalanced (alternated) to avoid potential gender effects.

In addition, Bulgarian has obligatory and overtly marked morphological agreement within the NP. In particular, adjectives and pronominal modifiers[27] have to agree in gender and number with the head noun. For example, the phrase ‘opiten detski lekar’ (*good pediatric doctor*) denotes a male and all its elements are marked for masculine while the corresponding phrase ‘opitna detska lekarka’ denotes a female and all its elements are marked for feminine. As the RC in Bulgarian is typically introduced by a relative pronoun, the modifier-head agreement requirement applies to the RC as well. As was pointed out earlier, a sentence containing a ‘NP of NP RC’ sequence will be globally ambiguous only if the two nouns have the same gender and number features, as illustrated in (13a). Otherwise, it will be disambiguated at the relative pronoun, which has to agree in features with the antecedent of the relative clause. The RC in Bulgarian may be disambiguated by gender as shown in (13b-c) or by number agreement. In this respect Bulgarian offers richer materials for experimental study than English, which has less

[27] For example, demonstrative pronouns like ‘tozi’ (this) also have a feminine, neuter and plural form: ‘tazi’, ‘tova’, ‘tezi’.

morphological disambiguation (only number, as in ‘Someone shot the servants of the actress who were on the balcony’), although gender can be used for pragmatic disambiguation. For example, Frazier and Clifton (1996) used reflexives to disambiguate RC attachment in English (as in “Fred never met the daughter of the fireman who shot himself/herself.’) and Henstra (1998) used both pragmatic disambiguation by gender (as in “Lily saw the father of the policewoman that had a red moustache and a beard.’) and syntactic disambiguation by number. Both studies found a reading advantage for sentences disambiguated toward low attachment. Teira and Igoa (2004) used number agreement disambiguation of RC attachment in Spanish, and Augurzky (2006) used gender disambiguation in German, as did Sekerina (2004) in Russian. Only gender disambiguation between masculine and feminine was used for RC attachment materials in the current research in order to simplify the design. Number disambiguation was used for the NP/S coordination materials.

The preposition ‘na’, which is used to connect the two nouns in the ‘NP of NP’ construction, e.g. ‘prisluzničata **na** aktrisata’, is the most common way to form genitive constructions in present-day Bulgarian. Although a preposition-less ‘N-Gen NP’ construction exists, its use is quite infrequent in comparison, with the first (genitive) noun mostly restricted to proper names and a small number of common nouns that usually denote close family status or special social status[28] e.g. ‘brat’ (brother) – ‘bratov’ (brother’s ), ‘baša’ (father) – ‘bašin’ (father’s). These remnant genitive forms are somewhat archaic or are lexicalized and behave in most respects like adjectives with a meaning of ‘belonging to’, e.g. obligatory agreement with the nominal head: ‘bratov sin’ (brother’s son) vs ‘bratova dašeria’ (brother’s daughter).

[28] Is preserved in Bulgarian proper names where by tradition every child takes as a middle name his or her father’s name with the genitive suffix –ov/a and it is also common in family names derived from a name (Ivanov, i.e. of Ivan) or a calling (Popov, i.e. of the priest).

The alternative (typical) construction does not involve case marking, which in Bulgarian is almost obsolete[29], unlike in other Slavic languages like Russian and Croatian. It also has the reverse word order, as illustrated in (15) below. This is different from Croatian where the preposition does not affect the case marking or word order of the construction and similar to English where the word order is also reversed. Also unlike Croatian, the preposition is obligatory in the NP of NP construction in Bulgarian.

(15)

| | N-Gen NP | NP of NP |
|---|---|---|
| a. | Ivanovata kašta se viždaše otdaleče.<br>Ivan-Gen-def house refl see from-far away | Kaštata na Ivan se viždaše otdaleče<br>House-def of Ivan refl see from-far away |
| | *Ivan's house could be seen from far away.* | |
| b. | Napusna bašinata si kašta.<br>Left-past father-Gen-def refl house. | Napusna kaštata na bašta si.<br>House-def of Ivan refl see from-far away |
| | *(He) left his father's house.* | |

In case it should prove to be relevant, it should be noted here that forming the genitive is only one function for this preposition 'na'. It can also be used, among other things, to express locative relations (16a), or direction (16b), to introduce an indirect object (16c) or to form idiomatic expressions (16d). (In other Slavic languages such as Russian these functions are expressed by case marking, so Bulgarian 'na' might be categorized as a multi-purpose case marker rather than a preposition.)

(16)
a. Knigata e na masata.
*The book is on the table.*
b. Složih knigata na masata.
*(I) put the book on the table.*
c. Dadoh knigata na Ivan.
*(I) gave the book to Ivan.*

---

[29]However, overt case marking in Bulgarian is preserved on most pronouns.

d. Dadoh pari na viatara.
*gave money to wind*

Finally, note that in Bulgarian sentences containing that structure are not very common to begin with and when they do occur in normal circumstances their meaning may be disambiguated by morphology and/or prosody. A manual search of the Bulgarian "Brown" corpus[30] showed that in it only about 8.6% of relative clauses following a NP occur after a NP prep NP combination (any preposition, not just 'of ') and very few of these are ambiguous. They are typically disambiguated by morphological agreement, semantics or pragmatic plausibility

2.3.4. Typical prosody of 'NP of NP RC' structures in Bulgarian

Beside morphological agreement, as just discussed, a morphologically ambiguous sentence such as (13a) may be disambiguated by the location of a prosodic boundary. In a sentence where RC attachment to the whole complex NP (high attachment) is intended, such as (13b), a prosodic boundary will normally be inserted after the second noun, grouping the 'NP of NP' complex together in one prosodic phrase. Alternatively, to signal low attachment, as in (13c), a prosodic boundary will typically be inserted after the first noun, which results in the second noun being enclosed in one prosodic phrase with the RC.  The two distinct prosodic contours can thus be used to disambiguate the syntactically/semantically ambiguous sentence in (13a) toward high attachment (by placing a prosodic break after N2) or toward low attachment (by placing a prosodic break after N1). The same type of prosodic disambiguation was used in the current research where morphological disambiguation was removed from the stimuli with

[30]The Bulgarian "Brown" Corpus (Brown university, Providence, Rhode Island, USA) consists of 500 text samples from fiction and informative prose, the majority dated after 2000 and has a total 1,001,286 words

noise substitution and location of the prosodic break was the only cue to the intended structure in the stimuli.

It should be noted, however, that if we consider the location of the prosodic break in (13a) in relation to the RC itself, the two prosodic contours are not equally common. In Bulgarian a boundary will generally be produced in normal speech between the noun and the RC which modifies it in the far more frequent cases when there is only one noun and RC attachment is unambiguous, as in (13d). The presence of a pre-RC prosodic boundary is not limited by the position in which the RC-modified noun occurs in the sentence, e.g., as object (17a) or as subject (17b), though it may be somewhat weaker in (17b) because there is another break following the RC, before the main clause VP.

(17)

a. Momčeto vidia aktrisata, koiato beše na balkona.
boy-det saw-3p actress-det who was on balcony-det.
*The boy saw the actress who was on the balcony.*

b. Aktrisata, koiato beše na balkona vidia momčeto.
actress-det who was on balcony-det saw-3p boy-det
*The actress who was on the balcony saw the boy.*

A similar phrasing applies in adverbial clauses, which are typically preceded by a prosodic break and may also be followed by a prosodic break depending on their position in the utterance. This 'default phrasing' of RC and adverbial clauses in Bulgarian is even reflected in punctuation. There is an obligatory comma in writing before an RC in Bulgarian, as well as an obligatory comma before adverbial clauses[31]. In sentences with 'NP of NP RC' construction, this obligatory comma goes between the RC and the noun immediately preceding it. There may thus be a requirement for a prosodic break at the left edge of adjunct clauses in Bulgarian similar to

[31]However, it should be noted that a comma in writing is also obligatory before complementizers like 'če' (that) which introduce complement clauses not normally preceded by a prosodic break.

the break at the left edge of PP in Croatian (Lovrić, 2003). However, it is also possible that the typical (henceforth default) pre-RC break may be an instantiation of a syntax-prosody alignment constraint in Bulgarian (Align $XP_R$ )that applies in general at adjunct clause boundaries, as was discussed in section 2.3.2. which in this case occurs at the right edge of the main clause. This constraint is obeyed in both the high-attachment (13b) and the low-attachment (13c) structures.

The ‘default’ status of the pre-RC break may be due to an interaction with other constraints, such as optimal length. An RC in Bulgarian is normally quite long. The RC minimally includes the relative pronoun (a two/three-syllable autonomous word, one stress) and a single-word verb form (at least a syllable, also stressed) which would satisfy a well-formedness constraint on minimal length. What is more, such an RC will be quite rare in Bulgarian: the majority of RCs are longer and more complex. In fact, manual search of the Bulgarian “Brown” corpus showed that less than 2% of relative clauses consist of only a relative pronoun and a verb form that is one prosodic word (including clitics). The ‘default’ break before the RC for Bulgarian described above may therefore be also related to length considerations. Note that there is not similar default break requirement for PPs in Bulgarian (unlike Croatian), but there may be a pie-pied preposition at the start of the RC or in an adverbial which will then be preceded by the prosodic break.

The default phrasing of RC should not be an issue in an experiment with spoken stimuli where the disambiguating prosodic break supports the intended interpretation. In fact, Lovrić (2003) found that a prosodic break after N1 diminishes the chance of a pre-RC break in this structure for Croatian. However, the obligatory presence of a comma may have some bearing on experimental designs involving the ‘NP of NP RC’ construction in Bulgarian: if the comma is treated as a prosodic break marker in an ambiguous sentence like (13a), it may induce (or strengthen) a high attachment preference. It is a factor to be considered in the silent reading experiments presented in Chapter 6.

2.3.5. Previous experiments on RC-attachment preferences in Bulgarian

In a study on RC-attachment in Bulgarian (Sekerina et al. 2003), Sekerina and colleagues conducted a standard silent reading questionnaire task (Experiment 1), that revealed an overall preference for high attachment of the RC (59%) in Bulgarian, as well as effects of RC length. Both results were expected in view of similar findings for other Slavic languages, namely Croatian (Lovrić, 2003), Polish (Nowak, 2000), and Russian (Sekerina, 2002).

The study also included two innovative experiments designed to minimize the semantic/ pragmatic complexity of the comprehension task by using a visual display with geometrical shapes (rather than references to servants, actresses, cowboys, etc.), and which provided immediate interpretive contexts. Each visual presentation involved a pair of identical geometric shapes, which differed only in their features or components (color, texture, contents). The participants' task was to answer a question (e.g., 'What color is the tip of the triangle that has an umbrella inside it?) by identifying the necessary information in the visual presentation. It was implemented in two modalities: auditory (Experiment 2) and written (Experiment 3).

In the auditory questionnaire in Experiment 2, the presentation of the visual display for each item was synchronized with the auditory stimulus, which consisted of a sequence of three sentences, as illustrated in (18) below: two preamble sentences (18a-b) that described the visual context while the visual display was being built, followed by a comprehension question (18c) that was heard after the visual display for the item was complete.

(18) a.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Eto | edin | rozov | triâgâlnik | i | edin | žâlt | triâgâlnik. |
| Here | one | pink | tiangle | and | one | yellow | triangle |

*Here is a pink triangle and a yellow triangle.*

b.

| | | | | |
|---|---|---|---|---|
| Vârxovete | im | sa | različno | ocveteni. |
| tips-det | of- them | are | differently | colored |

*Their tips are different colors*.

**c.**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kakâv | cvjat | e | vârxât | na | triâgâlnika | v | kojto | e | narisuvan | čadâr? |
| What | color | is | tip-det | of | triangle | in | which | is | drawn | umbrella |

*What color is the tip of the triangle that has an umbrella inside it?*

Contrary to expectations, Sekerina et al. found a low-attachment preference for the RC with these materials. With ambiguous visual contexts (i.e. for (18c) both triangles have an umbrella inside, one in the tip and one in the bottom part), participants preferred high RC attachment only 37% of the time. With an unambiguous visual context, response accuracy was generally high, but much more so when the disambiguation was toward low attachment (98.4% correct) than when the disambiguation was toward high attachment (63.5% correct).

In the written questionnaire task with visual context (Experiment 3), the same linguistic stimuli were presented in written form. The preamble sentences were synchronized with the visual presentation as they were with the auditory stimuli (but remained on the screen throughout the slide presentation, so they were available longer than their auditory counterparts), and the question followed after the visual display was complete. In ambiguous contexts, a low-attachment preference for the RC in (22% high attachment only) was found in Experiment 3, as in Experiment 2. With an unambiguous context, accuracy was again higher on items disambiguated toward low attachment (87.3%) than on those disambiguated toward high attachment (74.6%), but the gap was narrower than in Experiment 2, pointing to an interaction of disambiguation type with modality.

The findings of these abstract shapes experiments were surprising, because they were in conflict with the high RC-attachment preference (59%) obtained with a traditional paper-and-pencil questionnaire (Experiment 1). Finding an explanation for this discrepancy is important for the present project, because if RC-attachment in Bulgarian is unstable it would not be wise to use the RC-ambiguity as a test-ground for the new methodology based on phoneme restoration. The discussion below raises some possible explanations. What follows is necessarily speculation only. Without further experimentation which continues to contrast and compare these experimental methods, it is impossible to be sure which factor(s) are responsible for the radical shift to a low RC-attachment preference observed by Sekerina et al. However, there are many plausible candidates to consider.

Sekerina et al. propose to explain the shift toward low attachment in the presence of visual stimuli on the basis of the greater computational complexity of the abstract-shapes items. This is possibly one contributing factor. The preamble sentences describing the visual display for the experimental items depict various relations between the objects that have to be processed: the two big objects are the same shape, but different color (sentence 1) and have an element which is the same shape (sentence 2). So the preamble contains mention of two colors and one other characteristic, usually denoting another object (shape, pattern etc.), and the question always asks about the color (usually different from the first two) of an object in the display. In addition, the semantic relation between N1 and N2 in the abstract-shapes items is typically part/whole, which is not the case in the items for Experiment 1 and items in standard RC-attachment questionnaires in general. This fact may introduce a potential bias toward low attachment, because if N2 contains N1, then N2 always names a larger or more prominent, shape. It may also prompt more answers based on N2, since an answer based on N2 color is pragmatically correct for the example in (18) above where the umbrella is always in the triangle, whether in its tip or its lower part. Conceivably, using items with a part/whole relation between N1 and N2 task that do not refer to abstract shapes (e.g. ‘He found the leg of the doll, which was broken.’) may produce a similar bias in a standard silent reading questionnaire, although in the abstract shapes experiment the bias may be strengthened because there was also a similar semantic relation in the fillers.

Another possibly relevant difference between the experimental situations was that the relative clause in Experiment 1 was part of the stimulus sentence but in the abstract shapes experiments (Experiments 2 and 3) it was part of the comprehension question. This makes the participants’ responses in the abstract shapes task more immediate. In fact, Sekerina et al. interpret the preference as possibly indicating that this task taps the early phase of processing where only Late Closure is at play. However, it may also contribute to the semantic bias because the question ‘What color is/are …?’ (on targets and fillers) always asked about the color of a shape from the second display (e.g. the tip) to be identified in the fillers and disambiguated low items through a description of one of the shapes displayed first (e.g. one of the triangles), which may create an additional bias to answer referring to N2 (always the shape displayed first) on the ambiguous items. In addition, many of the RCs in the abstract shapes experiments contained passives, which may also have contributed to the puzzling shift to low-attachment preference. These possible confounds, whether or not they are ultimately found to be relevant, underline the need for experimental items to be screened for potential biases.

Although prosody was not the focus in the two abstract shapes experiments, it is possible that prosodic phrasing also played some part in them. Certainly, the fact that the RC appeared in a statement in Experiment 1 but was part of a question in Experiments 2 and 3 could manifest in different prosodic phrasing. No detailed description is available of the prosodic phrasing employed for the spoken question in Experiment 2, except that the report mentions “a long pause (400 ms, on average) preceding RC” which (as the authors observed) would be expected to induce high attachment interpretations, based on the findings on Croatian by Lovrić (2003). However, since the RC is contained in a question, this pre-RC pause may be modified by other prosodic properties in the question such as accentual focus marking or an earlier break. One can only speculate about what other properties might be relevant. Focus accent on one noun has been found to attract RC attachment in English (Schafer et al, 1996), so a similar effect in other languages is possible. Similarly, earlier prosodic breaks have been shown in English to devalue later ones as cues for ambiguity resolution in a study that included RC attachment (Carlson et al., 2001) so it could be expected in other languages. In fact, native-speaker intuition (my own, and of other speakers I have asked informally) suggests that in Bulgarian in order to mark the focus of a question such as (18c) there will be a pitch accent on one of the nouns to distinguish it. If that focal accent is on N1 (which is more probable since they were asking about the color of the shape designated by N1 in all questions) it may separate N1 tonally from the rest of the question, so that N2 and RC are grouped together despite the pause. Another possibility is that there may be break after ‘cvjat’ (color), which although it comes before the critical region for RC attachment may also interact with the pre-RC pause and intonational focus marking. In the silent reading questionnaire with abstract shapes there was no speech prosody, but the question was presented visually on two lines, centered: first ‘what color is’, and then ‘NP of NP RC’. Segmentation after a copula verb, not prompted by line length considerations, is unusual, and may itself have disrupted parsing in some fashion.

In short: some un-monitored aspects of stimulus design or presentation may conceivably have contributed to the very surprising results reported by Sekerina et al. from the abstract shapes task[32]. The abstract shapes experiments are innovative in experimental technique, addressing the problem with standard materials that there is a high density of information to be retrieved and remembered in the case of standard ('servant of the actress') sentence materials; but the results stand out as exceptional, albeit not fully explained as yet, so the data from the more conventional questionnaire in Experiment 1 may be regarded as a more reliable guide to what can be expected from the current experiments. The prosodic characteristics of the stimuli will be carefully controlled, and a sharp contrast in RC interpretation is expected, depending on the nature of the prosodic phrasing.

2.3.6. Why test these constructions in this language?

To reiterate, the two constructions discussed in this chapter: the NP/S coordination ambiguity illustrated in (1) and the relative clause attachment ambiguity illustrated in (2) were the focus of investigation of this research whose aim was to test the validity of a new method for eliciting ambiguity resolution preferences based on the phoneme restoration illusion, whose merit is a distraction of participants' attention both from the syntactic/semantic ambiguity of the stimulus sentence and from the relevance of prosody in its disambiguation.

The two Bulgarian constructions selected for this purpose are good candidates to use with a new method. Because of Bulgarian's rich morphology, these constructions can be temporarily ambiguous or globally ambiguous, that is obligatory overt morphological agreement which can

[32] Grillo and Costa (2012) explicitly propose an alternative explanation of the differential results between Experiment 1 and Experiments 2 and 3 of Sekerina et al. They claim that all high RC-attachment is illusory; it appears to be observed only for languages where relative clauses are *string-ambiguous* with perceptual complement constructions ('I saw the servant of the actress stand on the balcony') in which by linguistic necessity the predicate can modify only the first noun ('servant'). The important general issue will not be discussed in this dissertation, but the issue of perception verbs in the stimuli was considered.

disambiguate the intended structure, but it is not a disambiguator when the two potential heads / attachment sites share the same morphological features. This fact was used in the phoneme restoration experiments by obliterating the disambiguating morphology and thus turning temporary ambiguities into global ones. What commends these constructions (NP/S coordination and RC attachment) as a good choice for exploring the role of prosodic phrasing in syntactic parsing is that morphological disambiguation is available but can be neutralized, and that when it is neutralized, the two constructions are clearly disambiguated by the location of a major prosodic break.

As this was a methodological exploration, the fact that the disambiguating prosodic break is an IPh boundary was a desirable characteristic of both constructions, because it would be a prominent prosodic cue to the intended structure. Once the methodology is validated, effects of more subtle prosodic cues or other factors can potentially be investigated.

In addition, research on coordination and RC attachment ambiguities has been conducted in other languages with several different well-tested traditional experimental methods. While attachment preferences may of course differ across languages, universal trends are expected and departures call for explanation. It was therefore of value for the current research that ambiguity resolution preferences have been established in other languages, against which the outcomes of the newly proposed technique can be compared.

Moreover, both RC attachment and coordination ambiguities have been shown to be responsive to prosodic disambiguation in other languages (see references above), which makes it valuable to establish whether these same structural sensitivities are detectable employing the new prosodic methodology. This is especially so in the case of coordination (compared with RC-attachment) for which cross-language differences have not been reported.

There is also a potentially interesting difference between the two constructions of interest, which could be used in evaluating the novel research method. Previous studies on several languages discussed in Section 2.2.2 have found that in the RC attachment ambiguity, the two prosodic phrasings elicit a different pattern of responses and some have reported that a break after N1 has a greater effect on preferred attachment than a break after N2 (Lovrić, 2003; Fernández, 2007). There are no reports in the literature, to the best of my knowledge, of such an asymmetry between the two possible contours for coordination ambiguities, although the issue may simply not have been explored. If there is indeed a difference with respect to symmetry of prosodic influences between NP/S coordination and RC attachment, including the two constructions in a single study could provide a useful measure of the sensitivity of the new method. As noted, the relevant prosodic breaks in the two types of sentence are comparable both in size and in location distance. Thus, if a difference is confirmed by the new data, this will increase our understanding of how seemingly identical prosodic cues interact with other information (e.g. different types of syntactic structure) in ambiguity resolution.

## 2.4. Predictions of outcomes for Bulgarian

Given the evidence from other language that prosodic phrasing can effectively disambiguate coordination structures (e.g. Lehiste, 1973 and Clifton et al. 2006 for English) and RC attachment (e.g. Lovrić, 2003 for Croatian; Fernández, 2007 for English) and the fact that for both structures in Bulgarian a prominent prosodic cue that differentiates the two interpretations is available in the form of a distinct IPh prosodic boundary location, prosodic effects should be revealed in the phoneme restoration experiments on Bulgarian in the form of listeners restoring the noise-replaced phonemes in the stimulus to complete the word disambiguating the sentence toward the interpretation congruent with the prosodic contour of the stimulus.

In addition, given the findings of asymmetric effects of prosodic break location on RC attachment preferences, the same effect could be tentatively expected in Bulgarian, while no similar prediction could be made for NP/S coordination. The two constructions are compared in parallel, so inherent differences between them with respect to prosodic effects may emerge.

**Appendix to Chapter 2: Cross-language differences in RC-attachment biases in reading.**

The RC attachment puzzle uncovered by Cuetos and Mitchell (1998) who reported cross-linguistic variation of RC attachment preferences that could not be accounted for in terms of universal parsing strategy, made this ambiguity the focus of psycholinguistic research in a number of languages, aimed at establishing attachment preferences and identifying different factors that may affect them. Different theories have been proposed to account for the cross-linguistic variation in RC attachment interpretation and the apparent violation of Late Closure.

Findings of cross-linguistic variability with respect to this particular ambiguity persisted, grouping languages into high-attaching (e.g. Afrikaans, Croatian, Dutch, French, Polish, Russian, Spanish) and low-attaching (Egyptian Arabic, English, Romanian, Swedish), seemingly regardless of other characteristics. (See Lovrić, 2003 for a detailed list of RC attachment studies in different languages.) A number of studies also found within-language variation in attachment preferences, and in particular one that persists across languages: short RCs exhibit a stronger tendency toward low attachment than long RCs. (See among others Fernández (2003) for Spanish and English; Hemforth et al. (1999) for German, (Lovrić, 2003) for Croatian; Maia et al. (2004) for Brazilian Portugese; Pynte & Colonna (2000) for French, Sekerina (1997) for Russian). In addition, variation between participants in the same experiment is possible (e.g. Jun, 2003). For example some speakers of English have been found to be consistent high-attachers (Corley 1995) and factors specific to the individual (such as reading ability and memory span) have been shown to affect attachment preferences (Frenck-Mestre 1997, Mendelsohn & Pearlmutter 1999).

The **Tuning Hypothesis** (Cuetos & Mitchell, 1988; Mitchell and Cuetos 1991) assumes learning of attachment preferences through exposure. Corpus analyses of English and Spanish (e.g. Cuetos et al., 1996) showed that low RC attachment was more frequent in English while high RC attachment was more frequent in Spanish, i.e. frequency patterns match preference patterns for the two languages. This correspondence was taken as empirical evidence that the statistical frequency of a given structure in the language determines ambiguity resolution preferences. The within language differences are explained by individual exposure to a structure. However, a study on Dutch (Mitchell & Brysbaert, 1998) showed that a general frequency of high RC attachment structure in corpus does not always correspond to a high RC attachment preference in parsing, providing counter evidence or at least proving that coarse-grained frequency is not sufficient underlier of parsing preferences in a language. The Tuning Hypothesis also cannot explain the differences in online and offline data in the same language.

The **Two-Factor Model** (Gibson et al. 1996) derives attachment preference from the interaction of two principles: Recency ('attach incoming lexical items to structures built more recently') and Predicate Proximity ('attach as structurally close as possible to the head of the predicate phrase'). Recency favors attachment to N2, while Predicate Proximity predicts N1 attachment. The latter has a language-specific parameter that is set on the basis of word order patterns. This model correctly predicts the opposing preferences for English which has a strict word order and low attachment is preferred based on Recency vs. languages like German and French where a strong Predicate Proximity compensates for not so strict word order and high attachment is preferred. However, the model cannot account for empirical findings on RC attachment in some languages like Brazilian Portuguese where a high attachment preference was found (Maia and Maia, 2001) despite of word order being strict or the RC length effects found in many languages, since this approach does not consider constituent length.

The **Construal theory** (Frazier and Clifton 1996) is an extension of the classic Garden Path model, but it postulates a distinction between primary relations (between subject and main predicate with its arguments) and non-primary relations, with only the former being subject to Minimal attachment and Late Closure, while the latter are interpreted through a variety of non-structural mechanisms in different languages that guide their association into the thematic processing domain. The RC attachment preferences are explained by the application of Gricean principles like Clarity to RC interpretation, so if a language has an alternative unambiguous construction, it would be used. For example English has the so called Saxon genitive ('actress's servant') with which the RC can only be used for N1 modification, therefore N2 modification by RC is preferred with the NP of NP genitive ('servant of the actress'), but in Spanish the alternative does not exist, so high RC attachment is preferred because N1 is referential. Construal accounts for cross-linguistic differences in RC attachment without recourse to language specific parsing strategies. However, this Gricean account of RC attachment ambiguity resolution still does not account for the fact that languages without an alternative form may still exhibit a preference for low attachment, nor for the RC length effects on RC attachment or the fact that cross-linguistic differences are minimized when RC length is controlled.

**The Attachment-Binding Dualism** account (Hemforth et al., 1999) (Hemforth et al., 1999, 2000a, 2000b; Konieczny & Hemforth, 2000) explains cross-linguistic differences in terms of anaphoric processing vs. structural attachment. It argues that because relative clauses can be introduced by relative pronouns (in contrast to other modifiers like prepositional phrases) an appropriate antecedent for the pronoun is needed in order for the RC to be integrated and assumes that the most salient antecedent in terms of discourse structure is preferred. The cross-linguistic variation in RC attachment interpretation is related to whether the relative pronoun is obligatory in a language (e.g. German) or can be omitted (e.g. English). Empirical data on attachment preferences in German (Hemforth et al., 2000) showed that low attachment was preferred for PPs which have no anaphoric requirement vs. high attachment for RCs introduced by relative pronouns which do and that adverbial clauses pattern with RCs. This account thus explains the different RC attachment preferences in languages like English and German and RC length effects are accounted for in terms of an increased informativeness of a long RC. However, it does not explain differences in attachment preferences for the same language found across experiments, because it does not predict a difference between initial and ultimate RC attachment.

The **Implicit Prosody Hypothesis** (IPH; Fodor 2002) relates RC attachment preferences to the language-specific default prosody for this construction and in more general terms predicts prosodic effects in parsing even in silent reading.

It states that in silent reading “a default prosodic contour is projected onto the stimulus, and it may influence syntactic ambiguity resolution. Other things being equal, the parser favors the syntactic analysis associated with the most natural (default) prosodic contour for the construction.” (Fodor, 2002: 113)

The IPH is based on numerous findings that prosodic phrasing can facilitate interpretation in listening studies (e.g. Price et al. 1991) as well as prior findings on possible interference of prosody in silent reading (e.g. Bader, 1996)[33]. Its major assumption is that a default prosodic representation is always established when processing sentences even in silent reading and that implicit prosody is identical to the default overt prosody for that construction. Empirical support

[33] Bader (1996) established effects of default focus on interpretation on processing of pronominal ambiguity in German and formulated a prosodic constraint on reanalysis.

for the IPH with regard to RC attachment is provided by among others Hirose (2003) who found evidence for prosodic phrasing effects on reanalysis in silent reading of ambiguous RC attachment in Japanese, Lovrić (2003) who showed an effect of boundary placement manipulation in silent reading on RC attachment interpretation in Croatian, Augurzky (2006) who systematically investigated ERP effects of different factors on RC attachment in German and established a timeline for prosodic effects in reading, and Fernández (2007) who showed that different types of visual presentation could promote or suppress RC length effects in silent reading.

The appeal of a prosodic explanation is that it can handle both cross-linguistic and within-language variation and possibly also account for individual variation between participants found in experiments. The latter is accounted for in terms of prosodic sensitivity differences between individuals as well as dialectal differences. The RC-length effect is explained straightforwardly with prosody: a long RC in any language is more likely to form a prosodic phrase on its own and thus be attached independently of prior material, while a short RC is more likely to be phrased with the preceding word, i.e. the second noun (N2) and be attached within that phrase. The effect of constituent length on the interpretation of several other constructions in English led to postulating by Fodor (1998) of the Same Sister constraint ('Find a sister of your own size.') that captures the need for balanced prosodic structure of an utterance. And the puzzle of cross-linguistic variations in RC attachment preferences is accounted for in general terms by the operation of language-specific prosodic principles that have an influence on the silent parse. Analyzing overt prosody and comparing the prosodic constraints operating in different languages may help demystify the otherwise seemingly random grouping of languages on the basis of relative clause attachment ambiguity resolution found in standard silent reading questionnaire studies.

In a related line of research, a number of studies in the last decade have explored at the possible role of overt prosody in the RC attachment ambiguity resolution, using auditory materials and the RC attachment ambiguity has been shown to be sensitive to prosodic disambiguation, in a number of languages including Croatian (Lovrić, 2003), English (Fernández, 2007), German (Augurzky, 2006), Hebrew (Shaked, 2009), and Spanish (Teira & Igoa, 2004). The next section gives more details from experiments on prosodic effects in RC attachment ambiguity resolution, presented chronologically.

# CHAPTER 3

# PHONEME RESTORATION AS POTENTIAL TOOL IN SENTENCE PROCESSING RESEARCH: VISUAL WORD CHOICE EXPERIMENTS

This chapter presents three related experiments which implement the phoneme restoration illusion as an experimental technique for assessing the role of prosody in ambiguity resolution, using a forced-choice task (Visual Word Choice) to register which syntactic/semantic structure listeners thought they had heard. The experiments were designed to test the general validity of the method, as well as collect novel data on prosodic effects and a possible interaction with constituent length in ambiguity resolution in Bulgarian.

The method (Section 3.2) and the first experiment (Section 3.3) discussed in this chapter were first reported in a paper jointly written by the present author, Prof. Janet Dean Fodor and Prof. Eva Fernández and published in a special issue of *Language and Cognitive Processes* (Stoyneshka, Fodor, Fernández, 2010). The current experiments were preceded by preliminary versions that were presented at CUNY 2007[34] and FASL 2007[35].

## 3.1. Experimental stimuli

3.1.1. Morpho-syntactic characteristics of the sentence pairs used as target materials

The target materials used in these experiments included 24 items for each of the ambiguities described in the previous chapter: 24 NP/S coordination ambiguity items and 24 RC-attachment ambiguity items. An item is actually comprised of a pair of sentences that are temporarily ambiguous and differ in the morphological characteristics of a single word, which

---

[34] 20th Annual CUNY Conference on Human Sentence Processing, UCSD, San Diego, CA
[35] 16th Annual Workshop on Formal Approaches to Slavic Linguistics, SUNY Stony Brook, NY

disambiguates the sentence toward a particular syntactic structure. All sentence pairs for each item type are built from a simple syntactic template, although some minor optional elements and variations were allowed in order to achieve stylistic naturalness and make the object of the experiments less conspicuous to participants. Specifically, NP/S coordination materials were constructed using the syntactic template illustrated in (1) below, with optional elements given in parentheses and RC attachment materials were constructed using the template in (2)

(1) NP/S coordination: (Adverbial) (NP) Verb NP1 & NP2 & NP3 Copula PP

Two syntactic structures: (a) Object NP-coordination …. [NP1 & NP2] & NP3 …..
(b) Subject NP-coordination …. NP1 & [ NP2 & NP3] …..

(2) RC-attachment: Verb NP1 of NP2 RC

Two syntactic structures: (a) Low RC-attachment …[ NP1 of [ NP2 RC ] ]
(b) High RC-attachment …[ [NP1 of NP2] RC ]

In the NP/S coordination items, two of the three post-verbal noun phrases form a coordinate NP, which fills one of two syntactic positions: direct object of the first clause verb (a), or subject of the second clause copula verb (b). The two sentences in a pair are temporarily ambiguous, disambiguated toward one of the interpretations by the verb in the second clause. The detailed syntactic structure of each was discussed in Chapter 2. In the target materials, the last noun phrase (NP3) was always singular. Since Bulgarian has obligatory subject-verb agreement, the number of the copula verb in the second clause showed whether its subject was just NP3 (singular verb) or the coordination of NP2 and NP3 (plural verb).

The three NPs in a basic sentence pair were either short proper names (12 items) or common nouns (12 items), and were matched within each item (sentence pair) for animacy and length in syllables. The subject NP in the first clause was usually omitted, as this is typical for Bulgarian, which is a pro-drop language and has the morphological properties of the subject encoded on the verb through subject-verb agreement.

In the RC attachment items, the relative clause modifies either the complex NP or only the second noun of the complex NP in object position. The two sentences in a pair are temporarily ambiguous, each disambiguated toward one of the interpretations by the relative pronoun in RC: low attachment (a) or high attachment (b). The detailed syntactic structure of each was discussed in Chapter 2.

The head nouns of the two NPs in each RC-attachment sentence pair differed in gender: one was masculine and one feminine. The order was counterbalanced between items with 12 items having masculine N1 and 12 having feminine N1. Since the relative pronoun in Bulgarian obligatorily agrees with the noun that the RC modifies, its gender morphologically disambiguated the attachment of the RC. The two nouns in the NP of NP complex were high frequency common nouns, all were animate and were matched within a sentence for length in syllables. The RC always consisted of a relative pronoun and a VP, the latter having a transitive verb and a direct object; VP length was always two prosodic words (six syllables) which is relatively short for an RC in Bulgarian but fully acceptable.

The above templates were used to create pairs of sentences, such that the sentences within a pair were morphologically disambiguated toward opposite readings of the ambiguity, as illustrated in the examples in (3) and (4) below[36]. The disambiguating word is in bold in the examples. The || symbol marks the location of the prosodic break that is aligned with the

---

[36]Note that *i* is the coordinating conjunction ‘and’ in Bulgarian, and *na* is the preposition ‘of’ (discussed in Chapter 2).

syntactic structure assigned by the morphological disambiguation in each case. The prosodic properties of the stimuli are discussed in section 3.1.3.

(3) NP/S coordination: proper names

a.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Ani | ‖ | i | Ivan | i | Mimi | **biaha** | vav vaztorg. |
| [ | V | N1] | | conj | [N2 | conj | N3 | V | PP] |
| In the end | meet-past-1p.pl | Ani | | and | Ivan | and | Mimi | were | in ecstasy |

‘In the end, we met Ani and Ivan and Mimi were ecstatic.’

b.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Ani | i | Ivan | ‖ | i | Mimi | **beše** | vav vaztorg. |
| [ | V | N1 | conj | N2 ] | | conj | [ N3 | V | PP] |
| In the end | meet-past-1p.pl | Ani | and | Ivan | | and | Mimi | was | in ecstasy |

‘In the end, we met Ani and Ivan and Mimi was in ecstatic.’

NP/S coordination: common nouns

a.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Biah | govoril | s | kolegata ‖ | i | načalnika | i | direktora | **biaha** | v tečenie. |
| [ | V | | N1] | conj | [N2 | conj | N3 | V | PP] |
| had | talk-past | with | colleague | and | supervisor | and | manager | were | in current |

‘I had talked to the colleague and the supervisor and the manager **were** aware of that’

b.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Biah | govoril | s | kolegata | I | načalnika | i | direktora | **beše** | v tečenie. |
| [ | V | | N1 | conj | N2 ] | conj | [ N3 | V | PP] |
| had | talk-past | with | colleague | and | supervisor | and | manager | was | in current |

‘I had talked to the colleague and the supervisor and the manager **was** aware of that’

(4) RC attachment

a.

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata ‖ | na | pevitsata | **koiato** | kupi | imenieto. |
| [ V | N1 ] | | [ N2 | [ RC | | ] ] |
| underestimate-past | lawyer-m | of | singer-f | who-f | buy-past | estate-det |

‘(They) underestimated the lawyer of the singer **who**$_{agrN1}$ bought the estate.’

b.

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | Advokata | na | pevitsata ‖ | **kojto** | kupi | imenieto. |
| [ V | [ [N1 | | N2 ] | [ RC | | ] ] ] |
| underestimate-past | lawyer-m | of | singer-f | who-m | buy-past | estate-det |

‘(They) underestimated the lawyer of the singer **who** $_{agrN2}$ bought the estate.’

In addition, longer versions of the same sentence pairs were created by extending the relevant NPs (the three conjuncts for NP/S coordination items, and the two nouns in the NP of NP complex for RC attachment items). This was done either by using a longer name including last name (for proper nouns) or by adding an adjective or appositive (for common nouns). The short and long alternatives of the nouns in the examples for each structure are given below with their equivalents in English.

**Table 3-1:** Examples of short / long contrast.

| Type: | short | | Long | |
|---|---|---|---|---|
| NP/S coordination: proper names (5) | Ani<br>Ivan<br>Mimi | *Ani*<br>*Ivan*<br>*Mimi* | Antoaneta Markova<br>Ivaylo Stavrev<br>Mariela Peeva | *Antoaneta Markova*<br>*Ivaylo Stavrev*<br>*Mariela Peeva* |
| NP/S coordination: common nouns (5) | kolegata<br>načalnika<br>direktora | *the colleague*<br>*the supervisor*<br>*the manager* | novia kolega<br>prekia ni načalnik<br>zamestnik-direktora | *the new colleague*<br>*our direct supervisor*<br>*the assistant manager* |
| RC-attachment: common nouns (6) | advokata<br>pevitsata | *the lawyer*<br>*the singer* | drebnichkia advokat<br>našumialata pevitsa | *the small-framed lawyer*<br>*the newly-famous singer* |

These length contrasts are discussed in more detail in section 3.4.3. The long versions were constructed, assessed for plausibility and recorded simultaneously with the short versions. Each of the 24 target items for each construction thus had 4 versions: a short vs. long sentence pair and within each pair a morphological disambiguation contrast (plural vs. singular verb for NP/S coordination items; masculine vs. feminine relative pronoun for RC attachment items) that is supported in normal speech by the prosodic break location (after the first or after the second NP).

The same target materials were used to create the stimuli for all three experiments reported in this chapter.

### 3.1.2. Plausibility assessment

All target materials were assessed for plausibility by four judges (per list) who were native speakers of Bulgarian and were not aware of the purpose of the experiment. They were asked to read a list of possible items and rate each item on a scale. Examples of the two target constructions are provided in English in (5) below.

(5) Plausibility assessment questionnaire examples

NP/S coordination ambiguity example:

A chance encounter.
a. We met Ani and Mimi. Ivan was ecstatic.
b. We met Ani. Ivan and Mimi were ecstatic.

a ______________________________ b
3 2 1 0 1 2 3

RC-attachment ambiguity example:

They televised the granddaughter of the poet.
a. The granddaughter got an award.
b. The poet got an award.

a ______________________________ b
3 2 1 0 1 2 3

The lists presented each item as a set of three sentences. The first sentence in each set established a context and was followed by a pair of alternative ‘continuation’ sentences. The continuation sentences were rated on the seven-point scale, as illustrated in the examples. The mid-point of the scale was marked by 0 (no plausibility bias), i.e. both continuation sentences in a pair were equally plausible. The numbers on the left marked degree of perceived plausibility bias for continuation sentence (a) in a given pair and the numbers on the right for continuation sentence (b) in a pair. The end points of the scale (marked 3) signified that one sentence in a pair was the only plausible continuation for that context sentence.

The judges were asked to rate the two sentences in a pair on grounds of plausibility in the given context, i.e. ‘how likely’ each sentence in a pair was, given the context sentence. In the instructions they were given two examples where one of the suggested continuation sentences was extremely improbable and were told that the actual differences, if any, would be much smaller.

Sentence pairs were used as target items in the experiments reported here only if the two interpretations were judged to be equally plausible (scale point 0) by at least three of the four judges. For those items, on a scale from -3 (maximal N1 bias) to +3 (maximal N2 bias), with 0 midpoint (equal bias for both interpretations), the mean rating for NP/S coordination targets was +0.05, and for RC attachment targets -0.06. Analyses of variance showed that the judges did not significantly differ from each other in their ratings ($F < 1$) and that ratings for the two item types (NP/S coordination and RC attachment) did not differ significantly from each other or from 0 ($F(1,46) = 2.73$, $p > .10$).

### 3.1.3. Filler Items

The complete set of stimuli for the experiments reported in this chapter included 36 filler sentences of several types. Some of these sentences were ambiguous and some unambiguous. More specifically, twelve of the fillers contained an accusative/possessive reflexive ambiguity that was different from the two target ambiguities but was also disambiguated by a single word in the string and also allowed for prosodic disambiguation, as illustrated in (6) below.

(6) a. Običaše da **se** hvali. || Detsata i te go znaeha.
Like-sg-past to refl praise. Children also they it know-pl-past
*He liked to brag (about himself). The children even knew it.*

b. Običaše da **si** hvali detsata || I te go znaeha.
Like-sg-past to own praise children And they it know-pl-past
*He liked to praise his children. And they knew it.*

The disambiguating words in items like (6), which were used as word choices (the dependent measure in the visual word choice experiments) were *se* and *si* (underlined and in bold in the example). These are both short clitics that form one prosodic word with an adjacent lexical item like the verb ‘hvali’ (praise) in (6), but the two have different syntactic roles and meaning and each disambiguates the utterance to a different sequence of two sentences or clauses. In terms of phrasing that means the particle and the lexical verb form a prosodic phrase (6a) or the particle, the lexical verb and the following noun are grouped in one phrase (6b). The syntactic characteristics of these items will be discussed in more detail in Chapter 7.

The other 24 fillers were fully unambiguous; that is, the segment that would be replaced by white noise could be restored in only one way to create a word that would yield a grammatical and meaningful sentence. Of these, 6 contained one of the verb forms (three each of *beše/biaha*) used in the NP/S coordination target items, and 6 contained one of the relative pronouns (three each of *kojto/koiato*) used in the RC attachment target items; but in both cases, unlike the target items, the other word from the pair made the sentence ungrammatical, as illustrated in (7).

(7) a. unambiguous coordination

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kakto | obiknoveno | po | tova | vreme | Nina | i | bliznatsite | biaha | na | plaža. |
| As | usual | at | this | time | Nina | and | twin-pl | were | at | beach-det |

‘As usual at this time Nina and the twins *were* / **was* at the beach.’

b. unambiguous RC attachment

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Otnovo | obsaždaha | sekretarkata, | kojato | se obličaše | tvarde | predizvikatelno | za ofisa. |
| Again | discuss3p-pl | secretary-fem | who-fem | refl dress-past | too | provocatively | for office |

‘They were taking once again about the secretary who dressed too provocatively for the office.’

The remaining 12 filler sentences, illustrated in (8) below, contained an adverbial clause beginning with either *kadeto* (‘where’) or *kakto* (‘as, in such manner’) and these complementizers were subsequently partially replaced by noise (averaged for durational differences across all fillers of this type) and used as word choices. These fillers were also unambiguous, i.e. the noise-replaced segment could only be restored in one way to form a complete word that would make a grammatical sentence. In the examples below, only *kadeto* is acceptable in (8a); *kakto* makes the sentence semantically anomalous and the reverse is true of (8b). Half of the fillers of this type contained a *kadeto-clause* and half a *kakto-clause* as the correct response.

(8) a. Adverbial clause of place (where)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ogleda | s | pognusa | mjastoto, | **kadeto** | se | nalagaše | da | prespjat. |
| Look-past-sg | with | disgust | place-det | where | refl | need-past | to | sleep-perf-pl |

*(S/he) looked with disgust at the place* ***where / ?as*** *(they) had to spend the night.*

b. Adverbial clause of manner (as)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Liubimiat | mu | otbor | spečeli | mača, | **kakto** | Se | beše | nadiaval. |
| Favorite-det | his | team | win-past | game | as | refl | was | hope-past part |

*His favorite team won the game* ***as /?where*** *he had been hoping (it would).*

In all, 36 filler items were included in the experiments to draw attention away from the target stimuli. The items of each target construction type also served as fillers for the other type. The unambiguous fillers were also intended to provide accuracy data for screening out inattentive participants.

3.1.4. Preparation of the audio stimuli: prosodic properties

As discussed in the previous chapter, for both NP/S coordination and RC attachment, prosodic disambiguation can be achieved by placing a prosodic boundary immediately following N1 (henceforth, an **N1] break**) or immediately following N2 (henceforth, an **N2] break**). For NP/S coordination N1 and N2 are the first and second nominal conjuncts; for RC attachment N1 and N2 are the two nouns in the NP of NP complex.

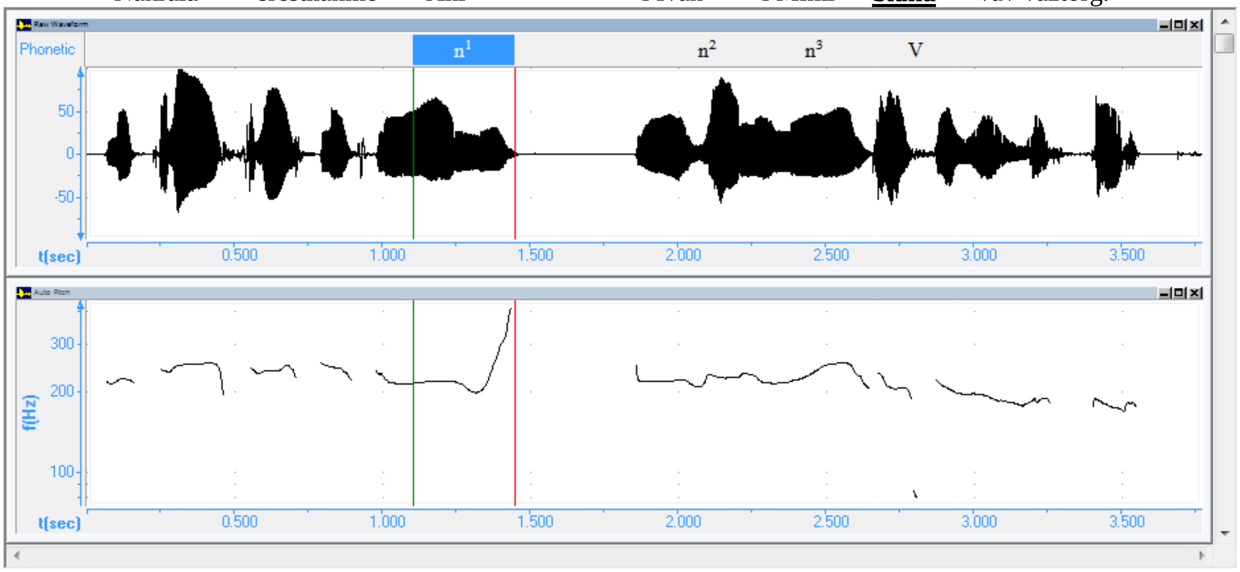
The 24 target items for each construction were recorded by the experimenter, a native speaker of Bulgarian. Each sentence (an experimental item consisted of four sentences in two sentence pairs) was recorded with a contour appropriate to its morphological disambiguation, i.e. an IPh prosodic break at one of the two locations marked with || in the examples (3) and (4). The speech was normally paced (approximately 150 words per minute) and its prosody was clear, but not exaggerated. The audio stimuli were digitized with a sampling frequency of 44100 Hz (with a resolution of 16 bits, monaural).

Separately recorded sentence versions produced by the same speaker were employed, rather than creating the different versions by splicing or manipulating the prosody digitally. This was done deliberately to ensure that the prosodic contours of interest were as natural as possible and to avoid introducing acoustic artifacts into the stimuli—a problem encountered by Samuel (1981). The aim in the current experiments was to establish the contribution of global sentence prosody to structural decisions, therefore it was deemed important to use completely natural sounding stimuli (including the noise, discussed in the next section, which does occur in natural situations such as over the phone or on the radio).

Sentence-internal prosodic breaks in Bulgarian are signaled by a rise in pitch and pre-boundary lengthening optionally followed by a pause (Misheva & Nikov, 1998). Sample pitch tracks provided in Figure 3-1 below illustrate the realization of the boundaries in the two locations for item examples given in (3) and (4) above. Only the short sentence pairs are given here, but the prosodic boundary realization in the long versions was the same.

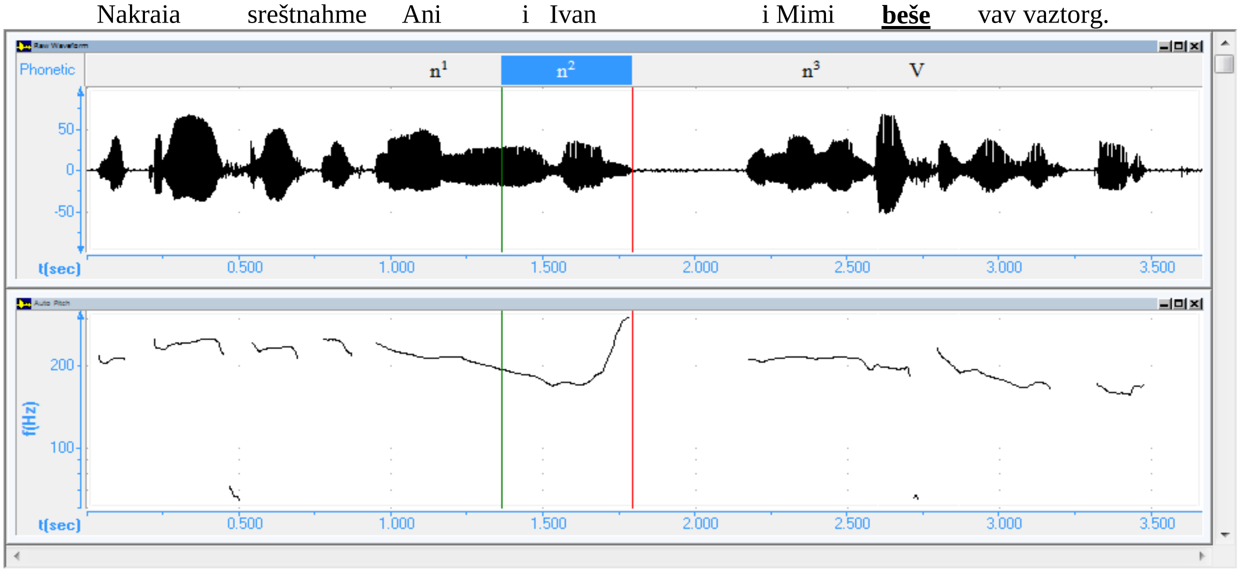
**NP/S coordination: N1] break (3a)**

Nakraia sreštnahme Ani i Ivan i Mimi **biaha** vav vaztorg.



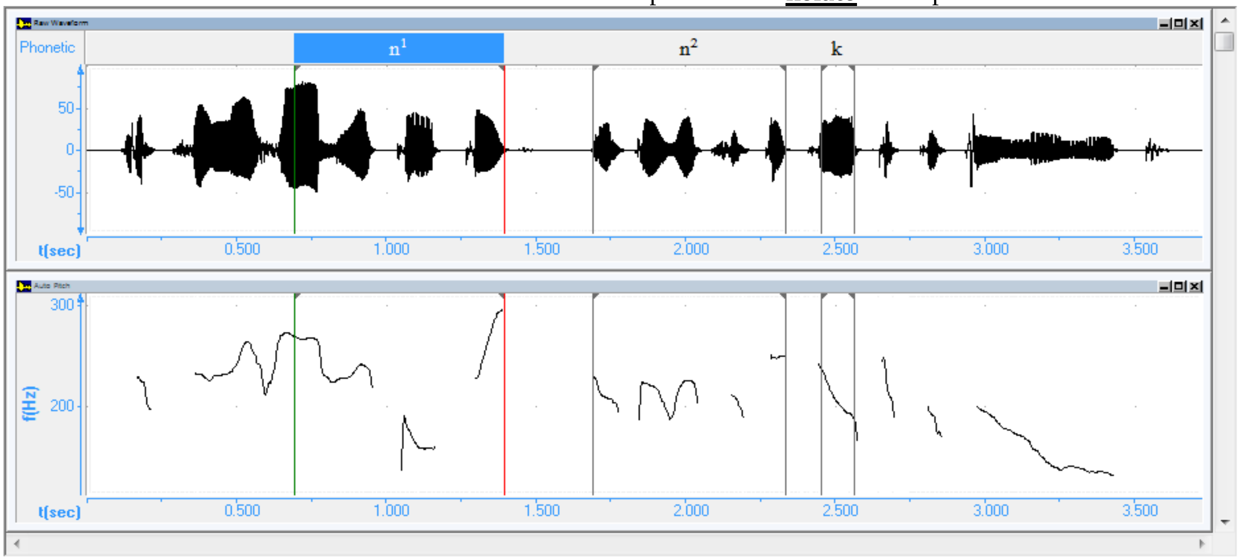

**NP/S coordination: N2]break (3b)**

Nakraia sreštnahme Ani i Ivan i Mimi **beše** vav vaztorg.



**RC attachment: N1] break (4a)**

Podtseniha advokata na pevitsata **koiato** kupi imenieto.




**RC attachment: N2] break (4b)**

Podtseniha advokata na pevitsata **kojto** kupi imenieto.

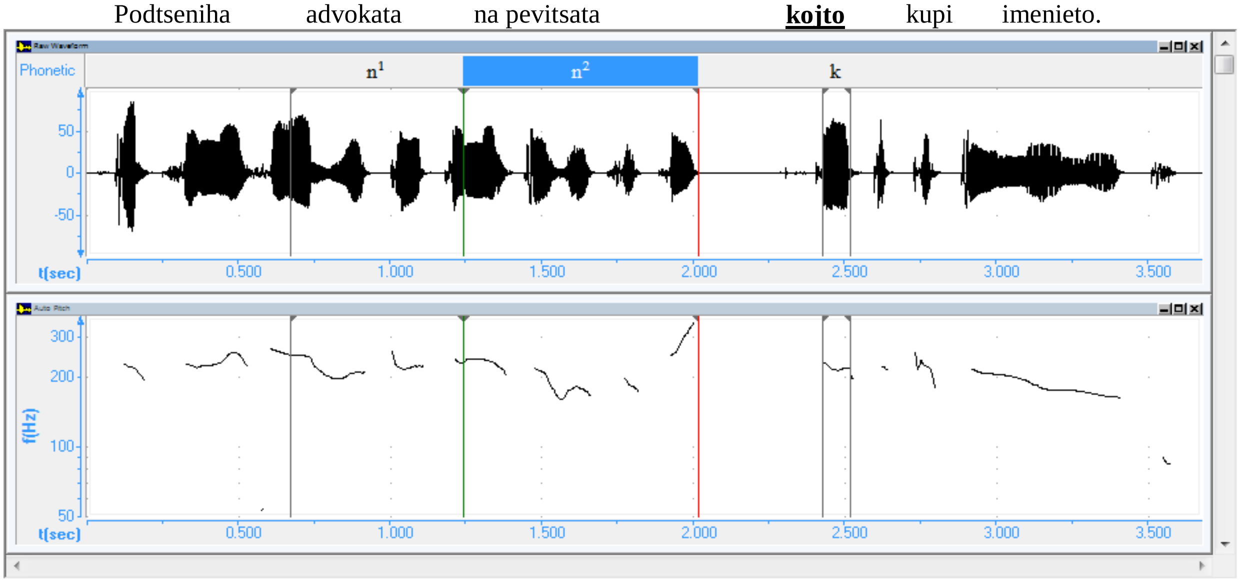



**Figure 3-1**. Sample pitch tracks with location of prosodic boundaries in stimuli (short sentence pairs)

To check for consistency, measurements of duration and pitch were taken at the regions where signals of an upcoming prosodic boundary would be acoustically realized in the stimuli in the N1] prosody and in the N2] prosody conditions. The mean durations and pitch movements for N1 and prep-N2 in the target stimuli are shown in Table 3-2 below.

**Table 3-2.** Mean durations for N1 and N2 (and following pauses) and pitch movements for N1 and N2 in the acoustic stimuli employed in Experiments 1, 2, and 3.

| | | Duration (ms) | | | | Pitch Movements ($\Delta$Hz)* | |
|---|---|---|---|---|---|---|---|
| | | N1 | Pause | N2 | Pause | N1 | prep-N2 |
| NP/S Coordination Ambiguity | N1] | 530 | 444 | 521 | — | +104.4 | –8.2 |
| | N2] | 445 | — | 607 | 464 | –4.4 | +108.4 |
| RC Attachment Ambiguity | N1] | 720 | 302 | 604 | — | +76.6 | +24.3 |
| | N2] | 583 | — | 701 | 327 | +3.1 | +127.8 |

* Pitch movement data are expressed as the difference between F0 measurements (Hz) taken at mid-point of the stressed syllable and at the offset of the word-final vowel. A positive number indicates a pitch rise, a negative number indicates a pitch fall.

Both the duration and pitch movement data reflect the intended asymmetries in the recordings. As desired, the duration of N1 was greater in N1] stimuli than in N2] stimuli, for both NP/S coordination materials ($t(23)=14.40$, $p<.001$) and RC attachment materials ($t(23)=16.32$, $p<.001$). Also, N1 was systematically produced with a rising intonation in N1] stimuli, and a comparatively flat intonation in N2] stimuli, for both NP/S coordination materials ($t(23)=5.22$, $p<.001$) and RC attachment materials ($t(23)=9.81$, $p<.001$). The N2 properties were also as intended: the duration of N2 was greater in N2] stimuli than in N1] stimuli for both NP/S coordination materials ($t(23)=8.18$, $p<.001$) and RC attachment materials ($t(23)=10.29$, $p<.001$), and the intonation of N2 was rising in N2] stimuli versus flat in N1] stimuli (NP/S coordination: $t(23)=14.51$, $p<.001$; RC attachment: $t(23)=18.50$, $p<.001$). Differences between N1] stimuli and

N2] stimuli in the duration of a silent pause following N1 or N2 did not reach significance for either construction.

The acoustic analysis thus confirmed that the prosody of each sentence supports the morphological disambiguation toward a particular syntactic structure.

The prosodic break in the ambiguous filler items like (6), which is marked in the examples by the || symbol, is aligned with the sentence boundary. In that respect these items differ from the target constructions, where the breaks were within one sentence. A sentential break is realized in Bulgarian typically by a falling boundary tone and a pause (Misheva & Nikov, 1998). The *se/si* ambiguity fillers were recorded with a sentential break after the verb (6a) or after the following noun (6b). More details on the two prosodies and the structure of these items are given in Chapter 7 where the data for this ambiguity are presented.

All unambiguous fillers were recorded with prosody appropriate to their respective constructions. Thus, some of the unambiguous fillers contained prosodic breaks comparable to the target items (at clause boundary), but in a variety of linear positions. For example, the sentences in (8) will have a break before the adverbial clause and the sentence in (7) contained a prosodic break after the first adverbial phrase (‘kakto obiknoveno’ *as usual*)[37].

In addition, the sentences were also recorded with all potential prosodic breaks neutralized, a neutral boundary-free prosody condition intended to be used as between-subject comparison, which will be discussed in more detail in Section 3.7.2.

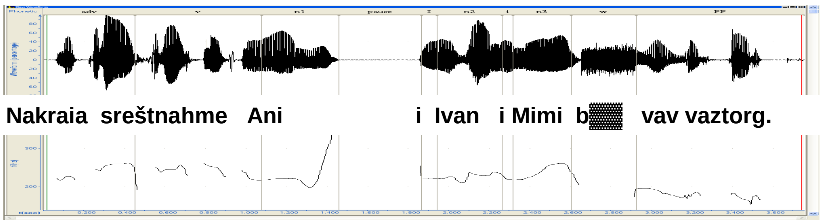
---

[37] This sentence can also be produced with a break after the second AdvP (‘po tova vreme’ *at that time*) which will slightly change the semantics. However, the different phrasing will have no bearing on the verbal argument argument or the morphological agreement. The sentence can only be grammatical with the plural copula verb. The phrasing was chosen because in that sentence a prosodic break is likely after the sentence initial manner adverbial if it was the only adverbial used, but not after the time adverbial if it was the only adverbial used.

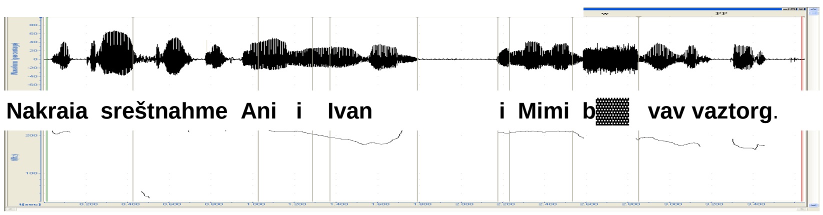
### 3.1.5. Phoneme replacement manipulation

For the target materials and ambiguous fillers, the disambiguating portion of the critical word was removed from the recordings. This included the phonemes that differed between the two lexical items, as well as parts of the preceding / following sounds that might have contained transitional cues. The removed portion of the signal was then replaced with a segment of white noise, synthesized using Praat (Boersma & Weenink, 2009), with the same sampling rate and bit rate as the recorded stimuli: 44,100 Hz, 16 bits monaural. The duration of the noise used in each sentence was the average of the duration of the segments removed from all versions of that item, to eliminate durational cues. The resulting signal had the same segmental content for the two different versions of each sentence pair in an item, but the sentence-level prosody differed between versions. Figure 3-2 below provides waveforms and pitch tracks for the two versions of examples (3) and (4). As the graphs illustrate, prosodic cues signaling prosodic boundaries (F0 rises and pauses), though differing across members of the pair, always preceded the region that was replaced by noise.

N1] prosody, coordination as subject of second clause




N2] prosody, coordination as object of first second clause




N1] prosody, low RC attachment


N2] prosody, high RC attachment


**Figure 3-2.** Location of noise-replaced word in stimuli sentence pairs.

For the unambiguous fillers, white noise replaced the phonemes that differed between the contrasting lexical items used in the relevant filler subtype, for example *kadeto* and *kakto* in sentences like (8), some of which were the same words as for the target items.

As a way to check whether the words were identifiable without the preceding prosodic/sentential context, fragments of the last portion of the recordings (from the complete noise-containing word to the end of the sentence, e.g. “b▓ vav vaztorg”) were played to a panel of listeners who were asked which word was present. They were not able to distinguish between the fragments from the two prosody conditions. In addition, three native Bulgarian speakers with a background in linguistics listened to all the noise-replaced[38] stimuli, and confirmed that they sounded natural and that the noise was not disruptive.

## 3.2. The task: Visual Word Choice

### 3.2.1. Overview

In the Visual Word Choice protocol, a participant listens to the stimulus, then sees two words on the screen; the task it to indicate which of the two words occurred in the sentence. Participants are instructed to listen carefully and answer as quickly as possible, and to guess if not sure. From the participants’ perspective the task was merely to decide which word had been in the sentence, similar to a standard word probe task (MacDonald, 1989; McElree and Bever, 1989, Caplan, 1972). The probes in the visual word choice task were designed to reveal the participant’s resolution of a syntactic ambiguity and the role of prosody in that process, since each of the two presented words was compatible with one and only one interpretation of the sentence.

---

[38]The phrase ‘noise-replaced stimuli’ may not be the most appropriate, as in fact only the disambiguating portion of the stimuli was replaced by noise. The stimuli in the current experiments are more appropriately described as ‘noise-containing’. The term ‘noise-replaced’ is borrowed from Samuel (1981) who used it to differentiate between the items where the speech sound was missing altogether (‘noise-replaced’) from the condition where it was masked (‘noise-added’). The stimuli in the current experiment are only of the first type, so the distinction is not necessary, but the terms ‘noise-replaced’ and ‘noise-containing’ may be used interchangeably.

### 3.2.2. Method

*Participants*

Participants in all three experiments were native speakers of Bulgarian. They were undergraduate students at the University of Economics in Varna and Varna Free University. Each took part in only one of the experiments (including the additional experiments reported in later chapters).

*Materials*

The target materials for each experiment were the 24 NP/S coordination items and 24 RC attachment items in different versions for prosody and/or length. The prosodic contrast was based on the presence of a prosodic break at one of two alternative locations, disambiguating toward different sentence structure, as described in Section 3.1.4. In addition, the two prosodic break conditions were contrasted (between-subject) with a no break prosody described in Section 3.6.2. The length contrast manipulation concerned the relevant NPs for both constructions, as described in Section 3.1.1.

The three experiments described in this chapter used a different combination of the prosody and length contrasts for the target items: location of prosodic break (Experiment 1a), location of prosodic break and length of constituents (Experiment 1b), length of constituents only (Experiment 1c). The exact details for each experiment are given in the method summary table, e.g., Table 3-4 for Experiment 1a. Target items of each type were counterbalanced across lists for the relevant prosody and/ or length contrast(s). In addition the control variables for the target items, NP type for the NP/S coordination (12 proper names, 12 common nouns) and gender order for RC attachment items (12 N1 masc and 12 N1 fem), were counterbalanced across conditions.

The two target constructions served as distractors for each other. In addition, these target items were interspersed with the 36 filler items (discussed in Section 3.1.3), of which 12 were ambiguous and had a prosodic contrast similar to the target items (i.e. alternative location of a prosodic break, disambiguating intended sentence structure) and 24 were unambiguous.

*Procedure*

In all three experiments a computer running DMDX (Forster & Forster, 2003) was used to present the audio stimuli and collect participant responses. The stimuli were presented via headphones, in a different pseudo-random order for each participant. For all three experiments reported in this chapter an experimental list contained seventy two target and filler test items, as well as three training items that could be followed by participant queries, and three covert warm-up items at the beginning of the list.

Though this was not apparent to the participants, the items were grouped in six blocks. Each contained 4 RC-ambiguity items (counterbalanced for prosody/length), 4 NP/S coordination ambiguity items (counterbalanced for prosody/length), two ambiguous filler items (counterbalanced for prosody in Experiments 1a-b) and 4 unambiguous fillers (two of each type). The program presented the blocks in random order and also randomized the order of the items within each block, subject to the constraint that two same-type items could not be adjacent.

The presentation was self-paced. Participants pressed a key on the keyboard to trigger the audio presentation of a given item. Immediately at the offset of the stimulus sentence, two words appeared on the screen and the participants' task was to choose the one that had been in the sentence s/he had just heard. Participants indicated which of the two words they thought had appeared in the preceding sentence by pressing one of two marked keys[39]. They had been instructed to listen to the sentence carefully and to answer as quickly as possible and guess if not

[39]The left SHIFT key for the word on the left and the right SHIFT key for the word on the right.

sure. The full instructions can be found in Appendix B. There was a fixed timeout of 9000 ms for responding to the visual word choice. The experiment was conducted individually with each participant in a quiet room.

The two words presented with each target item were the two morphological forms of the word that disambiguated the sentence to a particular interpretation, the disambiguating portions of which had been excised from the acoustic stimuli and replaced with noise. For the NP/S coordination ambiguity (3) and the unambiguous NP-coordination filler (7a), the two words were always the singular and plural past tense forms of the copula verb 'be' *biaha* and *beše*; for the RC attachment ambiguity (4) and the unambiguous RC filler (7b), they were always the masculine and feminine forms of the relative pronoun *koiato* and *kojto*. For the ambiguous fillers (6) the two word choices were *se* and *si* which are not morphologically related, but are phonetically very similar. For unambiguous filler sentences with an adverbial clause (8) the contextually appropriate word was paired with the other word used in the same subtype of fillers, e.g., *kadeto* and *kakto*. The order of the two words in a given pair (e.g., *se*/*si*) was kept constant throughout the experiment. Because the target items and the ambiguous filler items appeared in different prosodic contour conditions across versions, the prosody-congruent word choice was on the left half of the time and on the right side the other half. In the same way, for the unambiguous fillers the congruent word choice was on the left as often as it was on the right. The constant placement of each word on left or right was done in order to minimize visual confusion and make responses more automatic.

The number of specific items and word choices per version is summarized in Table 3-3 below. The number of items per construction type was the same for all three experiments, although different prosody and/or length contrasts within target items were employed.

**Table 3-3.** Items in each list by construction type.

| Construction type | Example | N items | Word choices |
|---|---|---|---|
| NP/S coordination ambiguity | (3) | 24 | beše / biaha |
| RC attachment ambiguity | (4) | 24 | kojto / koiato |
| Se/si ambiguity | (6) | 12 | se / si |
| Unambiguous NP-coordination | (7a) | 6 (3 sg verb, 3 pl verb) | beše / biaha |
| Unambiguous RC-attachment | (7b) | 6 (3 fem N, 3 masc N) | kojto / koiato |
| Unambiguous adverbial phrase | (8) | 12 (6 manner / 6 place) | kakto / kadeto |

Each of the three phoneme-restoration experiments in which the visual word choice task was used (1a, 1b and 1c) will now be reported separately.

## 3.3. Experiment 1a: Visual Word Choice with facilitating prosody

### 3.3.1. Overview and summary of experimental details

The purpose of Experiment 1a was to investigate prosodic disambiguation on its own, i.e. whether the location of a prosodic boundary would have an effect on ambiguity resolution for NP/S coordination and RC attachment in Bulgarian when no other disambiguation was present. Only short versions of the target items were used. Experimental details are provided in Table 3-4 below.

**Table 3-4:** Experimental details for Experiment 1a: Visual word choice

| | number | Details |
|---|---|---|
| Participants | N=24 | ages 19-25, 67% female<br>No participants excluded from experiment on any criteria. |
| Task: visual word choice | | Listen to the sentence and pick the word that was in the sentence out of two words on the screen. |
| Target materials: | | Contrast: prosodic break location |
| NP/S coordination ambiguity | N=24 | N1] break (N=12) vs. N2] break (N=12) |
| RC attachment ambiguity | N=24 | N1] break (N=12) vs. N2] break (N=12) |
| Lists | 2 | |

### 3.3.2. Predictions

As discussed previously (Chapter 2), existing data from other languages and obtained with a variety of other methods indicate that these two target constructions are sensitive to prosodic disambiguation of their syntactic structure. Therefore, the expectation was that participants would use the available prosodic cues to deduce the speaker's intended meaning. Specifically, it was predicted that in the visual word choice task they would most often choose the word that disambiguates the sentence toward the interpretation congruent with the prosodic contour they heard.

In addition, it was tentatively expected that RC-attachment may show asymmetric effects of prosodic break location, based on findings of such asymmetry for other languages (Lovrić, 2003; Fernández, 2007), but no similar expectations could be formulated for the NP/S coordination in the absence of prior data. Different patterns of prosodic break effect may emerge for the two target constructions, which have not previously been compared in the same experiment.

### 3.3.3. Results and discussion

Data for Experiment 1a are reported in Figure 3-3 below as percent word identifications (phoneme restorations) congruent with the prosodic break in each of the two prosodic break location conditions for each construction. The response timeout for the word choice resulted in a negligible (0.2%) amount of missing data.

The vertical scales for N1] congruent restorations and N2] congruent restorations are superimposed in the graph, meeting at 50%, so that 100% N1] congruent at the bottom corresponds to 0% N2] congruent and 100% N2] congruent at the top corresponds to 0% N1] congruent. This combined scale will be used for all experiments in Chapters 3 and 4.

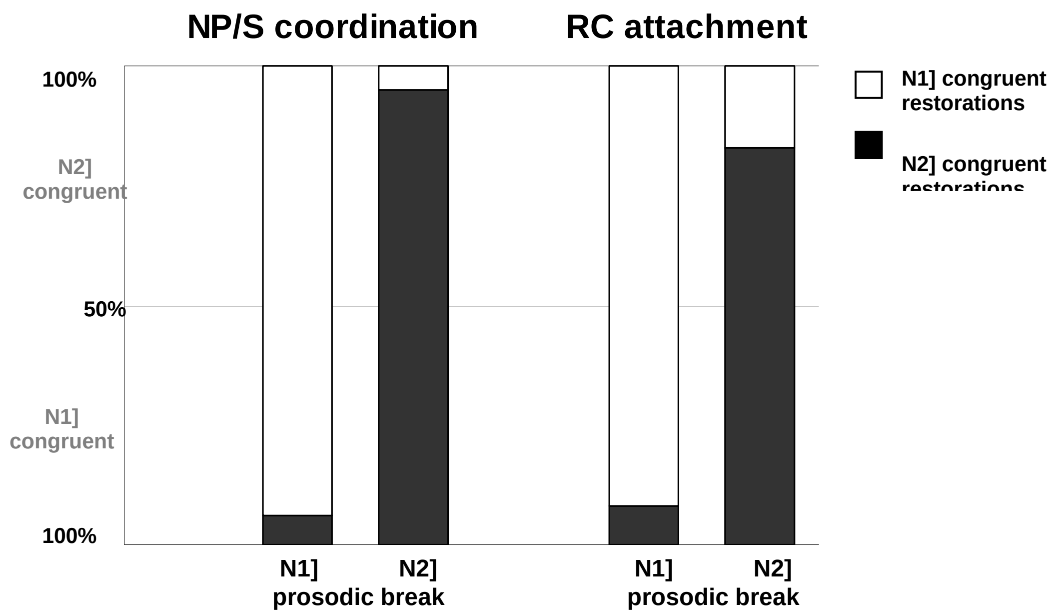



**Figure 3-3**. Percent prosody-congruent phoneme restoration responses for Experiment 1a: Visual word choice

As Figure 3-3 clearly shows, the overwhelming majority of phoneme restorations in Experiment 1a for both the NP/S coordination (on left) and the RC attachment ambiguities (on right) were restorations that were congruent with the prosody of the stimuli, the rates ranging between approximately 95% for NP/S coordination (both N1] and N2] breaks), and between 92% (N1] break) and 83% (N2] break) for RC attachment. An analysis of variance shows that prosody had a significant impact on phoneme restoration responses for both the NP/S coordination ambiguity: $F_1(1,22) = 1103$, $p<0.001$, $F_2$ $(1,20) = 2043$, $p<0.001$ and the RC attachment ambiguity: $F_1(1,22) = 463$, $p<0.001$, $F_2(1,20) = 431$, p<0.001. There was no interaction with either subject or item group. In short: the prosody of the stimuli had a powerful effect on sentence comprehension for both constructions (similar to what was established in prior studies;

see Chapter 2), and a contrast emerged between symmetry for the NP/S coordination ambiguity and an asymmetry for the high/low RC-attachment ambiguity, as anticipated.

Turning now to the details: With NP/S coordination materials, N1] and N2] prosody elicited similar amounts of congruent restorations ($F_1$, $F_2$ < 1), as had been tentatively expected in the absence of previous reports to the contrary. With RC attachment materials, N1] prosody elicited significantly more congruent restorations than N2] prosody ($F_1(1,22)=7.22$, $p=.013$; $F_2(1,22)=6.90$, $p=.015$), as had been anticipated in view of previous experimental findings of such asymmetry in other languages, noted above (section 2.2.2). However, even N2] prosody had a substantial effect on RC-attachment disambiguation preference.

The phoneme restoration data for Bulgarian which reveal the effectiveness of prosodic disambiguation of NP/S coordination and RC attachment in that language fits well with findings from other languages on prosodic disambiguation of coordination and RC attachment ambiguities. In particular, the NP/S coordination data correlates with findings for English showing that grouping of conjuncts via prosodic boundary location successfully disambiguates intended coordination interpretation (Lehiste, 1973; Clifton et al. 2006).

Both proper names and common nouns were included in a controlled comparison in Experiment 1a and items were counterbalanced for that factor across conditions. A similar comparison was included in Clifton et al. (2006) but as a between-subject factor[40]. In the current experiment the prosody-congruent phoneme restoration rates for items with proper names as conjuncts were 97% with N1] break and 96% with N2] break. For items with common nouns the rates were very slightly lower: 92% with N1] break and 94% with N2] break. There is no

[40]Clifton et al. (2006) compare responses on short vs. long proper names in Experiment 1a and short proper names vs. long definite descriptions in Experiment 1b. There is a difference is between both the short and the long items in the two experiments with an early break, but not with a late break.

difference in the amounts of congruent restorations between names and common nouns in either condition, i.e. the control factor does not interact with prosodic disambiguation.

The phoneme restoration data for RC attachment in Bulgarian also correlates well with findings that prosodic break location can resolve RC attachment ambiguities in a range of different languages (e.g. Croatian, English, German, Hebrew, Spanish and others; see section 2.2.2. and Appendix to Chapter 2). However, the effect of a prosodic break at the two locations is not equally strong in the present data, and indeed a N1] break has been found in other languages to produce a stronger disambiguating effect on RC attachment than an N2] break. For example, Lovrić (2003) reports such an asymmetry for Croatian in the listening data of his Experiment 5, stating that an N1] prosodic break "in effect forces low attachment" while an N2] prosodic break "encourages but does not force high attachment". Fernández (2007) reports for English that an N1] prosodic break produced substantial lowering of RC attachment, while an N2] break produced a modest increase of high attachment, compared to a baseline no-break condition.

To recap, the phoneme restoration data established the following about the disambiguation of NP/S coordination and RC attachment in Bulgarian: (1) prosodic break location at N1] or N2] can disambiguate both; (2) equally well for NP/S coordination but not for RC attachment. The prosodic boundaries in both constructions were used were the same in type (IPh breaks) and acoustic prominence, so the different effect they produce needs an explanation. Below, I will attempt several different approaches to an account of the data.

The first one is in terms of syntax prosody/mapping constraints, such as the ones proposed by Selkirk (2000). There is evidence that in Bulgarian a strong prosodic constraint is in place with respect to clause edges and intuitively it may be assumed to be right-edge aligned, because it has a clause-final boundary tone (continuation or final) that is not present for example at the beginning of an utterance. Thus, the constraint may be formulated as **$\mathbf{Align_R}$ CP IPh**. For now I will only assume an alignment constraint for clausal edge, though it may also apply to phrase edges.

As is illustrated in (9) below (using a globally ambiguous variant of the example sentence for each target construction), satisfying this constraint would require an IPh break at one of the two locations that were investigated or possibly the other locations marked ||[41] and not allow (or at least strongly discourage) an IPh break at the locations marked *||. Note that this only involves IPh breaks, which are realized through F0 rise (for a non-sentence-final clause) or F0 fall (statement-final) and lengthening of the phrase-final word with possible pause (depending on speech rate, register etc.).

(9)

a. Nakraia || sreshtnahme *|| Ani || i *|| Ivan || i *|| detsata || biaha *|| vav vaztorg.
In the end meet-past-1p.pl Ani and Ivan and children-det were in ecstasy

*In the end (we) met Annie and Ivan and the children **were** ecstatic.*

b. Podtseniha || advokata || na *|| pevetsa || kojto *|| kupi || imenieto.
Underestimate-past lawyer-m of singer-m who-m buy-past estate-det

*(They) underestimated the lawyer of the singer who bought the estate.*

For the globally ambiguous NP/S coordination sentence in (9a) a structure where only N1 is in object position of the first clause will require an IPh break after N1 (*Ani*) and prohibit such a break after N2 (*Ivan*) in normal stylistically neutral speech because N2 does not coincide with the right edge of a clause in this case. Conversely, a structure where a conjoined (N1 and N2) is in object position of the first clause, the alignment constraint will require an IPh boundary after N2 and permit such a break after N1, for the same reasons. Thus, if the constraint is in place, for

[41] There can be more than one IPh in an utterance. However, all of these permitted locations cannot host an IPh break in the same utterance.

each alternative structure there is only one viable IPh boundary location inside the three NP sequence[42]. Therefore, the location of the prosodic break will clearly indicate the clause boundary and the syntactic position in which NP coordination should be processed in (9a) and also in the target NP/S coordination items in Experiment 1a (thus enabling listeners to restore the segments carrying the verb agreement features for the structure congruent with the prosodic break location.

For the globally ambiguous RC attachment sentence in (9b), the alignment constraint would disallow an IPh break only between the preposition and N2 and between the relative pronoun and the RC-verb. It will also disfavor the breaks between the verb and object in both the main clause and the RC, but they may occur for other reasons like constituent length. In principle then, the two breaks in the N1 of N2 sequence should act in the way described above for coordination. A low attachment structure should correspond to an N1] boundary that separates the two heads and a high attachment structure to N2] boundary that consolidates them. The location of the prosodic boundary should disambiguate (9b) and the target RC attachment items to the intended structure. However, the two structures are not supported equally well by the corresponding boundary in Experiment 1a.

The edge alignment constraint possibly interacts with another constraint on prosodic structure and the most likely candidates are a wrap or sense unit type constraint[43] and well-formedness (optimal length). Motives for proposing such constraints in Bulgarian were discussed

---

[42] It is possible to have more than two NPs conjoined in object position, then there will be a break after the last one to coincide with the clause edge. But in this particular case (NP/S target items) only two IPh locations were possible inside the NP sequence.

[43] In the relevant respect the two will have the same effect of grouping together a syntactic constituent prosodically.

in section 2.3.2. Consider how they would affect the phrasing of the target constructions in (10) below[44].

(10)

a. (Nakraia) (sreshtnahme Ani) || i_( Ivan i_detsata) (biaha vav_vaztorg).

In the end meet-past-1p.pl Ani and Ivan and children-det were in ecstasy

1Pr wd 2Pr wd || 2Pr wd 2Pr wd

*In the end (we) met Annie and <u>Ivan and the children</u> **were** ecstatic.*

b. ( Nakraia sreshtnahme) (Ani i _ Ivan) || i_( detsata) (biaha vav_vaztorg).

In the end meet-past-1p.pl Ani and Ivan and children-det were in ecstasy

2Pr wd 2Pr wd || 1Pr wd 2Pr wd

*In the end (we) met <u>Annie and Ivan</u> and the children **were** ecstatic.*

c. ( Podtseniha advokata) || (na_pevetsa) (kojto kupi imenieto.)

Underestimate-past lawyer-m of singer-m who-m buy-past estate-det

2Pr wd || 1Pr wd 3Pr wd

*(They) underestimated the lawyer of the singer who bought the estate.*

d. (Podtseniha ) (advokata na_pevetsa ) || (kojto kupi imenieto.)

Underestimate-past lawyer-m of singer-m who-m buy-past estate-det

1Pr wd 2Pr wd || 3Pr wd

*(They) underestimated the lawyer of the singer who bought the estate.*

The alternative phrasings of the NP/S coordination and RC attachment will satisfy the first type of constraint that precludes prosodic boundaries within syntactic constituents. There is no prosodic break between the verb and its argument / modifier or inside the conjunction in (10a-b) and within the short RC in (10c-d). As for optimal length constraints, both phrasings violate for NP/S coordination and for RC attachment violate BinMin and the RC phrasing as a unit violates BinMax which is probably ranked low in Bulgarian. The phrasing seems more balanced in

[44]Brackets are used to mark constituents grouped together on the grounds of the constraint and underscore denotes cliticization.

(10a-b) than (10c-d), but there is no grounds to consider (10c) more optimal than (10d). Thus the three types constraints on prosodic phrasing are not enough to account for the Asymmetry of prosodic effects in RC attachment in Bulgarian, but there is no independent motivation for the type of constraint that may be interacting with them. So far, traditional alignment theory (Selkirk 2000) cannot adequately explain these differences, but it may be that the newer Match theory (Selkirk 2012) will be able to provide a theoretical environment that does so. A matter of especial interest for psycholinguistics is whether the left edges of different types of XP (such as PP adjunct to NP), versus CP (relative clause adjunct to NP) and CP (clausal complement to a verb or to a noun) can differ with respect to left-edge prosodic boundaries. This needs to be elucidated in future research on the syntax/prosodic interface.

An alternative way to define the syntax-prosody interface is not as edge effects but as domain effects, as they are considered in the Prosodic Visibility Hypothesis (Schafer, 1997) discussed briefly in Chapter 1. According to that view "attachment to a node depends on which prosodically-defined domain contains the node" (Schafer, 1997: p42). Indeed, an IPh break after N1 places N2 and the RC in one prosodic domain, separate from N1, so low attachment is predicted, but an IPh break after N2 separates the RC from both attachment sites. In principle this hypothesis can account for the stronger effect of N1] break in disambiguating structure, because it is unambiguously associated with one structure, while the N2] break is not. But with the N2] break the alternative attachment sites are in the same prosodic domain and should be equally visible, which does not predict rates of high attachment interpretation as found in Experiment 1a.

Perhaps a mix of the two approaches where prosodic visibility is related to syntactic availability may be applied. Let us assume that an IPh break in Bulgarian though it may not necessarily occur at a clausal edge in effect divides the utterance into clause-type constituents contained by intonational phrases. There are some grounds for a claim like that, because not having an IPh break at a clausal boundary may indicate it is interpreted as an argument inside the clause (11).

(11) (Kaza, če šte dojde v sabota,) (a dojde v nedelia.)
Pro said that pro will come on Saturday, but pro came on Sunday.
*S/he said s/he will come on Saturday, but came on Sunday*

In the target constructions IPh (10) always separates the sentence into two intonational phrases, each one a well-formed syntactic-semantic entity. However, the relations between the two large (clausal type) constituents of NP/S coordination and RC attachment are not the same. When the IPh prosodic break at the right edge of the first clause signals the end of one constituent and because it has a rising tone the beginning of another, the new constituent is attached as a sister of the first one in (10a-b) where the structure is more linear (in very simplistic terms), but in RC attachment the new constituent has to attach as a modifier and needs to find a head. With N1] break that modifier is actually the PP and with N2] break it is the RC. Importantly, with N1] break the RC is not the modifier that has to attach in the main clause, but a daughter of that modifier. It is thus precluded from attaching to N1 and can only attach to N2 which is the only nominal head within the PP modifier[45]. With N2] break the RC is the modifier that needs to attach into the main clause but can still potentially attach to either N1 or N2, if both nominal heads are equally available. However, there a relatively high ranking ‘sense unit’ constraint in Bulgarian that somewhat discourages attaching to N2 with this prosody: since N1 of N2 is now in the same intonational phrase, it forms a head-Gen constituent that occupies the object position

[45] The PP can in principle also attach ambiguously to the V or N1 in the main clause.

of the VP and the RC will preferentially modify the head of the nominal, which explains the N1 bias.

Another possible explanation as to why there would be an asymmetry in effectiveness of these two prosodic phrasings falls out from the Rational Speaker Hypothesis (RHS, Clifton, Carlson, & Frazier 2002), which incorporates a communicative perspective on the processing of prosody by assuming that the listener interprets prosodic breaks in term of how they are likely to have been intended by the speaker, and determines whether to take them seriously as markers of syntactic structure, or not, depending on an evaluation of the speaker's likely motivation. (This may or may not include conscious motivation; it could be merely a reflex of obeying the various requirements of the syntax-prosody alignment constraints in the grammar.)

The Rational Speaker Hypothesis claims that "listeners interpret intonation by assuming that speakers do not make prosodic choices without some reason (and are, therefore, rational). In particular, if a speaker intends a larger syntactic boundary before X than before Y in the sequence X....Y, the speaker cannot then place a larger prosodic boundary before Y than before X for no reason." (Clifton et al., 2006: 854) They specifically formulate this hypothesis to account for constituent length effects on prosodic disambiguation, and their interaction was the focus of a separate experiment (see section 3.5). Here the Rational Speaker Hypothesis is interpreted in a broader sense: that a prosodic break that could have been motivated by non-configurational considerations has less impact on perceived syntactic structure than a break without such alternative motivation. Constituent length was not a factor in Experiment 1a. However, in the case of Bulgarian RC an alternative prosodic break motivation is available regardless of constituent length. In Bulgarian there is no normally expected prosodic break between a head noun and a PP that modifies it, but there is a default prosodic break immediately preceding a relative clause (comparable to French, as discussed by Fodor 2002), which is reflected by more or less obligatory comma punctuation in writing (see section 2.3.3.). Speakers almost invariably break at the pre-RC position for an RC following a single head noun where there is no attachment ambiguity, and where length constraints are not a significant factor. This default break may actually be related to length considerations, however, as noted earlier (section 2.3.4.) RC in Bulgarian are not generally short and the relative pronoun, which is an obligatory element of an RC[46], is a 2-syllable word in Bulgarian and has one stressed syllable, so even a very short verb form (not very common) makes the RC a well-formed phrase. For example, the sentence in (12a) will quite likely be phrased with a break (though probably realized by pitch rise and duration, not a pause) before RC even if the RC is just the relative pronoun and the verb and the sentence in (12b) will have a break (again scaled down in prominence) both before and after the (parenthetical) RC.

(12)

a. Poznavam momčeto, koeto pia (na pranenstvoto).
know-1p sg boy-n who-n sang at celbration-det.
*I know the boy who sang (at the celebration).*

b. Momčeto, koeto pia (na taržestvoto), se kazva Ivan.
boy-n who-n sang at celbration-det refl call Ivan.
*The boy who sang (at the celebration) is called Ivan.*

Since the N2] breaks in our materials constitute a default pre-RC break, it might therefore be undermined as cues to high RC attachment. In contrast, an N1] break has no alternative motivation, which could make it more likely to be treated as genuinely indicative of the syntactic structure.

[46]Reduced relatives like ‘the horse raced past the barn fell’ are possible, but constructions like ‘the man the dog bit’ are not.

We may go further in explanatory power if we incorporate an extension of that line of reasoning, namely that the absence of an expected prosodic boundary may also be informative (Schafer, Carlson, Clifton, & Frazier, 2000) and adopt a modified version of the RSH, incorporating the assumption that in the same way that he must be choosing to break at a given location for a reason (syntactic or other), a rational speaker will not chose to omit a syntax-required break for no reason. Under this assumption, the available prosodic cues in NP/S coordination and RC attachment disambiguation have different motivation.

(13)

a. *In the end, we met Ani and Ivan and Mimi* ***were*** *ecstatic.*

| | | | | |
|---|---|---|---|---|
| Nakraia | sreštnahme | Ani ‖ | i Ivan i Mimi **biaha** vav vaztorg. | |
| In the end | meet-past-1p.pl | Ani | and Ivan and Mimi were in ecstasy | |
| Adv | V | N1 ‖ | ( N2 + N3) V | PP] |
| | | **IPh** | no IPh | |
| | | structural | structural | |

b. *In the end, we met Ani and Ivan and Mimi* ***was*** *ecstatic.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Nakraia | sreshtnahme | Ani | i | Ivan ‖ | i Mimi b**eše** vav vaztorg. | |
| In the end | meet-past-1p.pl | Ani | and | Ivan | and Mimi was in ecstasy | |
| Adv | V | ( N1 + | | N2 ) ‖ | [ N3 V | PP] |
| | | no IPh | | **IPh** | | |
| | | structural | | structural | | |

c. *They underestimated the lawyer of* ***the singer who*** *bought the estate.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata ‖ | na | pevitsata | **koiato** | kupi | imenieto. |
| underestimate-past | lawyer-m | of | singer-f | who-f | buy-past | estate-det |
| V | N1 ‖ | | N2 | RC | | |
| | **IPh** | | no IPh | | | |
| | structural=non-default | | structural=non-default | | | |

d. *They underestimated* ***the lawyer*** *of the singer* ***who*** *bought the estate.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata | na | pevitsata ‖ | **kojto** | kupi | imenieto. |
| underestimate-past | lawyer-m | of | singer-f | who-m | buy-past | estate-det |
| V | N1 | | N2 ‖ | RC | | |
| | no IPh | | **IPh** | | | |
| | structural | | structural | | | |
| | default | | default | | | |

With respect to NP/S coordination (13a-b), the combination of two structural cues (its presence at one position and its absence at the other position) are two mutually supportive prosodic cues that strengthen each other, making both prosodies very effective at disambiguating the NP/S coordination ambiguity. The same is true for the N1] phrasing in (13c) where a non-default break is present, but the default break is not[47]. This absence of a default prosodic break before the RC may in fact constitute a second strong cue to syntactic structure, making the N1] prosodic contour much more effective. In (13d), by contrast, both cues are ‘default’ (no break before PP is expected and a break before RC is expected), hence it is less effective as a syntactic cue. As noted earlier with respect to the default pre-RC break, the default non-break before the PP can also be length related. In this case, the preceding phrase is short and a break there must be intentional.

### 3.3.4. Conclusions and follow-up experiments

The prediction that listeners would make use of the prosodic contours of these stimuli to resolve syntactic ambiguity was confirmed. Results for Bulgarian obtained with this method are comparable to previous results for these two constructions in other languages obtained with a variety of methods (see Chapter 2, section 2.2). Thus, phoneme restoration with the visual word choice task proved to be a useful tool for studying ambiguity resolution in sentence processing.

There are valuable advantages of word choice over a standard comprehension questionnaire. Asking “What word did you hear?” rather than “What does the sentence mean?” can draw participants’ attention away from the sentence-level ambiguity. Also, although it is not

---

[47]The presence of a break after N1 does not absolutely preclude a break before the RC, which may still occur for length reasons, but in the stimuli the RCs were relatively short.

an on-line task, this protocol helps to minimize the delay between the stimulus and the response because there is no intervening comprehension question to parse and interpret, but just two (short) words to read. For a study of prosodic influence this is especially valuable, since phonological memory is limited, and there is a risk that the mental representation of the prosody of the target item may be overlaid by prosody projected onto an intervening question.

The additional experiments reported in this chapter also used visual word choice. They were designed to supplement the data from Experiment 1a. Since constituent length effects are often associated with prosodic phrasing effects, the first additional experiment (Experiment 1b) attempted to tease apart those factors by adding a phrase length contrast in the experimental design, using the same basic materials and experimental protocol as Experiment 1a. In the other additional experiment (Experiment 1c), the same experimental procedure was used with the same basic materials used in Experiment 1a, but the prominent prosodic phrasing cues in the stimuli were eliminated.

## 3.4. Constituent length effects in the coordination and RC-attachment constructions

### 3.4.1. Constituent length effects

Prosodic boundaries can occur almost anywhere in a sentence depending on a variety of factors including information structure (focus, contrast, etc.) and constituent lengths, as well as syntactic structure. Also, their presence or absence at a particular locus is to some extent optional, particularly for intermediate prosodic phrases (ip), though less so for Intonational phrases (IPh). The combination of these facts has posed a problem for research because it means that prosodic phrasing cannot be fully explained through a simple set of rules relating it to syntactic phrasing (or even to semantics). A major cause of this lack of straightforward mapping between syntax and prosody is the factor of constituent length. It was the motivation for postulating the optimal size BinMap constraint on prosodic phrases (Selkirk, 2000). The Rational Speaker Hypothesis (Clifton et al. 2002) discussed in Section 3.3.4 above was developed mainly to incorporate and account for the impact of constituent length on the effectiveness of prosodic boundaries in sentence comprehension.

Constituent length is also implicated as a factor that can modify ambiguity resolution in silent reading. Silent reading studies in different languages have established that longer phrases tend to attach higher in the tree than short ones of the same type. This phenomenon was dubbed the Anti-gravity effect by Fodor (1998). As already discussed in chapter 2, the RC-attachment ambiguity resolution preferences have been explored in a number of languages since the English/Spanish study (Cuetos & Mitchell, 1988) where cross-linguistic variation in ambiguity resolution was initially observed for this construction. The puzzling distinction of high vs. low attaching languages prompted a number of proposed explanations, but one factor that was found to modify attachment preferences within a language was constituent length. For example, a long ambiguous relative clause tends to attach higher than a short ambiguous relative clause (e.g. Fernández, 2000, 2003; Lovrić & Fodor, 2000; Pynte & Colonna , 2000; Quinn et al., 2000). For the RC studies, the proposed explanation is that long ('heavy') RCs form a separate prosodic constituent, separated by a prosodic boundary from the adjacent N2, while short ('light') RCs need to form a prosodic constituent with the adjacent N2 and are therefore grouped with it syntactically as well (i.e., attached low). The Anti-gravity effect and also the 'Same Size Sister' constraint (Fodor, 1998) which assumes that the processor seeks length-balanced prosodic structure have provided explanations for cross-linguistic variability of seemingly identical syntactic structures on the basis of length/weight.

The prosodic account is certainly not the only one proposed as an explanation of length effects in sentence processing. Several theories have proposed alternative explanations on the basis of information load (Hemforth et al., 2002) or production constraints (MacDonald, 1999) among others. But the discussion here will focus on the prosodic account of length effects in ambiguity resolution, as most relevant to the present research. Researchers have found evidence that constituent length is a factor influencing both the production of prosodic structure and its interpretation when listening. For example, Watson & Gibson (2001) found that if a noun in subject position was modified by a relative clause, the size of the relative clause correlated positively with the probability of boundary placement before the main-clause verb. It has also been established that speakers are more likely to produce a prosodic boundary before a longer constituent than before a shorter one (Quinn et al., 2000;Watson and Gibson, 2004). In listening studies there is evidence that judgment of prosodic appropriateness of prosodic boundaries is affected by the length of the upcoming phrase (Frazier et al., 2004).

Following the proposal of Fodor (1998), the length of the relative clause has been included as a factor in silent reading and listening studies on RC attachment ambiguity resolution in a number of languages. A number of studies have shown that RC length affects attachment preferences not only in listening, but also in silent reading, namely short RCs show a stronger tendency toward low attachment than long RCs among others, Fernández, 2003 for both English and Spanish) as predicted by Fodor (1998). The pervasiveness of this length effect across languages is easily explained on the basis of prosody. It can be expected to be a universal property, since a long RC in any language is more likely to form a prosodic phrase on its own, while a short RC is more likely to be phrased with the preceding word (N2). This is so even if the details of what counts as long and short for an RC may differ to some extent between languages (Shaked, 2006). Another cross-language difference may lie in the relative ranking of optimum length per se and balanced length; the work of Pynte suggests that in French the latter is a stronger influence than the former.

### 3.4.2. Length manipulation in the Bulgarian ambiguities in the current investigation

Clifton et al. (2006) empirically tested their Rational Speaker Hypothesis in a set of experiments devised to check whether constituent length interacts with how prosodic phrasing is interpreted by listeners, more specifically "whether prosodic boundaries will have a larger influence on listeners' choice of an analysis when they flank short constituents than when they flank long ones" (p854) i.e. whether listeners treat a prosodic boundary as more informative about the syntax when it precedes or follows a short constituent than when it precedes or follows a longer one). Clifton et al. used as targets sentences containing a type of NP coordination ambiguity involving conjunction and disjunction. The basic structure of this ambiguity was discussed in Chapter 2, and compared to the NP/S coordination ambiguity in the present research. Clifton et al. manipulated the length of relevant constituents (NP conjuncts) as illustrated in (14) below in order to find out whether length interacts with the effect of prosodic boundary location.

(14) Short version:

a. (Pat) or (Jay and Lee) convinced the bank manager to extend the mortgage.
b. (Pat or Jay) and (Lee) convinced the bank manager to extend the mortgage.

Long version:

c. (Patricia Jones) or (Jacqueline Frazier and Leticia Connolly) convinced the bank manager to extend the mortgage.
d. (Patricia Jones or Jacqueline Frazier) and (Leticia Connolly) convinced the bank manager to extend the mortgage.

Clifton et al. (2006) found, as anticipated, that the position of the prosodic break influences the preferred syntactic analysis of this construction, but also found an interaction with prosodic phrase length: prosodic breaks were treated by listeners as less relevant to syntactic disambiguation when they flanked long constituents. The explanation proposed was that with short constituents the presence of a boundary can only be taken as an indicator of the intended syntactic structure, but with long constituents their length provides an alternative reason for a prosodic break and the listener therefore does not treat it as a strong structural cue. That explanation, formulated as the Rational Speaker Hypothesis (Clifton et al. 2002), assumes that listeners are not simply processing prosodic breaks as cues to syntactic structure but are also making inferences (generally not consciously, of course) as to why a break is present in a given location (why a rational speaker would place a break there) and consequently treat a prosodic break as less informative syntactically if alternative reasons for it exist.

As already discussed in Chapter 2, section 2.2.1, the NP/S coordination ambiguity in Bulgarian which is used in this experiment is different from the one Clifton et al. (2006) studied for English, shown in (14). The contrast in (14) is between two different groupings of three NPs within the same syntactic position (main clause subject) while the three NPs in the NP/S coordination ambiguity used here span a clause boundary, so that they are distributed between two syntactic positions of two coordinated clauses (object of the first clause and subject of the second clause). Despite this difference, however, both structures include three NPs in consecutive order in the word string and in both cases prosodic grouping of the three NPs indicates the intended sentence structure (achieved by inserting a boundary either after the first or the second one) yielded high rates of prosodic break disambiguation of the intended interpretation. On those grounds, the length manipulation from Clifton et al. (2006) was adopted here. As noted in section 3.1., the same length contrast was used in both target constructions.

By using the same type of length manipulation for the NP/S coordination materials in Bulgarian which Clifton et al. (2006) used for subject NP-coordination in English, it is possible to make predictions of how NP-length may modify prosodic phrasing effects for the NP/S coordination in Bulgarian for which there is no prior research. It can be expected that NP length will interact with the prosodic grouping, since Clifton et al. 2006 found such an effect in English; more specifically, the proportion of participants' responses that were contrary to the prosodic grouping increased with long NPs.

With regard to RC-attachment, there is an extensive body of published research on RC-length effects in a variety of languages, including Bulgarian (Sekerina et al. 2003) reporting data which confirm that RC attachment preferences are sensitive to constituent length.

Replicating RC-length effects with a new method and materials would be of some interest. However, it might be more useful and informative to generate data on a different length contrast that has been studied far less, and with mixed results, namely the length of the two nouns that may be modified by the RC.

So far, few studies have been conducted that involve manipulating the length of the two NPs which can be modified by the RC. Henstra (1996) found no systematic NP-length effects on RC attachment in silent reading of English when she compared multiple types of NP-length combinations. However, Wijnen (2004) contrasted short and long NP in Dutch-based jabberwocky silent reading experiments and in Experiment 1 found that within the general low RC-attachment preference, short RCs were attached high significantly more frequently when N2 is longer than N1 (48% high attachment) compared to the reverse length contrast (25% high attachment).

Including the NP length contrast will provide novel data on Bulgarian and potential effects of NP length on RC attachment. Making the length contrast the same for the two target constructions will allows for a comparison of NP length effects if such were found and how they may modify the effects of the prosodic break location which was also comparable for the two constructions.

3.4.3. Stimuli with contrasted constituent length for Experiment 1b

The target materials for both NP/S coordination and RC attachment were created with a long and a short version (as discussed in section 3.1.) and the short-long version contrast was the same: to create the long version of a sentence the three NPs in the NP/S coordination items were expanded (by using a family name with proper names and adding an adjective for the common nouns) and the two NPs in the RC attachment items were expanded by adding an adjective to each.

The short versions only were used in Experiment 1a, but both versions were used in Experiment 1b. Thus, an experimental item in Experiment 1b is comprised of a quadruple of sentences, made up of a short-version pair and a long-version pair, illustrated in (15) and (16) below. Except for the word that disambiguates through morphological agreement, each pair is phonemically identical, but differs in prosodic phrasing. The appropriate location of the prosodic break for each interpretation is marked by the symbol || in the examples above.

(15) **NP/S coordination: proper names and common nouns**

a. N1] break, short

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Ani \|\| | i | Ivan | i | Mimi | **biaha** | vav vaztorg. |
| [ | V | N1] | conj | [N2 | conj | N3 | V | PP] |
| In the end | meet-past-1p.pl | Ani | and | Ivan | and | Mimi | Were | in ecstasy |

*In the end, we met* <u>*Ani*</u> *and* <u>*Ivan and Mimi*</u> ***were*** *ecstatic*.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Biah | govoril s | kolegata \|\| | i | načalnika | i | direktora | **biaha** | v tečenie. |
| [ | V | N1] | conj | [N2 | conj | N3 | V | PP] |
| had | talk-past with | colleague | and | supervisor | and | president | were | in current |

*I had talked to the colleague and the supervisor and the president* ***were*** *infromed*

b. N1] break, long

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Aneta Markova \|\| | i | Ivaylo Stavrev | i | Mariela Peeva | **biaha** | vav vaztorg. |
| [ | V | N1] | conj | [N2 | conj | N3 | V | PP] |
| In the end | meet-past-1p.pl | Aneta Markova | and | Ivaylo Stavrev | and | Mariela Peeva | were | in ecstasy |

*In the end, we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva* ***were*** *ecstatic.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Biah | govoril s | novia kolega \|\| | i | prekia ni načalnik | i | zamestnik direktora | **biaha** | v tečenie. |
| [ | V | N1] | | [N2 | | N3 | V | PP] |
| had | talked with | colleague | and | direct supervisor | and | vice president | were | in current |

*I had talked to the new colleague and our direct supervisor and the vice president* ***were*** *infromed*

c. N2] break, short

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nakraia | sreshtnahme | Ani | i | Ivan | \|\| | i | Mimi | **Beše** | vav vaztorg. |
| [ | V | N1 | conj | N2 ] | | conj | [ N3 | V | PP] |
| In the end | meet-past-1p.pl | Ani | and | Ivan | | and | Mimi | Was | in ecstasy |

*In the end, we met Ani and Ivan and Mimi* ***was*** *in ecstasy.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Biah | govoril s | kolegata | I | načalnika | i | direktora | **beše** | v tečenie. |
| [ | V | N1 | conj | N2 ] | conj | [ N3 | V | PP] |
| had | talk-past with | colleague | and | supervisor | and | president | was | in current |

*I had talked to the colleague and the supervisor and the president* ***was*** *informed.*

d. N2] break, long

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Aneta Markova | i | Ivaylo Stavrev \|\| | i | Mariela Peeva | **beše** | vav vaztorg. |
| [ | V | N1 | conj | N2 ] | conj | [ N3 | V | PP] |
| In the end | meet-past-1p.pl | Ani | and | Ivan | and | Mimi | was | in ecstasy |

*In the end, we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva* ***was*** *in ecstasy.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Biah | govoril s | novia kolega | i | prekia ni načalnika | i | zamestnik direktora | **beše** | v tečenie. |
| [ | V | N1 | | N2 ] | conj | [ N3 | V | PP] |
| had | talked with | colleague | and | supervisor | and | president | was | in current |

*I had talked to the new colleague and our direct supervisor and the vice president* ***was*** *informed.*

**(16) RC attachment**

a. N1] break, short

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata ‖ | na | pevitsata | **koiato** | kupi | imenieto. |
| [ V | N1 ] | | [ N2 | [ RC | | ] ] |
| underestimate-past | lawyer-m | of | singer-f | who-f | buy-past | estate-det |

*(They) underestimated the lawyer of the singer* ***who***$_{agrN2}$ *bought the estate.*

b. N1] break, long

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | drebničkia advokat ‖ | na | našumialata pevitsa | **koiato** | kupi | imenieto. |
| [ V | Adj N1 ] | | [ N2 | [ RC | | ] ] |
| underestimate-past | small-framed lawyer-m | of | newly famous singer-f | who-f | buy-past | estate-det |

*(They) underestimated the small-framed lawyer of the newly-famous singer* ***who***$_{agrN1}$ *bought the estate.*

c. N2] break, short

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata | na | pevitsata ‖ | **kojto** | kupi | imenieto. |
| [ V | [ [N1 | | N2 ] | [ RC | | ] ] ] |
| underestimate-past | lawyer-m | of | singer-f | who-m | buy-past | estate-det |

*(They) underestimated the lawyer of the singer* ***who*** $_{agrN1}$ *bought the estate.*

d. N2] break, long

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | drebničkia advokat | na | našumialata pevitsa ‖ | **kojto** | kupi | imenieto. |
| [ V | [ [N1 | | N2 ] | [ RC | | ] ] ] |
| underestimate-past | small-framed lawyer-m | of | newly famous singer-f | who-m | buy-past | estate-det |

*(They) underestimated the small-framed lawyer of the newly-famous singer* ***who*** $_{agrN2}$ *bought the estate.*

It should be noted here that although the length manipulation affects only the internal structure of the relevant NPs in both constructions, where extra material is added, it did not simply add prosodic weight. The long NPs inevitably contained richer semantic information and more complex phrase structure than the corresponding short NPs. However, the overall syntactic structure of the sentence is the same for short and long item versions and more specifically, the second-clause VP in the NP/S coordination items was the same across versions and the RC was the same across versions.

The long versions of the target materials were assessed for plausibility simultaneously with the short versions (section 3.1.2) and was recorded using the same equipment and procedure (see section 3.1.4). The same phoneme replacement procedure was subsequently applied to the recorded stimuli (section 3.1.5). As a result, the recordings for each short version pair or long version pair contain the same sequence of phonemes with the same-length burst of noise in place of the disambiguating phonemes (for both short and long versions), but have a distinct prosodic boundary placed either after the first or after the second of the relevant NPs. As for the previous experiment, the disambiguating prosodic boundary (signaled by F0 rise and pause) preceded the region that was replaced by noise.

The complete set of stimuli in Experiment 1b included the same 36 filler sentences used in Experiment 1a. (See Appendix and discussion in section 3.1.3.) No length manipulation was included for the filler items, so the recordings and the phoneme replacement procedure were the same as in Experiment 1a. However, the fillers were varied in length and some were comparable to long versions of RC attachment target items. (The NP/S coordination items had an extra NP that was expanded.)

The targets and fillers were counterbalanced across four lists, preceded by two overt practice items with feedback and two additional ‘warm-up’ items at the beginning of the testing session. The word choices were the same as in Experiment 1a (see Table 3-3 for details).

## 3.5. Experiment 1b: Visual Word Choice + constituent length

### 3.5.1. Overview and summary of experimental details

The purpose of Experiment 1b was to investigate whether and how constituent length impacts the effectiveness of prosodic boundary as a cue to syntactic structure for NP/S coordination and RC attachment ambiguities in Bulgarian. The dependent measure was the same as in Experiment 1a: which of two visually presented words was selected in response to a stimulus, in which the disambiguating word was partially replaced by white noise. The word choice indicates how the missing phonemes are restored and thus which structure is assigned to the sentence. A summary of experimental details is provided in Table 3-5 below.

**Table 3-5**: Experimental details for Experiment 1b:
Visual word choice with natural prosody and constituent length contrast

| | number | details |
|---|---|---|
| Participants | N=48 | age 20-26, 54% female<br>No participants excluded from experiment on any criteria. |
| Task: visual word choice | | Listen to the sentence and pick the word that was in the sentence out of two words on the screen. |
| Target materials: | | Contrasts:<br>**prosodic break** x **constituent length** |
| NP/S coordination ambiguity | N=24 | N1] break: short (N=6) vs. long (N=6)<br>vs.<br>N2] break: short (N=6) vs. long (N=6) |
| RC attachment ambiguity | N=24 | N1] break: short (N=6) vs. long (N=6)<br>vs.<br>N2] break: short (N=6) vs. long (N=6) |
| Lists | 4 | |

3.5.2. Predictions

On the basis of the previous experiment, the location of a prosodic boundary was expected to influence interpretation. Since a subset of the target materials (short versions) was identical to the materials for Experiments 1a and the task and procedure are the same, the results on these items should be similar to the results from Experiment 1a, i.e. responses on both constructions should be consistent with the prosodic contour of the stimulus, but with an asymmetry in the effect of N1] and N2] break for RC.

Based on previous research in other languages, the length manipulation should be expected to affect participants' responses, reducing the rate of prosody-congruent restoration responses for the long-NP versions. According to the Rational Speaker Hypothesis (Clifton et al, 2006) that effect would be due to listeners being sensitive to whether a boundary has 'multiple justifications', as discussed above. More specific predictions can be made, but are quite complex. For one thing, it is not clear whether the two constructions will be affected by phrase length in the same way. In the earlier experiment, the NP/S coordination data showed symmetrical effects of the two prosodic contours, whereas the RC attachment data pattern showed an asymmetry in favor of N1] prosody. If the N2] prosodic break for RC-attachment in Bulgarian is inherently less informative than the N1] break, introducing an additional ambiguity concerning the motivation of its presence in the stimuli may result in an even greater asymmetry in the data with long constituents.

On the basis of the RSH, it can be predicted that for NP/S coordination the longer NP conjuncts will weaken the effect of the prosodic breaks. If that is correct, the proportion of prosody-congruent responses should be higher on short version items that on long version items.

The predictions for RC attachment are different, since listeners were shown to be more sensitive to N1] prosody than N2] prosody with short constituents. It can be expected that constituent length would weaken the effect of each prosodic break in (16), but possibly to a different degree. The added NP length may have a lesser effect on the N1] break prosody (which was more strongly associated with a low-attachment interpretation in Experiment 1a and where constituent length would be the only non-structural reason for the break) than on the N2] break prosody. In (16d), N1 and N2 are phrased together which should favor high attachment, but since the N2] break (before the RC) was quite weakly interpreted with short constituents, greater length should weaken it further, resulting in less high attachment. In addition, in the long version items the RC is rather short compared to the preceding phrase, resulting in a lack of balance which might favor low attachment.

### 3.5.3. Results and discussion

Data for Experiment 1b are reported in Figure 3-4 below as percent restorations (word choices) congruent with prosodic break locations in the contrasted prosody and NP length conditions for each construction. The data from Experiment 1a are also included for comparison in Fig 3-4, as the stimuli used there were a subset of the stimuli in Experiment 1b, namely the short version items in Experiment 1b. The response timeout for the word choice resulted in a small (0.4%) amount of missing data.

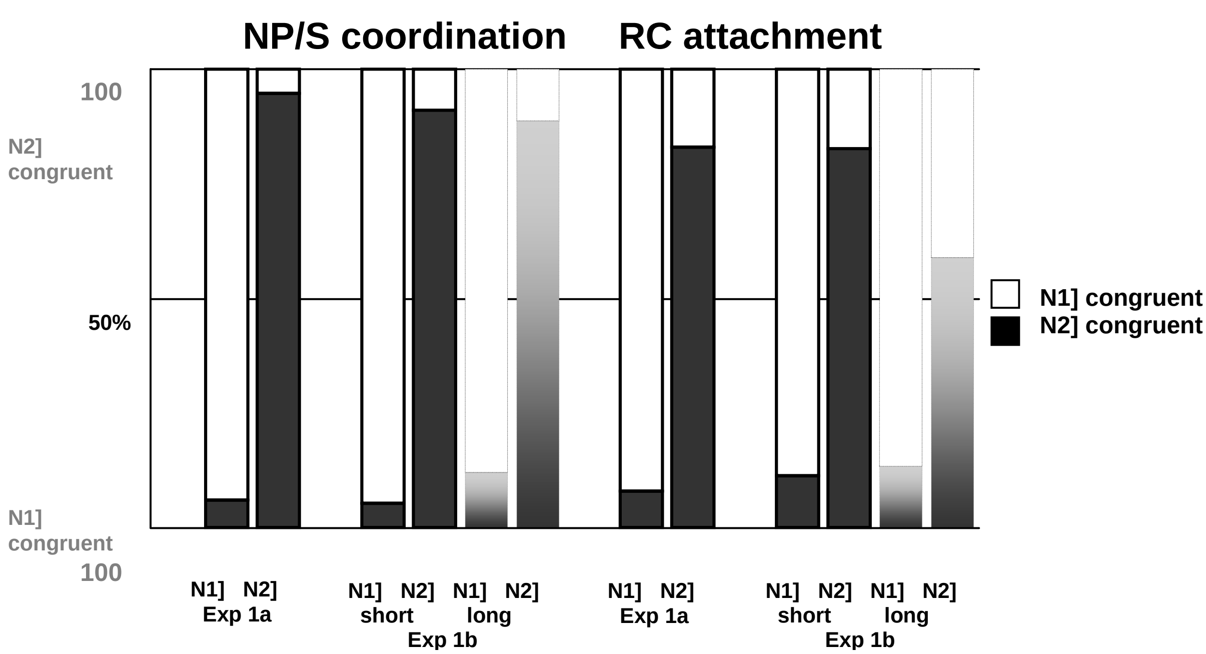



Figure 3-4. Percent prosody-congruent restoration responses for Experiment 1a and Experiment 1b.

Figure 3-4 clearly shows that, as in Experiment 1a, the majority of phoneme restorations indicated by word-choice responses in Experiment 1b were congruent with the prosody of the stimulus sentence for both NP/S coordination and RC-attachment. In fact, if we compare the phoneme restoration responses in Experiment 1a (on the left for each construction) with the responses on short version items in Experiment 1b (center for each construction), it is clear that the pattern of data was replicated closely. For those items, participants' phoneme-restoration responses (represented by the word choice) matched the syntactic structure indicated by the location of the prosodic break very closely. For the NP/S coordination items in particular the rate of prosody-congruent responses with both prosodic contours was over 90% on the short version items, as it was in Experiment 1a. An analysis of variance for independent samples shows that there is no statistical difference between that rate in the two experiments and the two prosodic breaks, ($F$=3.67, $p$>.05). For the RC-attachment items the rate of prosody-congruent responses is slightly lower in Experiment 1b, but still over 80% on average on short-version items. An analysis of variance for independent samples shows that there is no statistical difference between that rate in the two experiments ($F<1$). In addition, the difference in the effect of the two prosodic breaks is replicated, ($F$=8.32, $p$<.01).

In summary, it is clear that the data for short-version items replicate Experiment 1a. As in Experiment 1a, both N1] and N2] prosodies were very effective in disambiguating the NP/S coordination items, while for RC-attachment items N1] prosody elicited significantly more congruent restorations than N2] prosody. This consistency of results between the two experiments provides further validation of the phoneme restoration method as a reliable tool for investigating syntactic ambiguity resolution.

Now let us examine in more detail the Experiment 1b data, shown separately in Figure 3-5 below. The data in Figure 3-5 have been extracted from Figure 3-4 for clarity and reorganized, but are otherwise identical to the Figure 3-4 data.

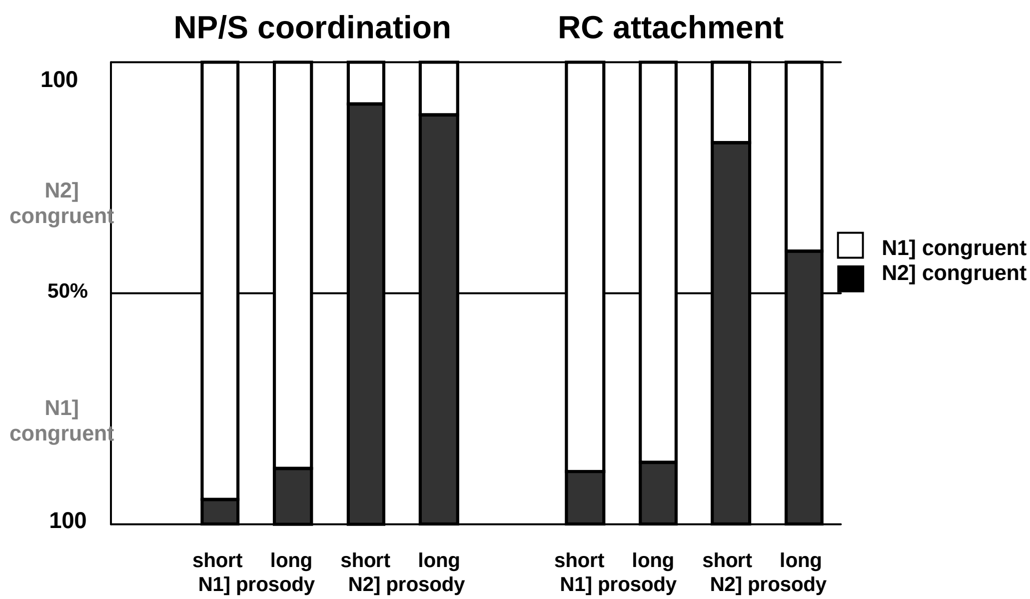



Figure 3-5. Percent prosody-congruent restoration responses for Experiment 1b: Visual word choice with prosodic break and NP length contrast

Fig. 3-5 shows that the length manipulation did modify the strength of the preferences for both constructions in the visual word choice task, and also that the size of this constituent length effect differed between the two constructions in the manner predicted. Namely, the long-version items had a numerically lower rate of congruent restoration responses for both NP/S coordination and RC attachment compared to the same type of short-version items, but the differences are very small for NP/S coordination and not statistically significant.

As in Experiment 1a, the data pattern for the NP/S Coordination items in Experiment1b was rather symmetrical. With a break after N1] the prosody-congruent restoration responses were 95% on short-version items and 88% on long-version items, and with a break after N2] the prosody-congruent restoration responses were 91% on short-version items and 89% on long-version items. The differences in the proportion of prosody congruent responses did not reach statistical significance, $F_1$ (1,44)=0.401, $p$>.05,

$F_2$ (1,20) = 0.380 $p$>.05. No main effect of constituent length was found, but the analysis of variance showed an interaction of constituent length and prosody $F_1$(1,44) =8.66, $p$<0.05, $F_2$(1,20) = 6.14, $p$<0.05. Paired comparison shows that there is an effect of length in the N1] prosody: $t_1$ (47)=2.25 p< 0.05, $t_2$ (23)=2.15 p< 0.05 but not in the N2] prosody $t_1$ (47)=0.79 p> 0.1, $t_2$ (23)=0.91 p> 0.1.

The effects of NP length in NP/S coordination are somewhat similar to what Clifton et al (2006) found in English with the same type of manipulation (length of NP conjuncts) in a different coordination ambiguity (main-clause subject NP-coordination) in a listening study with alternative paraphrase choice task. They report a significant interaction of NP-length and prosodic grouping: a higher proportion of ‘incorrect’ responses (i.e. opposite to the prosodic grouping) with long NPs. They interpret this as evidence that listeners take a prosodic boundary as less informative about syntax when it flanks long constituents than when it flanks shorter constituents. The numerical differences in the Experiment 1b data are in the right direction, and although the ‘suppression’ of the prosodic boundary effect was quite small with N1] prosody and even smaller with N2] prosody, there was a significant interaction of length and prosodic phrasing, just as in Clifton et al. (2006), so the RSH explanation may thus apply to the current findings. The smaller effects may be due to the fact that the coordination construction here is inherently different from the one tested by Clifton et al. The contrast in prosodic grouping established by boundary placement in their study is within one greater syntactic constituent (main-clause subject), whereas in the current experiment that is not the case. The two prosodic groupings place coordination not only in a different syntactic category (object vs. subject) but in a different clause, since the prosodic boundary coincides with a clausal boundary in both prosodic conditions. The prosodic cue here may be too prominent to be overridden by length effects. Also, the task was different. In their experiment, Clifton et al. (2006) had participants first indicate that they understood the utterance (pull a lever); then they saw the two paraphrases and had to pick the one that matched their understanding. In the visual word task participants heard a sentence and picked a word that was in it, so they did not have to keep the sentence in memory that long or consider two alternative interpretations.

For the RC-attachment items, as was tentatively expected, the effect of the length manipulation was very different in size for the two prosodic conditions. With the N1] break prosody, the rate of prosody-congruent restoration responses was 89% on short-version items and 87% on long-version items. With the N2] break prosody the difference was more dramatic: prosody-congruent restoration rate was 83% on short-version items, but only 59% on long-version items. An analysis of variance shows a main effect of prosody $F_1(1,44) = 55.2$, $p<0.001$, $F_2\ (1,20) = 13.0$, $p<0.001$ and a main effect of constituent length, $F_1(1,44) = 15.2$, $p<0.001$, $F_2\ (1,20) = 41.5$, $p<0.001$ as well as an interaction: $F_1(1,44) = 27.4$, $p<0.001$, $F_2(1,20) = 11.8$, $p<0.001$. Further comparisons confirm that N1] break prosody was not affected by the added length ($F_1\ (1,44) = 0.522$ $p>0.1$, $F_2(1,20) = 0.609$ $p>0.1$) and that added length affected performance with N2] prosodic break ($F_1\ (1,44) = 25.5$ $p<0.001$, $F_2(1,20) = 12.4$ $p<0.005$).

The further suppression of the disambiguating power of the N2] break for RC was not unexpected, since evidence that it is weaker than the N1] break as a prosodic cue for disambiguating RC-attachment in Bulgarian was present in the data from Experiment 1a. Constituent length obviously interacts with the factor that causes the asymmetry, but the none of possible explanations of that asymmetry considered in section 3.4.3. could difinitevely account for it.

Consider the alternative phrasing of the NP/S coordination in (17) below based on the interaction of the three constraints on prosody discussed in section 3.3.4.

(17)

a. (Nakraia) (sreshtnahme Ani) || i_( Ivan i_Mimi) (biaha vav_vaztorg).

In the end meet-past-1p.pl Ani and Ivan and children-det were in ecstasy

1Pr wd 2Pr wd || 2Pr wd 2Pr wd

*In the end (we) met Annie and Ivan and the children **were** ecstatic.*

b. (Nakraia sreshtnahme)(Aneta Markova) || i_( Ivaylo Stavrev)(i_Mariela Peeva) ¦ (biaha vav_vaztorg).

In the end meet-past-1p.pl Aneta Markova and Ivaylo Stavrev and Mariela Peeva were in ecstasy

2Pr wd 2Pr wd || 2Pr wd 2Pr wd ¦ 2Pr wd

*In the end, we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva **were** ecstatic.*

c. ( Nakraia sreshtnahme) (Ani i _ Ivan) || i_( Mimi) (beše vav_vaztorg).

In the end meet-past-1p.pl Ani and Ivan and children-det were in ecstasy

2Pr wd 2Pr wd || 1Pr wd 2Pr wd

*In the end (we) met Annie and Ivan and the children **were** ecstatic.*

d. (Nakraia sreshtnahme) ¦ (Aneta Markova) i_( Ivaylo Stavrev) || (i_Mariela Peeva)(beše vav_vaztorg).

In the end meet-past-1p.pl Aneta Markova and Ivaylo Stavrev and Mariela Peeva were in ecstasy

2Pr wd ¦ 2Pr wd 2Pr wd 2Pr wd 2Pr wd

*In the end, we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva **was** ecstatic.*

Both long versions satisfy the clause edge alignment constraint like the short ones and both allow an additional prosodic boundary (possibly an IPh) in the locations marked (¦), which may be motivated by an interaction of a length constraint that requires a break inside a long clause and a sense unit constraint that requires the coordinated NPs be phrased together. Perhaps the constraints are not strictly ranked but rather balanced across levels of prosodic structure. The wrap /sense unit type constrain maybe operates strongest on the level of words and then gradually weakens for higher constituents, while edge the alignment constraint operates strongest at the level of clauses and need not apply to clause internal breaks and the optimal length constraints may be the balancing mechanism. Speculations apart, the two long versions will have the same violations of the constraints, albeit in a different position. This may account for the fact that symmetric effects of prosodic break location for NP/S coordination persist in Experiment 1b. Now consider the possible phrasing of the RC attachment in (18) below.

(18)

a. ( Podtseniha advokata) || (na_pevitsata) (koiato kupi imenieto.)
Underestimate-past lawyer-m of singer-f who-m buy-past estate-det

2Pr wd || 1Pr wd 3Pr wd

*(They) underestimated the lawyer of the singer who bought the estate*

b. ( Podtseniha) ¦ (drebničkia advokat) || (na_našumialata pevitsa) ?¦ (koiato kupi imenieto.)
Underestimate-past small framed lawyer-m of newly-famous singer-f who-f buy-past estate-det

1Pr Wd 2Pr wd || 2Pr wd 3Pr wd

*(They) underestimated the small-framed lawyer of the newly famous singer who bought the estate.*

c. (Podtseniha ) (advokata na_pevetsa ) || (kojto kupi imenieto.)
Underestimate-past lawyer-m of singer-m who-m buy-past estate-det

1Pr wd 2Pr wd || 3Pr wd

*(They) underestimated the lawyer of the singer who bought the estate.*

d. ( Podtseniha) ¦ (drebničkia advokat) ?¦ (na_ našumialata pevitsa) || (kojto kupi imenieto.)
Underestimate-past small framed lawyer-m of newly-famous singer-f who-m buy-past estate-det

1Pr Wd 2Pr wd 2Pr wd 3Pr wd

*(They) underestimated the small-framed lawyer of the newly famous singer who bought the estate.*

The two long version phrasings have an IPh at the right edge of the main clause, and both may allow the alternative break (marked ?¦) for length reasons, though it will tend to be avoided (i.e. other positions will be preferred, such as after the main clause verb) and will likely not be an IPh break. The phrasing in (18d) may be less balanced than (18b), since it has three intermediate phrases in one intonational phrase and only one in the other, whereas (18b) has two in each but a similar disbalance is present in the short versions. So the three constraints cannot account for the difference in length effects.

Prosodic visibility may account for the decline in high attachment interpretations as it has the 'gradient' visibility component but the target materials were not designed to test the effect of smaller phrasal boundaries: the target sentences were actually produced with an IPh break after N1 for (18b) and after N2 for (18d) and did not have the breaks in alternative locations. Gradient visibility here will have to be determined in distance from each attachment size.

These data are in line with a modified version of the Rational Speaker Hypothesis, which includes the assumption made in section 3.3.4 that the <u>absence</u> of a predictable / expected prosodic boundary is also a viable structural cue. Perhaps the <u>absence</u> of a prosodic boundary whose presence would have been motivated by length considerations is also taken more seriously by listeners as an indicator of syntactic structure than the absence of a prosodic boundary whose presence is not mandated by length considerations. In particular, the <u>absence</u> of a pre-RC break would be more surprising to listeners following a long NP2 than following a short NP2. Compare the expectations for the two constructions in the short and long versions in (19) and (20) below.

(19)

*a. In the end, we met <u>Ani</u> and <u>Ivan and Mimi</u>* ***were*** *ecstatic*.

| | | | | | | |
|---|---|---|---|---|---|---|
| | Nakraia | sreštnahme | Ani ‖ | i Ivan i Mimi | **biaha** | vav vaztorg. |
| In the end | meet-past-1p.pl | Ani | | and Ivan and Mimi | were | in ecstasy |
| Adv | V | | N1 ‖ | ( N2 + N3) | V | PP] |
| | | | **IPh** structural | no IPh structural | | |

b. *In the end, we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva* ***were*** *ecstatic*

Nakraia sreštnahme Aneta Markova || i Ivaylo Stavrev i Mariela Peeva **biaha** vav vaztorg.
In the end meet-past-1p.pl Aneta Markova and Ivaylo Stavrev and Mariela Peeva were in ecstasy
Adv V N1|| ( N2 + N3) V PP]
**IPh** no IPh
structural / length structural (despite of length)

c. short NPs: *In the end, we met Ani and Ivan and Mimi* ***was*** *ecstatic*.

Nakraia sreshtnahme Ani i Ivan || i Mimi b**eše** vav vaztorg.
In the end meet-past-1p.pl Ani and Ivan and Mimi was in ecstasy
Adv V ( N1 + N2 ) || [ N3 V PP]
no IPh **IPh**
structural structural

d. *In the end, we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva* ***was*** *ecstatic.*

Nakraia sreštnahme Aneta Markova i Ivaylo Stavrev || i Mariela Peeva **beše** vav vaztorg.
In the end meet-past-1p.pl Aneta Markova and Ivan and Mimi was in ecstasy
Adv V ( N1 + N2 ) || conj [ N3 V PP]
no IPH IPh
structural (despite length) structural / length

In the long versions of the NP/S coordination the cues at the two relevant sites balance balance each other out. For example, in (19b) the effectiveness of the N1] break as a cue to structure may be weakened when a long phrase precedes it, but on the other hand the long conjuncts should boost the interpretation supported by the lack of N2] break despite the alternative motivation. Thus, i.e. the modulation of constituent length on prosody would be balanced, at least when all NPs are long as in the target items. The same logic holds for (19d).

For the RC attachment the default phrasing for RC and PP boosted both cues in (20a) and devalued both cues in (20c). With the added NP length there is an additional non-structural motivation for a prosodic break in this construction and it affects the two phrasings differently. In (20b) the impact of constituent length on the two cues balances out in a similar manner as for

NP/S coordination. However, in (20d) both cues are devalued by two non-structural alternative motivations. This may explain the decline in the effectiveness of N2] break prosody as a structural disambiguator with long version items in Experiment 1b.

(20)

a. *They underestimated the lawyer of* ***the singer who*** *bought the estate.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata \|\| | na | pevitsata | **koiato** | kupi | imenieto. |
| underestimate-past | lawyer-m | of | singer-f | who-f | buy-past | estate-det |
| V | N1 \|\| | | N2 | RC | | |
| | IPh | | no IPh | | | |
| | structural=non-default | | structural=non-default | | | |

b. *They underestimated the small-framed lawyer* ***of the newly-famous singer who*** *bought the estate.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | drebničkia advokat \|\| | na | našumialata pevitsa | **koiato** | kupi | imenieto. |
| underestimate-past | small-framed lawyer-m | of | newly famous singer-f | who-f | buy-past | estate-det |
| V | Adj N1 \|\| | | Adj N2 | RC | | |
| | IPh | | no IPh | | | |
| | structural = non-default | | structural= non-default (despite of length) | | | |
| | may be length | | | | | |

c. *They underestimated* ***the lawyer*** *of the singer* ***who*** *bought the estate.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata | na | pevitsata \|\| | **kojto** | kupi | imenieto. |
| underestimate-past | lawyer-m | of | singer-f | who-m | buy-past | estate-det |
| V | N1 | | N2 \|\| | RC | | |
| | no IPh | | IPh | | | |
| | structural | | structural | | | |
| | default | | default | | | |

d. *They underestimated* ***the small-framed lawyer*** *of the newly-famous singer* ***who*** *bought the estate.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | drebničkia advokat | na | našumialata pevitsa \|\| | **kojto** | kupi | imenieto. |
| underestimate-past | small-framed lawyer-m | of | newly famous singer-f | who-m | buy-past | estate-det |
| V | Adj N1 | | Adj N2 \|\| | RC | | |
| | no IPh | | IPh | | | |
| | structural | | structural | | | |
| | default | | default | | | |
| | length | | length | | | |

The interpretation of N1] phrasing was not significantly affected by NP length the 'uncertainty' of one cue is compensated by reinforcement of the other by the same factor. Thus, at least when all conjuncts are long, the length effects on prosodic grouping balance each other out and both prosodies decisively disambiguate the NP/S coordination ambiguity with long conjuncts as well as with short conjuncts. For RC, N2] prosody in general disambiguates less effectively, because the cues have default status and constituent length undermines them further via an additive effect. The N2] prosody thus becomes even less reliable as a cue to the intended RC attachment. Thus, for RC-attachment the length of the nouns seems to magnify the asymmetry in the effect of the two prosodic phrasings, while for the NP/S coordination it seems to only very slightly lessen their effectiveness. Since the length manipulation is the same in both types of items, the explanation must lie in the different kind of mapping between syntactic structure and legitimate prosodic cues for the two constructions. The next section presents an experiment that explores the same length effects in the absence of prosodic disambiguation.

## 3.6. Supplementary experiment 1c: eliminating the informative prosodic break

### 3.6.1. Overview

Experiment 1c, described in this section, was intended to establish a baseline ambiguity resolution preference for the two target constructions in the absence of relevant prosodic cues (i.e. a preference based only on syntax, semantics or plausibility), or – since the materials had been pre-tested for absence of bias (section 3.1.2) – it might yield performance at chance. For that purpose, the same materials were used as in Experiment 1b (i.e., with NP length contrasts), but the stimuli for Experiments 1c were recorded so as to contain no prosodic boundary or other useful prosodic information, in contrast to the stimuli for Experiment 1b. Experiment 1c was conducted concurrently with Experiment 1b, but was administered separately to a different group of participants. Originally, this baseline (neutral / uninformative) prosody condition was intended to be included in the same experiment as the N1] prosody and N2] prosody conditions, as was done in the study by Kjelgaard & Speer (1999). However, producing the target sentences for this experiment without prosodic clues to the structure resulted in very monotonous sounding stimuli that in the pre-test were judged unnatural sounding and hard to follow[48]. This motivated the decision to make the neutral (uninformative) prosody condition into a parallel experiment rather than incorporating it into the same experiment as the informative prosody conditions. It seemed possible that interspersing informative prosody and neutral prosody could have invalidated the trustworthiness of the informative prosody for some (or all) participants, or conversely might have clued them in to the fact that prosody provides relevant information and should be attended to. Either of these would defy the main purpose of the experiment, which was to test the validity of a new methodology for studying ambiguity resolution and the role that normal prosody in particular plays in that process.

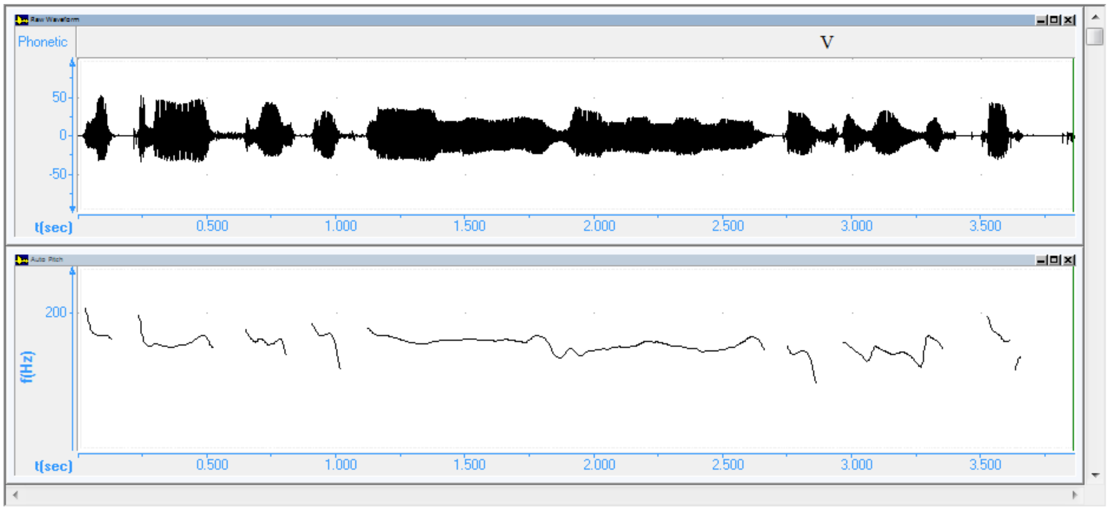
### 3.6.2. Stimuli

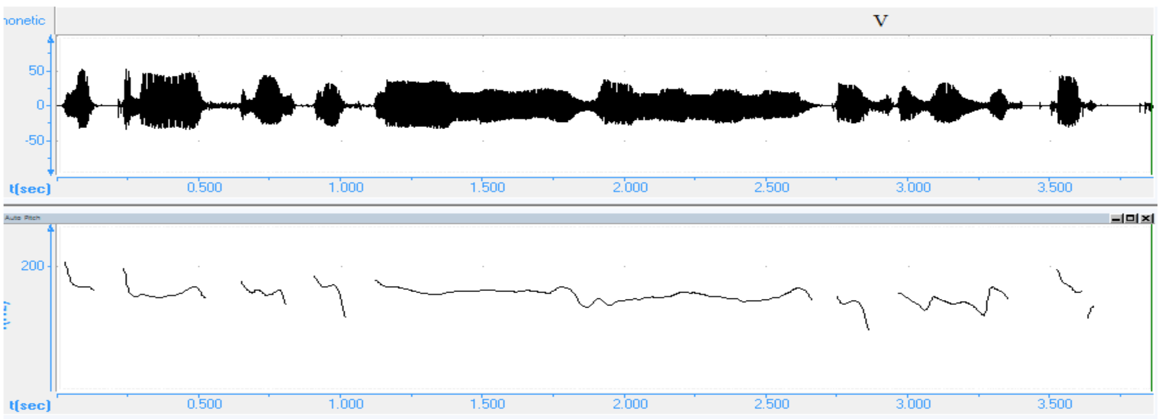
Experiment 1c used exactly the same sentence materials as Experiment 1b, (i.e. every target item had a short and a long version), but eliminated the informative prosodic contour in the target stimuli. The baseline ‘neutral’ prosody condition was recorded by the same native speaker (the author) for the long and the short versions of the 24 target sentences for each of the two target constructions (NP/S coordination and RC attachment). The absence of syntax-relevant acoustic features is illustrated by the examples in Figure 3-6 below.

---

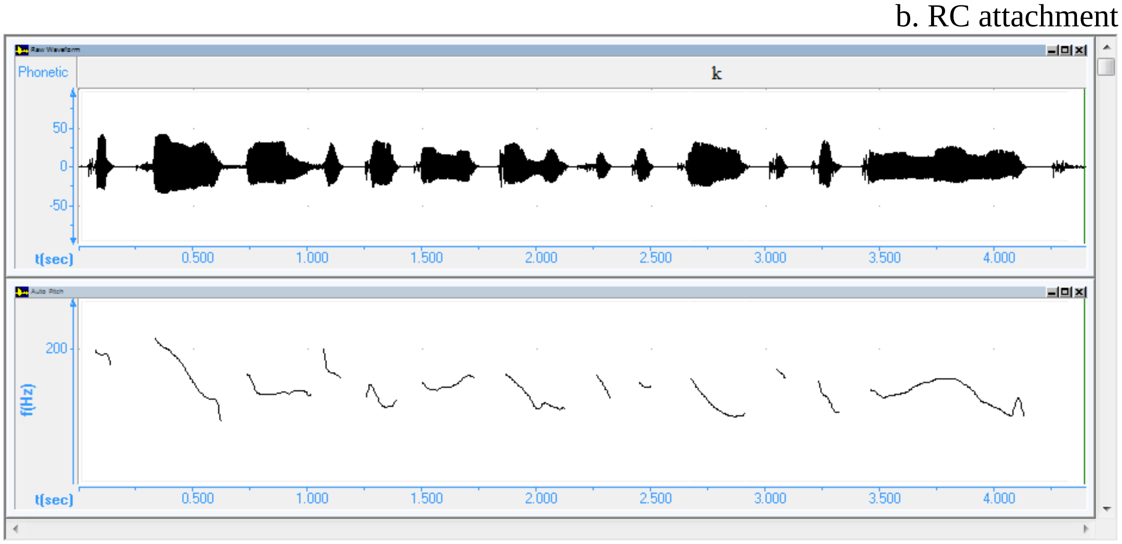
[48] In some cases the judges in the pre-tests needed to listen to a sentence in the neutral prosody condition several times in order to understand it.

a. NP/S coordination




b. RC attachment



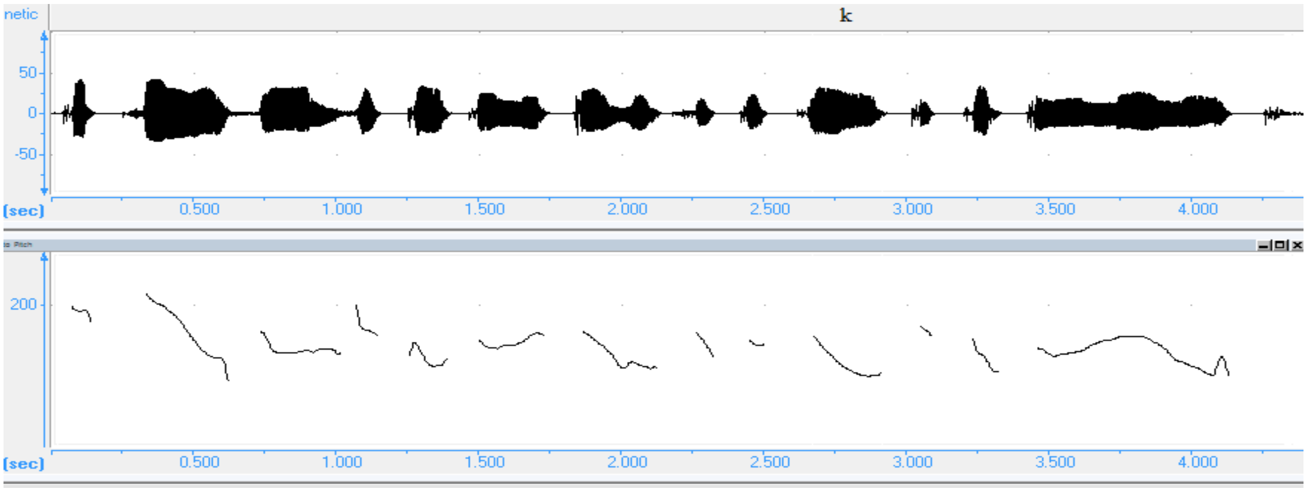
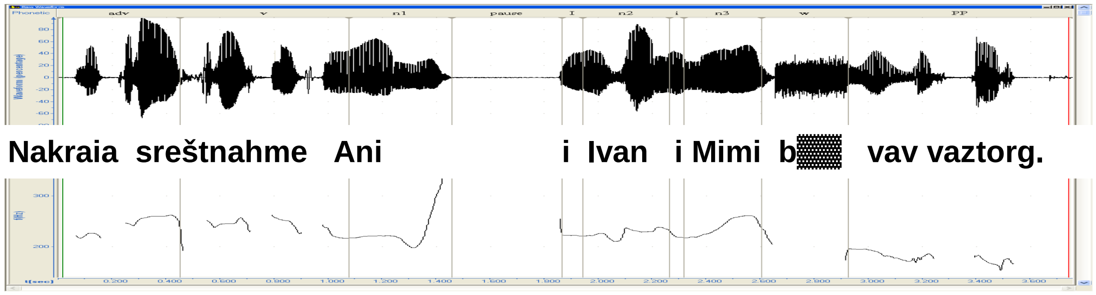


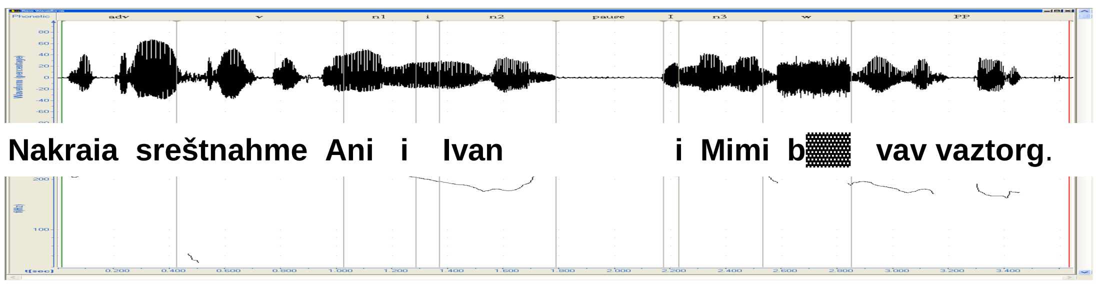

**Figure 3-6**. Neutral prosody

This neutral contour had no perceptible prosodic break at any point, i.e. no pauses or lengthening, and each word was uttered with a uniformly gently falling intonation, described as monotonous by the listeners/judges in the pre-test. Prosody should not therefore provide reliable cues as to how the ambiguous sentence is interpreted when the lexical disambiguation is removed and replaced with noise. An example of a (short version) stimulus sentence in Experiments 1a-1b and the corresponding stimulus sentence in Experiment 1c is given in Fig. 3-7 below.

N1] prosody, coordination as subject of second clause




N2] prosody, coordination as object of first clause




Neutral prosody, no cue for NP/S coordination

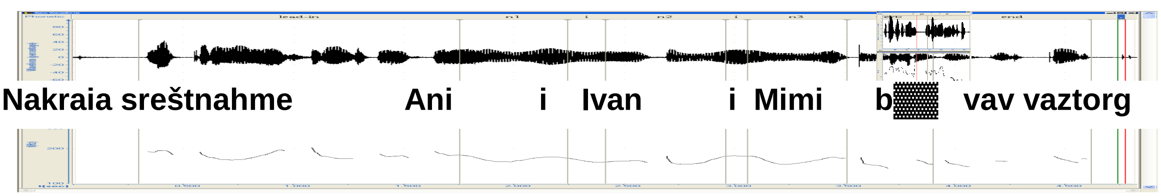



**Figure 3-7**. Informative prosody contours and baseline / neutral prosody contour compared.

The stimuli were recorded using the same software and equipment as for the informative prosody experiments 1a and 1b, but spoken at a slower rate to make sure tonal variation was avoided. In creating the neutral prosody stimuli, each target item was recorded with the two possible disambiguating words, but only one version was ultimately used. For NP/S coordination ambiguity materials, the lexical content used was consistently ‘beše’ (singular), because attempting to pronounce the plural verb after the third (singular) noun did not foster neutral prosody. For the RC attachment ambiguity materials, half of the items were created from the recording with ‘kojto’, the other half with ‘koiato’, again to align with the last noun, because the opposite was not conducive to producing neutral prosody.

To complete the stimuli for this experiment, the same ambiguous and unambiguous fillers were used as in Experiments 1a-b, but only the 12 ambiguous fillers were also recorded with neutral prosody. The unambiguous fillers were included with normal prosody as a way of screening out participants. The noise replacement procedure was exactly the same as for the stimuli in experiments 1a and 1 b.

## 3.7**. Experiment 1c: Visual word choice with neutral prosody**

### 3.7.1. Overview and summary of experimental details

The purpose of Experiment 1c was provide a baseline of listeners’ interpretations of the NP/S coordination and RC attachment ambiguities in Bulgarian when unaided by prosodic break location or morphological agreement. In addition, the constituent length contrast was included as a means of isolating pure phrase length effects from contributions of phrase length to the interpretation of prosodic information. Experimental details are provided in Table 3-6 below.

As in Experiments 1a-b, DMDX was used for presentation of the test (in a constrained pseudo random order to each participant) and recording of participants’ responses. Participants were given exactly the same instructions as in Experiments 1a-b.

**Table 3-6**: Experimental details for Experiment 1c:
Visual word choice with neutral prosody and constituent length contrast

| | number | Details |
|---|---|---|
| Participants | N=24 | Age 19-28, 67% female<br>No participants excluded from experiment on any criteria. |
| Task: visual word choice | | Listen to the sentence and pick the word that was in the sentence out of two words on the screen. |
| Target materials: | | Contrast: constituent length |
| NP/S coordination ambiguity | N=24 | short (N=12) vs. long (N=12) |
| RC attachment ambiguity | N=24 | short (N=12) vs. long (N=12) |
| Lists | 2 | |

3.7.2. Predictions

Since the location of the prosodic break was a strong disambiguator for both NP/S coordination and RC attachment in Experiments 1a and 1b, the removal of the prosodic break and any other useful prosodic information might result in no preference for ambiguity resolution (performance at chance) or else might effects of purely syntax-based parsing strategies such as Late Closure (LC). If that is the case, a preference may be predicted for both constructions: for NP/S coordination, NP coordination over S coordination preference, such as was found for Dutch in silent reading (Hoeks et al., 2002), manifested in a preference for parsing the NP coordination in the first clause object rather than the second clause subject; for RC attachment, LC would favor low attachment of RC.

Constituent length effects could be observed, since that factor has been shown to affect ambiguity resolution preferences in general and it was shown to modify the effectiveness of prosodic disambiguation in Experiment 1b. For NP/S coordination with normal prosody, the length of the conjunct NPs (all three were comparable in length) did not reach significance as a main effect, but showed up as interaction with prosodic break location, in particular for N1] prosody items, for which congruent restorations went down more. It is possible that in the absence of prosodic breaks the length factor may gain prominence. However, there is no basis for making predictions as to which direction it may sway the results. For RC attachment the phoneme restoration data with natural prosody in Experiment 1b showed that interpretation of the RC was affected significantly by constituent length, so a similar effect might be expected with no prosodic breaks: longer NPs favor lower RC attachment.

### 3.7.3. Results and discussion

The data from Experiment 1c are presented in Figure 3-8 below. The data are coded as percent phoneme restorations (measured by word choices indicating syntactic structure) that are compatible with each of the alternative prosodic break locations in the informative prosody experiments. This was done for consistency and for comparison with the data from the other experiments, as there were no firm expectations of a preferred interpretation associated with the neutral prosody. A pre-imposed timeout for responding to the visual word choice resulted in 0.8% of missing data for the visual word choice with neutral prosody. Figure 3-8 also includes the data from Experiment 1b for comparison.

Overall, the neutral prosody data was not as clear-cut as the data from the parallel task using stimuli with informative prosodic breaks. As can be seen in Figure 3-8 , the absence of a prosodic break resulted in a different pattern of responses compared to the informative prosody conditions, falling roughly in between the preferences obtained with an N1] and with an N2] prosodic break. However, a single mean t-test statistical analysis shows that responses were not at chance levels.

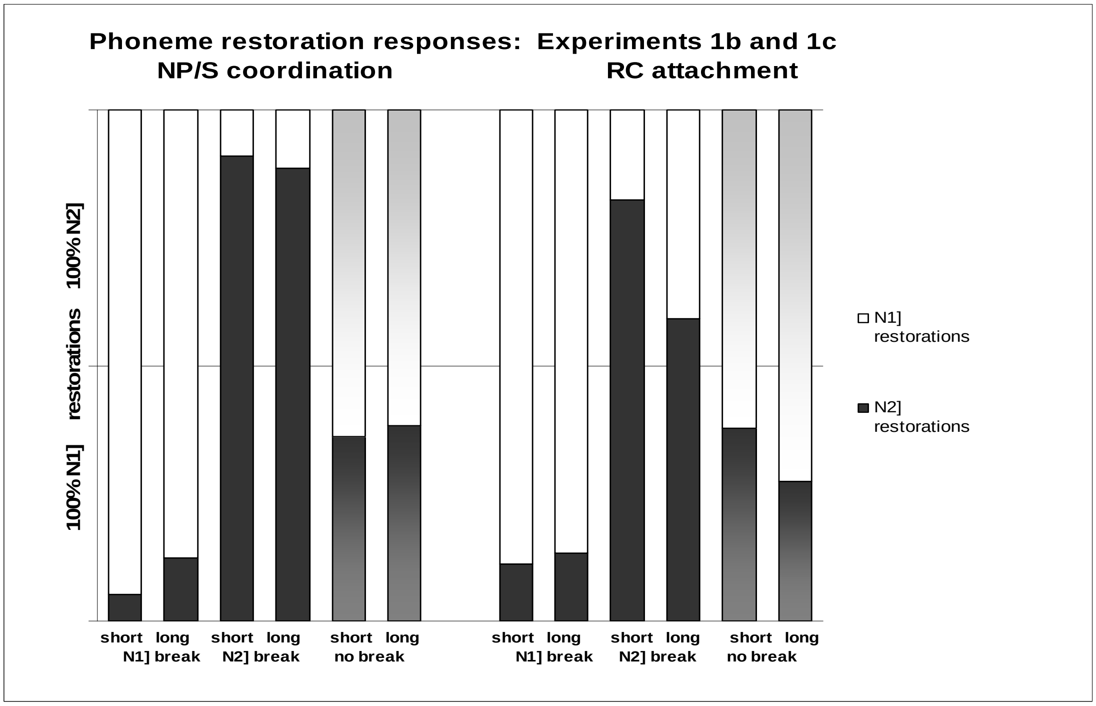



Figure 3-8. Phoneme restoration responses with informative and neutral prosody and added constituent length (Experiments 1b-c).

For coordination materials, the mean object coordination rate was significantly different from chance (presumed 50%) for both the short-version items at 36.2 % ($t_1$(23)= –3.51, p<.01; $t_2$ (23)= –2.81, p<.05) and the long-version items at 38.3% ($t_1$(23)= –2.64, p<.05; $t_2$ (23)= –2.60, p<.05). Also for the RC attachment responses, the high attachment rate with short-version items was 37.8%, significantly different from chance ($t_1$(23)= –3.54, p<.01; $t_2$ (23)= –2.71, p<.05), as was the 27.2% high attachment response rate with long-version items ($t_1$(23)= –6.74, p<.001; $t_2$ (23)= –4.07, p<.05). For NP/S coordination constituent length had no effect on ambiguity resolution with neutral prosody: $F_1(1,22) = 1.01$, $p<0.325$, $F_2(1,20) = 0.075$, $p<0.78$, whereas for RC attachment constituent length had a significant impact on how the ambiguity was resolved: $F_1(1,22) = 5.89$, $p<0.05$.

In effect, the neutral prosody condition yielded specific preferences for ambiguity resolution of both NP/S coordination and RC attachment in this task. Interestingly, these preferences are in the same direction as observed with an N1] break in Experiment 1a and 1b using the same visual word choice protocol. For the RC-attachment ambiguity that amounts to a low-attachment preference in the absence of other cues, which is in line with a general Late Closure parsing strategy. In fact, Kielgaard and Speer (1997) report an advantage for LC in the neutral prosody. For the NP/S coordination ambiguity, however, Late Closure would dictate that the second noun be parsed in the same phrase as the first, rather than in a new one, i.e. LC predicts the opposite preference to what was observed. It might be argued that some remnant transitional cue could conceivably have biased the results since the recordings that were used for the phoneme replacement were the sentences with one of the alternatives. But while the fact that agreement with N2 was used for RC attachment items would in fact boost the low attachment preference which was observed, the fact that singular was used in NP/S coordination items should have given an advantage to the NP coordination in the first clause (leaving singular subject in the second clause) the opposite was actually observed. In any case, great care was taken to remove such cues (by excising parts of preceding and following phonemes along with the disambiguating phonemes in the target word), and a pretest with sentence fragments was conducted, in which listeners were unable to tell which word had been spoken and noise-replaced when it was presented without prior context. Therefore, we must seek another explanation for this unexpected early closure preference for the NP/S coordination materials in the absence of disambiguating prosody.

A recent ERP study (Pauker, Itzhak, Baum and Steinhauer (2011) specifically tested the effect of inappropriate absence of boundary vs. the inappropriate presence of boundary and found that while both are dispreferred in an acceptability judgment task, but the associated ERP components indicate that mentally deleting a boundary in the input may be more costly than inserting a structural boundary which was not present in the input. It is possible therefore that the participants in Experiment 1c are assigning prosodic structure to the input they receive. But while they follow LC for RC attachment they don't seem to for NP/S coordination.

It is possible that the lack of prosodic grouping impacts how successfully the sentence is parsed by the listener. When the three nouns are not separated into a specific grouping by prosody, i.e., as N1 / (N2+N3) or as (N1+N2) / N3, listeners may interpret the neutral prosodic phrasing as a sign of a 3-way coordination (N1+N2+N3), and consequently would assume that the following verb must be plural – even though that does not yield a stable syntactic structure for the whole sentence. This is compatible with the assumption suggested earlier, that the absence of an expected prosodic break (as is required at the end of a clause) is treated as meaningful information, signaling in this case that no clause edge is present.

However, if that is indeed what participants are doing, then they are in fact disregarding the material that comes before the first conjunct and only constructing a partial structure for the latter part of the sentence. Possibly this local disregard of global syntactic wellformedness is open to an account in terms of short-term memory limitations, and could be taken as indirect evidence that prosodic information is essential in the efficient mental structuring of speech input. The preference for low RC attachment observed in Experiment 1c is compatible with such an account, as is the finding that longer NPs yielded more low attachment responses. When hearing the materials with informative prosody listeners were quite successful in parsing them and using the location of prosodic breaks to deduce the intended structure. Lack of informative prosody on the other hand hampers grammatical structuring of the input and keeping it in short term memory, so listeners are struggling with the very same task and are only partially processing the material. This is only speculation, however. This claim cannot be made with confidence on the basis of the results from Experiment 1c, because of possible experimental differences that were not controlled in this study. For example, as noted in section 3.7, the neutral prosody stimuli were spoken at a slower rate than the stimuli with natural prosody and such slow speech rate might impair on-line comprehension.

**3. 8. Summary of visual word choice experiments**

Overall, participants' performance in the visual word choice task validated the phoneme restoration method as a tool in sentence processing research and in particular for exploring the role of prosodic information in ambiguity resolution. The informative prosodic contours, containing disambiguating prosodic breaks, resulted in a very high proportion of prosody-congruent restorations for both the NP/S coordination ambiguity and the RC attachment ambiguity. The data reflected the difference between the two constructions with regard to prosodic disambiguation. As expected, both prosodic break locations disambiguated NP/S coordination equally well, while the N1] prosodic contour was more effective for disambiguating RC attachment, as reported for other languages. The data also showed the predicted constituent length effects on ambiguity resolution. The neutral / uninformative prosody data was less clear-cut, but in general confirmed the importance of prosodic facilitation in ambiguity resolution.

It was of interest to find evidence supporting the assumption that both breaks and absence of breaks are treated as meaningful, which contributes to the explanation of the natural prosody data. It may even be applicable to the way spoken input is structured in general. Assuming that the function of a prosodic break with respect to syntax (which should hold for any type of break whether between words, phrases or clauses) is first and foremost to separate two adjacent constituents that do not form a larger syntactic constituent and unite two adjacent constituents that do form one, syntax prosody alignment in parsing can start with a simple decision at the edge of each constituent (however minor) based on a binary distinction cue: no break means continue structure and a break means separate (discontinuity in structure).

From a methodological perspective, it must be noted that validating the phoneme restoration as a tool in sentence processing is not confined to investigations of prosody. The method may be applied to investigate other factors such as semantic priming or pragmatic plausibility. It can also be incorporated in other tasks besides visual word choice and was in fact tested in two elicited production task experiments that are presented in Chapter 4.

# CHAPTER 4

# EXPANDING THE PHONEME RESTORATION PROTOCOL: PRODUCTION EXPERIMENTS

## 4.1. Two experimental protocols for elicited production with phoneme restoration

### 4.1.1. Justification for using elicited production

The experiments presented in Chapter 3 showed that phoneme restoration can be a viable tool in sentence comprehension investigations. It was successfully employed as a measure of prosodic effects in ambiguity resolution, producing results that are comparable to published data obtained with well established methods and it may potentially be applied to study the effect of other factors besides prosody. The visual word choice task that was used in experiments 1a, 1b and 1c has several advantages, as was discussed in Chapter 1, especially in a study focused on prosody. In particular, it is an improvement over a questionnaire task, because it eliminates the actual question, which is additional material to process involving extra syntactic, semantic-pragmatic and prosodic representations that delay the response and may potentially introduce biases. The visual word choice task diminishes such biases and pulls the response closer to the stimulus, even though it is still a post-sentence task which does not yield data on the time-line of processing ambiguity. A potential disadvantage is that displaying the two potential target words on the screen to choose between may convey to participants at least a hint that two different words *might* have been compatible with the stimulus. The next logical step, then, is to try to eliminate even this modest element of awareness on the part of participants, by a change in the task by which participants' phoneme restorations are revealed in their behavioral response. The experiments presented in this chapter attempt to do this by expanding the phoneme restoration protocol to two new tasks: sentence repetition and sentence shadowing. The experimental protocols and some of the data were first presented in part in Stoyneshka, Fodor, Fernández, 2010.

4.1.2. Implementing the phoneme restoration technique in two production tasks

**Sentence repetition task**

In the Sentence Repetition protocol, the task is to repeat the sentence aloud immediately after hearing it. This task is also known in the literature as *elicited imitation.* It is widely used with children (e.g., Lust, Flynn, & Foley, 1996) and second language learners (e.g., Bley-Vroman & Chaudron, 1994). In this study the dependent measure was the frequency with which the noise in the critical word in the input was replaced in the participant's output by a phoneme (or phonemes) that created a word compatible with the syntactic structure favored by the prosodic phrasing.

**Sentence shadowing task**

The speech shadowing task was first used to investigate mapping from sound onto meaning by Marslen-Wilson (1973) who adopted the technique from earlier work[49]. In speech shadowing the listener reproduces the input while still continuing to hear and process the remainder of the sentence or passage. For Marslen-Wilson the most significant aspect was the discovery of a small proportion of "close shadowers" who could repeat back material at a lag of only 250-300 ms, with evidence of processing at the syntactic and semantic levels within that brief time-span. In a series of subsequent experiments (summary in Marslen-Wilson, 1985), he compared shadowing of normal prose, syntactically well-formed but semantically uninterpretable

[49]Marslen-Wilson (1985) credits Christovich (1960) with first use of the task and discovering the phenomenon of close shadowing, but notes that Christovich used primarily shadoing of isolated syllables.

prose, prose where only word order constraints are observed without syntactic or semantic structure, and Jabberwocky prose in which not even lexical content is retained but it is ‘prosodically and phonologically intact’.

Of interest for present purposes is that Marslen-Wilson (1975) observed spontaneous restoration of contextually appropriate phonemes in place of actual but contextually incorrect phonemes, in the shadowing of normal prose. For example, the non-word *tomorrane* was frequently reproduced as *tomorrow*, and *travedy* as *tragedy*, when the sentential context was syntactically and semantically supportive.

Additional observations reported by Marslen-Wilson (1985) may also be relevant to the present research. He notes that the close shadowers in his study “tracked the prosodic contour of the message as they were repeating it” (Marslen-Wilson, 1985: 58) and separately that when distant shadowers were pushed to shadow closely, they “a travesty of normal speech, an incomprehensible muttering that roughly preserved the prosodic structure of the original” (Marslen-Wilson, 1985: 58). These observations indicate that the sentence shadowing task will be sensitive to sentence-level prosody, which encourages anticipation that it should be a sensitive tool in the current research on prosody-based ambiguity resolution.

The shadowing experiment described here differed from Marslen-Wilson’s in three ways. It presented individual sentence stimuli rather than longer passages. As targets for restoration it employed noise-replaced rather than inappropriate phonemes. The restoration-supporting context was prosodic rather than syntactic/semantic. As in the Sentence Repetition task, the dependent measure was how often the noise in the input was replaced in the participant’s output by a phoneme (or phonemes) that created a word compatible with the syntactic analysis cued by the prosody.

## 4.2. Materials and procedure

*Materials*

The elicited production experiments presented here used a subset of the target materials for the visual word choice experiments reported in Chapter 3, namely the short versions. The length manipulation was not included in these elicited production tasks, because the primary purpose was to compare the efficacy of these production tasks compared with the listening comprehension task of experiment 1a. Production tasks put different demands on participants. In particular, greater sentence length could make the items more difficult to remember and reproduce, resulting in a high error rate and hence missing data. Given the more demanding nature of the procedure, the target materials were presented with a reduced number of filler items (the 12 ambiguous fillers only) so that the testing session would not be too lengthy. Also, as before, each set of target constructions (NP/S coordination and RC-attachment) served as fillers for the other. Larger-scale studies may be conducted in future.

The target stimuli consisted of 24 NP/S coordination items and 24 RC attachment items, each with two natural prosody versions with contrasting (informative) prosodic contours and one neutral (uninformative) prosody version. The ambiguous reflexive/possessive particle fillers (see Chapter 3, section 3.1.3.) also had two natural prosody versions with contrasting prosodic contours and one neutral (uninformative) prosody version. In order to make the design parallel and allow for comparison of the data collected with different tasks, naturalness of the prosodic contour was a between-subjects factor in the elicited production experiments as it was in the visual word choice experiments. Specifically, the targets and fillers with the two contrasted natural prosodic contours were used in Experiment 2a, and also in Experiment 3a, counterbalanced across two lists (12 items for each target construction in each of the two experimental conditions). The neutral prosody targets and fillers were used in Experiment 2b and Experiment 3b, in a single list.

Each list of targets and fillers was preceded by two overt practice items with feedback, and two covert fillers ('warm-up' items) at the beginning of the test.

*Participants*

Participants in the four elicited production experiments (72 in all) were all native speakers of Bulgarian, drawn from the same population as participants in the visual word choice experiments: undergraduate students at the Varna Free University and University of economics in Varna. Three additional participants took part in the sentence shadowing with natural prosody (Experiment 3a) but their data was not used because of over 25% missing responses (mostly due to recordings terminated prematurely). The missing data criterion was not applied to reject and replace participants in the neutral prosody experiments because the proportion of missing data was too high for reasons other than participants not responding (see section 4.4.3.).

*Procedure*

For all the production experiments, participants were tested individually in a quiet room on a laptop computer, as in the listening comprehension experiments reported in Chapter 3. The presentation was self-paced: when ready, participants pressed a button to hear a sentence via headphones. DMDX controlled the presentation, including the different pseudo-randomizations of the materials for each participant, and collected participant responses. A response time-out for completion of the sentence recording was set for 7000 ms from the point at which a prompt for repetition (a microphone icon) appeared on the screen.

In the sentence repetition task participants had to repeat the sentence aloud immediately after listening to the stimulus. They were told to start speaking as soon as they saw the microphone icon on the screen, which was synchronized with the end of the stimulus.

In the sentence shadowing task participants were told to repeat each sentence as they were hearing it, starting when they saw a microphone icon on the screen (synchronized with the beginning of the stimulus recording.) The instructions were to start repeating the sentence as soon as it began, and to continue as best as they could through to the end. Their job was to try to shadow the speaker in the recordings, by speaking the sentence aloud as they were listening to it, with as little delay as possible.

## 4.3. Experiment 2a: Sentence Repetition

### 4.3.1. Overview

The purpose of Experiment 2a was to implement the phoneme restoration method in a production task that would not require participants to explicitly choose a word and no attention was drawn the possibility that two different words would be compatible with the stimulus sentence. Instead, they would produce the sentence including the word which was partially replaced with noise, and what they produced was taken to reveal what structure they had assigned to the stimulus sentence, and whether it was consistent with the prosodic contour they were exposed to. Experimental details are provided in Table 4-1 below.

**Table 4-1**. Experimental details for Experiment 2a: Sentence repetition with informative prosody

| | number | details |
|---|---|---|
| Participants | N=24 | ages 18-27, 58% female<br>No participants excluded from experiment on any criteria. |
| Task: sentence repetition | | Listen to the sentence and repeat it back immediately after hearing it.<br>. |
| Target materials: | | Contrast: prosodic break location |
| NP/S coordination ambiguity | N=24 | N1] break (N=12) vs. N2] break (N=12) |
| RC attachment ambiguity | N=24 | N1] break (N=12) vs. N2] break (N=12) |
| Lists | 2 | |

4.3.2. Predictions

As for the word-choice task, the prediction was that participants would be sensitive to the prosodic contour of the stimulus as a cue to syntactic structure. Specifically, for the noise-replaced word in the each stimulus, they should produce predominantly the word that disambiguates the sentence toward a syntactic structure that is compatible with the prosodic contour of the auditory stimulus.

Further, on the basis of Experiment 1 results, and data for other languages, a greater effect of an N1] prosodic break can be expected for RC attachment compared to an N2] break.

4.3.3. Results and discussion

Data for Experiment 2a are shown in Figure 4-1. The dependent measure was which word was produced by the participant in lieu of the noise-replaced word in the stimulus, from which it could be inferred which interpretation had been imposed on the sentence. As for Experiments 1a and 1b, the data are presented as percent congruent phoneme restorations. Missing data in this task are the result of recordings terminated prematurely (i.e., before the critical word was uttered) because of the pre-set 7000 ms response timeout.  Recordings terminated prematurely made up 4.4% of the data.

As can be seen from Figure 4-1, congruent phoneme restorations were again overwhelmingly more frequent than non-congruent responses for both the NP/S coordination and the RC attachment constructions, ranging between 83% and 98%. Thus, as expected, listeners in Experiment 2a were responsive to the prosodic contour of the stimulus in resolving syntactic ambiguity. Results were similar in most respects to the listening comprehension data obtained with the forced choice task (visual word choice) in Experiments 1a and 1b.

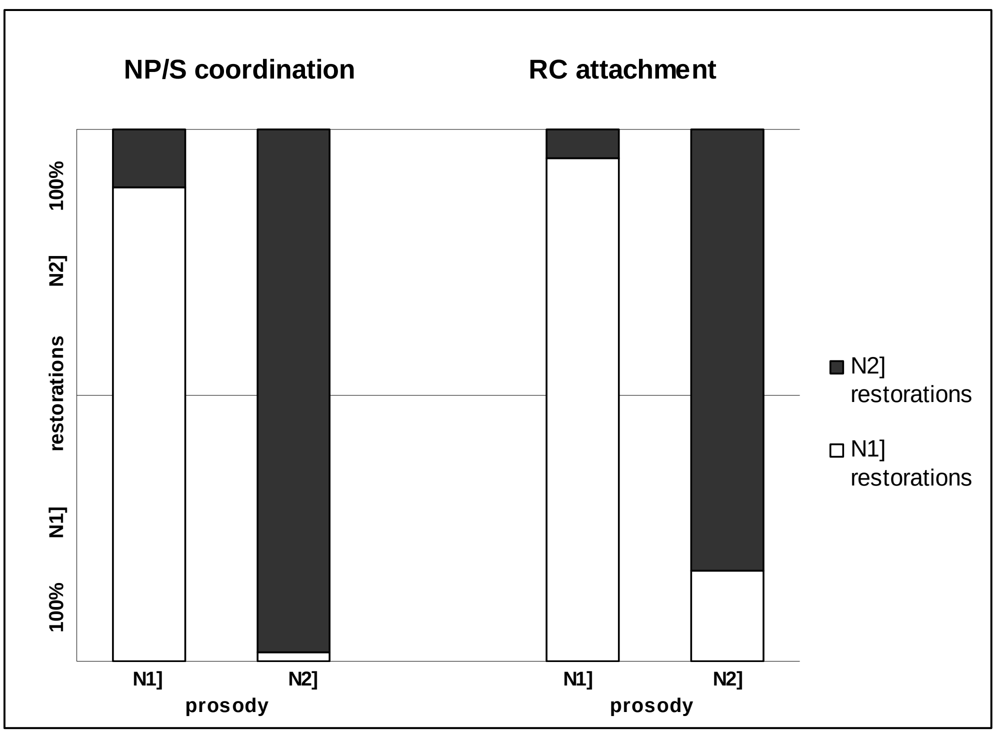



**Figure 4-1.** Percent prosody-congruent restoration responses for Experiment 2a: Sentence repetition

With regard to detailed effects: Experiment 2a data show again the expected asymmetry for RC-attachment: N1] prosody had a stronger effect on RC-attachment than N2] prosody did (94% and 83% prosody-congruent responses respectively), in keeping with results from Experiments 1a and 1b (visual word choice) and with findings on other languages as discussed in Chapter 2. The difference is significant ($F_1(1,22)=11.15$, $p=.003$; $F_2(1,22)=14.81$, $p=.001$). Also observed was an unanticipated asymmetry in the data for the NP coordination materials, in the opposite direction from RC-attachment: N1] prosody elicited fewer congruent restorations than N2] prosody (89% and 98% respectively; $F_1(1,22)=17.09$, $p<.001$; $F_2(1,22)=4.66$, $p=.042$). This difference is absent from Experiment 1a and Experiment 1b (visual word choice) and from Experiment 3 (sentence shadowing, see below). As noted in Chapter 2 (section 2.3) to my knowledge no such asymmetry has been reported in the literature on the processing of coordination. It is possible that the prosodic cue in the N2] condition is more recent and produces a stronger effect in a task that requires keeping more in memory, since there is a slight rise in congruent restorations on RC-attachment items with N2] compared to Experiments 1a and 1b. It is also possible that this is a manifestation of a preference for NP coordination over S coordination similar to what was found for Dutch in silent reading (Frazier, 1987; Hoeks et al., 2002). Further experimentation with this construction is required to check whether this effect replicates. Even so, the effect of both prosodic contours on syntactic interpretation as revealed by phonemic restorations is highly significant.

As expected, listeners were able to make use of the prosodic contour of the stimulus to resolve syntactic ambiguity. Results were similar overall to the data from Experiment 1 and comparable to previously reported data on other languages. Overall, the production data confirms that location of prosodic boundary effectively disambiguates the intended meaning of NP/S coordination and RC attachment in Bulgarian. The sentence repetition task proved a successful implementation of the phoneme restoration methodology for the study of prosodic effects on sentence processing. In some respects, this task can be regarded as an improvement over the visual word choice one. While still a post-sentence task, the sentence repetition task not only eliminates the need of a comprehension question, but also (perhaps more importantly) eliminates the overt word choices that are central to the visual word choice task. By not offering specific alternative word choices, the sentence repetition protocol does not draw attention even to the possible presence of *lexical* ambiguity in the stimulus. Participants are given no reason to believe that there is any uncertainty at all about what the word really was that they were attempting to hear 'through' the noise; their attention is focused on remembering and reproducing the sentence accurately. Note that in asking them to repeat the sentence we did not ask them to reproduce its prosody; the prosody of the stimuli was never mentioned in the instructions (see Appendix B). The extent to which the repetitions do match the prosody of the stimulus may provide additional insight into the role of prosody in sentence comprehension. Some details of participants' production are presented in Chapter 5.

The overall conclusion is that native speakers of Bulgarian were able to utilize prosodic boundary location as a structural cue and produce a morphologically disambiguated sentence with a syntactic structure consistent with the prosody they heard. The supplementary experiment described in the next section was meant to produce control data from elicited production without prosodic facilitation.

## 4.4. Experiment 2b: Sentence repetition with neutral prosody

### 4.4.1. Overview

The purpose of Experiment 2b was to investigate whether the absence of prosodic boundary disambiguation and other useful prosodic information would inhibit perception and production of spoken sentences. The word that participants produce in place of the noise-replaced word in the stimuli would indicate what structure they were choosing when neither morphological nor prosodic cues were available in the signal. Experimental details are provided in Table 4-2 below.

**Table 4-2**: Experimental details for Experiment 2b: Sentence repetition with neutral prosody

| | number | details |
|---|---|---|
| Participants | N=12 | age 19-25, 64% female<br>No participants excluded from experiment. |
| Task: sentence repetition | | Listen to the sentence and repeat it back immediately after hearing it. |
| Target materials: | | Contrast: none |
| NP/S coordination ambiguity | N=24 | short only, neutral prosody |
| RC attachment ambiguity | N=24 | short only neutral prosody |
| Lists | 1 | |

4.4.2 Predictions

In the listening comprehension task with neutral prosody (Experiment 1c) participants did not show a strong bias toward one interpretation for either NP/S coordination or RC attachment ambiguity, but they did not perform at chance. Their word choices indicated a low RC attachment preference which could be due to a Late Closure strategy, and a preference for NP coordination in the second clause, which was contradictory to the NP coordination over S coordination preference reported for Dutch. If these were genuine parsing preferences for the two constructions, the production data should replicate them. If it does not, the preferences with neutral prosody in listening must be related to the specific task as well as the lack of prosodic disambiguation.

4.4.3. Results and discussion

The data from Experiment 2b are presented in Figure 4-2 below. As was done with visual word choice responses with neutral prosody, the sentence repetition responses with neutral prosody are presented on a scale from 100% N1] / 0% N2] congruent restorations to 100% N2] / 0 % N1] congruent restorations. That is, the data are coded as percent phoneme restorations indicating syntactic structure that is compatible with each of the alternative prosodic break locations in the informative prosody conditions, as indicated by the agreement features of the word produced by participants in place of the noise-containing word. This presentation facilitates comparison with the data from the informative prosody experiment. Fig. 4-2 also includes the data from Experiment 2a for comparison.

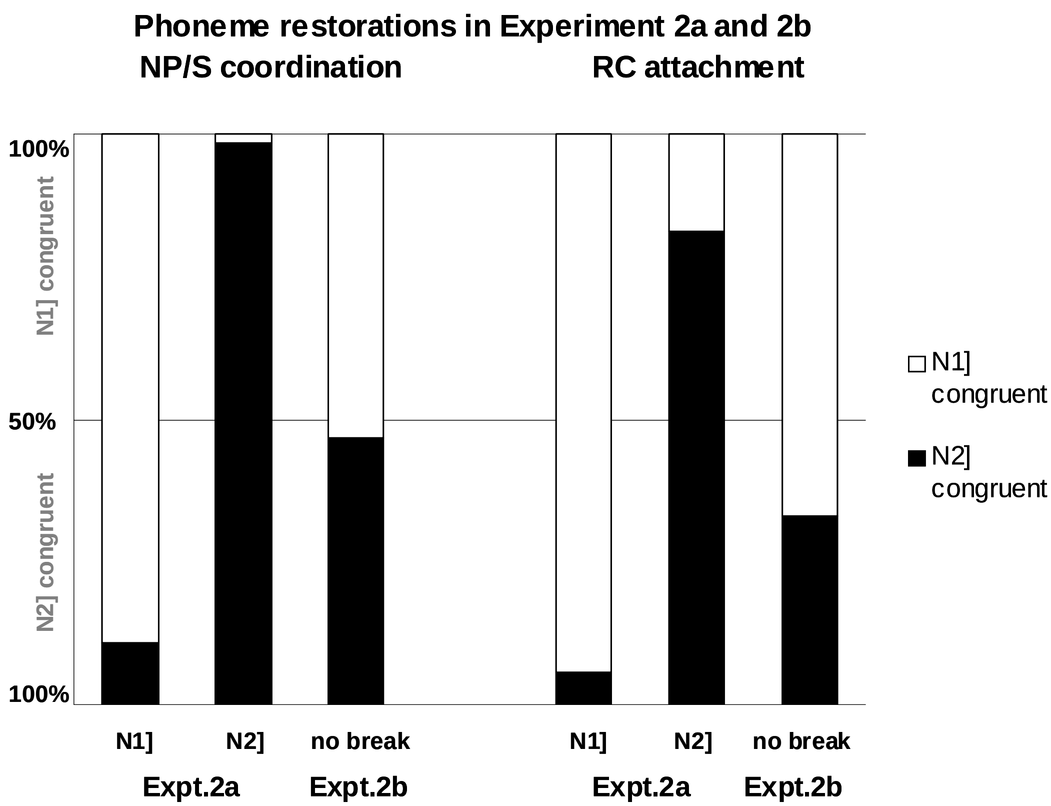



**Figure 4-2**. Phoneme restoration responses with informative and neutral prosody: sentence repetition.

It should be noted that the proportion of missing data in this task is 22%, which is notably larger than for any of the preceding experiments. As a whole, the sentence repetition task had a larger proportion of missing data compared to the visual word choice, because participants had to produce the sentence on cue and the occasional hesitation or false start resulted in premature termination of that response recording (before the critical word was uttered) due to the 7000ms pre-imposed timeout for responding resulted. However, the 22% of missing data with neutral prosody in Experiment 2b (33% NP/S coordination; 11% RC; attachment ; 21% on fillers) is a huge increase compared to the 4.4% of missing data in Experiment 2a with informative prosody. It is to be hoped that this does not distort the outcomes of Experiment 2b. On a more positive note: This may be an indirect indication of the facilitative role of natural prosodic contours in normal sentence comprehension.

With the neutral prosody, participants in Experiment 2b did not produce sentences disambiguated consistently toward one interpretation or the other as they did with the natural (informative) prosodic contours in Experiment 2a. As in the visual word choice task, responses with neutral prosody pattern in between responses with the two contrasting prosodic breaks.

Single mean t-tests show that for NP/S coordination materials the 46.1% object-coordination responses were not different from chance (assumed at 50%) ($\underline{t}_1(11) = -1.35$, $t_2\ (23) = -1.03$) but the 32.6% high RC-attachment responses were not at chance level ($\underline{t}_1(11) = -4.56$, p<.01; $t_2\ (23) = -3.96$, $p<.001$).

The NP/S coordination data pattern with neutral prosody, did not replicate between the two tasks. A preference for coordination in the second clause (i.e., N2+N3 grouped) was found in the visual word choice task, while NP/S coordination responses are at chance in the sentence repetition task. However, it should be noted that there was a much higher proportion of missing data for NP/S coordination (33%) than for RC attachment (11%) in this task. This difference is a product of an oversight in the experimental design and the fact that, as can be seen by comparison of the examples in (1) below, the critical disambiguating word comes later in the stimuli for the NP/S items (1a) than for RC attachment items (1b).

(1)

a. NP/S coordination

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nakraia | sreštnahme | Ani | i | Ivan | i | Mimi | **b**[redacted] | vav vaztorg. |
| | V | N1 | conj | N2 | conj | N3 | V | PP |
| In the end | meet-past-1p.pl | Ani | and | Ivan | and | Mimi | w** | in ecstasy |

‘In the end, we met Ani and Ivan and Mimi were/was ecstatic.’

b. RC attachment

| | | | | | | |
|---|---|---|---|---|---|---|
| Podtseniha | advokata | na | pevitsata | **k▒to** | kupi | imenieto. |
| V | N1 | | N2 | rel | V | NP |
| underestimate-past | lawyer-m | of | singer-f | who* | buy-past | estate-det |

'(They) underestimated the lawyer of the singer **who**$_{agrN1}$ bought the estate.'

As a result, the pre-imposed timeout cut-off resulted in more prematurely terminated recordings for the NP/S construction in which the critical word was among the words that were not produced. Thus any conclusions from the current data are only tentative and further experimentation with a more generous time allotted for production responses is necessary.

The preference for low attachment of the RC, on the other hand, is similar to what was found with the neutral prosody in the visual word choice task. It might be due to Late Closure. However, as was pointed out in Chapter 3 (section 3.7) this preference might be an artifact of the unnatural prosodic contour interfering with normal parsing and this problem may be exacerbated in a task that involves production. When recording the stimuli for the neutral prosody condition (see section 3.6) it was very hard to produce the baseline/neutral prosody in items with the relative pronoun agreeing with N1. So, if participants in the production task are mimicking the unnatural prosody of the stimulus, they might find it easier to produce a relative pronoun agreeing with N2, i.e. low attachment for the relative pronoun. A similar problem of producing the copula agreeing with a plural subject may have counteracted the preference found in Experiment 1c, whether it was a genuine preference or an effect of the lack of prosodic boundary in the stimuli. In the latter case, the fact that the stimulus has to be repeated may have forced participants to assign structure to the input despite the unnatural prosody in order to produce a grammatical sentence.

Taken as a whole, the data from the sentence repetition experiments point to a difference between the two target constructions with respect to how well they are disambiguated by prosody. For NP/S coordination, the two informative prosodies resulted in over 90% prosody-congruent disambiguation of the utterance by participants and the uninformative prosody data did not indicate a consistent preference. For RC attachment, both prosodic contours disambiguated, but the N1] prosodic contour prompted more prosody-congruent restorations than the N2] prosodic contour and the uninformative prosody gave rise to a low attachment preference as is normally associated with an N1] prosodic break.

The repetition task was easy to do with natural prosody, according to participants' feedback which will be discussed further in Chapter 5, though it was apparently quite challenging with neutral prosody. With some adjustments in the recording timeout, the task can be used successfully to elicit phoneme restoration data which reveal ambiguity resolution biases.

With age-appropriate (simpler) materials it could also be used to collect data from children who are too young to read well. This is an issue of interest, because on the one hand research has shown that infants use prosody to distinguish languages (Christophe and Morton, 1998) and are sensitive to prosodic patterns (Christophe et al., 2003; Mazuka, 2007) and on the other hand that children may be less able than adults to establish relations between prosody and lexical/syntactic structure (Cutler & J. A. Fodor, 1979). It has also been suggested by Trueswell, Sekerina, Hill, and Logrip (1999) that children are less able than adults to integrate non-syntactic factors of any kind (e.g. visual context) into their on-line syntactic processing. A recent study on children's interpretation of contrastive focus in Russian (Sekerina and Trueswell, 2012) underscores this. It shows that in utterances such as '*KRASnuju položite babočku v paket' (*'RED put butterfly in paper bag') with fronting of the adjective from a DP later in the sentence, 6 year old children did not utilize the very salient early prosody (the accented color adjective) to anticipate the referent, but instead waited to hear the noun. However, children as young as five have been shown to be capable of phoneme restorations (Newman, 2004). Sentence repetition with phoneme restoration could be potentially be utilized to study the developmental course of prosodic sensitivity in children. For example, in Bulgarian different types of utterances can be contrasted in a sentence pair for phoneme restoration experiment as in (2).

(2)

a. Ivo, **daj** knigata na Petar.
Ivo give-imp book to Peter
'Ivo, give the book to Peter'

b. Ivo **dal** knigata na Petar.
Ivo give-past book to Peter.
'Ivo gave the book to peter.'

The prosodic contrast in (2) is very salient because it differentiates types of utterance with different communicative intent: imperative (2a) and statement (2b)[50]. This prosodic contrast can be included in the same experiment as a same type sentence with different syntax, such as the NP/S coordination (with simplified content) and administered to children of different age groups to investigate whether children fine-tune their ability to map prosody to syntax as they mature.

Thus the sentence repetition task with phoneme restoration has the potential of expanding the population that can be studied compared to the visual word choice. The next step in expanding the phoneme restoration protocol is to try out a task that can potentially provide online data on ambiguity resolution. The experiments presented next attempted that by use of a

[50] A question-statement contrast of this type can also be created.

speech shadowing task, which is an elicited production task that can provide a very close temporal relation between spoken stimulus and spoken response.

## 4.5. Experiment 3a: Sentence Shadowing

### 4.5.1. Overview

The purpose of Experiment 3a which employed speech shadowing was to collect phoneme restoration responses that were made as close as possible to the noise-replaced stimulus, unlike the visual word choice and sentence repetition experiments reported so far in which post-sentence responses were collected. In other respects Experiment 3a resembled Experiment 2a with sentence repetition, reported above and the same materials were used. Experimental details are provided in Table 4-3 below.

**Table 4-3**. Experimental details for Experiment 3a: Sentence shadowing with informative prosody

| | number | Details |
|---|---|---|
| Participants | N=24 | ages 19-26, 58% female<br>No participants excluded from experiment on any criteria. |
| Task: sentence shadowing | | Repeat the sentence as you are listening to it, trying to follow the speaker as close as possible. |
| Target materials: | | Contrast: prosodic break location |
| NP/S coordination ambiguity | N=24 | N1] break (N=12) vs. N2] break (N=12) |
| RC attachment ambiguity | N=24 | N1] break (N=12) vs. N2] break (N=12) |
| Lists | 2 | |

### 4.5.2. Predictions

Speech shadowing is a very demanding task, so participants were expected to be less fluent in their output and to use the prosodic cues less effectively than in the other two variants of the phoneme-restoration method. With that caveat, the expectation was that prosodic information would influence syntactic ambiguity resolution for both constructions, as it did with the previous two tasks. More specifically, in place of the noise-replaced word participants would be expected to produce predominantly the word that disambiguates the sentence toward the interpretation supported by the prosodic contour of the auditory stimulus. In addition, by the nature of this task the phoneme restoration response is temporally much closer to the disambiguating prosodic boundary, so the outcomes may provide insight into how rapidly perceivers can incorporate prosodic information into their syntactic parse of the sentence. The time frame of prosodic effects in parsing has previously been investigated (e.g. Kjelgaard and Speer, 1999) in a cross-modal naming task where naming latencies on a visual probe are used as a measure of how fast the word is integrated with the auditorily presented sentence fragment. If the sentence shadowing task produces a similarly online behavioral measure of prosodic effects without the use of fragments and different modalities, it would be a valuable tool for studying prosody in parsing.

### 4.5.3. Results and discussion: phoneme restoration data

Data from Experiment 3a are shown in Figure 4-3 below, which plots percent congruent phoneme restorations. As for the visual word choice and sentence repetition experiments with informative prosody, the data is presented as percent congruent phoneme restorations. The dependent measure was the same as in Experiment 2a: which word was produced by the participant in lieu of the noise-replaced item in the stimulus, indicating which interpretation had been imposed on the input sentence.

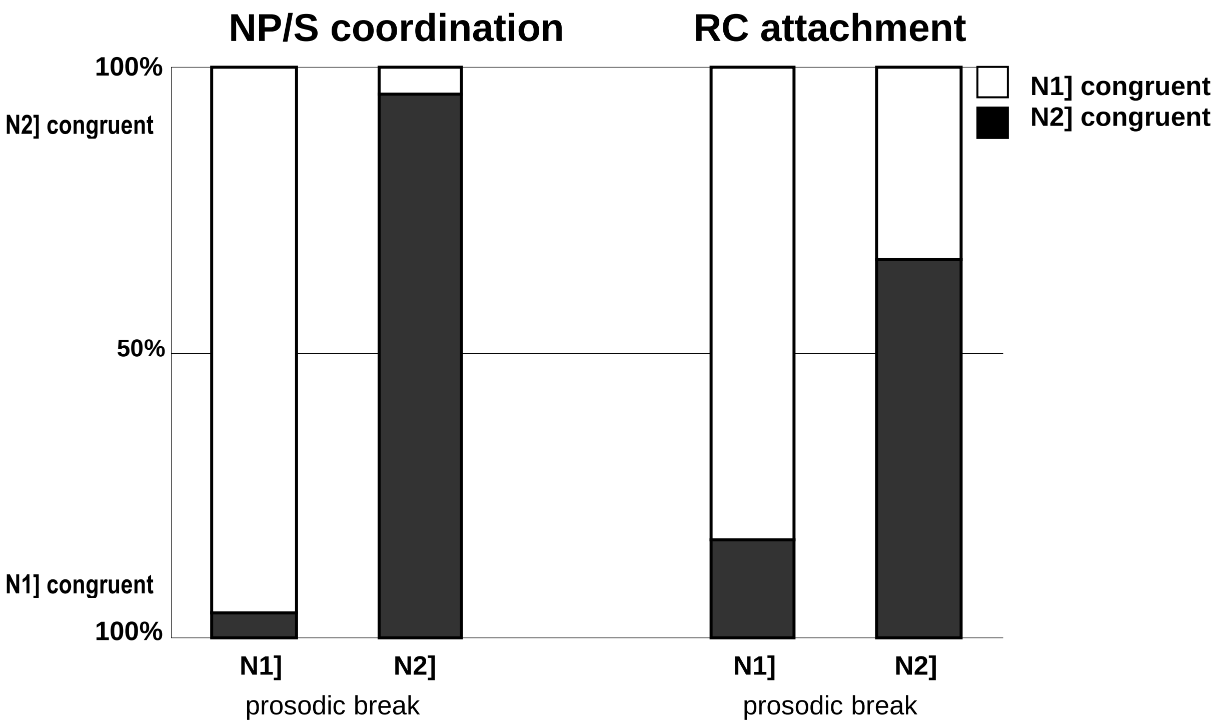



**Figure 4-3.** Phoneme restoration responses in the sentence shadowing task with informative prosody: Experiment 3a

As noted in Section 4.2.3. above, the pre-set 7000 ms response timeout resulted in some recordings being terminated before the participant had produced the critical word. In the sentence shadowing task missing data is 7.3% of the complete dataset (10.4% NP/S coordination; 3.3% RC attachment; 9.5% fillers). The loss of data was due to the same reason as in the sentence repetition task, but the proportion of prematurely cut responses is higher in the shadowing task because the time allotted for response started at the beginning of the stimulus, instead of the end.

As Figure 4-3 shows, the majority of phoneme restorations in the sentence shadowing experiment for both NP/S coordination and RC attachment were congruent with the prosody of the stimuli, with means ranging between 66% and 96%. Looking at the two ambiguities separately reveals interesting differences. For NP/S coordination the rates of congruent restorations with both prosodic contours were very high, and comparable to those in the other two tasks. Also, both prosodies were equally effective in cueing the associated syntactic structure; as in Experiment 1a and 1b, there was no asymmetry between them ($F_1$<1; $F_2$<1) as was observed in the sentence repetition Experiment 2a.

With RC attachment materials, on the other hand, congruent phoneme restoration rates, while still showing disambiguation by the prosodic break location, were dramatically lower than were observed in the visual word choice and the sentence repetition tasks. This was especially evident for the N2] prosodic break condition, where the congruent restoration rate is 66.4%. In comparison, the prosody congruent high RC attachment responses with the same prosodic contour were around 83% with the short stimuli in the other two tasks. With the N1] prosodic break the rate of prosody congruent responses also fell but the difference is smaller (82.6% compared to 89% - 94% in the other tasks). Possible reasons for this decline in prosodic facilitation for RC-attachment are discussed below. What was consistent for this ambiguity across the three tasks was (a) that both prosodic contours led to a reliable prosody-congruent syntactic bias in both constructions and (b) that the prosodic contours were not equally influential in the two constructions.

In the shadowing task, as in the prior tasks, congruent restoration rates are reliably different for the two prosodies ($F_1$ (1,22)=22.13, $p$<.001; $F_2$ (1,22)=5.21, $p$=.033) and showed the asymmetry observed in both Experiments 1 and 2, namely that N2] prosody has less impact on ambiguity resolution than N1] prosody. Though prosodic disambiguation of RC attachment by a N2] break was much lower than in the other two tasks, it did produce an effect in the sentence shadowing task as well. Participants' responses were significantly different from chance (presumed 50%) as shown by a single means t-test ($t_1$(23)= 2.27, p<.05; $t_2$ (23)= 4.49, p<.001).

Again, the prediction that listeners are sensitive to prosodic information in building one syntactic tree structure rather than another was confirmed, despite the demanding task and the time-constraints on processing that it imposes. Yet there is a striking difference between this task (Speech Shadowing) and the other two tasks (Visual Word Choice and Sentence Repetition) with regard to the RC-attachment ambiguity construction.

As noted, in the speech-shadowing task both prosodies for the RC construction resulted in rates of congruent restoration that were substantially lower than for the other tasks. This could not be ascribed to the difficulty of shadowing alone, since a comparable decrement in performance was not observed for NP/S-coordination. Two explanations are plausible and can be examined in future research. One is that RC constructions are more difficult to process, even under normal circumstances, than NP/S coordinations are, and that a more demanding task impacts difficult constructions disproportionately. Another possibility is that a variety of impinging factors – ranging from the contrast between restrictive and non-restrictive modification, to prescriptive punctuation rules in the orthography of Bulgarian – render the alignment between syntax and prosody more fragile for the RC construction than it is for coordination, making it less resistant to pressures such as the shadowing task imposes.

Also notable in the Experiment 3a data for the RC-attachment ambiguity is that the N2] prosodic phrasing was especially vulnerable, to an extent not fully accounted for by any general processing problem for relative clauses. Its rate of 66.4% congruent restorations was by far the lowest in the whole study with short version stimuli. The decrement in prosody-congruent restoration rate for RC-attachment items with N2] phrasing was approximately 150% bigger than for RC items with N1] phrasing. However, this has a natural explanation, given that speech shadowing with N2] prosody in the RC attachment construction is the only situation across all the experiments in which the participant's reconstruction of the critical word is tapped immediately following the biasing prosodic cue; see Figure 4-4, below, where the relevant portion is repeated.

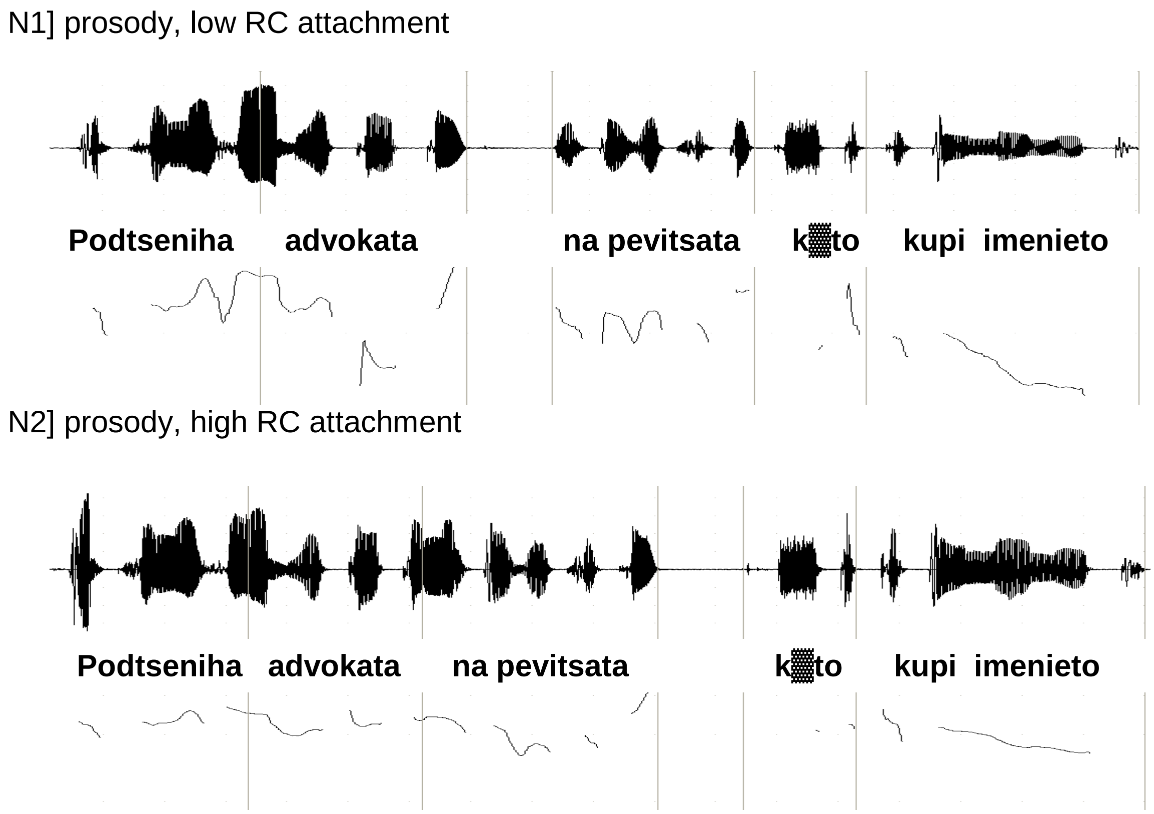



**Figure 4-4.** Location of the relevant prosodic break with respect to the noise-replaced word

In the N1] prosody condition, the prosodic break comes earlier and the intervening phrase ('of N2') between the relevant prosodic cue and the restoration site gives more time (around 600ms on average, see Table 1) for the prosodic break to be processed before the critical word has to be articulated. It can be speculated, therefore, that the particular combination of N2] prosody with the instruction to shadow closely affords too little time for prosodic processing to initiate a reliable phoneme restoration. It may be beneficial to pursue this possibility with planned comparisons in future investigations, because it may offer a way of bracketing how long it takes for the listener to integrate prosodic cues into the sentence parse – an important question raised at end of 4.5.2 predictions section.

### 4.5.4. Close vs. distant shadowing

An early speech shadowing study investigating the mechanisms of immediate speech processing (Christovich, 1960) uncovered an interesting phenomenon dubbed ‘close shadowing’. Apparently, some individuals apparently were able to repeat back the stimulus at 150-200ms delay (compared to the typical population who shadow at over 500ms to over a one second delay). The fact was exciting because, although the speed came at the price of intelligibility, close shadowers’ performance can be explored to investigate the immediate properties of the analyses processes that operate on the speech input as it is heard. Close shadowing was investigated in depth in the work of Marslen-Wilson, who considered the phenomenon a valuable resource of information with theoretical significance, as close shadowing is presumably indicative of the minimum time-window over which the process of speech analysis can operate. With those aims, Marslen-Wilson conducted preliminary studies to identify close shadowers and compare their performance with distant shadowers in order to uncover what kind of processes are implicated in close shadowing (see Marslen-Wilson, 1985 for a review).

The special status allotted to close shadowing in previous research merits the question whether there were any close shadowers in the current experiment. The utterances recorded in the shadowing task in Experiment 3a reveal that very few of the participants were able to closely shadow the stimulus and probably none can qualify as ‘close’ shadowers in the sense of Marslen-Wilson (1985). In fact, the smallest mean latency for a participant was well over 400ms, far from the 250ms observed by Marslen-Wilson in his close shadowers. The mean latency by participants in the current experiment was calculated but only at three points in each item: at the onset of the stimulus, at the onset of N1 and at the onset of N2. These points were chosen because they afforded comparable measures in both NP/S coordination and RC attachment items. In the future perhaps the production data may be analyzed in more detail.

The participants in the shadowing task fall roughly into 4 groups: comparatively close shadowers (N=4) with mean delay of 554ms; normal rate shadowers (N=7) with mean delay of 891ms (less than a second); distant shadowers (N=9) with mean delay of 1.150ms. Finally, there were very distant shadowers (N=4) with mean delay of 554ms who rather consistently adopted a strategy of waiting for the stimulus sentence to end (or at least waiting to hear the majority of it) before they started speaking, so they were essentially repeating the stimulus sentence, not shadowing it.

The observation that there were no close shadowers in this experiment is not surprising, since in order to identify the 8 close shadowers that he later used in his research, Marslen-Wilson conducted a rigorous screening study where 65 participants were trained in the task (first familiarized with the procedure, shadowing at their natural speed, afterwards asked to shadow closely). The participants in the present experiments were not pre-screened in any way, nor were they trained extensively in the shadowing task. Their training was part of the procedure at the time of the experiment and consisted of a limited number of practice items (which they could go over a few times. Nevertheless, there were some participants in the sentence shadowing task who were evidently trying their best to shadow closely.

Another reason for these longer latencies may well be attributable to a difference in the task. Participants in Experiments 3a and 3b were shadowing single sentences, rather than connected prose consisting of several sentences as in Marslen-Wilson’s studies. They had to resume shadowing anew for each sentence, which did not allow them to establish a comfortable but rapid pace and maintain it. Perhaps for that reason there was a lot of variability in individual performance. In future work this could be avoided by embedding target sentences in paragraphs.

In the end, the validity of the prosody congruent phoneme restorations data collected in Experiment 3a as a measure of prosodic effects on ambiguity resolution is not contingent on whether the participants were shadowing particularly closely. Marslen-Wilson compared 7 of the close shadowers to a control group of distant shadowers in a series of studies and reached the conclusion that there is no difference in the depth or extent of perceptual processing between close and distant shadowers. The participants in Experiment 3a were able certainly able to use prosodic information in the stimulus to assign syntactic structure to the input. For NP/S coordination in particular they restore the phonemes that coded morphological agreement for the structure supported by prosodic break location over 90% of the time. Also, despite the demanding nature of shadowing, participants do mimic the prosody of the stimulus to a certain extent, even when they are shadowing comparatively closely, as illustrated in Figure 4-5 below. The marking of a prosodic boundary at the relevant location is confirmed by the F0 rise on N1 and the following pause in this particular ptoduction token. However, the shadower is not by any means producing a normal prosodic contour: there is lengthening at a number of places, for example, which was probably used as a time to listen to the whole following phrase before producing it.

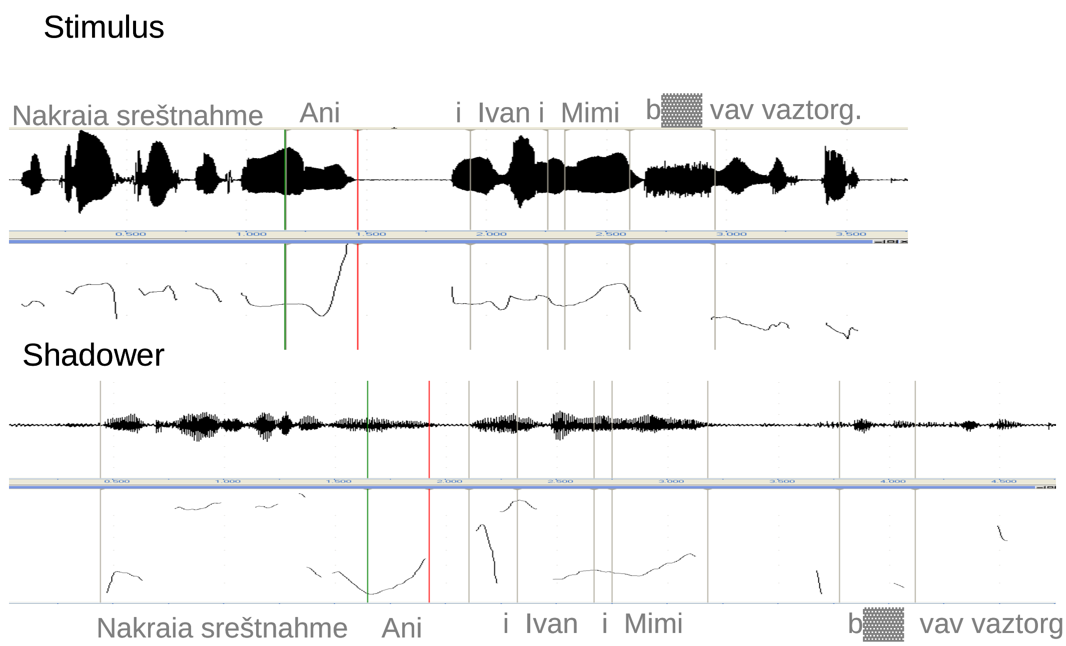



**Figure 4-5**. Sample shadowing token of comparatively close shadowing (mean delay of 550ms) of NP/S coordination item.

This is just one example of what a shadower is doing in this task. The production data that was collected has not so far been analyzed in detail, because the main purpose of this research was to determine if each task can be used as a tool in sentence processing research. The prosody congruent phoneme restorations data confirm that it is indeed a useful tool for assessing prosodic effects in parsing. The production data can be a valuable source of information in a research on prosody because it provides (or at least can provide) an online measure of prosodic effects. The shadowers in Experiment 3a (with the exception of the 4 very distant shadowers) were responding closer to the stimulus than participants in the sentence repetition task and as example in figure 4-5 shows even untrained participants are capable of shadowing relatively closely at least some of the time. (Performance was not consistent across items, possibly because of having to start shadowing anew for each sentence.) Despite the variability, the production data from Experiment 3a can when analyzed shed some light on the timeline of prosodic effects if they reveal the shortest delay range at which prosody congruent restorations occur most of the time before that stops being possible

The shadowing task proved to be a valuable tool for online investigation of the contribution of higher-level factors such as syntax and semantics in speech processing research (see Marslen-Wilson, 1985) and shadowing latencies can be equally valuable as a measure of how rapidly prosodic information can influence the syntactic parse while avoiding the cross modality integration of a lexical probe (see Kielgaard and Speer, 1999). In order to achieve that potential, however, the dataset for investigation needs to be streamlined by discounting the productions of the very distant shadowers and perhaps finding ways to elicit closer shadowing.

The subsidiary experiment reported in the next section explores how participants cope with the shadowing task in the absence of prosodic information.

## 4.6. Experiment 3b: Sentence shadowing with neutral prosody

### 4.6.1. Overview

The purpose of Experiment 3b was to investigate how the lack of prosodic boundary disambiguation would impact the closely time-locked perception and production of spoken sentences in the shadowing task. The word produced in place of the noise-replaced word in the stimulus sentence is would indicate whether spoken input is structured more or less immediately upon receiving it when it is morpho-syntactically ambiguous and there is no disambiguating prosodic information. Experimental details are provided in Table 4-4 below.

**Table 4-4**: Experimental details for Experiment 3b: Sentence shadowing with neutral prosody

| | number | Details |
|---|---|---|
| Participants | N=12 | age 19-24, 64% female<br>No participants excluded from experiment. |
| Task: sentence shadowing | | Repeat the sentence as you are listening to it, trying to follow the speaker as close as possible. |
| Target materials: | | Contrast: none |
| NP/S coordination ambiguity | N=24 | short only, neutral prosody |
| RC attachment ambiguity | N=24 | short only neutral prosody |
| Lists | 1 | |

4.6.2. Results

The data from Experiment 3b are presented in Figure 4-6a below. As with the other experiments with neutral prosody, the sentence shadowing data are coded as percent phoneme restorations indicating syntactic structure that is compatible with each of the alternative prosodic break locations in the informative prosody conditions, indicated by agreement features of the word produced by participants instead of the noise word. This facilitates comparison with the data from the informative prosody conditions in Experiment 3a. The data from both shadowing experiments is included in Figure Fig. 4-6 for convenience.

Missing data, i.e., participant response recordings terminated prematurely before the critical word was uttered because of a pre-set recording timeout made up 39.9% of the responses for the sentence shadowing with neutral prosody. The rate is extraordinarily high, even compared toi the 22% missing data in the sentence repetition task with neutral prosody (Experiment 2b) and it is several times more than the 7.3% in the sentence shadowing task with natural prosody

(Experiment 3a). This is due to a combination of two reasons. First, the pre-set timeout unfortunately did not allow much time for false starts and hesitations on the part of participants, in addition to which the allotted response time in this task was tied to the *start* of the stimulus recording, which made the cut-off earlier. Secondly, the unnaturally flat prosodic contour of the stimulus may have slowed down the shadowers in this task, resulting in an even higher proportion of prematurely terminated recordings, especially for NP/S coordination, where around 60% of the recordings were terminated prematurely, but also for the RC items which had 18% missing data. Unfortunately, it was not possible to replace so many participants, but the partial recordings provided some useful data, which is reported in Chapeter 5.

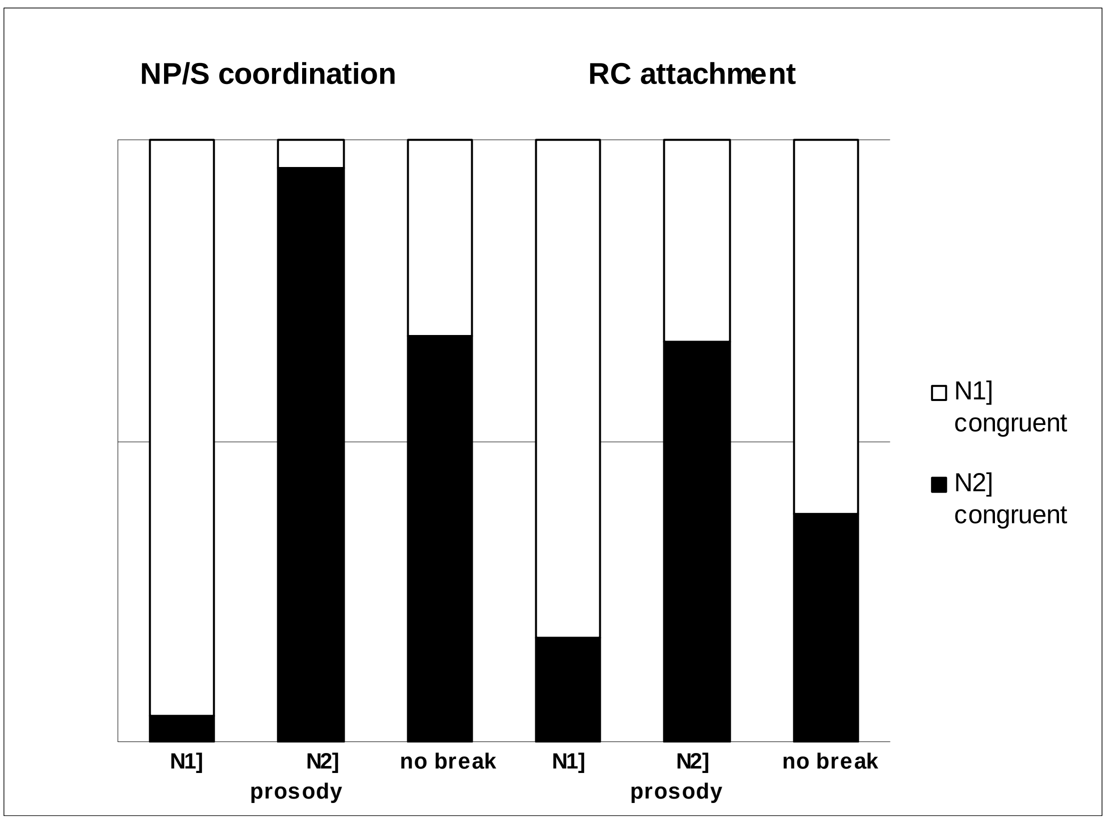



Figure 4-6. Phoneme restorations with informative and neutral prosody in sentence shadowing

As for the previous two experiments with neutral prosody reported in this research, neutral prosody responses on this task pattern in between responses with N1] and with N2] prosodic breaks.

Single mean t-tests show that for NP/S-coordination those responses which indicate a preference for NP coordination (N1+N2) in object position are significantly different from chance (presumed at 50%) by both subject and item $t_1$ (11)=2.60, p<0.05 $t_2$(23)=3.69, p<0.005 and for RC-attachment the 40% high attachemtn responses are also not different from chance $t$1(11)=-2.17, p<0.05, $t_2$(23)= -2.74, p<0.005).

The very high proportion of missing data in Experiment 3b obviously dictates caution in interpreting the results. With that caveat, there are still potentially informative details in the neutral prosody data. The data pattern in the shadowing task is different than in the sentence repetition task. In particular, the 46.1% object-coordination responses on NP/S coordination items in Experiment 2b (sentence repetition with neutral prosody) were not statistically different from chance and the 36.2 % object-coordination responses in Experiment 1c (visual word choice task with neutral prosody) showed the opposite preference.

Therefore, it is possible that there is an effect of task for NP/S coordination. Perhaps the different demands of the three behavioral tasks used pull preferences in different directions. In the visual word choice task the ‘no break’ condition may be interpreted as (N1+N2+N3) grouping of conjuncts resulting in more plural verb choices (see section 3.7.) In the shadowing task on the other hand, participants’ production has to follow closely the stimulus and participants may tend to respond very locally, producing a singular verb more often as it immediately follows a singular noun. Possibly, the grouping of constituents (which in normal speech is signaled by prosody) is essential for parsing coordination and when that essential prosodic grouping information is missing, the listener is stumped and struggles to cope with the unstructured input.

On the other hand, the 40% high attachment responses on RC attachment items in the sentence shadowing task reproduced the results with neutral prosody in the other two tasks. It is comparable to the 37.8% high attachment responses (on short items) in Experiment 1c and 32.6% in Experiment 2b. For the RC attachment ambiguity on the other hand, the data pattern was consistent across tasks. The low RC attachment preference may be accounted for as an effect of Late closure which shows up in the absence of counter-evidence, though the effect may be compounded by the unnatural flat prosody in these experiments.

## 4.7. Summary of the production experiments

Overall, participants' were able to use the relevant prosodic cues to disambiguate the utterance they heard and reproduced. With informative prosody they produced a very high proportion of prosody-congruent disambiguations. This makes the production tasks promising for future research, at least with natural sounding stimuli. The sentence repetition task makes a nice addition to experimental techniques on ambiguity resolution and prosodic effects, because it is a task that could be administered to children to observe how sensitivity to prosodic information develops with age. Of course, the materials will have to be modified, especially to limit the memory demands. But the task itself is simple and can be accomplished by children: there is evidence in the literature that children are capable of phoneme restoration as young as age 5 (Walley, 1988; Newman, 2004).

The shadowing task needs to be improved if it is to be maximally useful in future. The technical parameters need to be fine-tuned to avoid losing crucial data, as noted. But also, it is essential to elicit comparatively close shadowing in order to achieve the promise of tapping into the fine-grained time-course of prosodic effects on sentence processing. Excluding all but the most proficient shadowers might be impractical, in light of Marslen-Wilson's experience. But closer shadowing than in the present study may perhaps be achieved by adding preceding material to the stimuli, so that performance is smoother and more automated by the time the critical region is reached or training participants in advance and having them shadow all the items in a continuous fashion instead of having them stop after each sentence. In fact, having them shadow the whole set of items in a loop (perhaps not just once or in perhaps in the two different conditions) may not just help them achieve fluency in the task, but yield a different kind of data for comparison.

# CHAPTER 5
# COMPARISON OF THE THREE BEHAVIORAL TASKS WITH PHONEME RESTORATION

## 5.1. Overview

All of the experiments reported in Chapter 3 and Chapter 4 used the phoneme restoration phenomenon to assess the effect of prosody on syntactic processing, but it was implemented in different tasks that elicit different types of behavioral responses and place different demands on participants: visual word choice, sentence repetition and sentence shadowing. The results from the experiments described in the previous two chapters have been shown to be largely comparable across the tasks and compatible with findings reported in previously published research on the processing at the prosody-syntax interface for NP/S coordination and RC-attachment ambiguities. Thus, the primary purpose of the experiments was achieved, which was to test a new method and validate it for future research on spoken language processing and evaluation of the role of prosodic cues and possibly other factors such as pragmatic plausibility, construction frequency or referential complexity.

This chapter compares the three different tasks in which phoneme restoration was implemented in this research: visual word choice, sentence repetition and sentence shadowing. Their relative advantages and possible limitations are discussed (section 5.2), as well as some practicalities (5.3.1), plus some questions of interest concerning the phoneme restoration phenomenon itself, such as the illusory perception of the missing sound (5.3.2). Some of the issues discussed in this chapter were first introduced and discussed in Stoyneshka et al. (2010).

### 5.2. Comparison and evaluation of the three tasks used for eliciting phoneme restorations

The three experimental protocols that were used in Experiments 1–3 employ different ways of determining which word the listener believed was in the sentence despite its being partially 'masked' (in reality replaced) by noise. In the visual word choice task used in Experiments 1a-c, participants indicated which of the two visually presented words they thought had been in the sentence they heard. In the sentence repetition and the sentence shadowing tasks participants produced an intact word in lieu of the noise-replaced word in the stimuli when they reproduced the sentence. The difference is that the former is strictly a post-sentence task and the latter is more online. Importantly, identical target materials were used in all three experiments, so that cross-task comparisons can be drawn.

All three tasks have been used in psycholinguistic research in some variant or other. For example, the visual word choice task is a variant of a standard one-word probe recognition task such as has been used to investigate antecedent reactivation in traditional studies of pronominal anaphora in written language processing (among others, MacDonald, 1989; McElree and Bever, 1989). The single-word probe task has also been used with auditory materials very early on investigate word recognition latencies with a similar task as the visual word choice (Caplan, 1972).

The two-word probe task employed in the present experiments offers a binary forced choice. In that respect it resembles traditional questionnaire studies where two alternative answers to a comprehension question are given, or a choice between two paraphrases, as has been used with written materials by Webman Shafran (2011) and with auditory materials by Clifton, Carlson and Frazier (2006).

Sentence repetition is a perception-production task which requires participants to process the stimulus sentence and then reproduce it from memory. It is often used to assess the development of language competence in preliterate children, where it is assumed that accurate repetition indicates accurate processing above the mere lexical level (Lust, 1996), though with much simpler sentence constructions than the present ones. With the present materials the sentence repetition task may place a greater demand on working memory than the visual word choice task, because in the visual word choice task participants do not actually have to hold a complete representation of the sentence (lexical and syntactic) active in memory in order to respond[51], whereas in the sentence repetition task they do.

Sentence shadowing is a version of sentence repetition, i.e., a perception-production task which requires listeners to simultaneously reproduce the stimulus they are processing. In the experiment that used the technique, Marslen-Wilson (1975) reported that it is possible to shadow speech at latencies as small as 250ms, though few people were able to shadow so closely. Sentence shadowing is by far the most demanding of the three tasks used in this research, because it provides so little time for processing the input sentence at all linguistic levels, and precludes normal end-of-sentence wrap-up processing before producing the response.

Though it was clear that the three response tasks make very different demands on the parsing mechanism and on short-term memory, it was unclear in advance whether one or other of

[51] That does not mean that in the visual word choice tasks participants only keep the word with noise active in memory. They could do that only if they were aware of which is the word with noise in it, which is not generally the case: in the early phoneme restoration studies, participants were not able to identify the location of the noise. (see Warren, 1970). However, in order to complete the probe task participants do not need to remember word order or other syntactic details of the sentence but only the words it contains. Also, in view of the limited number of probe words used in Experiments 1a-c, participants may have formed expectations as to which word in a sentence was likely to be probed, thus reducing their memory load further (see Gordon, Hendrick and Foster, 2000).

the three tasks would be optimally effective as a gauge of ambiguity resolution preferences. It seemed possible, for example, that shadowing might be too taxing on participants and therefore not produce clear evidence of prosodic effects. Using different behavioral tasks to obtain data on the same syntactic ambiguities with the same auditory stimuli was inherent to the methodological exploration which motivated this research. Implementing the phoneme restoration method in different tasks can reveal what is stable across tasks and what is task-specific.

The fact that all three tasks, when used with naturally sounding stimuli, yielded predominantly prosody-congruent responses from participants indicates that each of them can be used as a measure of prosodic effects in ambiguity resolution. The fact that the phoneme restoration data reflected the asymmetry of prosodic effects on RC attachment interpretation in all three tasks indicates that it is also a sensitive measure of prosodic disambiguation and can perhaps be applied to other factors besides prosody. The value of each task will depend to some extent on the particular variable of interest and research goals. Practical considerations may also be relevant for some purposes. For example, visual word choice responses are collected and coded automatically by the computer and so can provide a quick glimpse at an ambiguity resolution preference, while sentence repetition and shadowing responses require human coding, at least in the present state of technology. In compensation, however, the production tasks provide rich prosodic information (see section 5.4. for a brief discussion.) which may potentially be more revealing than the merely binary visual word choice. Also, by eliminating the written word the production tasks can be used with non-literate participants including some indigenous populations whose languages have no standardly written form, and also young children (Walley, 1988) with suitably simplified materials. Of the three response tasks employed, sentence shadowing produced the least amount of congruent restorations. However, it has the potential to provide an online measure of prosodic effects, as discussed in section 4.5.4.

While the three tasks discussed above are not novel in themselves, in the current research they were used to implement a new method of gauging ambiguity resolution preferences and assessing the role of prosody in parsing. Therefore it needed to be established whether these tasks can be performed by participants without undue difficulty with the phoneme replaced materials. This issue was addressed informally along with other factors relevant to evaluating the tasks and the methodology in general in a discussion of participants's (informal) feedback in section 5.3. below. Among such considerations are naturalness and unobtrusiveness, which recommended phoneme restoration in the first place, as well as participants' (un)awareness of the ambiguity and of the role of prosody.

## 5.3. Ecological evaluation of the phoneme restoration paradigm

### 5.3.1. Participants' perspective

A short informal evaluation of the method's naturalness was included in a questionnaire that participants in all the experiments filled out at the end of the test session together with the language background questionnaire. It consisted of only three questions, given in (1) below, which participants answered as briefly or as wordily as they wanted.

(1)

A. Did you find this task hard to do? Why?

B. Did you notice anything unusual in any of the sentences?

C. What helped you understand the words when there was noise in the recording?

The answers to these open-ended questions are roughly categorized[52] and summarized in table 5-1. Some of the reasons offered by the participants are presented further below. Note that these data were clearly insufficiently systematic to be subjected to any statistical comparisons; all comments below are based on numerical comparisons only.

**Table 5-1** Participants' feedback on difficulty and naturalness of response task with phoneme replaced stimuli. Gray text is used for experiments with neutral prosody.

| | Visual word choice | | | Sentence repetition | | Sentence shadowing | |
|---|---|---|---|---|---|---|---|
| | **Expt 1a** | **Expt 1b** | **Expt 1c** | **Expt 2a** | **Expt 2b** | **Expt 3a** | **Expt 3b** |
| Number of participants | 24 | 48 | 24 | 24 | 12 | 24 | 12 |
| ***A. Did you find this task hard to do? Why?*** | | | | | | | |
| No | 80% | 82% | 58% | 71% | 58% | 58% | 42% |
| Somewhat | 12% | 12% | 21% | 12% | 17% | 13% | 33% |
| Yes | 4% | 4% | 17% | 13% | 17% | 21% | 25% |
| No answer | 4% | 2% | 4% | 4% | 8% | 8% | 8% |
| ***B. Did you notice anything unusual in any of the sentences?*** | | | | | | | |
| No | 80% | 82% | 38% | 54% | 8% | 42% | 25% |
| The noise | 8% | 8% | 8% | 21% | 8% | 17% | 17% |
| Yes | 4% | 2% | 33% | 4% | 50% | 13% | 33% |
| No answer | 8% | 6% | 21% | 21% | 33% | 28% | 25% |
| ***C. What helped you understand the words when there was noise in the recording?*** | | | | | | | |
| Heard it | 4% | 4% | 4% | 33% | - | 29% | - |
| Listened to the sentence | 17% | 21% | 17% | 8% | 4% | 8% | 8% |
| Intuitively | 12% | 8% | 4% | 13% | 4% | 13% | 8% |
| Context | 40% | 40% | 32% | 21% | 17% | 21% | 17% |
| Grammar | 6% | 6% | 8% | - | 8% | 4% | 8% |
| Guessed | - | - | 8% | 4% | 25% | 8% | 17% |
| Don't know | 6% | 6% | 6% | - | 8% | - | 8% |
| No answer | 15% | 15% | 21% | 21% | 33% | 17% | 33% |

The answers on question A (***Did you find this task hard to do?)*** indicate that participants' perception of task difficulty reflected the gradient of difficulty that was anticipated

[52] For example, answers like 'a little' or 'sometimes' are grouped into the category labeled 'somewhat' in the table.

in the experimental design: word choice is fast and not fully demanding of sentence memory; sentence repetition demands detailed storage of the sentence in memory until response time; shadowing requires memory for a shorter time but requires simultaneous perception and production and is known to be especially challenging. Note that the proportion of ‘yes’ (‘hard to do’) answers are greater for the neutral prosody experiments than for the natural prosody experiments, in keeping with other indications of this in the behavioral data reported in previous chapters.

**Table 5-2**. Some reasons offered by participants regarding their answer to question A, "Did you find this task hard to do?" The experiment number is given in parenthesis.

| | Experiment Type | |
|---|---|---|
| Participant Response | Natural Prosody | Neutral Prosody |
| NO | “It was easy.” (1a)<br>“The words could be guessed.”(1a)<br>“I was able to concentrate.” (1a)<br>“The noise in the earphones was not that strange.” (1b)<br>“I did not try too hard.” (1b)<br>“I have good hearing.” (2a)<br>“I heard almost everything.” (3a)<br>“I know Bulgarian.” (3a) | “No, but the noise is unpleasant.” (1c) |
| SOMEWHAT | “Only the names.” (2a)<br>“Only the names and long sentences.” (1b)<br>“Not much, I found my pace quickly.” (1b)<br>“I can’t speak at the same time as someone else.” | “The noise was distracting at times.” (1c)<br>“The names I had to memorize.” (2b) |
| YES | “Not sure why.” (1b)<br>“Some sentences were (too) long.” (1b)<br>“Some sentences were too noisy.” (2a)<br>“I have never done a task like this before.” (3a)<br>“Too fast.” (3a)<br>“It was hard to talk so fast.” (3a)<br>“Yes, because I had to repeat it as soon as it came.” (3a) | “Yes, some words were hard to get.” (1c)<br>“Yes, I could not understand what the speaker was saying.” (3b)<br>“I could not concentrate enough.” (3b) |

The ‘why’ portion of question A was largely ignored by participants, but the responses that were provided included the following comments, presented in Table 5-2 sorted by the type of response on the first part of the question. Note that this list of example comments combines responses to the different tasks

Question B (***Did you notice anything unusual in any of the sentences?)*** was included as a probe for possible awareness of ambiguity and a judgment of naturalness. For the natural prosody experiments, the relation of ‘yes’ answers to expected task difficulty shows a similar pattern across tasks as for question A, though fewer people in general answered ‘no’ to question B than to question A. This may indicate that they had not detected the morphosyntactic ambiguities, or the role of prosody in disambiguating them. Certainly, no participant mentioned any such thing. In fact, several people wrote things like ‘some sentences were noisy’, when in fact there was a portion of noise in every sentence they heard. These comments may indicate that participants were not aware of the ambiguity. On the other hand, the scantier response to question B might simply reflect the fact that the participants did not understand how to interpret the notion of ‘unusual’ in this context, or possibly because they thought the question essentially repeated the previous one in different words. The question was purposely vague in order not to point explicitly to the existence of ambiguity and thereby bias responses; but perhaps it is a risk that could be taken in future work.

The proportion of ‘yes’ (‘notice anything unusual’) answers to question B is notably higher in the neutral prosody experiments. Among the participants in these experiments who answered ‘yes’, several commented that ‘some sentences made no sense’, one explicitly said that some sentences were not grammatical, and one used the words ‘some were tricky’ which might (but might not) indicate that s/he was aware there was ambiguity involved. Interestingly, with the neutral prosody, the most ‘yes’ responses were given by participants in the sentence repetition tasks, who had the most time (compared with the other two tasks) to process the input before giving a response that revealed their preferred interpretation of the stimulus.

On question C ***.( What helped you understand the words when there was noise in the recording?)***, responses were even more varied and participants’ replies most often indicate as helpful things like ‘context’, ‘intuition’ and ‘listening/hearing’. Unfortunately, it is not clear what they mean when they make these qualifications. For example, ‘context’ is a vague term, which may be referring to the semantics or pragmatics (of the earlier part) of the sentence or may be used more broadly to include other properties, even detailed properties of the acoustic signal. Most probably, however, the participants were not making such fine distinctions and rather using the word in most general terms to refer to any and all aspects of the complete utterance - possibly including its prosodic contour. The ‘intuition’ answers may fall into the same category.

The answers that explicitly mentioned ‘listening’ and ‘hearing’ are classified separately in Table 5-2. The former implies that the participants felt they needed to listen carefully to hear all the words despite the obscuring noise burst. The latter implies they felt that they had heard all the words in a normal way (including the noise-replaced word). Note that this is compatible with their being unable to identify which word contained the noise.) This is a fine distinction between ‘listening’ and ‘hearing’, but if it could be followed up it might provide some insight into the phenomenological experience of listeners to phoneme-replaced stimuli.

Overall, participants’ responses in the exit questionnaire support the idea that the noise-replaced items were not particularly stressful as long as the sentences had a natural prosodic contour, and also that the tasks, except for shadowing, were quite easy to perform. However, the open-ended questions generated responses that were diverse and not easy to classify. In future work it will be advisable to use a more detailed and structured questionnaire in order to collect more systematic and quantifiable data (e.g. from ratings on a scale rather than from personal remarks) that would be more informative and afford generalizations of interest.

One question that cannot be settled on the basis of the participants' responses to these questions is how convinced they were that they had in fact heard an intact word overlaid with noise, which was a central issue in the investigations by Samuel (1981). In future work the exit questionnaire might include among other querries a question like "What proportion of the sentences do you think had some noise in them?" and a range of answers on a scale from 'just a few' to 'almost all' which will provide some insight or at least quantifiable responses.

5.3.2. Long-standing methodological query: how illusory is the missing phoneme?

It is important to note that the advantages of phoneme restoration for studying ambiguity resolution do not turn on the assumption that participants experience a true perceptual illusion, in which they are convinced that they actually heard the missing phoneme. This is an intriguing question, nonetheless, and is made more so by the strong phenomenological reports in the literature.

In Warren's presentation of his first experiment he wrote "The illusory perception of the absent phoneme was in keeping with the observation of others (graduate students and staff), who, despite knowledge of the actual stimulus, still perceived the missing phoneme as distinctly as the clearly pronounced sounds actually present" (1970, p. 392). In the first experiment investigating whether phoneme restoration can be supported by sentential context, Sherman (1971), having clearly informed the subjects in advance in one condition "that a cough did replace a single speech sound in a sentence", then asked them to judge after each item "whether or not the replaced sound was clearly missing". Subjects gave "no" responses on 57% of trials, even after their fourth hearing of the same item (pp. 12, 16, 37). In later work Samuel (1981) took a more skeptical stance, though even there he refers to phoneme restoration as "a powerful auditory illusion" (p. 474).

Samuel (1981) raised a doubt as to whether sentential contexts are as effective in creating the illusion as within-word contexts which may be more uniquely constraining, such as *legi▓latures* (from Warren, 1970) or *fu▓erals* (from Samuel, 1981). This is an interesting point which deserves to be taken seriously, but again with the caveat that the experiments reported here were not designed to investigate the phenomenological status of the restoration phenomenon. For Samuel, phoneme restoration as a genuine illusion was a more central concern than it is in  the current study on ambiguity resolution and prosody, because his aim was to test a basic model of speech perception, specifically "the hypothesis that restoration (and more generally, speech perception) depends on the bottom-up confirmation of expectations generated at higher levels" (p. 474). In pursuit of this, he applied a signal detection theoretic analysis to a discrimination task. Participants were required to judge an item as either "noise-replaced" or "noise-added" and their responses generated four types of data: noise-replaced stimuli correctly identified as noise-replaced (hits), noise-replaced stimuli incorrectly identified as noise-added (misses), noise-added stimuli incorrectly identified as noise-replaced (false alarms) and noise-added stimuli correctly identified as noise-added (correct rejection). On that basis, the d′ (d-prime) discrimination measure was calculated to represent the distance between hits and false alarms.[53] If noise-replaced items really sound to listeners as if the phoneme is present beneath the noise, then those items should be indiscriminable from noise-added items even to participants clearly alerted to the difference. (as in Samuel's study where "the nature of the stimuli was clearly explained beforehand", p. 478). At the level of single words, the d′ measure was lower for real words than for pseudo-words, that is, noise-replaced and noise-added versions were less well discriminated for real words than they were for non-words. This indicates that the contextual predictability of a particular phoneme affected perceptual processing, and was not merely a post-perceptual response bias. These findings support the intuitive claim that this technique elicits a substantial perceptual illusion.

In his Experiment 3, Samuel (1981) used stimuli like the sentences discussed in Chapter 1, section 1.4.2. repeated in (1) below where the word-level context does not uniquely constrain the restoration of phonemes. Participants heard each item in both the noise-replaced and noise-added version during the course of the test and for each item they had to indicate whether it was noise-replaced or noise-added, then as a second task identify the word. In one condition participants listened to sentence fragments only, while in another condition they heard complete sentences.

(1) a. The soldier's thoughts of the dangerous battle made him very nervous.
b. The pitcher's thoughts of the dangerous batter made him very nervous.

In contrast to single word stimuli, with sentential contexts the d′ for the noise-replaced versus noise-added versions did not significantly differ for words that were predictable in the sentence context versus words that were less predictable in that context. However, Samuel

[53] d′ "measures the distance between the signal and the noise means in standard deviation units." (Stanislaw and Todorov, 1999)

(1981) also points out that “listeners did report predictable words to be intact more than unpredictable ones; less ‘psychological intactness’ is required when a word is expected.” (p.489). A significant difference between conditions was reflected in the β (or response bias) measure[54], which reflects post-perceptual biases. The β scores were higher for contextually predictable versus non-predictable words (e.g., *batter* in the context of *pitcher* versus *batter* in the context of *soldier*), which would indicate that the sentential contexts did affect restorations but via post-perceptual guessing strategies rather than by an influence on perception. In other words, there was no real illusion at the perceptual level.

In explanation Samuel noted that in the sentential materials “the critical words were designed to be multiply restorable” and that possibly “the existence of more than one potential percept inhibited restoration, improving discriminability” (p. 491). This contrasts with the experiments with isolated words, where each target word with a masked or replaced phoneme corresponded to only one possible word in the language. If this is the right explanation for the partial failure of the illusion in the sentential materials, it could apply equally to the materials in the current experiments as well, because there were in fact two licit lexical items in the visual word choice task and potentially more in the production tasks where no specific word choices were offered. (For example, the noise-containing word in the NP/S coordination items could be restored as ‘beše’ (was) or ‘biaha’ (were) but also potentially as the shortened form of ‘beše’ (be) and other words that would result in a meaningful sentence, quite apart from other words compatible with the stimulus though not resulting in a complete and meaningful sentence.) This opens the possibility that in the experiments reported here there was no perceptual illusion. Samuel himself was inclined toward the conclusion that for the sentential contexts “the higher

[54] β is based on a likelihood ration of the likelihood of obtaining *x* on a signal trial and the likelihood of obtaining *x* on a noise trial.” (Stanislaw and Todorov, 1999)

level (syntactic-semantic) information was not being passed down to the lower phonetic-phonological level" (Samuel, 1981, p. 491).

Note that although discriminability was unimpaired by predictability for the added vs. replaced data, discriminability was low between which word was used in the noise-replaced items: the lexical item congruent with the context or its mate (the lexical item from the other sentence) which is the critical issue in the current research. In addition, the stimuli in the present experiments are not exactly parallel with the sentential stimuli used by Samuel (1981). The sentential contexts in Samuel's target items (of which the only example given in his paper is the *battle~batter* item above) were only weakly constraining and did not decisively favor one version of the word over the other (e.g., in the context of (1a), *battle* and *batter* differ in plausibility based on world knowledge but neither creates a non-sentence of the language). In the current experiments the expectation is that the restorations are constrained by the syntactic structure built in accordance with the prosodic cues in conjunction with syntactic rules of the grammar, so one of the alternative words will result in a grammatical and prosodically well-formed utterance, while the other will results in an utterance where syntax and prosody are in conflict, e.g. "In the end we met Ani || and Ivan and Mimi was ecstatic."

Thus, Samuel's conclusion that the phonological illusion is weak would not extrapolate to the experiments reported here if the prosodic contexts in these experiments are more constraining than the pragmatic (world knowledge) contexts in Samuel's. That seems very likely to be the case, although further experimentation would be needed to confirm it.

However, Samuel points out that there could be an alternative reason for the greater discriminability in the sentential contexts than in the lexical contexts in his experiments. He notes a flaw in the preparation of his acoustic stimuli, which led to "an artifactual cue for discriminating added and replaced versions in sentences” (p. 490). Samuel suggests that the likely culprit “is the influence of prosody (especially pitch contour) in sentences. The replacement version of a sentence will often introduce a break into the prosodic structure, whereas the added version seldom does” (p. 490). In view of this, it remains an open question whether or not a sentential context – affording either pragmatic/semantic disambiguation or prosodic disambiguation – can effectively limit the construal of an ambiguous word to such an extent that a speech sound is confidently ‘perceived’ in the absence of any acoustic cues from the input. This question could be pursued in a program of experimentation modeled on Samuel’s discrimination paradigm. However, the discrimination measure was not implemented in the current research, because the replaced/added discrimination task draws extreme attention to the critical lexical item which is used as a probe for ambiguity resolution. Also, in Samuel’s protocol the added/replaced discrimination task crucially precedes other tasks, so it would delay the primary response of interest in word choice or repetition, and would be incompatible with shadowing. Applying it in the current experiments would have counteracted the naturalness of the phoneme restoration phenomenon as reported in the original studies (e.g. Warren, 1970) which had recommended it for the study of spontaneous sentence-level processing.

In summary, prior experimental data provide no clear reason to *doubt* that restoration of the missing phoneme was experienced as an illusion by the participants in the present experiments, but they also do not positively support the illusion claim for sentential materials. Fortunately, though the issue is a natural topic of curiosity, it is not crucial for the validity of the present research. It is maintained here that creating a bona-fide phonological illusion is not essential in ambiguity resolution research with this method. What is essential to this methodology is that minimal attention is drawn to the syntactic/semantic ambiguity, unlike in comprehension questionnaires, and that minimal attention is drawn to the relevance of the prosody, unlike in prosodic well-formedness judgment questionnaires.

The aim is to tap processing that is as spontaneous as in normal everyday language use, avoiding unnatural self-conscious language processing and the formation of experiment-specific strategies. Those criteria were largely met in the phoneme restoration experiments with natural prosody reported in this dissertation.

**5.4. Evaluating participants' prosody in the production tasks with natural prosody.**

The sentence repetition and sentence shadowing tasks with informative prosody each elicited 576 productions of each target construction for a total of 2304 utterances, of which 2170 were coded as complete responses (the critical word was produced) and 134 were coded as missing (the critical word was not produced). The prosody of these elicited utterances can be examined. What follows is a preliminary and informal look at this considerable body of data.

Informal ear-judgment evaluation of the utterances by the investigator showed that in over 80% the produced prosody matched the prosody of the stimulus, i.e. a prosodic boundary was realized in some way in the location of the prosodic boundary in the stimulus. Two other native speakers who were asked to judges by ear a small portion of the utterances (4 token per participant) and confirmed that a prosodic boundary was perceived in most of them at N1] or N2], as appropriate. Note that the participants in these production experiments were not instructed to reproduce the prosody or told that prosody was important to attend to. Their mimicking of the contour of the sentence they heard was spontaneous.

Durational measures were taken from a subset of the collected recordings to support the ear judgments. It included recordings from all participants producing two items for each of the target constructions: one that they heard with the N1] break prosody and one that they heard with the N2] prosody. This makes a small but representative sample of the production data collected, since each participant contributed one production per prosody per construction.

Figure 5-1 and Figure 5-2 below present the mean durations per region of the analyzed target items produced by participants in the sentence repetition task.

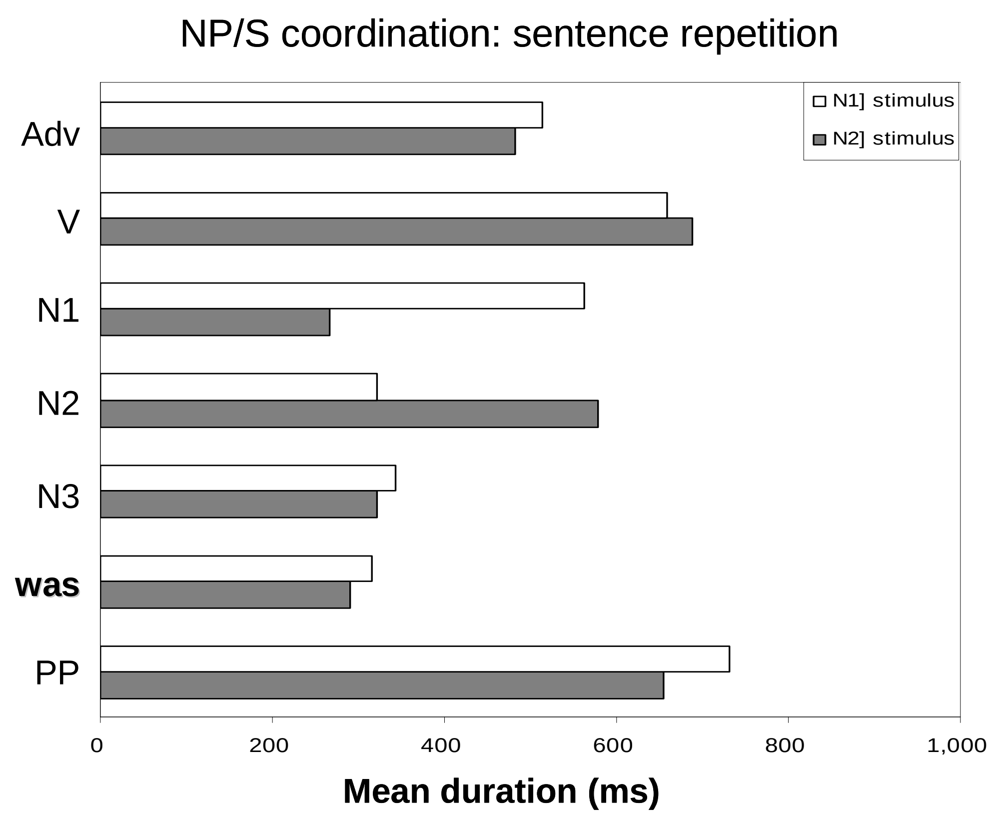



**Figure 5-1**. Mean durations of critical regions for the analyzed NP/S target items in the sentence repetition task depending on the prosody of the stimulus participants heard

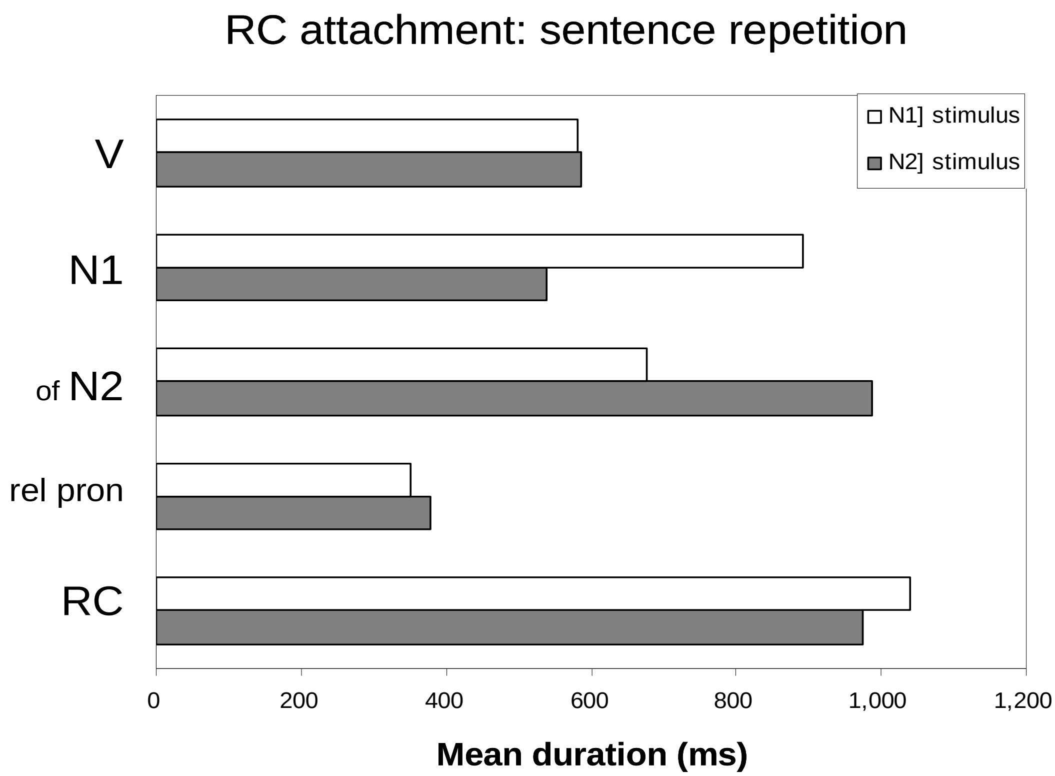



**Figure 5-2** Durations for the analyzed RC attachment target items in the sentence repetition task depending on the prosody of the stimulus participants heard

As can be seen from the graphs, for the sentence repetition task, the durations of the critical regions (N1 and N2) show evidence of a prosodic break location either at N1] or at N2], which corresponds to the prosodic break in the stimulus sentence. The durational contrast between conditions in the sentence repetition productions is very clearly defined and contained in the two critical regions (N1 and N2). Paired comparisons show that the interaction of prosodic condition and noun duration is significant for both NP/S coordination ($F(1,46) = 37.4$ $p<0.001$) and RC attachment ($F(1,46) = 41.3$, $p<0.001$).

Participants' phoneme restoration reponses (the word restored in place of the noise) indicated prosodic information in the stimulus is utilized consistently in the sentence repetition task (Chapter 4, section 4.3.3). The ear judgments and duration measurements of the participants' productions reveal that the prosodic contour was generally preserved when reproducing the sentence.

Note that this is not spontaneous production data or even speech production in a discourse setting. Participants were not trying to disambiguate and they were not instructed to say the sentence in the same way they heard it. Their task was just to repeat each sentence from beginning to end or as much as they could. Thus, the fact that they are producing clear prosodic boundaries is quite interesting. It might indicate that the prosody helped them in the task of memorizing and reproducing the sentence or that they assumed it to be an inherent part of the utterance, so they reproduced it. In fact, there are some cases when a different lexical item is produced (e.g. a different name in the NP/S coordination items with proper names), but the prosody and the interpretation are consistent, which indicates that they were using it to reproduce the message (meaning) of sentence. Thus, although the production in this task is not spontaneous, it may involve the same mechanisms as spontaneous processing.

Figure 5-3 and Figure 5-4 below present the mean durations per region of the analyzed target items produced by participants in the sentence shadowing task.

The graphs below clearly show, the durational contrasts between the two prosodic contours are different in the productions of participants in the sentence repetition task and the sentence shadowing task. There is a reliable effect of task ($F=6.27$, $p<.001$) and of region ($F=3.62$, $p<.001$) as well as an interaction of prosody and region ($F=11.004$, $p<.001$).

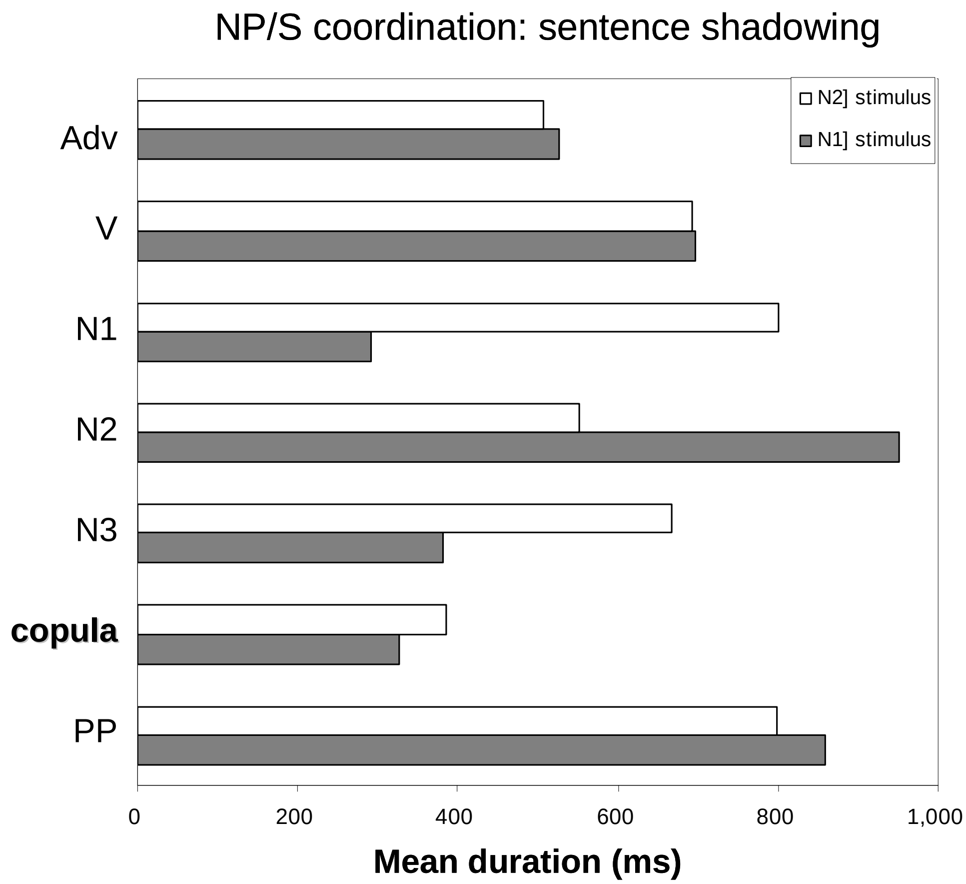



**Figure 5-3** Durations for the analyzed NP/S coordination target items in the sentence repetition task depending on the prosody of the stimulus participants heard

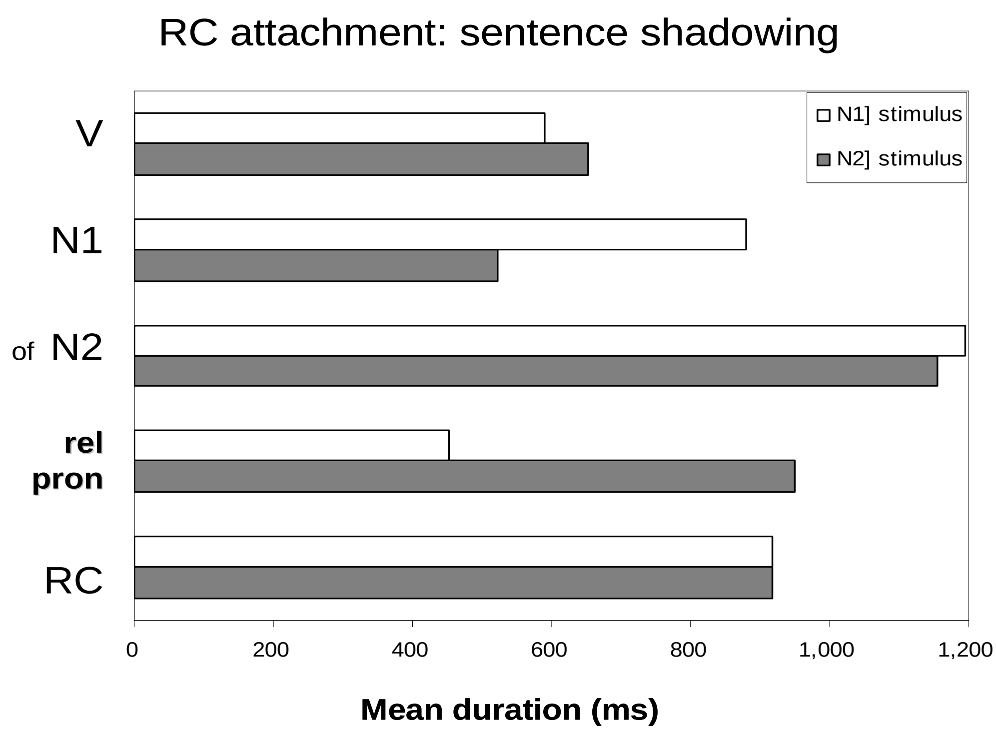



**Figure 5-4.** Durations for the analyzed RC attachment target items in the sentence repetition task depending on the prosody of the stimulus participants heard

In the shadowing task the productions of the participants with the NP/S coordination items show the expected differentiation in those two critical regions (N1 and N2) but also show a duration contrast in the region of the third noun and with the RC attachment items even the N2 region and the relative pronoun region diverge from the sentence repetition productions.

These differences in the durational patterns may reflect the specifics of the two tasks. In the sentence repetition task participants have processed the input and they produce a prosodically well-formed utterance afterwards, whereas in the sentence shadowing task they are trying to process one portion of the input sentence and reproduce a different portion of it at the same time, so their output is probably less well under control.

The duration data are perhaps not the right measure for prosodic patterns in this task, because shadowers may (perhaps unconsciously) be lengthening some words in their production in order to hear the rest of the phrase before producing it (see section 4. 5.4). Further analyses of the data are necessary to extract a more accurate pattern of their productions. Still, the shadowers are perceiving the prosody quite accurately as shown by the phoneme restoration data and the ear judgments indicate that most are marking it in some way in their productions.

In fact, there is a correspondence with the stimulus prosody in participants' production for both the sentence repetition and sentence shadowing task that strongly suggests how they are disambiguating the sentence, even in the cases where the disambiguating word was not produced. Table 5-3 below presents a quantitative description of the data in the natural prosody production experiments that was coded as missing due to prematurely terminated recording.

**Table 5-3**. Distribution of different prosody types produced in trials coded as Missing, for Experiments 2a (Sentence Repetition) and 3a (Sentence Shadowing)

| | Sentence repetition (Expt 2a) | | Sentence shadowing (Expt 3a) | |
|---|---|---|---|---|
| | NP/S coordination (N=43) | RC attachment (N=8) | NP/S coordination (N=63) | RC attachment (N=20) |
| Matching the boundary location of the stimulus | 31 (72%) | 5 (63%) | 48 (76%) | 9 (45%) |
| Boundary at both locations | 1 (2%) | 2 (25%) | 2 (3%) | 4 (20%) |
| Boundary at a different location | 1 (2%) | - | 3 (5%) | 2 (10%) |
| Terminated too early* | 6 (14%) | - | 7 (11%) | 3 (15%) |
| Missing (skipped item) | 4 (9%) | 1 (13%) | 3 (5%) | 2 (10%) |

*Participants started to say the item, but did not reach a point where a prosodic cue is realized

As can be seen from table 5-3, a sizeable portion of these productions match the prosody of the stimulus (even though incomplete), which may be taken as an indication of prosody-congruent structure. For NP/S coordination in particular this proportion is over 70%. This observation alleviates to some extent the concerns about the inordinately high rates of missing data for NP/S coordination in both task since the productions which didn’t include the phoneme replacement word do not appear to be generally anomalous.

For the RC attachment the proportion of recordings matching the prosody of the stimulus is lower (less than 50% in the shadowing task) and the rest show a tendency to place or add a boundary in a location different from the boundary in the stimulus.

While the observations reported here are of interest, they cannot fully compensate for the rather large proportion of missing phoneme replacement data in the production tasks, as noted in section 4.4.3 and section 4.5.3. In future experiments with a sufficient response-time allowance (i.e. longer time limit or participant-controlled response time), the rates of prosody-congruent restorations may hold more steady across tasks.

## 5.5. Conclusion

The comparison and evaluation of the phoneme restoration tasks on various different criteria discussed in this chapter sustain the restoration method’s viability in one form or another as a tool for assessing ambiguity resolution and the role of prosody in particular. It bears repeating that phoneme restoration stimuli resemble speech that is natural and occurs in everyday situations, where noise abounds, and also that whether or not it creates a bona-fide perceptual illusion is not essential for the method to work for psycholinguistic purposes. The three tasks used in these experiments to elicit phoneme restoration responses (visual word choice, sentence repetition and sentence shadowing) produce very largely comparable results, with some explicable differences, and they can be applied (individually or in combination) to investigate ambiguity resolution with spoken stimuli. The next chapter presents additional experiments that implement a similar masking procedure in a different perceptual modality: silent reading.

# CHAPTER 6

# EXPERIMENTS WITH WRITTEN STIMULI: VISUAL GROUPING AND AMBIGUITY RESOLUTION IN READING

## 6.1. Adapting the restoration method to reading.

### 6.1.1. Prosodic effects and visual prosody in silent reading

There are impressive early auditory studies, some of which were discussed in Chapter 1 (e.g. Lehiste, 1973; Marslen-Wilson et al, 1992), but experiments with auditory stimuli were not the norm in psycholinguistic research. Silent reading experiments have been used for decades as the primary tool for studying ambiguity resolution. In the early days of ambiguity resolution studies, researchers had little other recourse since the technology for creating auditory stimuli and conducting audio experiments was clumsy and not widely accessible. But although it is true that the ‘tradition’ of using written stimuli was largely a matter of practicality, reading studies are of interest in their own right and retain an important role in psycholinguistic research today.

Written stimuli were originally used in self-paced reading studies (e.g., Frazier, 1978, among many others) with post-sentence tasks such a comprehension question or grammaticality judgment. Subsequently they were increasingly used in combination with eye movement recording (e.g., Frazier & Rayner, 1982) and in ERP studies (e.g., Friederici et al., 1996). For example, Frazier & Rayner (1982) recorded eye-movements to investigate the processing of temporary structural ambiguities in reading and Trueswell et al. (1994) used eye-movement measures in an investigation of semantic constraints on interpretation of reduced relatives. ERP studies have identified components associated with syntactic and semantic violations and have shown that they are elicited in a similar fashion by identical spoken and written stimuli (Hagoort and Brown, 2000). The appeal of using eye monitoring and ERP technology is that the researcher is able to explore very closely the time-course of ambiguity resolution and the role of different factors. Traditional written questionnaire studies, however, are also still widely used for obtaining data on post-sentence ambiguity resolution preferences. Lately, researchers are utilizing the web-based platforms such as Amazon's Mechanical Turk to conduct research with written materials, obtaining responses such as acceptability judgments (e.g., Gibson, Piantadosi and Fedorenko 2011).

Following the proposal of the Implicit Prosody Hypothesis (Fodor, 1998), researchers have investigated possible prosodic effects in silent reading in a number of languages, initially with a focus on the 'problematic' cross-linguistic differences in RC attachment in and how it relates to prosodic properties of the construction. Data on a number of languages (see Chapter 2) shows that RC attachment preferences in silent reading are susceptible to RC length variation in a similar way across languages but can be modified in different ways by phrasing characteristics that are specific for a given language such a prosodic break before the preposition in Croatian (Lovrić, 2003). In her dissertation, Augurzky (2006) systematically investigated different factors and managed to tease out implicit prosody effects and show that they occur late in the parse. Other constructions have been shown to be sensitive to prosody as well. For example, Kitagawa and Fodor (2003) demonstrate that in some cases (e.g., the 'not-because' ambiguity in English) accurate grammaticality judgments cannot be obtained on written stimuli without supplying prosodic contours. Prosody has thus been shown to play a role in silent reading and produce tangible effects.

In related work, it has been shown that sentence processing difficulties in reading can be modified and neutralized by the visual presentation of the text. Research has been done for example on how different types of visual presentation affect readers' processing speed and comprehension, and even their ability to focus on the text. For example, Bever et al. (1990) investigated the effects of visual grouping of text. They experimented with varying between-word space sizes in different ways to check how the visual spacing modulates text readability. They found that a computer-implemented heuristic analysis that assigned extra spaces between major syntactic phrases was more effective than spacing which reflected the depth of the phrase structure analysis, or extra spaces assigned in proportion to between-word pauses in speech. The authors speculate that the facilitative effect of such spacing between major phrases comes from its resemblance to the way "good readers guide their eye movements by a similarly crude initial parse of texts" (p. 74).

A different type of presentation manipulation that involves segmentation rather than spacing has been investigated for effects on ambiguity resolution. The RC attachment ambiguity, which is one of the target constructions in the current experiments, was the focus of investigation in one study on segmentation effects. Gilboy & Sopena (1996) found that RC-ambiguity resolution was affected by whether the sentence was broken into large segments vs. smaller segments. In particular, presenting the sentence in larger segments with the two nouns together (e.g. *El perro mordió al cuñado de la maestra / que vivió en Chile con su esposo.*) yielded high attachment for Spanish, while presenting it into smaller segments (e.g. *El perro mordió /al cuñado /de la maestra / que vivió en Chile / con su esposo.*) did not produce a preference. Gilboy and Sopena (1996) offer a prosodic explanation for their findings, on the assumption that the readers were using segmentation of the text to create a prosodic contour. Spanish has a fixed phrasal accent placement that will apply in the large segmentation version and will produce a boundary at N2, which is relevant for RC attachment, whereas small segmentation does not provide a prosodic cue relevant to ambiguity resolution and RC attachment is determined on plausibility grounds instead.

More recent studies have been specifically designed to look for prosodic phrasing effects in reading, in relation to the Implicit Prosody Hypothesis (IPH; Fodor, 1999). For example, Fernández (2007) conducted a series of experiments using several types of visual presentation. She found that a fixed-rate Rapid Serial Visual Presentation (RSVP) diminished the RC-length effects found with whole sentence reading, but variable-rate RSVP restored them. She also reports that inserting a visual pause (blank screen) after one of the nouns in a variable rate RSVP experiment boosted the same RC interpretation as a similarly located break in auditory materials, but a longer display time designed to mimic accentuation had no effect. Maia et al. (2007) used visual segmentation that matched prosodic boundaries in speech and found parallel effects on RC-attachment ambiguity resolution. Koizumi (2009) conducted an investigation on the processing of the ambiguity of negation scope in the *not-because* construction in English (e.g., The owls aren’t increasing because they are under federal protection.) in two self-paced reading experiments. In her Experiment 2 she used a two-line display of the sentences to encourage a prosodic break in silent reading and found that a line-break before ‘because’ favored the reading with ‘because’ taking scope over ‘not’, compared with when the sentences were displayed on a single line.

The data from such experiments that implement ‘visual prosody’ through segmentation or presentation rate show that the visual presentation can create prosodic-like effects or modify them in ways similar to prosodic manipulations in auditory stimuli. The next section proposes that visual presentation of written stimuli can be combined with masking as a parallel to the phoneme restoration experiments in silent reading.

### 6.1.2. Motivation for the grapheme restoration experiment

Based upon previous findings noted above that visual display for silently read materials can imitate prosodic phrasing, a grapheme-restoration paradigm was developed as a counterpart of the phoneme restoration paradigm to be applied with written materials. Because the stimuli were presented visually instead of auditorily, a simulated 'ink blot' was used to replace morphological disambiguation in the original sentences, similarly to the noise-replacement in the auditory stimuli. The contrast of prosodic boundary placement in the auditory stimuli was mimicked by contrasting patterns of visual grouping, as a means to confirm prior findings that a specific prosodic contour can be induced in silent reading and in particular to establish whether it would affect ambiguity resolution of the two structural ambiguities of interest (NP/clausal coordination and relative clause attachment) in a way similar to the overt prosody in the auditory experiments. While visual grouping has empirical precedents in psycholinguistic research (see above), it has not previously been paired with visual masking as in the grapheme restoration experiments reported here.

Two response tasks were used to obtain ambiguity resolution responses: a binary visual word choice and a reading aloud task. The first task, employed in Experiments 4a-b, was essentially the same as was used in Experiments 1a-c with auditory stimuli. As in those experiments, the aim was to dispense with a post-sentence comprehension question because it delays response and might introduce unwanted biases. It was anticipated that the visual grouping would bias ambiguity resolution preferences (as revealed in the word choice responses) in a similar fashion as the prosodic break location in word choice task with auditory materials, but that it might induce smaller effects than overt prosody. The second task, employed in Experiments 5a-b, was similar to the sentence repetition task used with auditory stimuli in

Experiments 2a-b. The aim was to investigate whether the two contrasting visual grouping conditions would create similar effects in a production task as the prosodic breaks in Experiment 2a. As it uses the same target sentences as Experiment 2 (section 4.2) and a very similar task, the attachment preferences obtained with the two modalities can be directly compared. Both of the visual-presentation experiments reported in this chapter contrast the same two grouping patterns as were studied in the corresponding auditory experiments, Experiments 1a and 2a: N1 separated by a boundary from the following N2 vs. N2 separated by a boundary from the following material (conjunction + N3; or RC). In addition there was a third presentation condition without any grouping of constituents, which was intended to parallel the neutral prosody.

The fact that the sentence materials and response tasks are parallel across the modalities permits close comparison between the role of prosodic grouping in the auditory experiment and visual grouping in the silent reading experiment. A prior study on Bulgarian (Sekerina et al., 2003) compared RC attachment preferences in the two modalities, but the stimuli in the experiments were abstract shapes in various spatial and part-whole relations. Similar results were obtained with auditory and written sentences materials, but the preference was opposite to the preference found with semantically rich ‘real-world’ sentences in a standard reading questionnaire. See discussion of these results in Chapter 2 (section 2.3.5). It is hoped that the present experiments using more typical RC attachment sentences will provide some further clarification.

## 6.2. **Visual Stimuli**

### 6.2.1. Materials description

The materials used in the reading experiments were exactly the same as the ones used in the experiments with auditory stimuli described in detail in chapter 3. The constituent length contrast discussed for Experiment 1b and Experiment 1c was also included in this experiment. The templates for the NP-coordination ambiguity items and the RC-attachment ambiguity items are repeated in (2a) and (2b) respectively:

(2)

a. NP/S coordination: (Adverbial) (NP) Verb NP1 $i_{conj}$ NP2 $i_{conj}$ NP3 **COPULA** PP

b. RC attachment: Verb NP1 Prep NP2 [$_{RC}$ **REL PRON** VP]

Examples of the temporarily ambiguous sentence pairs that were created from these templates and used as target materials can be found in Chapter 3 (section 3.1). The word in bold capitals in each template in (2) is the word that differentiates the two sentences in a pair due to morphological markings (number on the copula verb; gender on the relative pronoun) and it is the word that is partially obliterated by a blot in the visual stimuli to create a fully ambiguous word for restoration. The filler sentences were also identical to those used in the auditory experiments (see Chapter 3, section 3.1.3).

The target materials had already been pre-assessed for plausibility before preparing the auditory experiments, as explained in Chapter 3 (section 3.1.2). In addition, the written materials were first piloted in a paper and pencil ‘fill-in-the-blanks’ reading task in which participants were given the sentences printed in Cyrillic script with blank spaces in several places throughout the sentence, including the critical parts of the disambiguating word, as shown in (3) below[55]. Their task was to fill in the missing letters[56].

(3)

(a) NP/S coordination example with blanks:

**Накр_я срещн_ _ме Ани и Иван и Мими б_ _ _ в_в възт_рг.**

*_n the end we m_t Ani and Ivan and Mimi w__ ecstatic.*

(b) RC attachment example with blanks:

**П_ _цениха адвок_т_ на певиц_та, ко_то купи им_ниет_ .**

*They underestimat_d the l_wyer of the sing_r who bough_ the estate.*

In this fill-in-the-blanks task, participants showed a 2+1 grouping preference for the NP/S-coordination items (i.e. the first two nouns interpreted as a coordinated object and the third one as subject of the second clause) as was expected on the basis of the study in Dutch (Hoeks et al., 2002); see discussion in Chapter 2 (section 2.2.1) above. For the RC materials no reliable preference was found (47% high attachment). The fill in the blanks task required readers to stop and fill in the letters: this probably disrupted fluent reading of the sentence and may have influenced the results. On this consideration, the current format of the grapheme restoration task was used, which gives with greater flexibility in the presentation.

6.2.2. Visual masking

[55] This pre-test was reported at 20th Annual CUNY Conference on Human Sentence Processing, UCSD, San Diego, CA (2007)

[56] In all but the critical words the missing letters were uniquely identifiable. In the critical words participants had to supply the morphological agreement that disambiguated syntactic structure.

To create the stimuli for the reading experiments, the disambiguating portion of the critical word was removed from the sentence. The grapheme or graphemes encoding morphological agreement markings were removed from the target items, as was done for the fill in the blanks task. For example, the two letters in the middle of the relative pronoun was removed, so that its masculine form 'ко**й**то' and its feminine form 'ко**я**то' become identical 'к__то'. In place of the removed letter(s) an 'ink-blot' was inserted, which was intended as a visual parallel of the white noise. (The same shape and size blot was used for the four different versions of each target item, although the blots differed between items.) As a result, the two sentences in each pair (short or long version of an item) became identical visually, as illustrated with the sentence examples in (4) shown in Cyrillic script which is standardly used in written Bulgarian.

(4)

a. NP/S coordination example with ink blot:

Накрая срещнахме Ани и Иван и Мими б█ във възторг.

**Adv V N1 N2 N3 V PP**

*In the end we met Ani and Ivan and Mimi w█ ecstatic.*

b. RC attachment example with ink blot:

Подцениха адвоката на певицата, к█то купи имението.

**V N1 of N2 rel pron V N**

*They underestimated the lawyer(m) of the singer(f) who bought the estate.*

It should be noted that, unlike phoneme-replacement, the visual masking procedure is not unobtrusive. The white noise that was used in the auditory stimuli is similar in acoustic characteristics to the recorded utterance and is not perceived as replacing or even masking a speech sound, but rather as a background noise that co-occurs with the speech signal. By contrast, the ink blot in the visually presented stimuli is certainly not inconspicuous and clearly masks part of a word (There can be no doubt as to its location, unlike with noise-replacement.) Another difference between the noise and the blot is that while the actual blot looks fairly natural and a smudge like that is possible in written materials, it is not a common occurrence, unlike background noise, especially nowadays when writing with pen and ink is growing less common. In short, we cannot expect the blot manipulation to create an illusion of an uninterrupted signal as a basis for restoration. But one aspect of the ink blot masking is similar to the noise-replacement: the temporarily ambiguous sentences in a pair become globally ambiguous, because the replacement procedure turns them into identical strings.

When presented on a single line[57], as in (4) above, the visual stimulus is actually globally ambiguous, because it contains no other cues to disambiguation, unlike the auditory stimuli where a relevant prosodic break remains in the stimulus. These versions of the target sentences were used as the counterpart of the neutral prosody in the auditory experiments or rather as a baseline condition in the silent reading experiments, because unlike the neutral prosody without which sounded unnatural and hard to follow, the written versions were perfectly readable (except for the inkblot). Note that in Bulgarian there is an obligatory comma in writing before the

[57] Not all items were presented on a single line, because of length, see section 6.2.3.

relative clause, which reflects the typical phrasing of RC. It could not be omitted in written materials.

As the written sentences were only disambiguated by morphological agreement and did not originally contain grouping cues, a different presentation of the visual stimuli was used to mimic the prosodic contours in the auditory experiments and is described in the following section.

To sum up, the properties of the stimuli could not be identical in the two modalities (auditory and written), although they were created from the same materials. However, the tasks used with written stimuli were essentially the same as the tasks with the auditory stimuli and stimuli and the presentation conditions were as parallel as possible.

6.2.3. Visual presentation: single-screen and two-screen

As a way to simulate the relevant prosodic breaks in the reading experiments the now ambiguous written sentences (with blot) were presented on two consecutive screens, creating a visual 'break' at one of two positions: after N1 (coinciding with the N1] prosodic boundary in the auditory stimuli) or after N2 (coinciding with the N2] prosodic boundary in the auditory stimuli). Thus the visual presentation now contains a possibly useful cue to the intended structure, though there is no obligation for the reader to treat it as such. Because line breaks in printed prose are typically arbitrary with regard to syntactic constituency (i.e. there are no alignment constraints in normal written text), they must frequently be ignored by readers in syntactic parsing of the text. To boost the perceived 'break' in the visual stimuli, the first portion of the sentence was kept on the screen slightly longer than the second one, relative to the number of words in each. The length of time for each display was 50ms per word on the screen (which is within normal reading range) plus 150 ms blank after the first screen (which is shorter than the duration of silent pause in the auditory materials). Importantly, the blot-word always appeared on the second screen, after the visual break, much like the noise-containing word in the auditory stimuli which always followed the relevant prosodic boundary. The displayed portion of the sentence was centered on the screen and it filled a longer line across the screen for the long version of an item than for the short version.

In addition, a single-screen presentation was used as a control condition in a separate list, with different participants, as a baseline to be compared with the neutral prosody condition with the auditory stimuli though the two are not fully parallel, as noted above. Due to the specifics of Bulgarian morphology and the particular lexical items used,[58] some of the complete sentences in the long version were too long to be presented on a single line on a computer screen in a font that could be read comfortably by participants. Therefore, single-screen presentation in the visual word task was not in fact always single-line presentation for some target items. However, care was taken that the relevant portion of the sentence always be kept together: in the NP/S Coordination items that could not fit on a single line, the three nouns and the copula verb partially obscured by the ink-blot were always on the same line, and in the two RC-attachment ambiguity items that did not fit on a single line the two nouns and the relative pronoun were kept on the same line. The line break came after the ambiguous portion of the item and looked like a regular line break in typed materials that occurs at a random point because the right-hand margin of the page had been reached. Similar looking breaks were present in some of the adverbial clause fillers that were too long to fit on a single line.

[58] The definite article, for example, is a morpheme that is suffixed to the nouns, which are quite long in their bare form and in the 'long' versions it is also repeated on the adjectives.

The single-screen presentation was illustrated in (4) above. The two-screen presentation is illustrated in (5) and (6) below where the rectangles demarcate the material that appeared on each screen (but not necessarily how it was positioned on the screen).

(5)

a. NP/S-coordination: two-screen presentation with sentence split after N1

| | |
|---|---|
| Накрая срещнахме Ани | и Иван и Мими б[redacted]във възторг. |
| Adv V N1 | N2 N3 V PP |

b. NP/S-coordination: two-screen presentation with sentence split after N2

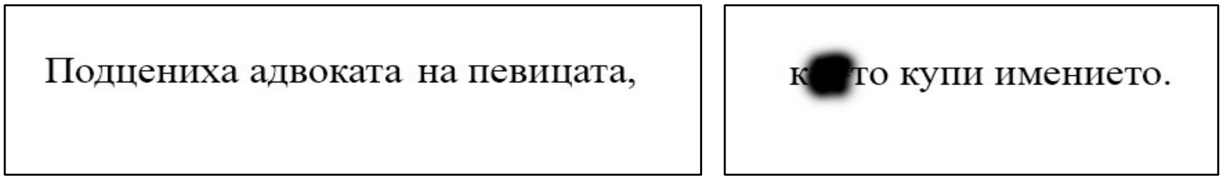
| | |
|---|---|
| Накрая срещнахме Ани и Иван | и Мими б[redacted]във възторг. |
| Adv V N1 N2 | N3 V PP |

(6)

a. RC-attachment: two-screen presentation with sentence split after N1

| | |
|---|---|
| Подцениха адвоката | на певицата, к[redacted]то купи имението. |
| [ V N1 ] | [ of N2 rel pron V N ] |

b. RC-attachment: two-screen presentation with sentence split after N2




**[ V N1 of N2 ] [ rel pron V N ]**

For consistency, the reflexive-possessive fillers also had contrasting two-screen visual presentations when the target items were presented on two screens, although those filler items were not ambiguous, and had a one-screen presentation when the target items were presented on one screen. The sentence was split after the verb or after the noun (the point of each prosodic break in the auditory stimuli) and the location was crossed with the punctuation contrast. The other unambiguous fillers were presented on a single screen or split between two screens, depending on sentence length, but their presentation was constant across all the experiments.

The visually masked stimuli in the three presentation conditions were used in their long and short versions in the silent reading visual word choice task, but only the short version was used in the reading with repetition production task. The two-screen presentations were contrasted in the same lists, while the one-screen presentation was in separate list(s) like the neutral prosody.

**6.3. Experiment 4: 'Ink blot' silent reading experiments with visual word choice**

6.3.1. Overview

This is the silent reading equivalent of Experiment 1b and Experiment 1c, using the same set of materials in written form and the same visual word choice task. Participants would read a stimulus sentence in one of the experimental conditions, then see two words on the screen, and their task was to indicate which of these two words was in the sentence they had just read.

Ostensibly, the task was merely to decide which of two words corresponded to the ink blot-word in the preceding sentence, but each of the two word-choices actually made a congruent sentence in Bulgarian. Thus what the choice indicated was how readers were resolving the syntactic ambiguity in the stimulus sentence. The different experimental conditions were designed to probe the effects of presence and location of visual breaks and of constituent length. They are summarized in table 6-1 below:

**Table 6-1**: Experimental details for Experiment 4: Visual word choice

| | Experiment 4a | Experiment 4b |
|---|---|---|
| Target materials | | |
| NP/S coordination ambiguity | N=24 (12 short/12 long) | N=24 (12 short/12 long) |
| RC attachment ambiguity | N=24 (12 short/12 long) | N=24 (12 short/12 long) |
| Presentation | two-screen | one-screen |
| Contrast: | Visual grouping<br>–split at N1<br>–split at N1<br><br>Constituent length | –<br><br><br><br>Constituent length |
| Lists | 4 | 2 |

The two-screen presentation was designed as a silent reading parallel of the informative prosody in the experiments with auditory materials and the one-screen presentation as a parallel of the uninformative prosody. They were administered to different groups of participants and treated as separate, related experiments: two-screen presentation Experiment 4a (Lists 1-4) and one-screen presentation Experiment 4b. This was done to facilitate direct comparison with the respective auditory experiments.

### 6.3.2. Method

*Materials*

The target items were the 24 NP coordination items and 24 RC attachment items described above. Each of them had a short and long version. The long or short version of each target sentence appeared in one of the two different two-screen presentations (Experiment 4a) and also in the one-screen presentation (Experiment 4b). Each participant only saw one version of each item. The targets were counterbalanced across lists for item length and in the two-screen lists also for visual presentation. They were interspersed among the 36 filler items which were identical to the Experiment 1 filler items and included 12 sentences with the reflexive/possessive (see Chapter 7), 12 with unambiguous NP/S coordination or RC attachment and 12 with unambiguous adverbial clause. The unambiguous fillers were used for screening out inattentive participants, and also to encourage participants to assume that there would be just one possible grammatically correct interpretation of a sentence. The reflexive-possessive fillers had two-sentence and one-sentence versions, crossed with where the sentence was split in the two-screen presentation (Experiment 4a) and counter-balanced in the one-screen presentation (Experiment 4b). The rest of the fillers were presented in the same way in all versions of the silent reading experiment with visual word choice. Each list was preceded by two overt practice items with feedback, and two additional ‘warm-up’ items at the beginning of the testing session. The types of target and filler items are summarized in table 6-2 below.

**Table 6-2.** Items in each list by construction type.

| **Construction type** | **example** | **N items** | **Word choices** |
|---|---|---|---|
| NP/S coordination ambiguity | | 24 | beše / biaha |
| RC attachment ambiguity | | 24 | kojto / koiato |
| Se/si ambiguity | | 12 | se / si |
| Unambiguous NP-coordination | | 6 (3 sg verb, 3 pl verb) | beše / biaha |
| Unambiguous RC-attachment | | 6 (3 fem N, 3 masc N) | kojto / koiato |
| **Unambiguous adverbial phrase** | | 12 (6 manner / 6 place) | kakto / kadeto |

*Participants*

Altogether 72 native speakers of Bulgarian (56 % female) participated successfully in the silent reading with visual word choice experiments: 48 in the two-screen (Experiment 4a) and 24 in the one-screen (Experiment 4b). They came from the same population (undergraduate students at the University of Economics in Varna and Varna Free University) as the participants in the auditory-stimuli experiments, but had not participated in them.

*Procedure*

The experiment was conducted individually with each participant in a quiet room. A computer running DMDX (Forster & Forster, 2003) was used to present the visual stimuli in a different pseudo-random order for each participant and to collect participant responses.

Participants pressed the space bar on the keyboard to trigger the visual presentation of an item. Each sentence (target or filler) contained a word partially obscured by a simulated ‘ink-blot’. After the stimulus sentence, participants saw two words located on a single line in the middle of the screen (at the two opposite ends of the line, with clear space between). Their task was to select the word which had been 'smudged' in the sentence they had just read. Participants indicated their choice by pressing one of two marked keys (the shift keys on the keyboard) located on the side corresponding to the word they chose. They had been instructed to answer as quickly as possible and to guess if not sure. There was a fixed timeout of 9000 ms for responding to the visual word choice.

The two word-choices presented with each target item were the two morphological cognates that disambiguated the sentence to a particular interpretation and the disambiguating portions of which had been obliterated from the visual stimuli and replaced with the 'ink blot'. For the NP/S coordination ambiguity the two words were always the number-marked forms of the copula verb: *biaha* ('were') and *beše* ('was'); for the RC attachment ambiguity they were always the gender-marked forms of the relative pronoun *koiato* (fem) and *kojto* (masc). For the filler sentences the two word choices were the contextually appropriate word was paired with the other word used in the same subtype of fillers (Table 6.2.).

The experiment was self-paced in the sense that participants prompted the next stimulus when they were ready, but the visual presentation of each sentence had preset timing constraints that were controlled by the program, as indicated above.

### 6.3.3 Predictions

As noted in previous section, the two-screen presentation (Experiment 4a) was designed to mimic the prosodic breaks in auditory stimuli therefore the two contrasting visual presentations of the stimuli were expected to provide a cue to the intended structure by invoking a 'break' which groups certain words together on one screen, while separating others onto separate screens. When the reader encounters the simulated visual break with the screen change, s/he would perhaps project a prosodic boundary in that location and consequently build an interpretation of the ambiguous syntactic structure congruent with it. If that is the case, upon encountering the blot-word on the next screen s/he would most naturally project a complete word that would fit lexically and morphologically into the already projected syntactic structure.

Thus, for the NP-coordination ambiguity, participants are expected to interpret the blot-word as a plural copula verb when the sentence is split by a simulated visual break after N1 and as a singular copula verb when the sentence is split after N2. For the RC-attachment ambiguity, participants are expected to interpret the blot-word as a relative pronoun that has the same gender as N2 when the sentence is split by a simulated visual break after N1 and a relative pronoun that has the same gender as N1 when the sentence is split after N2. The obligatory comma may independently promote a break before the RC (i.e. after N2) and support the latter interpretation.

### 6.3.4. Results

Data for Experiment 4a (Visual word choice with silent reading in two-screen presentation) are presented below separately for the two constructions to make reporting easier. The dependent measure is the word selected by participants as the word that belongs in the sentence but was obscured by the ink blot. As Figures 6-1 and 6-2 clearly show, visual grouping resulted in different data patterns for the two target constructions. The response timeout for the silent reading with visual word choice task resulted in a negligible amount of missing data (less than 1% for RC attachment and less than 0.1% for NP-coordination).

The coordination ambiguity data, presented in Figure 6-1, are coded as percent object-coordination (N1+N2) responses (i.e. how often the copula verb form chosen indicates by singular number agreement that only N3 fills the subject position in the second clause, while N1 and N2 are grouped together in object position of the first clause) and percent subject (N2+N3) coordination responses (i.e. how often the copula verb form chosen indicates by plural number agreement that N2 and N3 are grouped in subject position in the second clause, while N1 is the object in the first clause).

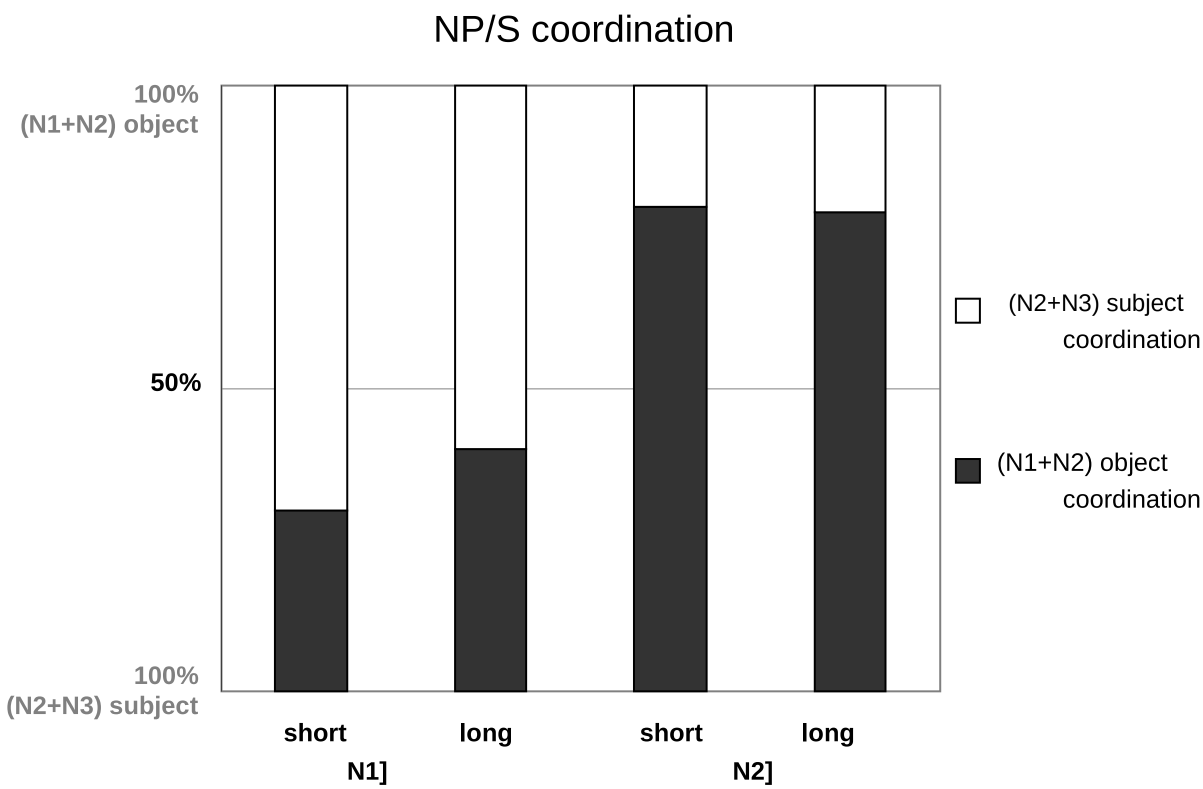



**Figure 6-1**. Grapheme restoration responses for NP/S coordination ambiguity in Silent reading (two-screen presentation) with visual word choice

As can be seen from Figure 6-1, for the NP/S coordination ambiguity, the location of the simulated visual break (visual grouping) had a robust effect on the interpretation, similar to the effect of prosodic boundary location in the corresponding auditory stimuli experiment. When the stimulus sentence was split between two screens after N1, participants judged N1 and N2 to be grouped together far less (35%) than they did when the sentence was split after N2 (80%). The observed preferences by visual break (visual grouping) are in the directions anticipated in section 6.3.3 above on the basis of the auditory experiments.

Constituent length also influenced preferences on ambiguity resolution in this task, but the effect of constituent length was only present in one of the break conditions and not in the other. An analysis of variance confirms the effect of visual break position ($F_1(1,44) = 185$, $p<0.001$, $F_2(1,20) = 190$, $p<0.001$) and shows an effect of NP length ($F_1(1,44) = 4.18$, $p<0.05$, $F_2(1,20) = 3.56$ $p<0.074$) and an interaction by subject ($F_1(1,44) = 4.81$ $p<0.05$, $F_2(1,20) = 4.22$ $p<0.053$).

The length contrast for NP/S coordination items was achieved by expanding the names (N=12) with a second name and the common nouns (N=12) with an adjective, as described in Chapter 3 (Experiment 1b). As a result, the length difference between the long and short conditions of an item is three words.  Manipulating the length of NPs in the sentence produced an effect only when the sentence was visually divided immediately after N1. In that case, participants only grouped N1 and N2 together in object position of the first clause (the grouping opposite to the visual break) around 30% of the time for short-NP items and around 40% of the time for long-NP items. A paired t-test shows that this difference is statistically significant: $t_1(47)=1.95$, $p<.05$, $t_2(23)=2.63$, $p<.01$. Thus, in effect, when the NPs to be processed are longer, the visual break after the first noun tends to be disregarded more often than when the NPs are short. When the sentence was visually split after N2 the pattern of responses is identical for short-NP and long-NP items: N1 and N2 were grouped together in object position of the first clause equally often for the two NP lengths: 80% of the time for short-NP items and 79% of the time for long-NP items.

The data in general are in line with what the Rational Speaker Hypothesis (RHS, Clifton et al., 2006) predicts: greater constituent length makes the interpretive contrast less sharp. However, it is not clear why the NP length manipulation only affects the early visual break condition. Perhaps because the N1] break in the short version comes sooner than in the long version it is ignored less often. However, it might be that the steady effect of the N2] break is upheld by a Late Closure parse that would disfavor opening a new clause early. A related preference for NP coordination over S coordination was reported for similar sentences with only two nominal conjuncts in silent reading in Dutch (Hoeks et al., 2002) which they explain by reference to a simpler topic structure (see Chapter 2 for details).

Responses for the RC-attachment ambiguity resolution, presented in Figure 6-2 below, are coded as percent high-attachment choices (i.e., how often the word choice indicates that the RC is taken to modify the whole noun complex, as shown by gender agreement of the relative pronoun with the first noun). The length contrast (only common nouns in this construction, N=24) was achieved through an adjective added to both N1 and N2, making a two-word difference for each sentence.

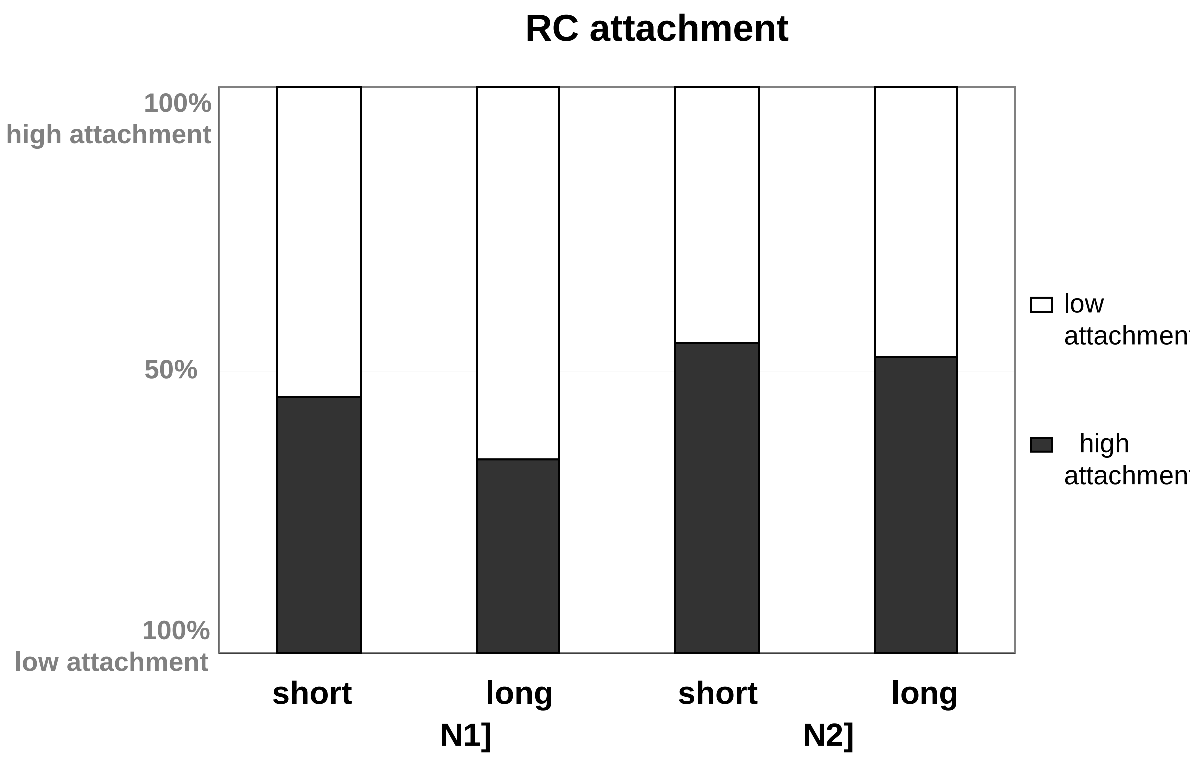



**Figure 6-2**. Grapheme restoration responses for RC attachment in silent reading (two-screen presentation) with visual word choice

As is evident from the graph, visual grouping did not produce strong effects on the interpretation for RC-attachment. For this ambiguity, participants' choices hovered around 50% with both break locations with the exception of long items split at the first noun. However, the means in each of the four conditions shows at least a numerical tendency in the direction that can be expected based on the auditory experiments data. With the short items there is a switch from 45% high attachment responses on items split at N1 to 55% on items split at N2. With the long items the high attachment responses decrease further when the item is split at N1 (34%), but are at chance when the item is split at N2. An analysis of variance shows an effect of visual break position $F_1$ (1, 44) = 14.4, p<0.05, $F_2$ (1,20) = 9.66 p<0.005. The visual break contrast produced only a small difference in responses on short items (10%), but a more sizeable difference on long items (18%). Paired comparisons show that both differences are significant (short items: $t_1(94)=-2.1$, $p<.05$, $t_2(46)=-1.98$, $p<.05$; long items: $t_1(94)=-4.05$, $p<.001$, $t_2(46)=-3.63$, $p<.001$).

There are some parallels that can be made with the auditory data. For example, splitting the sentence at N1 produced in general a bigger effect than splitting the sentence at N2, parallel to the fact that the prosodic break after the first noun was a stronger cue to structure than a prosodic cue after the second noun. There is a different pattern of responses on the short and the long items. In particular, the short-NP condition appears to be less sensitive to the presence / position of the visual line-break than the long-NP condition is.

The data from the one-screen presentation (Experiment 4b) are presented in Figure 6-3 below for the two constructions. The data are coded in the same way as for Experiment 4a.

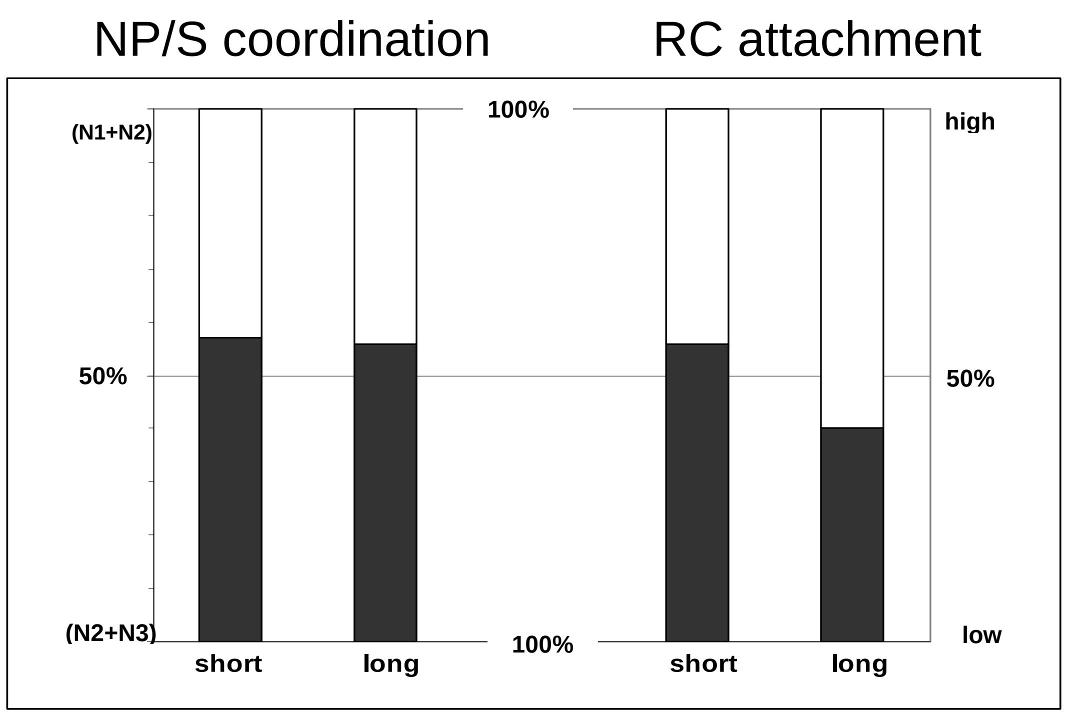



**Figure 6-3**. Grapheme restoration responses for NP/S coordination and RC attachment in Experiment 4b: silent reading with visual word choice (one-screen presentation).

For the NP/S coordination ambiguity items participants' word choices indicate no reliable preference with the single-screen presentation. The pattern of responses is similar for short-NP and long-NP items, showing no effect of visual grouping (visual break position). Specifically, when participants read an NP/S coordination sentence with the ambiguous region all on one screen, they grouped N1 and N2 together in object position of the first clause equally often with short-constituent items (57% of the time) and long-constituent items (56% of the time). As shown by a single mean t-test, the means were not different from chance (presumed at 50%) for either the short ($t1(23)= 1.76$, $p>0.05$, $t2(23)=1.71$, $p>0.05$) or the long items ($t1(23)= 1.48$, $p>0.05$, $t2(23)=1.30$, $p>0.05$), thus indirectly supporting the conclusion that the divergent preferences in the two-screen conditions were due to the relevant break in the visual presentation. There was no effect of constituent length**:** $F_1(1,22) = 0.063$, $p<0.805$, $F_2(1,20) = 0.019$, $p<0.891$.

For the RC ambiguity items, when participants read the structurally ambiguous sentence on one screen, not divided by a visual line-break, they chose the word indicating high attachment of the RC 56% of the time with short-NP items, which was not found to be different from 50% chance $t_1(23)=1.49$, $p>.05$, $t_2(23)=1.53$, $p>.05$, but 40% of the time with long-NP items $t_1(23)=-2.35$, $p<.05$, $t_2(23)= -2.76$, $p<.01$. An analysis of variance shows an effect of constituent length $F_1(1,22) = 23.3$, $p<0.001$, $F_2(1,20) = 16.8$, $p<0.05$.

The percentage of high RC attachment responses with short items is actually very close numerically to what was reported with comparable items in the previous study on Bulgarian. Sekerina et al. (2003) investigated different contrasts in their standard silent reading questionnaire study (position of RC and RC length), but the short RC items in canonical RC position are similar to the short version items in Experiment 4b. For those items Sekerina et al.

(2003) report 56.4% high attachment which is similar to the 55.5% found with short items in Experiment 4b. Another comparable finding in the previous (Sekerina et al., 2003) and the current experiments in Bulgarian was that length of constituents affected preferences, although different constituents were contrasted for length. Sekerina et al. found that increasing RC length produced more high RC attachment responses (63.9% with long RCs in canonical position). In the current study (Experiment 4b) the long NPs (not long RCs) drove the RC attachment preference in the opposite direction, lowering high attachment responses to 40%. The RC in all items in the current experiment is kept constant across versions and is comparatively short. The long NP items on the other hand have added length on both the first and the second noun, so the NP of NP phrase is quite long. Therefore, a finding that with longer NPs as the potential heads, the relative clause tends to attach low is in line with a balanced prosodic structure proposal like the Same Size Sister constraint (Fodor, 2002).

The combined data for the silent reading with visual word choice experiments is given for comparison in Figure 6-4 below, which clearly shows the different data pattern for the two constructions. The data are presented as % object (N1 and N2) vs. subject (N2 and N3) coordination for the NP/S coordination construction and % high vs. low RC attachment.

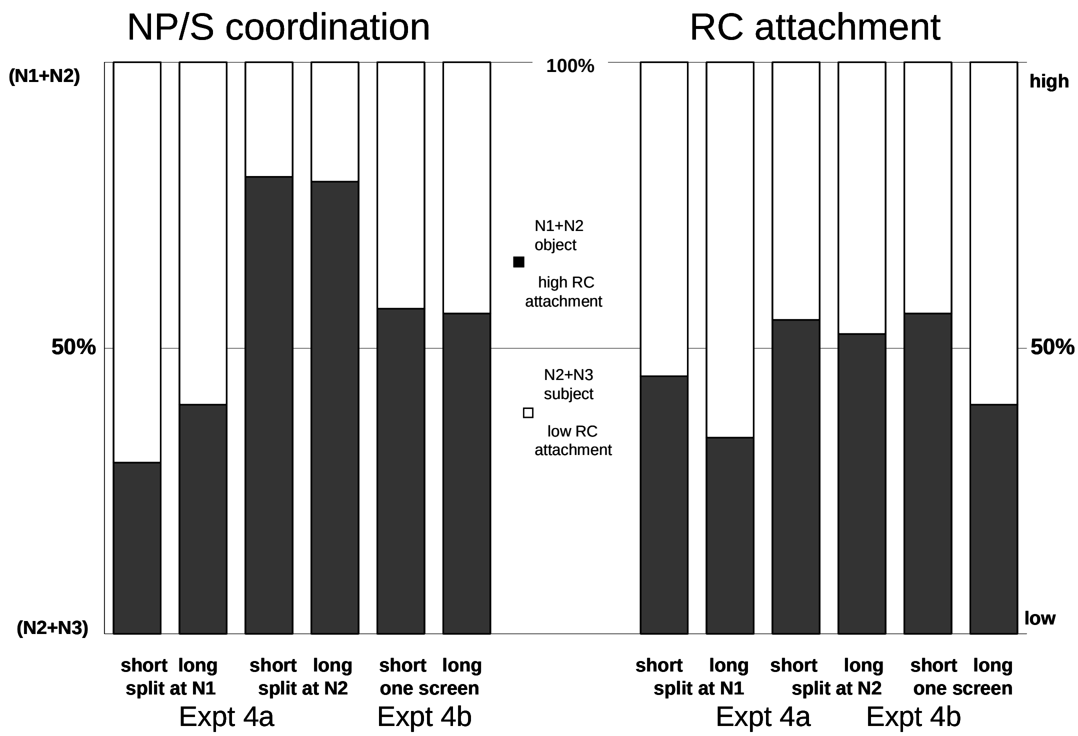



Figure 6-4. Silent reading with visual word choice: comparison of the contrasting two-screen presentations (Experiment 4a) and the one-screen presentation (Experiment 4b)

For the NP/S coordination ambiguity the data pattern is distinct and somewhat resembles the pattern with the auditory materials. The two-screen presentations in Experiment 4a yielded reliable preferences in the expected directions for each visual break, though not as strong as the preferences created by the prosodic breaks in the auditory experiment. The one-screen presentation, however, did not produce a preference, unlike the neutral prosody in Experiment 1c. An analysis of variance further confirms that the three conditions produce different effects on the NP-coordination ambiguity ($F(2,46) = 78.0$ $p<0.001$) and showed no interaction with NP constituent length ($F(2,46) = 2.35$ $p>0.10$).

For the RC attachment ambiguity, responses on the contrasted versions were quite close and mostly at chance level (with the exception of long items with N1] break), but showed at least a tendency in directions of the preference with each visual break corresponded to the disambiguation by the prosodic break in that location in the auditory stimuli. An ANOVA on the response means by item[59] shows that the visual grouping of the sentence (sentence divided at N1] or N2], or one-screen) affected word choice in both the short-NP condition, $F(2,46) = 5.12$, $p<0.005$, as well as the long-NP condition, $F(2,46) = 12.7$ $p<0.001$ and an interaction, $F(2,46) = 3.54$ $p<0.03$. Constituent length affected the pattern of responses in all presentations in the same direction: the added length of the NPs produces more low attachment interpretations of the rather short RCs that were used in the target items. The effect was miniscule in the items split after N2 where it was counteracted by the visual break pause position, but was more pronounced in the items split after N1 and the one-screen presentation. With the one-screen presentation the observation of interest is that the data pattern in the present study resembled the results from the previous study on Bulgarian, insofar as the two are comparable.

### 6.3.5 Discussion

All in all, the results of this experiment are much more variable than for the parallel auditory stimuli experiment (see Chapter 4, section 4.3.4). It may be speculated that performance is affected by individual-level factors such as memory span and/or reading speed. A participant with low memory span may have lost track of the beginning of the sentence by the time of the word choice task, especially for the longer sentence versions. A slow reader might need the full display time for the first sentence segment just in order to decode the words, and would not perceive the break so prominently as a fast reader who has read all the words and has to wait for the next screen.

---

[59] Only the items data could be compared, because the item groups are constant across lists but the subjects are different for the one-screen and two-screen conditions.

Nevertheless, there are certain interesting similarities between the visual and the auditory experiments that can be explored. Figure 6-5 below shows the grapheme-restoration responses in response to visual break locations in Experiment 4 alongside the phoneme-restoration responses in response to prosodic break locations in Experiment 1. The data are coded differently (only as % object coordination and % high attachment) in order not to make the graphs too busy (the upper part of each bar in the other graphs is removed here in order to use one scale from 0 to 100).

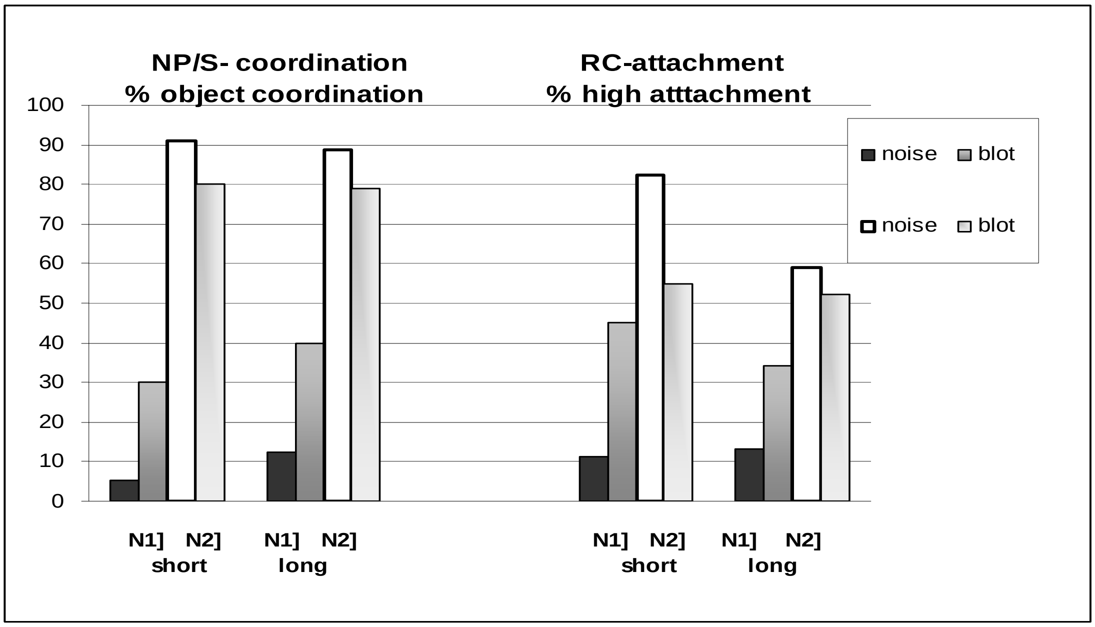



Figure 6-5. Comparison of visual word choice data with auditory and written stimuli

Clearly the effects of a visual break in the silent reading experiment bear some partial resemblance to the effects of a prosodic break in the same position. Note that the aim of this study was to mimic as closely as possible the phoneme restoration experiment in the written modality, so the visual breaks in this experiment were quite prominent and incorporated a pause, which is not typical of breaks in text in general. The comparison shows that while they were helpful to some extent, the visual breaks in the presentation in silent reading did not achieve the same level of disambiguation as overt prosodic breaks in the listening study. This finding can be expected, as overt prosody and visual presentation do not have the same status. Prosodic phrasing is linguistic in nature. Though it has some latitude for variability, it is governed by linguistic rules/constraints, and is a standard cue for disambiguating syntactic structure. In contrast, visual breaks in text are usually arbitrary from a linguistic perspective and regulated by nothing more than practical matters such as the font and the page/screen size. Because of this they are not standardly used as a cue to structure. Locating the visual breaks in the positions characteristic of prosodic breaks can give the former some of the power of the latter, by influencing the prosodic contour projected by the reader onto the stimulus (Fodor, 2002), (perhaps just mechanically, due to extra time allotted by the visual break). But it does not guarantee that the reader will make use of the visual information. In other words: though 'visual prosody' phenomena undoubtedly do occur in sentence processing, there are good reasons for expecting them not to be as robust as prosodic cues in auditory presentation.

Another general finding is that visual grouping was not equally effective across syntactic constructions. It had a substantial influence on structuring the NP/S-coordination sentences, but only a weak effect on the RC-attachment sentences. To compare with the auditory experiments: the effect of an overt prosodic contour was manifested in both constructions but it was stronger (or more stable) for the NP/S-coordination than for RC-attachment. Perhaps some syntactic structures, such as coordination, are more inherently aligned with prosody (overt or projected) than other structures, such as RC-attachment. As discussed in Chapter 3, prosodic grouping through placing prosodic breaks in one position but not in another is essential for structuring the NP/S coordination (and coordination in general) in spoken language. The RC attachment construction on the other hand is not so straightforwardly disambiguated by prosody and the effects of the prosodic breaks in the two locations are quite different: the N1] break is a strong prosodic cue for low RC attachment, whereas the N2] break has a lesser effect on promoting high attachment. This asymmetry may be related to the discontinuity or lack of it in the syntactic structure, or to the location of the break inside a strong sense unit (discussed in Chapter 3). Or it might be a function of the greater linear distance between N1 and the RC in the string: in order to promote high attachment, a prosodic boundary separates the RC from N2, but that also inadvertently makes it more distant from the head of the complex NP that the high-attaching RC modifies. This crucial difference between the two target constructions with respect to prosodic effects transfers to reading, at least with the type of presentation that mimics prosodic structure.

Constituent length effects were manifested for the two constructions in a similar pattern: the responses on items split at N2 were not significantly affected by added NP length. The fact that for the NP/S coordination ambiguity the NP length manipulation showed an effect only with the N1] break is compatible with the RSH proposal (for auditory input) that a non-structural reason for a break makes it less effective as a structural disambiguation cue. In the N1] visual break presentation, the visual break is ‘ignored’ (i.e. N1 and N2 are grouped together in spite of the break) more often when N1 is long (40% of responses) than when it is short (30% of responses). This can be attributed to the fact that in the latter case the break could have been prompted just by the length of the first conjunct. In the N2] visual break presentation N1 and N2 are not separated even when they are long, which supports the intended interpretation. Also, as noted earlier, there is evidence that NP coordination is preferred over clause coordination in silent reading in the absence of other cues (Hoeks et al., 2002 for Dutch; Frazier, 1987 for English), which in the materials for the current experiment may translate into a Late closure advantage for object coordination over subject coordination. For RC attachment a similar explanation can account for the significant effect of added NP length in the N1] break presentation compared to the very slight numerical difference in the N2] break presentation. On the other hand, we cannot exclude a simple 'distance' explanation of constituent length effects for both NP/S coordination and RC constructions in this experiment: longer NP put more distance between the relevant break in the stimulus and the post-sentence response (word choice). For RC attachment in particular the longer NP after the break creates a greater distance from the head of the complex NP at the response point, which might allow the 'closer' possible antecedent for RC to take over more often.

It should be noted that the obligatory comma did not boost high RC attachment as was tentatively expected. That seems strange at first glance, because that comma is a marker for the default pre-RC prosodic boundary in speech discussed in Chapter 2 (section 2.3.4). However, these very facts may hold an explanation. Note that the V NP of NP RC construction is very rare in Bulgarian and the more typical utterance or written sentence involving a RC will actually contain a different string, namely NP RC, in which the phrasing and punctuation also apply.

A comma is also obligatory before adverbial clauses in Bulgarian with a similar correspondence to phrasing. That is, a comma marks the beginning (or the end, or both depending on its position in the sentence) of any subordinate clause in Bulgarian[60] that will be marked prosodically in speech. Thus, neither the obligatory comma in an NP of NP RC sentence, nor the default prosodic break in that position which it stands for is inherently associated with high RC attachment. The comma serves to separate the two clauses and perhaps indicates that the subordinate clause refers to some element in the main clause (i.e. the relative pronoun or adverbial complementizer need to find a coreferen). However, RC attachment will still be

[60] Contrastive clause that start with 'no' (but) and 'a' (and/but) also are preceded by an obligatory comma.

ambiguous, unless it is disambiguated by morphological agreement (as the case often is in Bulgarian). Perhaps this discussion relates also to the role of prosodic break associated with the comma in those positions. If the prosodic break at N2] indicates that the RC needs to find a referent in the main clause (and there are two) while the break at N1 indicates that the PP needs to attach to N1 and thus blocks the RC, that will explain the persistent asymmetry of the prosodic effects for NP of NP RC.

The above may be speculative. But there are cases when the obligatory a comma, corresponding to a prosodic break will disambiguate successfully an ambiguity involving RC interpretation in Bulgarian. However, it is not an attachment ambiguity, but a main clause – reduced clause ambiguity such as the one in (7) below.

(7)

a. . Patnitsite izpusnali poleta i se naložilo da si tarsiat hotel.
Travelers miss-past flight-det and need to refl search hotel
'The travellers missed the flight and had to find a hotel.'

b. Patnitsite, izpusnali poleta, mogat da polučat vaučer za hrana na informatsiata.
Travelers miss-past flight-det can to receive voucher for food at information
'Travellers (who) missed the flight can get a food voucher at the information desk.'

The sentence in (7a) has two conjoined clauses and a straightforward 'sequential' interpretation while the sentence in (7b) resembles the ambiguous "The horse raced past the barn fell." However, it will not be hard to process in written form, because the obligatory punctuation marks the beginning and the end of the relative clause which correspond to the way the sentence will be spoken.

All in all, the data pattern in the visual word choice experiments reported in this section show that visual breaks in the input for silent reading can to some extent mimic the effects of prosodic breaks and give readers cues to the grouping of constituents, but the strength of the disambiguation is contingent whether the breaks are located at positions where prosodic breaks tend to be most effective. Constituent length on the other hand is not an arbitrary factor in written text and can create prosody-like effects or modify them.

From a methodological perspective, the grapheme restoration paradigm may be a useful tool in reading studies. But more subtle ways to mask the disambiguating word and mimic prosody in reading would make it more valuable as an investigative tool.

## 6.4. Experiment 5: Silent Reading with Sentence repetition

### 6.4.1. Overview

Experiment 5 is the silent reading equivalent of Experiment 2's auditory presentation with the Sentence repetition response task. Participants see each stimulus sentence in one of the experimental conditions described in section 6.2.3. They read it silently and after it has been removed from the screen they have to say it aloud. How they pronounce the word with graphemes obscured by the 'ink blot' reveals how they have resolved the syntactic ambiguity. From this it can be established whether participants' interpretation is affected by the presence/location of visual breaks. Much like the sentence repetition protocol with auditory input, the Reading with repetition task does not offer specific word choices, so it does not draw attention even to the lexical ambiguity of the blot-word. Participants' attention is focused on remembering and reproducing the sentence accurately. As in Experiment 4, the two-screen presentation versions are contrasted within participants (Experiment 5a) and the one-screen presentation version is administered to a different group of participants (Experiment 5b). No constituent length contrast was included in order to make the production experiments with auditory and visual stimuli parallel, and to avoid overloading participants' memory capacity. They details are summarized in table 6-3 below.

**Table 6-3**: Experimental details for Experiment 5: silent reading with sentence repetition

| | Experiment 5a | Experiment 5b |
|---|---|---|
| Target materials:<br>NP/S coordination ambiguity<br>RC attachment ambiguity<br>Presentation | <br>N=24<br>N=24<br>Two-screen | <br>N=24<br>N=24<br>One-screen One screen |
| Contrast: | Visual grouping<br>–split at N1<br>–split at N1 | – |
| Lists | 2 | 1 |

6.4.2. Method

*Participants*

Thirty-six native speakers of Bulgarian (53% female) participated successfully in the silent reading with repetition experiment: 24 in the two-screen presentation (Experiment 5a) and 12 in the single screen presentation (Experiment 5b). All were native speakers of Bulgarian, drawn from the same population as for Experiment 4 participated. None had taken part in the previous experiments.

*Materials*

Experiment 5 used a subset of the visual stimuli with an ink-blot word that were created for Experiment 4, namely the short-NP versions. This was done in order to make the target items parallel to those in the Sentence repetition with auditory stimuli (Experiment 2a-b) where only the short versions of the auditory stimuli were used, and also to make the participants' task less demanding in terms of short-term memory. The presentation conditions were as described for experiment 4. Two contained contrasting visual grouping of constituents with the sentence split after the first noun or after the second noun. The third presented the sentence on a single screen with no explicit grouping of constituents. They were administered as separate experiments (see Table 6-3) to match the informative and neutral prosody experiments with auditory stimuli.

*Procedure*

As in Experiments 2a-b, participants were tested individually in a quiet room. The presentation was self-paced in the limited sense that the participant, when ready, had to press a button to call up the next stimulus sentence. The presentation algorithm was the same as in Experiment 4 (50ms per word and in the two-screen versions an added 150ms to imitate the pause in auditory stimuli).

The task was to silently read the sentence on the screen and then say it aloud, beginning to speak as soon as the microphone icon appeared on the screen, which was synchronized with the offset of the visual sentence presentation. Again, this was done in order to make the task parallel to the sentence repetition task with the auditory stimuli. DMDX controlled the presentation, including the different pseudo-randomizations of the materials for each participant, and collected participant responses. A response time-out was set for 9000 ms from the point at which the microphone icon appeared on the screen.

The dependent measure in this experiment was the frequency with which the blot-word in the stimuli was replaced in the participant's output by a word that created syntactic structure compatible with the visual line-break, e.g., a plural verb in the coordination items when the sentence was divided after N1, but a singular verb when the sentence was divided after N2.

### 6.4.3. Predictions

As for the visual word choice (Experiment 4a) it was predicted that the visual break in the stimulus sentence in the two-screen presentation (Experiment 5a) would facilitate a particular interpretation of the sentence. More specifically, each visual break position should encourage restoration of the missing graphemes in the blot-word to create a word that makes the sentence structure compatible with a break in that location. The effects were expected to be comparable in directionality but not in size to the effects of prosodic breaks in the auditory experiments.

### 6.4.4. Results

Data for Experiment 5 (Silent reading with sentence repetition) are reported below. The dependent measure is the word produced by participants in place of the blot-word. The response timeout was 9000ms, which was higher than in the auditory production experiments, but still resulted in a rather large proportion of missing data compared to the silent reading with visual word choice task in Experiment 4 due to some recordings being terminated before the target word had been spoken. A higher percentage of responses are missing for NP/S coordination items (17% missing responses) than for RC attachment items (7% missing responses), because the NP/S coordination sentences were sometimes longer (the template included optional elements in the beginning of the sentence for naturalness) and the target word came very close to the end of the sentence, so recordings were more likely to be cut off before the target word was pronounced than for the RC construction where sentences were uniform in length (number of words) and the relative pronoun was more or less in the middle of the sentence. Another factor potentially contributing to the higher percentage of missing data for NP-coordination is the fact that half of the NP-coordination items contained a string of names which may be hard to recall and reproduce (as the names, unlike the common nouns, were arbitrary in relation to each other and to the semantics of the sentence), resulting in more hesitations and false starts and ultimately more terminated recordings. Note that in the silent reading with visual word choice task (Experiment 4) remembering the specific names was not crucial to responding on an item. It was enough for participants to compute a structure for the sentence (i.e. one person or two people) during their silent reading of it, based on which they could form an expectation about the grammatical markings of the word that was masked (e.g., referring to one person or two, hence singular or plural morphology. The participants were asked to read carefully and answer promptly, but they were also told in advance that the word choices will be repeated often, so they knew that they were not going to be asked about the proper names for example and could safely ignore these, for memory purposes.

In Experiment 5, by contrast, the participant had to commit every word to memory during the silent reading in order to repeat the sentence. This may have caused greater difficulty with the proper names items in the NP/S coordination.

The data for the two-screen presentation (Experiment 5a) are shown in Figure 6-6 below. The data are coded as in figures 6-1 and 6-2 above for Experiment 4. That is the NP/S coordination ambiguity data are coded as % object NP-coordination responses vs. % subject NP-coordination responses (i.e., how often N1 + N2 are grouped in object position of the first clause as revealed by verb agreement with the singular N3 vs. how often N2 + N3 are grouped in subject position of the second clause as revealed by verb agreement). The RC-attachment data are coded as % high-attachment responses vs. % low attachment responses (i.e., how often the relative pronoun produced by participants agrees in gender with N1 and how often it agrees with N2).

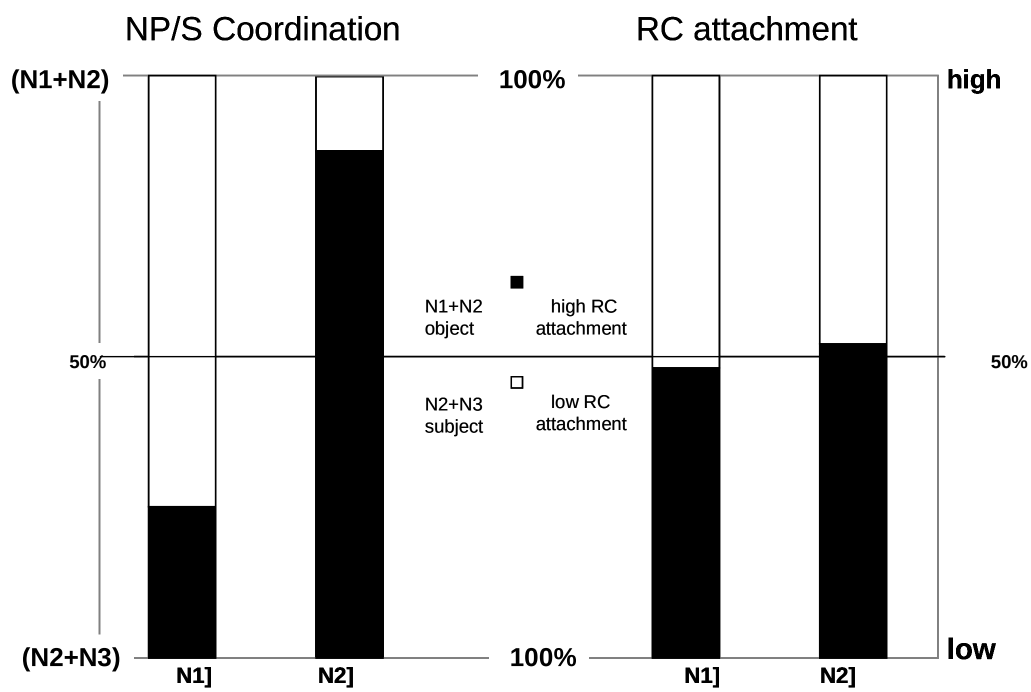



**Figure 6-6**. Grapheme restoration responses in Experiment 5a Silent reading (two-screen presentation) with sentence repetition

It is clear from Figure 6-6 that (as in Experiment 4) visual grouping did not affect the two structural ambiguities of interest equally. It was an effective tool for disambiguating NP/S coordination structure (on the left in Figure 6-6), but not so for the RC-attachment ambiguity (on the right in Figure 6-6). For the NP/S coordination ambiguity a visual break dividing the sentence immediately after N1 resulted mostly in sentences grouping N2 and N3 as a coordinate subject of the second clause, whereas a visual break dividing the sentence immediately after N2 resulted in a much higher proportion of grouping N1 and N2 as a coordinate object of the first clause. The difference between the proportion of object NP coordination responses with the two contrasting presentations (26% and 87% respectively; the black bars on left) is statistically significant, showing a main effect of visual break position: $F_1$ (1,22) = 176.99, $p$<.001, $F_2$ (1,20) = 122.42, $p$<.001. There is a slight numerical advantage for the visual break after N2 in the number of interpretations consistent with the break location. This was not predicted on the basis of the auditory experiments, but it is consistent with the preference for NP over S coordination in silent reading found for Dutch (6.3.4). In general, the responses for this ambiguity with the two screen presentations replicate the short items data from Experiment 4a.

For the RC-attachment ambiguity, on the other hand, the type of visual presentation (position of the visual break) did not constitute a useful cue for structural disambiguation. Responses in the two conditions with a visual break in the ambiguous region were not statistically different (N1] v. N2], Δ 3%, $F_1$ (1,20) <1 and $F_2$ (1,22) <1).

The data for the single screen presentation (Experiment 5b) are presented in Figure 6-5 below in conjunction with the data from Experiment 5a. The dependent measure is again the word produced by participants in place of the ink-blot word and coding of the data is the same as for the two-screen presentation.

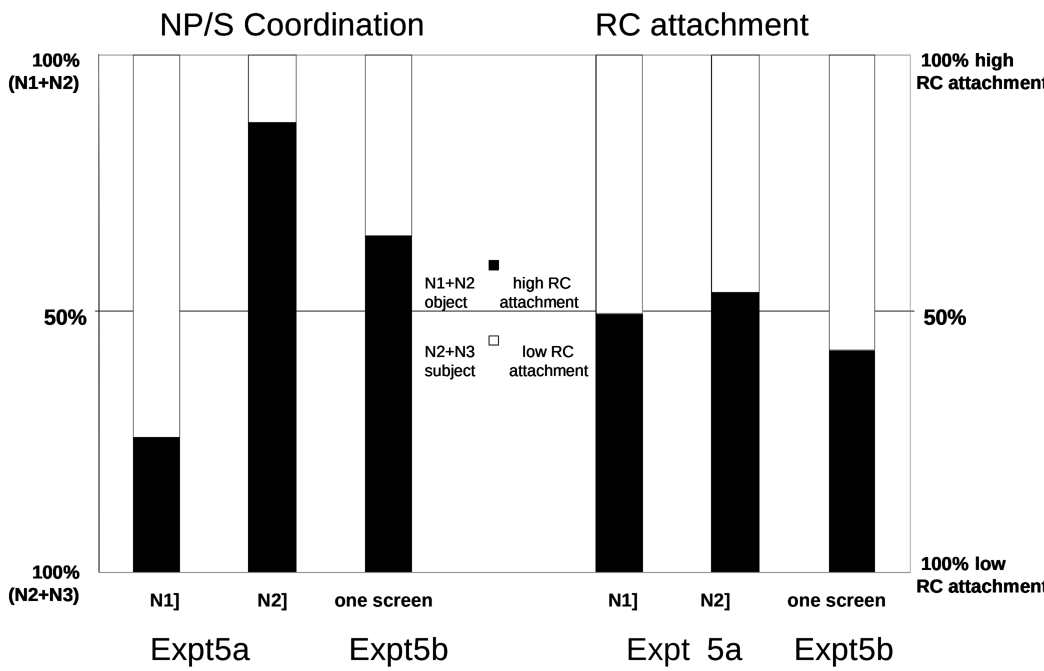



**Figure 6-7**. Grapheme restoration responses in Experiment 5 Silent reading with sentence repetition

With single-screen presentation (no break in the ambiguous region) the pattern of responses differed for the two constructions. For NP/S coordination items participants gave numerically more object-coordination responses in this task with one screen presentation (65%) than were given in the word-choice task (Experiment 4b), but were still at chance in the subjects analysis as shown by a single-means t-test (Δ from chance=+15%, $t1$=(11) 1.74, $p$=.054; $t2$=(23) 3.38, $p$<.01). For the RC attachment items participants produced the relative pronoun indicating high attachment less in this task (43%) than they did with the short items in the visual word choice task (Experiment 4b), although the mean was not different from chance by subjects (Δ from chance= –7%, $t1$=(11) 1.72, $p$>.05; $t2$=(23) 3.37, $p$<.01).

6.4.5 Discussion

The prediction that participants would make use of the visual break in the stimulus to resolve syntactic ambiguity in their reproduction of silently read sentences was confirmed only for one construction type: NP/S coordination.

Since the task in the present experiment is an off-line production task, memory and attention span are likely play a part in participants' performance. Note, however, that the NP/S-coordination items which were in general longer than the RC attachment items responded better to the visual break manipulation. The two item types differed with respect to position of the blot-word in the sentence. For NP/S-coordination items the blot-word came later than in the RC-attachment items. There is no obvious reason why this would give an advantage to the former, but perhaps having processed more of the sentence before having to supply the missing piece of the critical word allowed the reader to form stronger expectations of its features.

This observation is in alignment with the word-choice data from Experiment 4 and may be related to the difference between the two constructions with respect to the disambiguating role of prosody in the experiments with auditory stimuli. As the results of the visual word choice silent reading experiments reported in this chapter in general show, visual grouping is an effective way of disambiguating NP/S coordination, perhaps because grouping by prosody is essential in disambiguating it in speech. (See discussion in section 6.3.5 above.)

Participants' responses on the two target constructions in Experiment 5b were at chance, but they show a similar tendency toward a structure that is consistent with a Late Closure interpretation. For the NP/S coordination the tendency is for grouping the second noun with the first and opening a second clause later. For the RC attachment items the tendency is to produce low attachment sentences.

**6.5. Summary**

The experiments reported in this chapter confirm that a visual break in a specific location does provide the reader with useful hints as to the syntactic structuring of the sentence. Granted, the visual break in the written stimuli is not equivalent to a prosodic break in spoken stimuli, which provides genuine prosodic cues to sentence structure derived from the syntax-prosody mapping constraints. As noted above, a regular line break in reading, unlike a prosodic break, is not linguistically driven, and is rarely (indeed, only accidentally) correlated with a syntactic boundary. In contrast, the visual breaks in the current experiment were purposefully aligned with prosodic break locations and made more prominent, because the aim was to find out whether it was possible to induce prosody-like breaks and associated interpretive effects in parallel to the auditory experiments. It may be argued whether the visual breaks in Experiment 4a and 5a provided a genuine cue to structure or whether the pause simply delayed parsing, allowing time for various phrase-completion processes which would not have occurred in fully fluent reading. The different effects on the two constructions, especially the fact that coordination structures are consistently disambiguated by grouping in speech and the fact that the NP/S coordination benefitted more from the visual grouping in these experiments, lend some support to the former.

All in all, the experiments reported in this chapter were useful for the overall purpose of this research. The identical materials and parallel tasks make it possible to establish similarities and contrasts in sentence processing in the auditory and visual modalities. The reading tasks reported here retain the advantage that the phoneme-restoration protocols of Experiments 1 – 3 have, of eliminating intrusive comprehension questions, and encouraging more naturalistic processing, while still uncovering ambiguity-resolution preferences.

A practical conclusion is that the visual-masking method needs to be refined to make grapheme replacement by a visual ‘ink-blot’ as unobtrusive and natural as phoneme replacement by white-noise in the auditory stimuli. Perhaps an ink blot is not so natural looking in the digital age and an alternative masking of the graphemes will work better. For example, a strategically placed pop-up on the screen may obscure them from view. The presentation set-up can also be made to resemble an everyday situation, by having the sentence displayed on a ‘screen’ or a ‘web page’ with the relevant configuration of words showing and the rest blurred, which would actually give the experimenter flexibility to more freely manipulate the display.

# CHAPTER 7
# DIRECTIONS FOR FURTHER RESEARCH

## 7.1. Extending the phoneme restoration paradigm to other constructions.

The coordination and relative clause constructions discussed in previous chapters were deliberately chosen for testing the new methodology because they are familiar in psycholinguistics; there are existing data collected in other languages using different methods. Now that the phoneme restoration method has been validated for these constructions, it can be used with confidence to explore other constructions that have not been studied before. One such construction, an accusative/possessive reflexive contrast, was included as a filler item in all the experiments reported so far. Details on the syntax and prosody of this construction, and the data collected with the three response tasks are presented in section 7.2. The item power was low (only 12 item pairs), so a more extensive study may be called for in the future, but the present results are nevertheless of some interest.

Five additional constructions in Bulgarian were included in a separate pilot experiment using spoken input and the visual word choice task discussed in Chapter 3. They exemplify a variety of types of prosodic disambiguation, in which the various prosodic cues (such as presence or absence of prosodic boundary, location of prosodic boundary, intonation contour, and grouping) interact with lexical-morphological disambiguation that can be obscured by phoneme replacement. The syntactic and prosodic contrasts compared and the data for these constructions are discussed in section 7.3.

## 7.2. Accusative/possessive reflexive

7.2.1. Syntax and semantics of the accusative/possessive reflexive sentence pairs

The Bulgarian accusative/possessive reflexive ambiguity was described briefly in section 3.1.3, because it was included as a filler construction in all the experiments reported so far. They were the 12 ambiguous fillers that were disambiguated morphologically and prosodically in the auditory experiments reported in Chapter 3 and Chapter 4. Each of these items consisted of a sequence of two statements which required an IPh break between them. The morphological disambiguation involves a different reflexive pronoun in (1a) and (1b) that fits into a different structure. The prosodic disambiguation involves the location of the prosodic break. The example in (1a) will be referred alternatively as “accusative reflexive” or “early break” and the example in (1b) will be referred as “possessive reflexive” or “late break”.

The first sentence in each utterance contained a verb that could be either transitive or reflexive. The word that differed between the two versions was the reflexive particle *se* versus the direct object possessive modifier *si*. The accusative/possessive reflexive ambiguity is illustrated in (1) below.

(1)
a. Accusative reflexive (reflexive as direct object, establishing that the action of the transitive verb is directed at self, i.e. subject=object)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Običaše | da | se | hvali ǁ | Detsata | i | te | go | znaeha. |
| Like-sg-past | to | refl | praise | children-det | and | they | it | know-pl-past |

b
. *He liked to brag (about himself). The children even knew it.*

b. Possessive /genitive reflexive (establishing a relation between the direct object and the subject of the transitive verb)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Običaše | da | si | hvali | detsata. ǁ | I | te | go | znaeha. |
| Like-sg-past | to | one’s | praise | children-det | and | they | it | know-pl-past |

*He liked to praise his children. And they knew it.*

The particle ‘se’ in (1a) is the accusative short form of the reflexive personal pronoun in Bulgarian. The full form of the reflexive personal pronoun is ‘sebe si’ (*oneself*) and like all personal pronouns in Bulgarian it has a short form for the accusative that cliticize to the verb (Pashov, 1999), e.g. on the verb ‘hvali’ (*praise*) in (1a). In general, the clitic ‘se’ adds reflexive meaning to the verb, i.e. ‘do the action to one-self’, as in ‘skrivam’ (*hide*) vs ‘skrivam se’ (*hide myself*) or ‘obličam’ (*dress*) vs. ‘obličam se’ (*get dressed*)[61]. The reflexive particle fills the direct object argument slot, so that a transitive verb used with ‘se’ cannot take another direct object, e.g. ‘obličam bebeto’ (*dress the baby*) is a grammatical phrase, but ‘obličam se *bebeto’ (*dress refl the baby*) is not. Unlike the other personal pronouns the reflexive clitic does not change in person or number for agreement.

The reflexive se-particle can precede or follow the verb, depending on phrase structure but also perhaps on rhythmic/prosodic grounds, as illustrated in (2) below. When ‘hvali’ is the head of a verb phrase that has an overt subject, the particle will obligatorily precede the verb, as in (2a), but when the subject is null (which is more common), the particle will follow the verb, as in (2b), unless there is another element of the verb phrase that precedes it, such as an adverbial phrase (2c).

(2) a. Ivan se hvali, če ima vrazki.
Ivan refl brag that have connections
*Ivan brags that he has connections.*

b. Hvali se, če ima vrazki.
Brag refl that have connections

[61] However, it is also obligatorily used with some verbs where the action is not strictly reflexive, e.g. ‘usmihvam’ (*smile*). The experimental items in this research contained only the accusative reflexive ‘se’

*He brags that he has connections.*

c. Večno se hvali, če ima vrazki.
Always refl brag that have connections
*He is always bragging that he has connections.*

These word orders are obligatory, and may be summed up as 'the short form of the accusative reflexive particle cannot be the first overt element in the verb phrase'. In that respect it behaves like the short forms of all accusative pronouns in Bulgarian[62]. The accusative/possessive reflexive ambiguity items used in Experiments 1-3 were constructed so that the reflexive always preceded the verb it was cliticized to. For example, in (1) it obligatorily comes between the subordinating conjunction 'da' (*to*) and the lexical verb 'hvali' (*praise*) which is the subordinate verb in the complex VP.

The reflexive possessive particle 'si' in (1b) is similar to 'se' in that it is also a reflexive clitic. It is the short form of the possessive reflexive pronoun in Bulgarian 'svoj' (*ones own*). In their full form, the possessive pronouns in Bulgarian (including the reflexive possessive) are overtly marked for gender and number to agree with the features of the noun they modify, as shown in (3a) below and can take the definite article, as shown in (3b). The short forms, however, do not inflect and can never be used without a noun, as shown in (3c).

(3)

| a. | Possessive | | Reflexive possessive | |
|---|---|---|---|---|
| Masculine | moj telefon | my phone | svoj telefon | (one') own phone |
| Feminine | moia kola | my car | svoia kola | (one') own car |
| Neuter | moe jake | my jacket | svoe jake | (one') own jacket |
| Plural | moi detsa | my children | svoi detsa | (one') own children |

b.
Vze moia<u>ta</u> kola. Vze svoia<u>ta</u> kola.

[62] All personal pronouns have a full and a short accusative form and the short form is used in the same position in sentences like (2) as the short form of the reflexive.

Take-past my(fem-<u>def</u>) car(fem)
*(S/he) took my car.*

Take-past one's own(fem-<u>def</u>) car(fem)
*(S/he) took his/her own car.*

c.

Vze kola<u>ta</u> mi.
Take-past car(fem-<u>def</u>) mine
*(S/he) took my car.*

Vze kola<u>ta</u> si.
Take-past car(fem-<u>def</u>) one's own
*(S/he) took his/her own car.*

Vze mi kola<u>ta</u>.
Take-past mine car(fem-<u>def</u>)
*(S/he) took my car.*

Vze si kola<u>ta</u>.
Take-past one's own car(fem-<u>def</u>)
*(S/he) took my car.*

The short form of the possessive pronouns in Bulgarian (including the reflexive) coincides phonologically with the short dative form of the personal pronouns. In some cases, the two may be hard to distinguish. For example, the short form in (4a) below is dative and the short form in (4b) is possessive, but the status of the short form in (4c) is less clear. It appears very similar to (4a) but the verb is not ditransitive like the verb in (4a) and the sentence in (4c) means means the same as (4b).

(4)

a. Sipa mi /si pitie.
pour-past to me / refl drink
(He)[63] poured me / himself a drink.

b. Izpi pitieto mi / si.
drink-past drink-def my / refl
(He) drank my / his drink.

c. Izpi mi / si pitieto.
drink-past my / refl drink
(He) drank my drink.

---

[63] The null pronoun and the reflexive pronoun *<u>si</u>* in these sentences are not gender marked in Bulgarian; 'he' and 'himself' in the glosses are used here for simplicity.

The ‘si’ in the accusative/possessive reflexive in (1b) is similar in that respect. It is treated a possessive, not a dative because it modifies the noun, not the action. The sentence in (1b) can have the full form of reflexive possessive (as in 3a), i.e. ‘Običaše da hvali svoite detsa.’ or have the short form follow the noun as in (3c) and (4b) ‘Običaše da hvali detsata si.’ They all have the same meaning, but using the full form makes it more formal.

7.2.2. Prosodic properties of the accusative/possessive reflexive utterances

The prosodic contrast for the accusative/possessive reflexive items involved the position of a sentential or clausal break, which is illustrated in Figure 7-1 below. In the accusative reflexive example (1a) the first sentence ends after the verb (early break prosody), and the following NP functions as the overt subject of the second sentence. In the possessive reflexive example (1b) the first sentence ends after the noun which is the direct object of the transitive verb (late break prosody) and the second clause (or sentence) has a null subject. Bulgarian signals a sentence boundary prosodically with an intonational phrase break marked by pre-boundary lengthening often accompanied by a pause and typically a falling intonation. That is the prosodic contour of (1a) shown in the upper part of Figure 7-1. The prosodic contour of (1b), which is shown in the lower part of Figure 7-1, has a continuation rise that is more typical of non-final clauses, but is also used in utterances with more than one sentence to signal that there is more to come. In a sense, the early prosodic boundary contour in (1a) is more definitive than the later one in (1b) because in (1a) a clearly marked sentential boundary comes between the initial statement and the follow up statement, whereas the two sentences in (1b) are produced more like clauses in coordination.

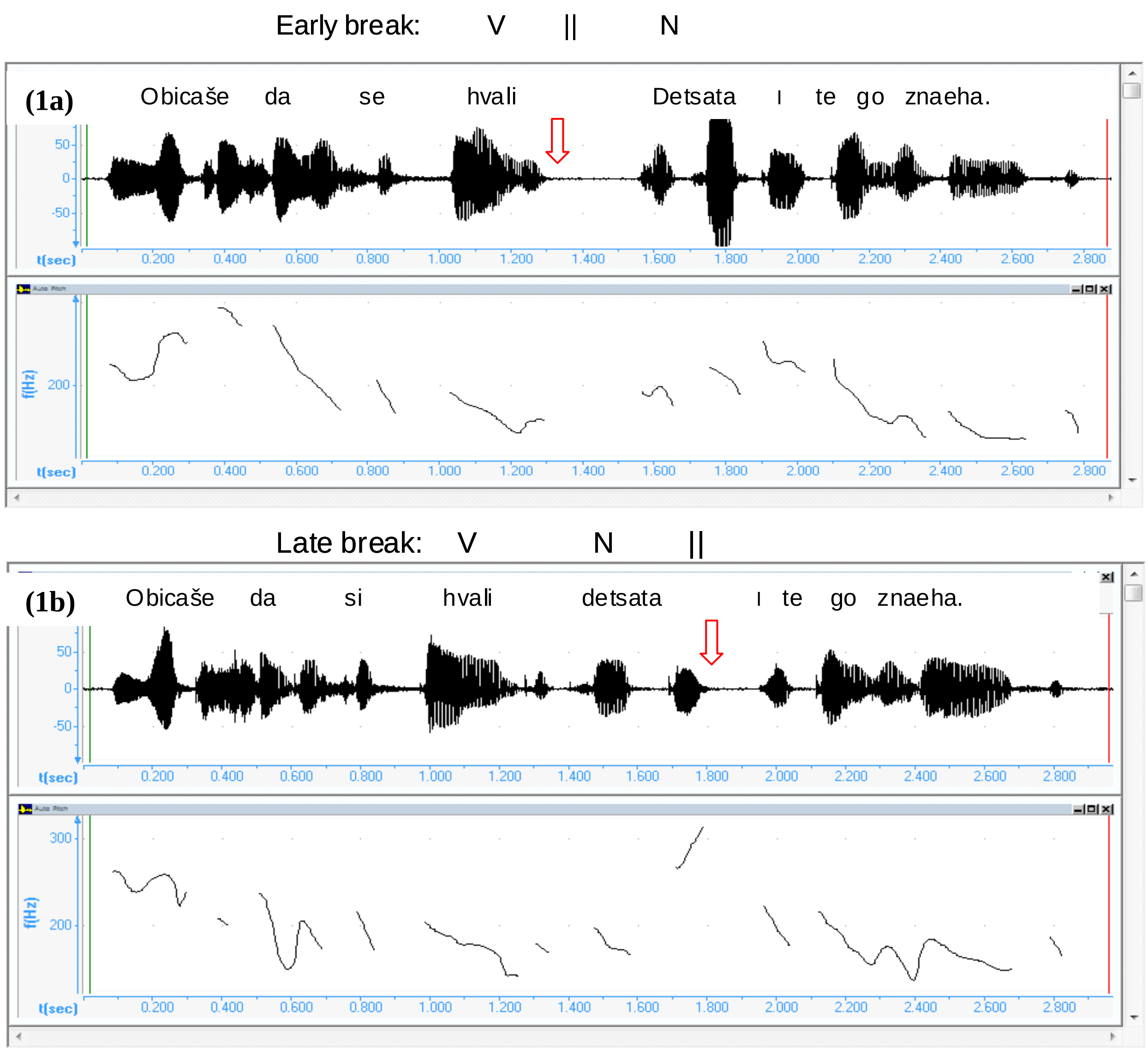



**Figure 7-1.** The prosodic contours of the two-sentence and two-clause utterances with accusative/possessive reflexive with an early prosodic break (after the verb) and late prosodic break (after the noun), indicated by the red arrow.

After the phoneme replacement procedure (which was described in chapter 3, section 3.1.5) the segmental distinction between (1a) and (1b) is removed, but the disambiguating prosodic distinction remains, as can be seen in Figure 7-2 below. As with the NP/S-coordination and RC-attachment constructions, removing the disambiguating segments (in this case almost all of the reflexive particle, although the ‘s’ is still distinguishable) and replacing them with noise did not affect the region where the prosodic boundary is realized.

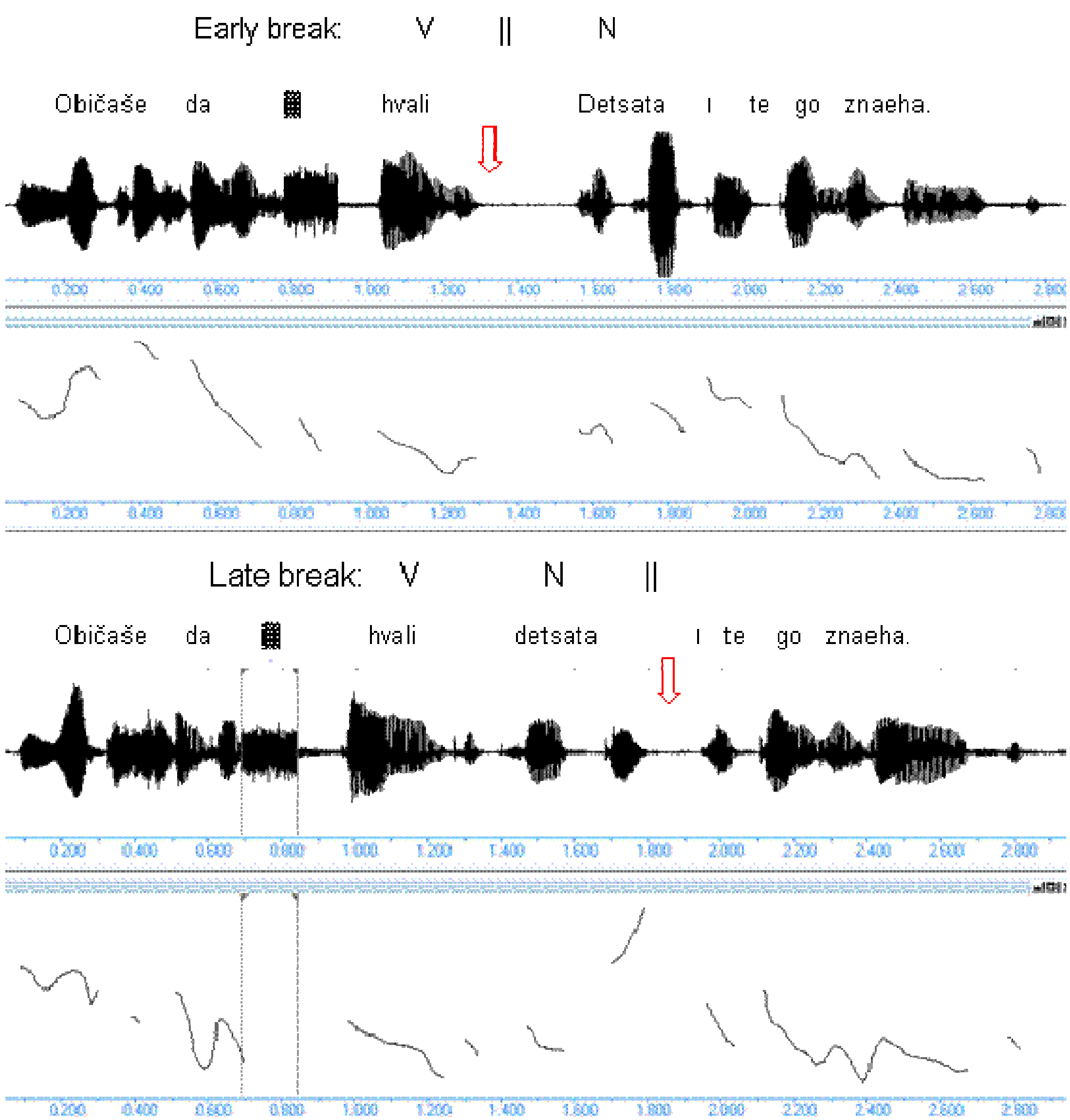



**Figure 7-2**. The accusative/possessive reflexive with phoneme replacement.

There was a major difference, however, that made this an interesting case to include alongside the two main item types discussed in the previous chapters. Unlike in the NP/S coordination and the RC attachment constructions, where the phoneme-replaced word follows the disambiguating boundary, in the accusative/possessive reflexive ambiguity the prosodic cue that disambiguates comes after the phoneme-replaced word that disambiguates the structure morpho-syntactically in the original utterance. Therefore the word has to be restored ‘retroactively’, as in the ‘*eel on the …’ experiment (Sherman, 1971) that was discussed briefly in Chapter 1, section 1.4.2. The following context (e.g., ‘shoe’ or ‘table’) in the early study successfully disambiguated the noise toward the unique lexical item supported by the semantics/pragmatics of the sentence.

Since the older experiments did not systematically manipulate prosody, it is of interest to explore whether the location of a prosodic boundary in the utterances of items such as (1a) and (1b) would be sufficient to support retroactive phoneme restoration of the noise-replaced word to the particle appropriate for the syntactic-semantic meaning congruent with the boundary location.

7.2.3. Experimental design

As noted earlier, the accusative/possessive reflexive ambiguity was included as filler in all the experiments described in Chapter 3 and Chapter 4: the visual word choice (Experiment 1), sentence repetition (Experiment 2) and sentence shadowing (Experiment 3). The 12 items had the two versions described earlier, which will be called early break (1a) and late break (1b), that were counterbalanced across versions in the informative prosody experiments. There was also an uninformative neutral prosody condition (no break) which sounded rather unnatural (see Chapter 3), which was tested alongside the neutral prosody versions of the NP/S coordination and RC attachment items in experiments 1c, 2b and 3b. The details of all the experiments that included the accusative/possessive reflexive ambiguity are summarized in table 7-1 below. The procedure for the visual word choice task is described in detail in Chapter 3 (section 3.2.2) and the procedures for sentence repetition and sentence shadowing in Chapter 4 (section 4.1.2).

**Table 7-1**. Tasks and prosodic conditions for the accusative/possessive reflexive items in the phoneme restoration experiments

| Task | Prosodic contours | Expt | participants | lists |
|---|---|---|---|---|
| Visual word choice | early vs. late break | 1a | 24 | 2 |
| | | 1b | 48 | 4* |
| | neutral | 1c | 24 | 2* |
| Sentence repetition | early vs. late break | 2a | 24 | 2 |
| | neutral | 2b | 12 | 1 |
| Sentence shadowing | early vs. late break | 3a | 24 | 2 |
| | neutral | 3b | 12 | 1 |

* due to length contrast in the other constructions

7.2.4. Results and discussion.

The data on the accusative/possessive reflexive ambiguity for the three response tasks of Experiments 1 – 3 are presented in Figure 7-3 below, coded as proportion of early break congruent (‘se’) restorations vs. late break congruent (‘si’) restorations.  (The data for the visual word choice task in Figure 7-3 are based on all participants in Experiments 1a-c because no length manipulation was included for this construction.)

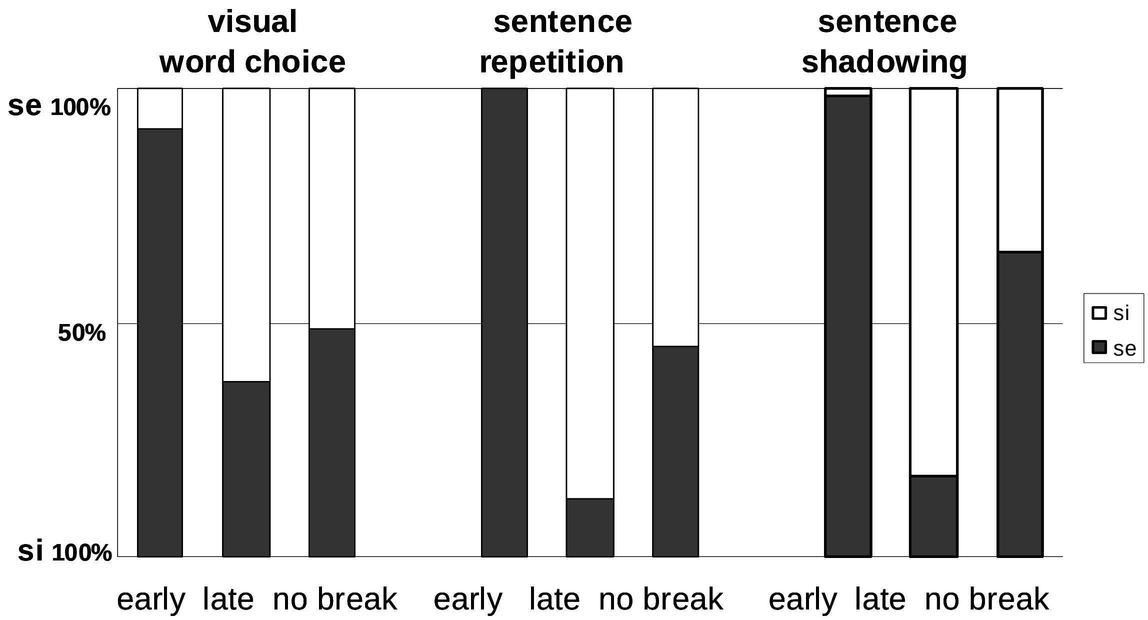



**Figure 7-3**. Phoneme restoration responses on the accusative/possessive reflexive items by task

The data pattern for the *se/si* ambiguity is similar to the outcomes for the two main ambiguities tested, with some minor differences. As the bar graph shows, both informative prosodic breaks successfully disambiguated the utterance, each producing phoneme restorations in the expected direction, with the neutral prosody patterns in between. An analyses of variance shows a marginal effect of task $F(2,33) = 3.20$, $p<0.053$, a main effect of prosody $F(2,66) = 23.2$, $p<0.001$, as well as an interaction $F(4,66) = 63.9$, $p<0.001$.

The responses for the contrasting informative prosodic breaks are very well differentiated in all three tasks, but there is an asymmetry in the effects: an early break (after the verb) yielded almost exclusively prosody-congruent responses, while a late break (after the noun in direct object position) yielded largely congruent interpretations, but not to such a degree. Paired t-tests show that the difference in prosody-congruent restoration rates with the two prosodies is significant in the visual word choice task $t(11)=6.15$ $p< 0.001$, the sentence repetition task $t(11)=4.01$ $p< 0.002$ and the sentence shadowing task $t(11)=3.51$ $p< 0.005$.

The asymmetry in the data may be linked to the different degrees of ‘definitiveness’ of the prosodic break mentioned earlier (section 7.2.2). The falling contour in (1a) signals the ‘end-of-sentence interpretation’, whereas the rising contour is less specific as to the interpretation of in (1b). The more definitive break seems to support more robustly the structure it is associated with. However, another factor related to the prosody may have contributed to the effect: the sentential break in (1a) comes earlier, so there is less material to process, but more importantly, the break is closer to the site of the restoration than the late break in (1b). Finally, the structure in the first sentence of (1a) is arguably simpler than the first sentence in (1b) which involves a possessive modifier distant from its nominal head.

Not only are responses with the two informative prosodic contours reliably different from each other, but the early break prosody also produces a more stable data pattern across tasks, whereas the late break data have a different pattern in the visual word choice compared to the other two tasks. Analyses of variance show that there is no effect of task in the early break data $F(2,33) = 2.34$, $p<0.11$, but there is a significant effect in the late break data $F(2,33) = 9.57$ $p<0.001$. One possible explanation for this difference by task is that the two choices presented visually for this item type are particles which normally cliticize to another word, so it may be hard to process them in isolation. Such a problem would be avoided in the sentence repetition and sentence shadowing tasks, because participants produce the word normally, especially in the sentence repetition task where they produce the entire sentence fluently. Indeed, of the three response tasks, the sentence repetition task produces the most polarized results in the contrasted prosodic conditions.

With the neutral prosody, the responses are variable in the three tasks, but there was no effect of task $F(2,33) = 1.22$ $p<0.307$ and none of the means was statistically different from chance (presumed at 50%): visual word choice (48.7% ‘se’ restorations) $t(11)=-0.046$, $p>0.1$; sentence repetition task (48.5% ‘se’ restorations) $t(11)= -0.032$, $p>0.1$; sentence shadowing task (58.2% ‘se’ restorations) $t(11)= -0.042$, $p>0.1$.

In sum, the data for this construction complement the data on NP/S coordination and RC attachment collected in the same experiments. The data pattern for the *se/si* ambiguity with the informative prosody is similar to the data for the other two constructions, in that listeners were able to use the prosodic break location as a disambiguator in all three tasks, and it resembles the RC attachment data in that there is asymmetry in the effect. The latter confirms the finding that different prosodic contours for the same utterance do not necessarily disambiguate equally strongly toward the respective structures; thus RC attachment is not an isolated exception. The explanation may lie in the different strength of association between each type of prosody and a specific structure/meaning.

The most important finding based on the accusative/possessive reflexive data, however, is that phoneme restoration based on prosodic contour can happen retroactively. It is apparently possible for a prosodic break not only to create strong expectations for upcoming material that supports a congruent restoration but also to influence a restoration in the preceding material. It is not clear what the mechanism of such restorations is, but possibly in the se/si ambiguity the noise-containing word is processed online as just a short form pronominal verbal complement (it follows a verb and an infinitival, so another verb phrase is projected) and this underspecified representation is fleshed out as a specific reflexive form when the structure is disambiguated further. Something of this nature may be happening in listening without phoneme replacement, because at the point of the reflexive particle in (1a) and (1b) it is not always clear what its function will be until the verb is processed: 'si' can be a dative form and 'se' is required by some verbs that do not take a direct object.

Alternatively, it is possible that one structure is assigned initially and is then confirmed by the prosodic contour or a reanalysis is initiated. Since the accusative structure is simpler (i.e. might well be the first guess) and is confirmed sooner, it has an advantage over the possessive.

Including the accusative/possessive reflexive ambiguity in the main experiments alongside the two constructions that had been tested in other languages created a richer data set and confirmed retroactive prosodic disambiguation, which promises to be an interesting phenomenon to explore in the future (See also some of the constructions in 7.3. below). The aim of the pilot experiment presented in the next section was to further expand the scope of this research program, by employing the phoneme restoration methodology to collect preliminary data on a range of other constructions in Bulgarian that have not been investigated previously in other languages.

## 7.3. Piloting other ambiguities: Experiment 6

### 7.3.1. Overview of experiment design and constructions tested in Experiment 6[64]

The pilot study used only the visual word response protocol that was described in Chapter 3 for Experiments 1a-c. This task was convenient to use for a preliminary exploration of new constructions because participants' responses require no additional coding (unlike the data from sentence repetition and shadowing) but are automatically extracted by the software and available for analysis. The goal was to collect preliminary data on a wider variety of constructions to see which of them might merit closer investigation with a larger set of items and possibly the other

[64] This research was facilitated by a grant from the CUNY Doctoral Student Research Grant Program.

response tasks. Some of the constructions used are more complex than others and not all of them were included to investigate prosodic effects. The types of test items included in Experiment 6 are summarized in Table 7-2 below with reference to the examples in the next section.

**Table 7-2.** Experimental items included in pilot visual word choice phoneme restoration experiment

| Construction | Contrast | Word choices | Example | Items |
|---|---|---|---|---|
| Pronoun co-reference ambiguity | Prosodic break presence and location<br><br>early V]N<br>vs. late VN]<br>vs. no break | go / ia<br>him / her | (5) | 24 |
| Sentence /contrastive clause ambiguity | Prosodic break type: sentential break vs. clausal | po / no<br>more / but | (7) | 12 |
| statement/contrast ambiguity | Clausal intonation: statement vs. contrast | če / no<br>that / but | (8) | 12 |
| statement/contrast disambiguated by semantics and prosody | Clausal intonation (statement vs. contrast) with preceding / following lexical disambiguation | če / no<br>that / but<br><br>šte / ne<br>will / not | (9) | 24 |
| PP attachment ambiguity | Phrasal grouping by prosody | ni / ne<br>us / not | (11) | 12 |
| Semantic (temporal adverbial) disambiguation | Early or late (before / after noise) | šte / ne<br>will / not | (10) | 24 |

7.3.2. Syntactic properties and relevant disambiguation for the different item types.

This section provides a brief description of each item and its characteristics relevant to the phoneme restoration experiment.

7.3.2.1. A pronoun co-reference ambiguity

The example in (5) below illustrates the pronoun co-reference ambiguity with supporting prosodic disambiguation. The location of each prosodic boundary is marked by ||.

(5) pronoun co-reference ambiguity

a. [Adv – *pro* - Acc pron – V1 ] [ NP (N1– Gen) – V2 – NP (direct object V2)]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Otkakto | **go** | napusna | \|\| | saprugat | i | zanemari | kaštata |
| since | him-Acc | left | | husband-det | her-Gen | neglect-past | house-det |

*Since (she) left him, her husband neglected the house.*

b. [Adv – Acc pron – V1 NP (N1– Gen) ] [ *pro* – V2 – NP (direct object V2)]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Otkakto | **ya** | napusna | saprugat | i | \|\| | zanemari | kaštata |
| since | her-acct | left | husband-det | her-Gen | | neglect-past | house-det |

*Since her husband left her, (she) neglected the house.*

The sentences in (5) are disambiguated by the gender of the accusative pronoun in the first (subordinate) clause, which is the direct object of the verb that follows and is co-referent with the subject of the second (main) clause. The pronoun is always the short form of the accusative personal pronoun and its distribution is similar to 'se' (see section 7.2.1), i.e. it is a clitic and it cannot be the first element in the VP. The co-reference relations are quite complex. In (5a) the first clause has a null subject and the NP (her husband) following the verb (*left*) is the subject of the second clause and it is also the co-referent of the pronoun 'go' (*him*). In (5b) on the other hand, the NP (*her husband*) is a post-posed subject of the first clause verb (*left*) and the second clause has a null subject, which is co-referent with the pronoun 'ya' (*her*). The syntactic components of the two clauses are shown in (5a) and (5b).

The accusative pronoun in (5) is always coreferent with the subject of the main clause: the NP in (5a) and *pro* in (5b). In addition, the null subject in both (5a) and (5b) is coreferent with the genitive. In related sentences which have an overt subject of the Adv clause, as in (6), the genitive will agree with it in gender/number, as in (6a) below. However, the overt subject makes that sentence less natural, perhaps redundant because of the overt pronoun and the N-Gen phrase.

(6)
a. Otkakto Maria go napusna, saprugat i zanemari kaštata.
since Maria him l eft husband her neglected house
*Since Maria left him her husband neglected the house.*

b. Otkakto ia napusna saprugat i, Maria zanemari kaštata.
Since her left husband her Maria neglected house
*Since her husband left her Maria neglected the house.*

In the materials for Experiment 6, the gender of the Gen pronoun and the overt NP was always contrasted and an equal number of feminine and masculine nouns were used, counterbalanced across lists. Thus, the coreference relations between the overt NP, the Genitive pronoun, the accusative pronoun and pro were not ambiguous originally.

In addition, the sentences are disambiguated by an IPh prosodic boundary between the subordinate clause and the main clause, marked by a boundary tone, which is located early (after the verb) in (5a) or late (after the NP) in (5b). The items were recorded with the appropriate prosody for each construction. In addition, a neutral prosody version was recorded which did not contain a boundary. The neutral prosody did not sound very natural, but was not entirely devoid of intonation as in the main experiments of this research. In the pilot experiment the neutral prosody was closer to a list intonation, with a small break after each stress-bearing word. It was recorded using a different lexical item (the plural accusative pronoun ‘ni’) in place of the gender-contrasting singular pronouns in (5), in order to avoid any inadvertent prosodic bias and eliminate any transitional cues which are possibly more obvious in the neutral prosody. The complete pronoun in all item versions was subsequently excised from the recording and replaced with white noise, creating the target stimuli. As with the stimuli in the previously reported experiments, the two utterances are now completely identical in segmental content, but the prosodic break location disambiguated the intended structure of the sentence. Only one of the two accusative pronouns makes the sentence interpretable and only one of them is consistent with each prosodic contour. Importantly, this is another case where, if phoneme restoration occurs, it must take place retroactively, because the disambiguation by prosody comes after the noise-replaced pronoun. Considering the complex co-reference relations that this construction requires to be established, finding a retroactive effect of prosody on phoneme restoration responses would be a testament to the strength of prosodic cues in parsing and would further validate the sensitivity of the phoneme restoration method.

7.3.2.2. A sentence-contrastive clause ambiguity

Another type of ambiguity tested, which contrasts a between-sentence break and a between-clause break, is illustrated in (7). The syntactic contrast here is similar to the accusative/possessive reflexive ambiguity sentences. Items like (7a) contain two consecutive statements expressed in two separate sentences, the second of which begins with a comparative '**po**' (*more*). Items like (7b) have contain two clauses in one complex sentence, the second clause beginning with the contrastive '**no' (***but*). The location of each prosodic boundary is marked in (7) by || and the direction of pitch change by an arrow.

(7) sentence-contrastive clause ambiguity

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| a. Svikna | s | kvartirata. | ‖↓ | Po- | rano | sutrin | se | drazneše | ot šuma |
| got used | to | rental | | compar | early | morning | refl | annoy-past | by noise |

*(S/he) got used to the place. Earlier (s/he) got annoyed by the noise in the morning.*

b. Svikna s kvartirata ||↑ no rano sutrin se drazneše ot šuma
got used to rental conj early morning refl annoy-past by noise
*(S/he) got used to the place, but early in the morning the noise was annoying.*

The two utterances shown in (7) both contain an IPh prosodic break at the same location, but they differ in what the typical prosodic contour of the sentence will be: (7a) contains an intonational phrase break with falling intonation at the end of the first sentence, while (7b) has a continuation rise at the end of the first clause, in the same position of the auditory string, to signal that a contrasted clause is coming. When the disambiguating word (**po**/**no**) is partially replaced by white noise to create the stimuli, the prosodic contour should indicate the intended meaning. This prosodic contrast is more subtle than the contrasts tested so far, because the two contrasting prosodic cues are realized in the same location, immediately preceding the noise-replaced word. It can be expected that the sentential break will be a stronger cue to the structure in (7a) than the clause break is for the structure in (7b).

7.3.2.3. A statement-contrast clause ambiguity

The example in (8) below illustrates a statement-contrast clause ambiguity. Each item of this type is a complex sentence, containing two clauses that are connected either by the complementizer **če** ‘*that*’ as in (8a), or the contrastive conjunction **no** ‘*but*’ as in (8b).

(8) statement-contrast clause ambiguity

a.
Napravi greška | **če** vednaga prizna vsičko na žena si
made$_{3p.sg}$ mistake that immediately admitted$_{3p.sg}$ everything to wife refl-Gen
*(He) made a mistake by immediately admitting everything to his wife.*

b.
Napravi greška ↑|| **no** vednaga prizna vsičko na žena si
made$_{3p.sg}$ mistake but immediately admitted$_{3p.sg}$ everything to wife refl-Gen
*(He) made a mistake, but he immediately admitted everything to his wife.*

The two structures differ in the following way. The former contains a main clause and a subordinate clause that is a complement of the noun (*mistake*) in matrix direct object position. The latter contains two coordinate clauses whose meanings stand in contrast to each other. These structures are summarized as follows, where optional adverbial elements are shown in parentheses.

a. [ (Adv) *pro* V1 N1 [that – (Adv) – *pro* - VP]]
b. [ (Adv) *pro* - V1 – N1] (conj) [(Adv) *pro* VP]

Prosodically, the complement clause sentence in (8a) has a final falling intonation (statement contour), with no major boundary between the two clauses, while the contrastive clause sentence in (8b) has an IPh break marked by rise and lengthening at the end of the first clause (contrast contour). When the disambiguating word (**če/no**) is replaced fully (as there are no segments that overlap) by white noise, the prosodic contour should indicate the intended meaning. This is a difference in type of prosodic cue rather than in the location of the prosodic break; therefore the effects of these prosodic contours are not expected to be as strong as the effects found in Experiments 1-3.

7.3.2.4. A statement-contrast clause ambiguity with two disambiguation sites

The example sentence pair in (9) below is similar in some respects to the sentences in (8) above. The sentence (9a) contains a main and subordinate clause which is a complement to the verb introduced by the complementizer '**če**' (*that*), and the sentence in (9b) contains two contrastive clauses linked by the conjunction '**no**' (*but*).

(9)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a. | Iskaše | i | se | da | viarva ↓\| | **če** | na | drugia | den | toj | **šte** | se | obadi |
| | Wanted | her | refl | to | believe | that | on | next | day | he | will | refl | call |

*She wanted to believe that he would call the next day.*

b. | Iskaše | i | se | da | viarva ↑\|\| | **no** | na | drugia | den | toj | **ne** | se | obadi
---|---|---|---|---|---|---|---|---|---|---|---|---|---
 | Wanted | her | refl | to | believe | but | on | next | day | he | not | refl | call

*She wanted to believe (him) but he did not call the next day.*

Prosodically (9) is also similar to the prosodic contrast in (8): a sentence like (9a ) will typically have a falling (statement) intonation at the end of the first clause with a smaller ip break, whereas a sentence like (9b) will typically have an IPh break with continuation rise at that location. Thus, the intonation contour should indicate the intended meaning.

One difference from (8) where the agent was the same in both clauses is that in (9) the two clauses have different agents. The first clause has a null subject and the second an overt pronominal subject (toj). A major difference from all the constructions described so far is that the sentences differ from each other not in one, but in two words, at separate locations in the sentence. The first lexical disambiguation is the word that connects the two clauses, just as in (8). The additional lexical disambiguation is the particle preceding the verb in the second clause. The main-subordinate clause structure (9a) contains a morphological marker for the future tense '**šte**' *(will)*, while the coordinate clause structure (9b) contains a morphological marker for negation '**ne**' *(not)*. The future particle shows that the subordinate clause in (9a) denotes a future event, so it fits as a complement to the main clause verb. The negation particle in the second clause in (9b) shows that the second clause contradicts the expectation expressed in the first clause.

Originally, these items were constructed in order to test multiple phoneme restorations in the same utterance, but they were used for a different purpose in the pilot experiment reported here. Only one of the lexical disambiguators in each item was replaced with white noise: either the earlier or the later one in different versions of an item. Thus, these items were all disambiguated by both morphology and prosody, but the point at which the noise-replaced word occurred was varied. In the examples in (9), when **če/no** were noise-replaced, the noise follows the prosodic cue but precedes the morphological cue; but when **šte/ne** were noise-replaced, the noise follows both the prosodic cue and the morphological cue. These doubly disambiguated items were included in the pilot experiment because they can be compared with the items like (8) where a similar prosodic contrast is not supported by lexical disambiguation and also to compare the restoration rates at the different sites. The expectation is that restorations at the later point, when both the lexical cue and the prosodic cue have already been processed, should be more stable, with fewer incongruent restorations, than when the noise-replaced word comes earlier in the sentence with only the prosodic cue preceding it (perhaps depending on which prosodic contour is present).

In the future, the doubly morphologically disambiguated items can be used in a sentence repetition or shadowing experiment with both disambiguating words in a sentence replaced by noise, to find out whether prosodic disambiguation will support multiple restorations.

7.3.2.5. Lexically disambiguated items

24 additional items illustrated in (10) below were included in the pilot experiment as fillers and resemble the last clause in (9). They contained the same future / negation contrast as (9), but were very short sentences disambiguated by a temporal adverb, the position of which was varied across versions. When the particles were replaced by while noise, it did not create ambiguity, because the adverb indicated future or past.

(10).

a. Drugia uikend mažat i **šte** hodi za riba.
next weekend husband her will go for fish
Next weekend her husband will go fishing.

b. Mažat i **šte** hodi za riba drugia uikend.
husband her will go for fish next weekend
Her husband will go fishing next weekend.

c. Minalia uikend mažat i **ne** hodi za riba.
last weekend husband her not go for fish
Last weekend her husband did not go fishing.

d. Mažat i **ne** hodi za riba minalia uikend.
husband her not go for fish last weekend
Her husband did not go fishing last weekend.

7.3.2.6. PP attachement to NP or VP

The sentence in (11) below illustrates a PP attachment ambiguity. These items contain a verb which is a three-place predicate and requires an overt goal argument like 'give' in this example 'dade', past tense form of 'davam'*(give*). They also contain a prepositional phrase (in this example '**na Nina**') that can modify the noun immediately preceding it (the direct object of the verb in (10a), or can modify the verb as in (10b).

(11) PP attachement to NP or VP

| | | | | | | |
|---|---|---|---|---|---|---|
| a. | ( Bibliotekarkata) | ( ni | dade ) | (knigata | na | Nima) |
| | Librarian-det | us-Dat | give-3p-past | book-def | of | Nina (Gen) |
| | *The librarian gave us Nina's book.* | | | | | |
| b. | (Bibliotekarkata | ne | dade | knigata) | (na | Nima) |
| | Librarian-det | not | give-3p-past | book-def | to | Nina (Gen) |
| | *The librarian did not give the book to Nina.* | | | | | |

In (11a) the goal argument position is overtly filled by the pronoun '**ni**' (*us*) which precedes the verb, and the prepositional phrase '**na Nina**' *(of Nina'***)** modifies the object noun **'knigata'** (*book*) Sentence (11b) contains a negative particle (**ne**, '*no*') in the preverbal position instead of the dative clitic. The goal position is then filled by the PP '**na Nina**' *(to Nina'***)** with the unmodified noun **'knigata'** (book) in the direct object position. Thus, the two sentences differ in one word through which each is disambiguated to a particular syntactic structure. They also differ in how the words are grouped prosodically: in (11a) the PP is part of the complex object NP, so both the PP and the noun are contained in the same minor prosodic phrase, whereas in (11b) the PP modifies the verb and is phrased separately from the noun[65]. However, the prosodic differences in this case are more subtle than in any of the other item types discussed above. Namely, there is no major prosodic boundary located at a relevant point or well-defined differences in the intonation contour, but simply different grouping of the words into minor prosodic phrases. These items were intended as a probe into whether minor prosodic phrases (ip) are effective structural cues in Bulgarian.

Once the disambiguating word is replaced with white noise, to create the experimental stimuli, the sentence is disambiguated only by prosody. The expectation is that these grouping cues will not be as effective as the grouping by major prosodic boundary placement in other constructions.

### 7.3.3. Pilot experiment with new ambiguities

*Stimuli*

Pairs of sentences of the types just illustrated were recorded using the same equipment and software as described in Chapter 3. Each pair except the **če/no, šte/ne** construction in (9) differed in a single lexical item (a phonologically light functional category) and in associated prosodic characteristics as discussed above. Afterwards, the relevant portion of the recordings (phonemes that differed between the sentence pair or the complete short word together with parts of the surrounding phonemes in order to eliminate transition cues) were excised and substituted with white noise that was averaged for duration across the durations of the corresponding phonemes

[65] There is also a slight phrasal accent on the object noun in (11a) and on the verb in (11b).

in the intact versions. The resulting sentence pair contained no phonemic cue to the intended meaning but preserved the original prosodic cues. All target item types incorporated prosodic disambiguation, either on its own or in conjunction with lexical disambiguation in materials like (9). The type and strength of prosodic characteristics providing the relevant structural cues differed for the different item types, ranging from sentence breaks to minor prosodic phrase and included prosodic grouping and intonation. Prosodic manipulations were in general binary, contrasting the relevant cues.

For one type of item, the **go/ya** (pronoun coreference) items illustrated in (5), a neutral (no break) prosodic contour was included in addition to the informative prosodic boundary locations contrast (early vs. late). This was intended as a source of a baseline preference for this construction. The experiments with neutral prosody only were very hard for participants and including a neutral prosody condition for all items in this experiment might have been disruptive, possibly obscuring effects of prosodic disambiguation. The doubly disambiguated items (9) crossed the relevant prosodic contour with the site of lexical disambiguation.

The lexically disambiguated items as in (10) manipulated the place (sentence initial/sentence final) and semantics (past/future) of the temporal adverb. Additional fillers were deemed unnecessary since the different types of constructions could act as distractors for each other. Four lists were compiled, each containing a total of 108 target and filler items, preceded by 4 practice items with feedback. The items in (9) and (10) had 4 versions and the items in (5) had three versions, but the neutral prosody was included in two lists only. The rest of the item types had two versions, which were repeated twice across lists, so that the data is from more participants.

*Method*

40 native speakers of Bulgarian, members of a local library/cultural center in the Zvezditsa neighbourhood in Varna, Bulgaria took part in the experiment. They were assigned to one of the 4 groups consecutively in order of participation.

The procedure, visual word choice, was exactly the same as in Experiments 1a-c. Participants' task was to listen to each sentence and indicate which of the two words that appeared on the screen post-sentence s/he had heard in the sentence.

*Expectations*

The items included in the pilot experiment were meant to test more subtle prosodic contrasts than the location of a major prosodic break that was shown to effectively disambiguate NP/S coordination and RC attachment. The contrasted prosodic cues in this experiment were in general not distinguished by location but by difference in strength and/or tonal realization. As in the previously reported experiments, the items were originally not globally ambiguous and prosody was only supporting the intended structure/meaning of the utterance. After the disambiguating word part was replaced by noise, listeners had to rely on the prosodic cues to restore the meaning. The main question of interest in this experiment was whether these more subtle prosodic disambiguations would support phoneme restoration congruent with the corresponding syntactic structure, and to what extent different prosodic cues would be effective as disambiguators.

7.3.4. Results and discussion

As with the constructions previously used in Experiments 1-3, the prosodic contours of the items in Experiment 6 influenced ambiguity resolution for all of the item types described above. However, the effects were not equal in size for all construction types. The phoneme restoration data for each construction in the pilot experiment are presented in this section and briefly discussed.

Data for the pronoun co-reference ambiguity, illustrated in (5) above, are given in Figure 7-4, coded as the percentage of phoneme restorations congruent with each prosody. As the graph shows, responses on these items differed by condition, but not as radically as on the ambiguities in the main experiments.

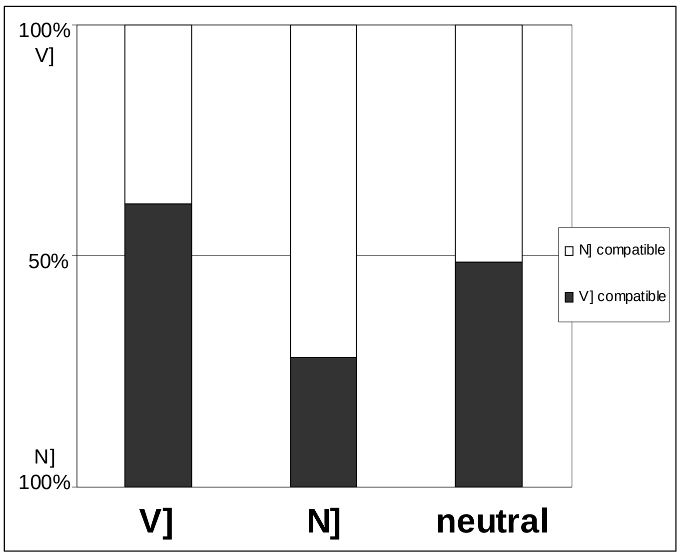



**Figure 7-4**. Phoneme restoration responses on pronoun co-reference items

For the pronoun co-reference (go/ya) items participants gave 61% responses consistent with early main clause interpretation (i.e. analyzing the ambiguous NP as the overt main clause subject, as indicated by the noise-word being interpreted as co-referent with that NP) when the item had an early prosodic break after the verb, and they gave 72% responses consistent with late main clause interpretation (i.e. analyzing the NP in the first clause as the postposed subordinate clause subject, as indicated by the noise-word being interpreted as not co-referent with that NP) when the item had a prosodic break after the noun. For these items, a neutral prosody condition was included as a within-subject control. When there was no prosodic break in the recording, participants performed at chance, choosing the main-clause subject interpretation 49% of the time. An analysis of variance reveals a main effect of prosody $F(2,22) = 15.3$ $p<0.001$. The responses in the two informative prosodic conditions indicate that, as in Experiment 1a-b, the location of the prosodic break was a reliable structural disambiguation cue. The data for this construction are not as clear-cut as for the NP/S-coordination and RC-attachment data (i.e. the data points for the two prosodies are less sharply different), but that is quite understandable. First of all, the morphological disambiguation of this construction is not achieved through a straightforward agreement between head and modifier or object and verb, but requires more complex computations for establishing co-reference on the part of the listener in order to utilize the prosodic cue. Secondly, as noted in section 7.3.2.1 above, phoneme restoration here is performed retroactively. The inclusion of neutral prosody as a within-subject factor may possibly be yet another reason. The fact that listeners hear some (albeit quite few) sentences that sound unnatural may actually devalue the prosodic cues when those are. This is not certain, but it is a possible indicator that mixing neutral prosody in with informative prosody is not a wise tactic.

An additional finding of interest is that for this construction, as for the RC ambiguity and the accusative/possessive reflexive construction, one contour (in this case the late break after the noun) is more effective than the other one (early break after the verb). A paired t-test shows that the difference is statistically significant by subject $t1(39)=2.51$, $p< 0.016$; $t2(23)=0.15$ $p< 0.884$. It is not clear why the late break prosody is more salient. It may be related to something in the syntax: the structure associated with that prosody has a post-verbal subject, which is a non-canonical word order. Or possibly this contour is supported by the preference to delaying opening of the next clause (Late Closure). The contrast in (5) is not unlike the ”early closure/late closure” ambiguity discussed in chapter 1 (section 1.2) and elsewhere in this dissertation.

The data for the sentence / clause break items illustrated in (7) are given in Figure 7-5 below, coded as phoneme restoration responses congruent with each contour.

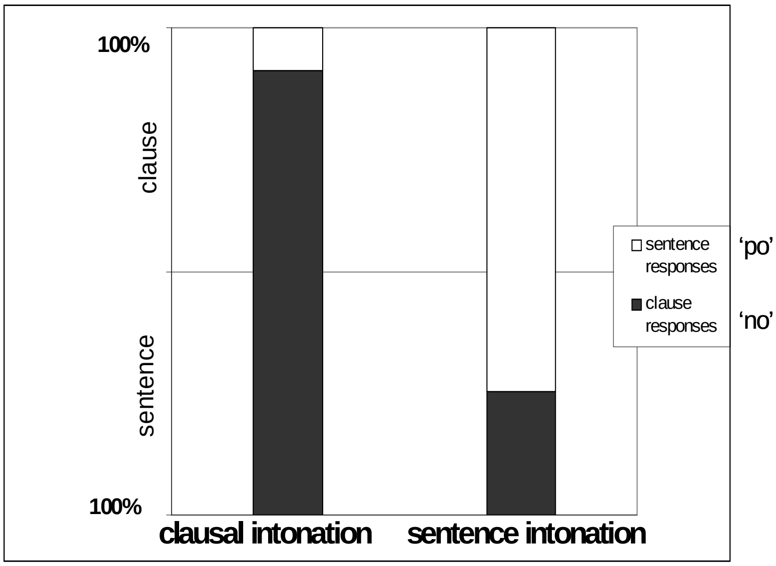



**Figure 7-5**. Phoneme restoration responses on sentence-clause ambiguity

As can be seen from the graph, the data pattern is not symmetrical for this type of ambiguity. Participants preferred the contrast ('but') interpretation 91% of the time with the clausal break contour (continuation rise at the end of the first clause). They favored the follow up statement interpretation 71% of the time with the sentence break contour (intonational phrase boundary with falling intonation) at the same location. While there is a significant difference in phoneme restoration responses between these two conditions, the data show an overall bias toward the contrast interpretation. Since the prosodic breaks occur at the same locations in both sentence versions, that preference is probably not a parsing bias, but it may be an induced prosodic bias. Although each structure has a typical prosodic contour, the two prosodic contours are not on a par as cues to structural disambiguation. The clause break with continuation rise (contrast intonation) is associated strongly with a particular interpretation (contrasted clauses) and does not allow the alternative (follow-up sentence) interpretation. However, the other intonation contour (sentential IPh break, with falling intonation) is less specific. While it rules out an analysis with two clauses in one sentence, it does not disallow a contrasting follow-up sentence, in which the contrastive conjunction 'no' begins a well-formed sentence that expresses a follow up statement contrasting with the previous (complete) sentence. It is also a fact that the comparative morpheme 'po'(*more*) is more restricted in use than the contrastive 'no' (*but*), which could also be a contributing factor, undermining the impact of the prosodic contrast in this particular construction. This could be explored in future experiments. The important point to note, however, is that the prosodic contour does disambiguate this construction, albeit not equally well for both versions. This adds significantly to the previous findings, because the relevant prosodic cues in this item type are realized in the same location for the two versions, whereas for the other constructions discussed so far there was a difference in the location of the prosodic break.

The data on the statement – contrast intonation, illustrated in (8) is presented in Figure 7-6 below, coded as phoneme restoration responses congruent with each prosodic contour. As in cases discussed earlier, the responses for sentences of type (8) show one contour (statement) producing more congruent restorations than the other (contrast).

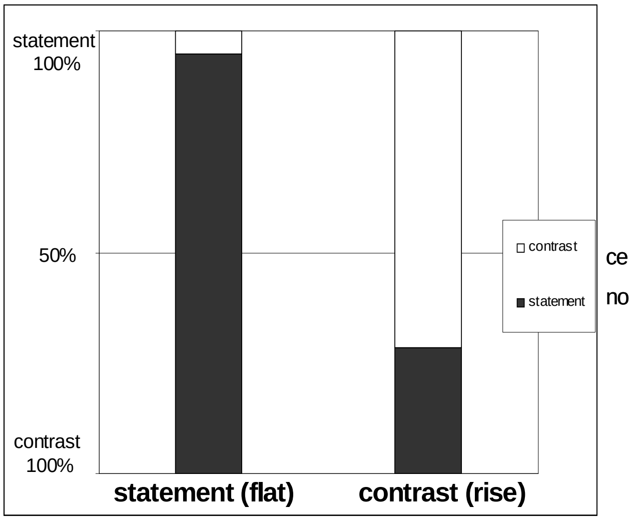



**Figure 7-6**. Phoneme restoration responses on statement-contrast (8)

Figure 7-6 shows that for the statement/contrast alternation (8), participants chose the prosody-congruent statement interpretation 94% of the time when the first clause had a statement contour (final falling intonation) and chose the prosody-congruent contrast interpretation 72% of the time when the first clause had a contrast contour (continuation rise and lengthening). An analysis of variance shows a main effect of prosody $F_1(1,36) = 27.3$ $p<0.001$; $F_2(1,10) = 39.5$ $p<0.001$.

The fact that both prosodic contours disambiguate quite well fits with the data for the previously discussed construction (7), because this is another case where the intonation contour rather than a prosodic phrasing break location disambiguates. But there is a difference. The statement contour is more helpful in this construction (8), whereas the contrast intonation was more helpful in (7). So it can be concluded that it is not the case that one prosodic contour is more salient or effective in general. Rather, as suggested above, the difference may be related to how closely each type of prosody is associated with one particular structure/meaning. In (7) the contrastive intonation blocks the alternative meaning (statement) but the sentential break (which is acoustically the stronger cue) is less influential because it allows the alternative meaning (contrasted sentence) and thus allows the alternative lexical item (contrastive conjunction ‘no’) as a coherent constituent of the sentence. In (8) the statement intonation blocks the alternative meaning (contrast), whereas the so-called ‘contrast’ intonation may be more inclusive, compatible with continuation as well as contrast, and therefore would not block a subordinate clause interpretation.

It is noteworthy that in both cases one prosodic contour - but not always the same one - appears to be less decisive, more open to different interpretations, while the other has a specialized function and excludes any alternative interpretation. This may be just a fact about prosodic (or at least intonational) contours in Bulgarian, but it may also be a more general property of prosody in many languages. At very least, it suggests that this factor (i.e., *how* disambiguating a prosodic contour is for syntactic structure) should be taken into account in future experiments investigating prosodic disambiguation of syntax.

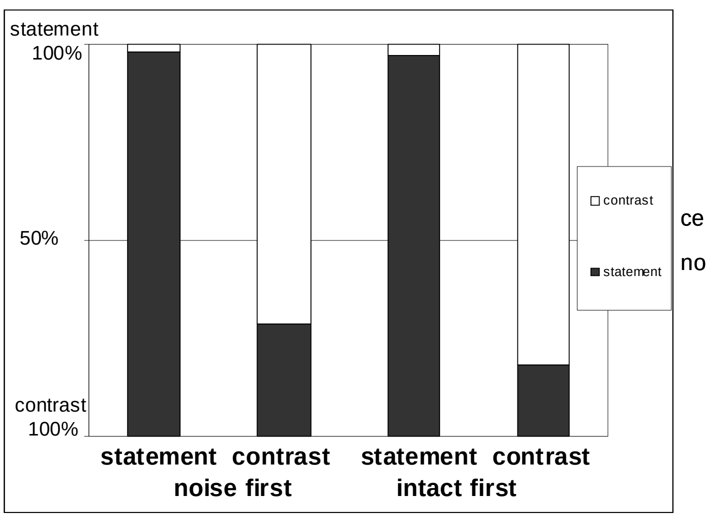



**Figure 7-7**. Phoneme restoration responses on statement contrast with lexical disambiguator

Figure 7-7 shows the data for items like (9), where both prosodic and lexical cues to the intended interpretation were available even after phoneme replacement in one location. It was expected that participants would perform with high accuracy, regardless of prosody, due to the definitive morphological cues, though possibly depending on where the cues were located. However, it was found that the morpholexical cues were not decisive.

The results indicate that listeners' performance did depend to some extent on where the lexical disambiguation occurred. When the item was presented with a statement contour (falling intonation), participants chose the word compatible with statement interpretation 98% of the time when lexical disambiguation was available early (only the second of the two potentially disambiguating words was replaced with noise) and 97% when it was available late (the first potentially disambiguating word was replaced with noise). However, when the item was presented with a contrast intonation contour (a continuation rise at the end of the first clause), participants chose the prosody congruent contrast interpretation 82% of the time when lexical disambiguation was available early and 71% of the time when it was available late. An analysis of variance shows a main effect of prosodic-lexical disambiguation type $F(1,36) = 625$ $p<0.001$. Thus, the combination of prosodic and lexical disambiguation is not equally effective in all conditions. With the statement contour it did not matter whether lexical disambiguation came early or late in the sentence; accuracy was at ceiling in both cases. With the contrast contour, there were more non-congruent restorations for (9) overall, and late lexical disambiguation was associated with more errors than early lexical disambiguation. An analysis of variance show that the order of the lexical disambiguator and the noise word had an effect on restoration rates $F(1,36) = 9.83$ $p<0.003$.

The difference in effectiveness of the two contours is the same as in (8), which is not surprising since they have a similar overall structure. But the responses for (9) not only match the responses for (8) directionally; when the lexical disambiguation comes late they are very close numerically. Given that the items of type (9) provide two cues to the intended interpretation by prosody and morpho-lexical identification, it is surprising, that they pattern with the items where only prosodic disambiguation is provided (8). It appears that the late lexical disambiguation is received too late to overcome an interpretation of the noise-word that was made without its benefit, earlier in the on-line processing. However, even the early lexical disambiguation did not prevent 18% of errors. It is unclear why the strong lexical cues do not boost performance more.

The data for the prepositional phrase attachment items illustrated in (10), is shown in Figure 7-8 below. With these items participants prefer the noun modification (low PP attachment) interpretation 76% of the time when the PP was phrased together with the object noun, and 46% of the time when they were phrase separately.

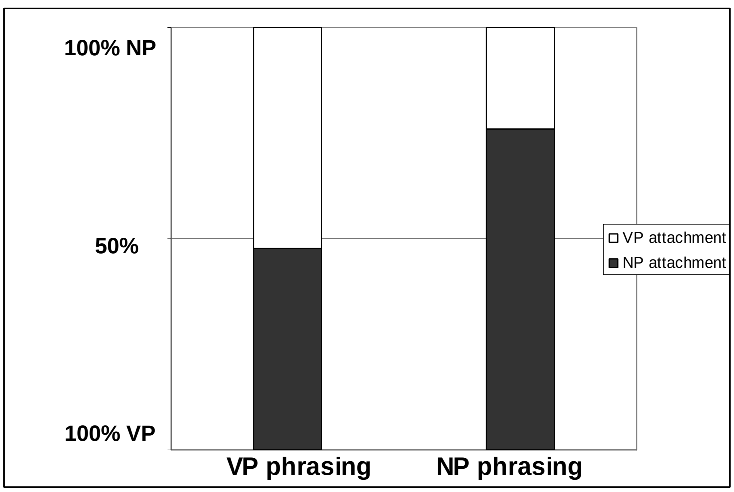



**Figure 7-8**. Phoneme restoration responses on PP attachment to VP or NP

Responses with the two kinds of phrasing were found to be reliably different from each other in an analysis of variance $F_1(1,36) = 17.8$ $p<0.001$, but the response rate for the separate phrasing condition is not different from chance, although it shows a numerical difference in the expected direction. Only the phrasing of the PP with the noun was helpful in disambiguating, $t_1(19)= 0.5036$, $p>.05$; $t_2$ $(11)=1.6896$, $p>.05$. The weak results for this comparison are probably due to the fact that the prosodic contrast here is much more subtle and it is also disambiguated later than the site of phoneme restoration, so it has to be restored retroactively.

Still, the fact that only one contour was helpful fits with the data for other constructions in Bulgarian that showed asymmetry of prosodic effects and in particular the RC attachment ambiguity which was explored in depth.

To sum up, phoneme restoration responses in the visual word choice task reveal that most constructions tested in this pilot experiment were disambiguated by prosodic information toward one interpretation or the other, and it has uncovered some interesting questions for future investigation. One concerns the linguistic complexity of the linkage between the prosodic contour and the sentence interpretation. Prosodic break location did not disambiguate the pronoun co-reference items like (5) as well as it disambiguated the two constructions in the main experiments. This was most probably due to the complexity of the co-reference relations that needed to be established for this construction. Also emerging from this broad pilot study is the existence of asymmetries in the effectiveness of different prosodic contours as disambiguators for some of the constructions tested (as also for the RC-attachment construction in the main experiments). Although each prosodic contour is preferentially associated with one sentence structure, the association may not be one of uniqueness but rather a degree of exclusiveness: one prosodic contour excluded all alternative interpretations, while the other was open to them. In future work it will be worthwhile to explore what determines whether or not a prosodic contour fully excludes alternative interpretations, and whether particular asymmetries are language-specific or possibly universal.

## 7.4. Improvements and extensions of the methodologies employing phoneme restoration

The data on the NP/S coordination and RC attachment ambiguities collected with the three response tasks in the main experiments of this research (Chapter 3 and Chapter 4) have validated the phoneme restoration paradigm as an accurate and sensitive tool for future ambiguity resolution research. The data on a set of other ambiguities in Bulgarian obtained with the visual word choice task in the subsequent pilot experiment have shown some potentially interesting effects that will be worth investigating more deeply in future research. The investigation as a whole has yielded ideas for the future: ideas for improvement of the details of the phoneme restoration protocol and associated response tasks, and ideas for new applications of this methodology in psycholinguistics.

### 7.4.1 Recommendations for improvements to the phoneme restoration protocol and response tasks

The response task employed with phoneme replaced materials should not be so difficult for participants that is interferes with their normally efficient sentence processing routines. In this respect, the sentence shadowing task discussed in Chapter 4 fell a little short. However, in conjunction with phoneme replacement, speech shadowing could potentially deliver valuable information about the timing of different levels of processing. If this is undertaken in future research it is recommended that participants receive adequate pre-training, and that a target sentence should if possible be embedded toward the end of a longer passage so that performance will have settled into a comfortable and fairly close shadowing rate by the time the critical phoneme-replaced words are encountered.

With respect to the sentence repetition and sentence shadowing tasks, not pre-testing more rigorously the time-out for responses was an unfortunate oversight in the present experiments, costly in terms of missing data. Since different people speak at different rates, a generous recording time is advisable, as long as participants can stop their recording when complete so that fast speakers do not have to wait through a long pause before the next item presentation.

In all the auditory experiments in this research, participants were stumped by the neutral prosody condition, which in fact did not sound natural and was defined as ‘mechanical’ by some participants. Concern about this was the reason the neutral prosody was used in separate experiments (with one exception in the pilot experiment 6), instead of in direct three-way contrast with the informative prosodic contours. The data collected in the neutral prosody condition did prove to be interesting in the context of this research, as it indirectly supported the finding that prosody is essential for normal sentence processing, but it could not be regarded as a neutral baseline for comparison. This may not be the case for all languages. In English, researchers (e.g. Kielgaard and Speer, 1999) have used a neutral prosody condition as a reference point. But in a language like Bulgarian, where clause-edge prosodic breaks cannot be omitted without making the sentence sound unnatural, it would be better to dispense with the neutral prosody condition.

The short informal exit questionnaire provided some insight into how participants perceive the task and the nature of the stimuli. Implementing a more richly structured exit-questionnaire in future experiments could be useful, in particular using questions that include a quantifiable scale rather than open-ended ones. For example, we can ask “Did you find the sentences easy to understand?” and provide a scale with possible answers, so that a participant could pick a range they think is appropriate from scale point (1) “Yes, none of them was hard.” to scale point (7) “No, most of them were hard to understand.” Answer choices could be offered as in: “I found the noise that sometimes was heard in the headphones: (a) loud (b) distracting (c) annoying (d) acceptable (e) did not bother me.” An ideal option might be to provide a range of answers but leave space for open-ended comments also. The aim in all cases would be to discern whether participants are consciously guessing for appropriate target words as a strategy, or whether they are naturally integrating the phoneme-replaced words into the input stream and parsing as they would in normal language processing. In this regard, a comparison of exit-questionnaire responses for the auditory and the visual presentation experiments could be informative, on the assumption that readers of the ‘ink-blot’ materials are aware that some part of the stimulus has been deliberately withheld from them.

Researchers interested in pinning down whether the phoneme restoration effect is an authentic auditory illusion could follow the lead of the discrimination (d-prime, d′) analysis employed by Samuel (1996). It could be implemented perhaps as a two-step task with a single-word probe task in which participants first answer whether the word was in the sentence they heard, then make a judgment on whether it was partially overlaid by noise or partially replaced by noise. However, this procedure would draw attention to the location of the noise in the sentence, and would not be consistent with the aim of eliciting maximally natural responses uninfluenced by awareness of the special properties of the materials. As an alternative, in the sentence repetition task it would be possible to ask the participant after each sentence presentation to say which word the noise overlapped with. If they cannot do this accurately (as suggested by informal reports from previous studies) that would seem to be good evidence that they are mis-hearing the relation between the noise and the linguistic properties of the sentence, as occurs in ‘click-location’ experiments (Fodor, Bever & Garrett 1974).

For the visual presentation experiments, naturalness could perhaps be improved by using some masking device other than a simulated ink-blot and perhaps masking at least one more (irrelevant) word in the sentence. One variant, currently being employed in research in progress on prosodic influences on French sentence processing by Hemforth, Colonna and Fodor, uses a vertical line moving back and forth across a screen, which sometimes stops at a location where it masks the relevant portion of a disambiguating word in a target sentence. Another approach might be the appearance of a ‘pop up’, as suggested in Chapter 6, section 6.5, which is a common occurrence when reading on the internet. This may have the advantage of combining naturalness of masking with naturalness of presentation. The sentence can be displayed on the screen with a desirable layout and line-break(s) and made to appear as part of a larger printed text that has been blurred around it.

Another way to improve the presentation of the visual materials would be by using variable-rate RSVP as was done by Fernández (2007) to control the presentation rate and make it resemble the rate of speech (see Chapter 6, section 6.1.1).

### 7.4.2 New applications of this methodology in psycholinguistics

As noted, the phoneme restoration paradigm is potentially applicable to studying other factors in sentence processing besides prosody, such as plausibility. For example, Thornton and MacDonald (2003) report an experiment on the effects of plausibility on subject-verb agreement errors. Participants see a verb on the screen, e.g. ‘PRAISED’ then hear a spoken sentence fragment (a complex noun phrase that has a singular and plural noun), e.g. 'the album of the classical composer(s) and have to produce a passive sentence starting with the noun phrase and using the verb they saw. In some conditions the verb creates a bias that may result in an agreement error. The repetition task with phoneme restoration could perhaps supply the same data without the visually presented verb. Instead the sentence could contain an auxiliary verb obscured by noise replacement and participants would repeat the sentence they had 'heard'.

One of the most promising aspects of the phoneme restoration method is that it can be adapted for studying sentence processing in children and other non-literate populations. Despite the extraordinary sensitivity of infants to prosodic patterns (e.g. Christophe et al., 2003), there are indications that children are less competent than adults at establishing relations at the interface between prosody and lexical/syntactic structure (Cutler & J. A. Fodor, 1979) or integrate rapidly prosodic information into their on-line syntactic processing (e.g. Sekerina and Trueswell, 2011). There are reports indicating that young children are capable of phoneme restoration (e.g. Walley, 1988; Newman, 2004) and the sentence repetition (or elicited production task) has been used with children (e.g. Lust et al., 1996) and is something children will do naturally. With materials of appropriate complexity, especially if presented attractively (e.g. a puppet show where children have to parrot what they hear) it can be used with children to investigate the developmental course of prosodic sensitivity (see section 4.4.3). Like the Visual World approach (Wagner & Watson, 2010) the sentence repetition task with phoneme restoration does not require any reading; and the visual word choice can perhaps be redesigned as a picture choice task.

A possible practical limitation on the extension of phoneme restoration methodology in psycholinguistic research is that it may not be suited to all languages. For Bulgarian, the prevalence of inflections and particles makes it possible to craft sentence pairs that differ only in one or two phonemes within a functional morpheme and yet which differ radically in their syntactic structure due to the syntactic role of that morpheme. Then, replacement of the distinguishing phoneme creates a syntactic ambiguity in what would otherwise not be ambiguous sentences, as well as enabling the experimenter to detect how that ambiguity is resolved on-line. Other languages have this property also, e.g., Turkish, Finish. For languages more impoverished in this regard, like English, there are fewer opportunities to create ambiguities with PR in functional morphemes, though perhaps examples can be composed with pronouns or prepositions or auxiliary verbs. Nothing in principle rules out use of phoneme replacement within full lexical items, content words such as nouns and verbs. The early PR experiments by Warren and colleagues (e.g. Warren, 1970; Warren & Sherman, 1974; Bashford & Warren, 1987) replaced phonemes in content words. The results of Samuel (1981) indicate that phoneme restoration is strong in content words when only a unique restored phoneme can create a valid word, though not so strong when there is ambiguity, i.e., two or more possible restorations. It would need to be explored to what extent this would be an impediment, since multiple possible restorations are required for the methods presented here. Also, it may be more difficult to manipulate syntactic structure by obscuring a contrast between two content words than a contrast between two function words, so this approach might be easier to employ for studying semantic rather than syntactic ambiguities in such languages.

### 7.5. Conclusion

This investigation validated a new method for studying ambiguity resolution and collected data and demonstrated prosodic effects on ambiguity resolution in Bulgarian, a language that has not been studied much in sentence processing. The phoneme restoration data from Bulgarian fits the data on the two constructions from other languages. The data collected on the NP/S coordination ambiguity in Bulgarian shows definitive disambiguation by prosodic boundary placement as was found for another coordination construction in English (Clifton et al., 2006). The data on collected RC attachment in Bulgarian shows asymmetric effects of prosody similar to those found in Croatian (Lovrić, 2003), English (Fernández, 2007) and Spanish (Igoa and Teira, 2004; Fernández, 2007).

The phoneme restoration technique (in any of its three variants, and extending to grapheme restoration also, if appropriate) can be applied to study other matters besides the syntax/prosody interface. It could be used to test the influence on ambiguity resolution of non-acoustic factors of interest, such as lexical frequency, syntactic priming, information structure and discourse context.

# Appendix A: materials

## Appendix A-1: Target items in experiments 1-5: NP/S coordination

This appendix lists the 24 NP/S coordination items (sentence pairs) used as auditory stimuli in the phoneme restoration experiments reported in Chapters 3 and 4 and as visual (written) stimuli in the experiments reported in Chapter 6.

The NP/S coordination items consisted of two coordinated clauses and contained a sequence of three NPs, two of which formed an NP coordination construction whose location was disambiguated by the number of the second clause verb. More details are given in Chapter 3. The three nouns in half of the items were proper names and in the other half common nouns.

All NP/S coordination items had short and long versions. The short versions of the items only were used as auditory stimuli for phoneme restoration in Experiment 1a (visual word choice), Experiments 2a-b (sentence repetition) and Experiments 3a-b (sentence shadowing), as well as visual stimuli for grapheme restoration in Experiments 5a-b (silent reading with sentence repetition). Both the short and the long versions were used as auditory stimuli for phoneme restoration in Experiment 1b-c (visual word choice), as well as visual stimuli for grapheme restoration in Experiments 4a-b (silent reading with visual word choice).

Short version
Long version

1. Nakraia srešnahme Ani i Ivan i Mimi **biaha / beše** vav vaztorg.
   In end meet-1pl-past Ani and Ivan and Mimi were/was in ecstasy
   'In the end we met Ani and Ivan and Mimi were/was ecstatic.'

   Nakraia srešnahme Aneta Markova i Ivaylo Stavrev i Mariela Peeva **biaha / beše** vav vaztorg.
   In end meet-1pl-past Aneta Markova and Ivaylo Stavrev and Mariela Peeva were/was in ecstasy
   'In the end we met Aneta Markova and Ivaylo Stavrev and Mariela Peeva were/was ecstatic.'

2. Večerta pokaniha Petio i Dora i Marin **biaha / beše** v čudesno nastroenie.
   Evening invite-past Petio and Dora and Marin were / was in wonderful mood
   'That evening they invited Petio and Dora and Marin were/was in a wonderful mood.'

   Večerta pokaniha Petar Zahariev i Dora Aleksieva i Marin Petkov **biaha / beše** v
   Evening invite-past Petar Zahariev and Dora Aleksieva and Marin Petkov were/was in
   čudesno nastroenie.
   wonderful mood

‘That evening they invited Petar Zahariev and Dora Aleksieva and Marin Petkov were/was in a wonderful mood.’

3. Parvo zakarahme Anton i Vania i Ema **biaha / beše** oše v taksito.
First drove-1p-pl-past Anton and Vania and Emma were/was still in taxi
‘First we dropped off Anton and Vania and Ema were still in the cab.’

Parvo zakarahme Anton Makaveiski i Vania Penkova i Emilia Koleva **biaha / beše**
First drove-1p-pl-past Anton Makaveiski and Vania Penkova and Emilia Koleva were/was
oše v taksito.
still in taxi
‘First we dropped off Anton Makaveiski and Vania Penkova and Emilia Koleva were/was still in the cab.’

4. Edva dnes naučih za Mišo i Sonia i Vili **biaha / beše** s men kato mi saobštiha.
Just today lean-past about Mišo and Sonia and Vili were /was with me when me notify-past
‘I just learned today about Mišo and Sonia and Vili were there when they told me.’

Edva dnes naučih za Mišo Vasilev i Sonia Koleva i Violeta Toneva **biaha / beše**
Just today lean-past about Mišo Vasilev and Sonia Koleva and Violeta Toneva were /was
s men kato mi saobštiha.
with me when me notify-past
‘I just learned today about Mišo Vasilev and Sonia Koleva and Violeta Toneva were / was there when they told me.’

5. Sledobed se razhodihme v parka s Reni i Dian i Polia **biaha / beše** v kafeneto do rozariuma.
Afternoon refl walk-past in park with Reni and Dian and Polia were / was at coffee place next to rose garden
‘We went for a walk in the park with Reni and Dian and Polina was / were at the coffe-shop next to the rose garden.’

Sledobed se razhodihme v parka s Reni Aleksandrova i Dian Petkov i Polina Miteva
Afternoon refl walk-past in park with Reni Aleksandrova and Dian Petkov and Polia Miteva
**biaha / beše** v kafeneto do rozariuma.
were / was at coffee place next to rose garden
‘We went for a walk in the park with Reni and Dian and Polina was / were at the coffe-shop next to the rose garden.’

6. Kam 10 časa se obadi na Elka i Rumen i Valia estestveno **biaha / beše** veče na rabota.
Around 10 o’clock refl call to Elka and Rumen and Valia naturally were / was already at work
‘Around 10 (s/he) called Elka and Rumen and Valia of course were/was already at work.’

Kam 10 časa se obadi na Elka Rosenova i Rumen Dimitrov i Valia Angelova
Around 10 o’clock refl call to Elka Rosenova and Rumen Dimitrov and Valia Angelova
estestveno **biaha / beše** veče na rabota.
naturally were / was already at work
‘Around 10 (s/he) called Elka Rosenova and Rumen Dimitrov and Valia Angelova of course were/was already at work.’

7. Snošti vsički govoreha samo za Ivo i Sevda i Tedi **biaha / beše** na sedmoto nebe.
Last night everybody talk-past only about Ivo and Sevda and Tedi were / was in seventh heaven
'Last night everybody was talking only about Ivo and Sevda and Tedi were/was in seventh heaven.'

Snošti vsički govoreha samo za Ivelin Zahariev i Sevdalina Dobreva i Teodora Bineva
Last night everybody talk-past only about Ivelin Zahariev and Sevdalina Dobreva and TeodoraBineva
**biaha / beše** na sedmoto nebe.
were / was in seventh heaven
'Last night everybody was talking only about Ivo and Sevda and Tedi were/was in seventh heaven.'

8. V nedelia otidohme do ezeroto s Maya i Gheri i Dančo **biaha / beše** na edna ot lodkite.
On Sunday went-past to lake-det with Maya and Gheri and Dančo were/was on one of boats-det
'On Sunday we went to the lake with Maya and Gheri and Dancho were/was in one of the boats.'

V nedelia otidohme do ezeroto s Maya Valkova i Ghergana Vaseva i Dančo Gospodinov **biaha / beše** na edna ot lodkite.
On Sunday went-past to lake-det with Maya Valkova and Ghergana Vaseva and Dančo Gospodinov were/was on one of boats-det
'On Sunday we went to the lake with Maya Valkova and Ghergana Vaseva and Dančo Gospodinov were/was in one of the boats.'

9. Minala sedmitsa se skara s Angel i Bistra i Lili **biaha / beše** v roliata na bufer.
Last week refl fought with Angel and Bistra and Lili were / was in part of buffer
'(S/he got into a fight with Angel and Bistra and Lili were /was the go-between.'

Minala sedmitsa se skara s Angel Ovčarov i Bistra Simeonova i Lili Peikova
Last week refl fought with Angel Ovčarov and Bistra Simeonova and Lili Peikova
**biaha / beše** v roliata na bufer.
were / was in part of buffer
'(S/he got into a fight with Angel Ovčarov and Bistra Simeonova and Lili Peikova were /was the go-between.'

10. V danoto na salona merna Kosio i Zara i Rosen **biaha / beše** pred kaminata.
In back of salon glimpsed Kosio and Zara and Rosen were/was in front of fireplace
'In the back of the room s/he caught a glimpse of Kosio and Zara and Rosen were (sitting) in front of the fireplace.'

V danoto na salona merna Konstantin Tsevetkov i Zara Božilova i Rosen Mladenov
In back of salon glimpsed Konstantin Tsvetkov and Zara Božilova and Rosen Mladenov
**biaha / beše** pred kaminata.
were/was in front of fireplace
'In the back of the room s/he caught a glimpse of Konstantin Tsevetkov and Zara Božilova and Rosen Mladenov were (sitting) in front of the fireplace.'

11. Ne se znaeše koj šte naseldi delata na Aleksei i Dimitar i Iulia **biaha / beše** v panika.
Not refl known who will inherit cases of Aleksei and Dimitar and Iulia were/was in painc
'Nobody knew who will get the cases of Aleksei and Dimitar an Iulia were/was panicking.'

Ne se znaeše koj šte naseldi delata na Aleksei Osetinov i Dimitar Avramov i Iulia
Not refl known who will inherit cases of Aleksei osetinov and Dimitar Avramov and Iulia
Karamaneva **biaha / beše** v panika.
Karamaneva were/was in painc
'Nobody knew who will get the cases of Aleksei Osetinov and Dimitar Avramov and Iulia Karamaneva were/was panicking.'

12. Neobmislenata sdelkata razori Sašo i Boris i Ivana **biaha / beše** zle finansovo.
Thoughtless-det business deal ruined Sašo and Boris and Ivana were/was ill financially
'The poorly planned business deal ruined Sašo and Boris and Ivana were/was in bad shape financially.'

Neobmislenata sdelkata razori Sašo Kalkandžiev i Boris Goranov i Ivana Štereva
Thoughtless-det business deal ruined Sašo Kalkandžiev and Boris Goranov and Ivana Štereva
**biaha / beše** zle finansovo.
were/was ill financially
'The poorly planned business deal ruined Sašo Kalkandžiev and Boris Goranov and Ivana Štereva were/was in bad shape financially.'

13. Predi godina podpailha fabrikata i sklada i dvora **biaha / beše** grozna gledka.
Before year fire-pl-past factory-det and storage-det and yard-det were/was ugly sight
'A year ago someone set fire in the factory and the storage facility and the yard were/was an ugly sight.'

Predi godina podpailha starata fabrika i sasednia sklad i zapustelia dvor **biaha / beše** grozna
Before year fire-pl-past old-det factory and nearby storage and yard-det were/was ugly
gledka.
sight
'A year ago someone set fire in the old factory and the nearby storage facility and the abandoned yard were/was an ugly sight.'

14. Edva smogvaše da otopliava spalniata i kuhniata i hola **biaha / beše** sašinski
Barely manage-past to heat bedroom-det and kitchen-det and living room were/was real
hladilnik.
fridge
'(S/he) barely managed to heat the bedroom and the kitchen and the living-room were / was like a fridge.'

Edva smogvaše da otopliava ednata spalnia i tiasnata kuhnička i mračnia hol
Barely manage-past to heat one-det bedroom and tiny-det kitchen and dark living room
**biaha / beše** sašinski hladilnik.

were /was real fridge
'(S/he) barely managed to heat one of the bedrooms and the tiny kitchen and the dark living-room were/was like a fridge.'

15. Staiata ni gledaše kam moreto i parka i tsentara ni **biaha / beše** nablizo.
Room our look-past toward sea-det and park-det and center-det us were/was nearby
'Our room overlooked the sea and the park and the (town)center were/was close.'

Staiata ni gledaše kam morskia briag i razkošnia park i tsentralnata ulitsa
Room our look-past toward sea-det shore and beautiful-det park-det and center-det street
ni **biaha / beše** nablizo.
us were/was nearby
'Our room overlooked the sea shore and the beautiful park and the main street were/was close.'

16. Plati v broj za materialite i dostavkata i raztovarvaneto **biaha / beše** za smetka
Pay-past in cash for materials-det and delivery-det and unloading-det were/was for account
na stroitelnata firma.
of building company
'(S/he) paid cash for the materials and the delivery and the unloading were/was paid by the building company.'

Plati v broj za vsički materiali i ekspresnata dostavka i tovaro-raztovarvaneto **biaha /**
Pay-past in cash for all materials-det and express-det delivery and loading-unloading-det were/
**beše** za smetka na stroitelnata firma.
was for account of building company
'(S/he) paid cash for all the materials and the express delivery and the loading-unloading were/was paid by the building company.'

17. Prez may pusnaha singala i klipa i albuma **biaha / beše** siguren hit
During May release-past single-det and video-det and album-det were/was sure hit
'In May they released the single and the video and the album were/was a sure hit.'

Prez may pusnaha zakačlivia singal i predizvikatelnia klip i novia im album **biaha / beše**
During May release-past catchy-det single and provocative video and new-det their album were/was
siguren hit
sure hit
'In May they released the catchy single and the provocative video and their new album were/was a sure hit.'

18. Parvo nahrani ribkite i koteto i kučeto **biaha / beše** v ochakvane na svoia red
First feed-past fish-pl-det and kitten-det and dog-det were/was in waiting for own turn
'(S/he) first fed the fish and the kitten and the dog was waiting for their/its turn.'

Parvo nahrani dekorativnite ribki i rižavoto kote i staroto kuče **biaha / beše** v ochakvane na
First feed-past decorative-det fish-pl and ginger-det kitten and old-det dog were/was in waiting for
svoia paj

own turn
'(S/he) first fed the decorative fish and the ginger kitten and the old dog were/was waiting for its/ their turn.'

19. Sled kato otvliakoha akstrisata i deteto i saprugat í **biaha / beše** v opasnost.
After that kidnap-past actress-det and child-det and husband her was/were in danger
'Then someone kidnapped the actress and the child and her husband were/was in danger.'

Sled kato otvliakoha izvestnata aktrisa i petgodišnoto í dete i bivšiat í saprug
After that kidnap-past famous-det actress and five-year-old-det her child-det and ex-det her husband
**biaha / beše** v opasnost.
was/were in danger
'Then someone kidnapped the famous acress and her five-year old child and her ex-husband were/was in danger.'

20. Biah govoril s kolegata i načalnika i direktora **biaha / beše** v tečenie.
Had talk-past with colleague-det and supervisor-det and manager-det were/was in current
'I had talked to my colleague and the supervisor and the manager were/was aware of that.'

Biah govoril s novia kolega i prekia ni načalnik i zamestnik direktora **biaha /**
Had talk-past with new-det colleague and direct-det us supervisor and assistant manager-det were/
**beše** v tečenie.
was in current
'I had talked to the new colleague and our direct supervisor and the assistant manager were/was aware of that.'

21. Lipsvaha mu tsigarite i kafeto i sladkoto **biaha / beše** slab zamestitel
Lack-past him cigarettes and coffee and jam were/was weak substitute
'He missed having cigarettes and coffee and jam were/was a poor substitute.'

Lipsvaha mu finite tsigari i kajmakliata kafe I bialoto sladko **biaha / beše** slab zamestitel
Lack-past him fine cigarettes and thick-det coffee and white-det jam were/was weak substitute
'He missed having fine cigarettes and thick coffee and white jam were/was a poor substitute.'

22. Poneže kupi točiloto i nožovete i postavkata **biaha / beše** kato podarak.
Because buy-past sharpener and knives and stand were/was a bonus.
'Because he bought the sharpener and the knives and the stand were/was a bonus.'

Poneže kupi vaprosnoto točiloto i komplekta nožove i krasivata postavka **biaha / beše** kato podarak.
Because buy-past said sharpener and set knives and pretty stand were/was a bonus.
'Because he bought the above mentioned sharpener and the set of knives and the beautiful stand were/was a bonus.'

23. Omraznaha mu skite i sarfa i motora **biaha / beše** novata mu strast.

Bored him ski and surf and motorcycle was/were new his passion
'He was bored with skiing and surfing and the motorcycle were / was his new passion.'

Omraznaha mu ski kurortite i windsarfinga i šumnia motor **biaha / beše** novata mu
Bored him ski resorts and windsurfing and noisy motorcycle was/were new his
strast.
passion
'He was bored with ski resorts and windsurfing and the noisy motorcycle were / was his new passion.'

24. Takmo be izpratil dašteria si i vnučkata i kučeto **biaha / beše** ošte navan.
Just had seen off daughter-det refl and granddaughter-det and dog-det were/was still outside.
'He had just seen off his daughter and the granddaughter and the dog were/was still outside.'

Takmo be izpratil dovedenata si dašteria i goliamata vnučka i puhkavoto kuče
Just had seen off step-det refl daughter and oldest granddaughter and dog-det
**biaha / beše** ošte navan.
were/was still outside
'He had just seen off his daughter and the granddaughter and the dog were/was still outside.'

**Appendix A-2: Target items in experiments 1-5: RC attachment**

This appendix lists the 24 RC attachment items (sentence pairs) used as auditory stimuli in the phoneme restoration experiments reported in Chapters 3 and 4 and as visual (written) stimuli in the experiments reported in Chapter 6.

The RC attachment items contained a NP of NP construction and a RC which could modify either the first or the second noun head. RC attachment was disambiguated by the gender of the relative pronoun. More details are given in Chapter 3. The target items were counterbalanced for gender of N1 and N2: half of the items had a masculine N1(m) - feminine N2(f) noun order and the other half had a feminine N1(f) - masculine N2(m) noun order.

The short versions of the items only were used as auditory stimuli for phoneme restoration in Experiment 1a (visual word choice), Experiments 2a-b (sentence repetition) and Experiments 3a-b (sentence shadowing), as well as visual stimuli for grapheme restoration in Experiments 5a-b (silent reading with sentence repetition).

Both the short and the long versions were used as auditory stimuli for phoneme restoration in Experiment 1b-c (visual word choice), as well as visual stimuli for grapheme restoration in Experiments 4a-b (silent reading with visual word choice).

SHORT VERSIONS

1. Podtseniha advokata na pevitsata, koiato kupi imenieto.
   Underestimated$_{3p.pl.}$ lawyer(m)-det of singer(f)-det who(f) bought$_{3p.sg.}$ estate-det.
   ‘They underestimated the lawyer of <u>the singer</u> who bought the estate.’

   Podtseniha advokata na pevitsata, kojto kupi imenieto.
   Underestimated$_{3p.pl.}$ lawyer(m)-det of singer(f)-det who(m) bought$_{3p.sg.}$ estate-det.
   ‘They underestimated <u>the lawyer of the singer</u> who bought the estate.’

   Podtseniha drebničkia advokat na našumialata pevitsa, koiato kupi imenieto.
   Underestimated small-framed-det lawyer(m) of newly-famous-det singer(f) who(f) bought$_{3p.sg.}$ estate-det.
   ‘They underestimated the lawyer of <u>the singer</u> who bought the estate.’

   Podtseniha drebničkia advokat na našumialata pevitsa, kojto kupi imenieto.
   Underestimated. small-framed-det lawyer(m) of newly-famous-det singer(f) who(m) bought$_{3p.sg.}$ estate-det.
   ‘They underestimated <u>the lawyer of the singer</u> who bought the estate.’

2. Predupprediha bašata na ludata, koiato hraneše kučeto.
   Warned$_{3p.pl.}$ father(m)-det of lunatic(f)-det who(f) fed$_{3p.sg.}$ dog-det.
   ‘They warned the father of <u>the lunatic</u> who fed the dog.’

   Predupprediha bašata na ludata, kojto hraneše kučeto.
   Warned$_{3p.pl.}$ father(m)-det of lunatic(f)-det who(m) fed$_{3p.sg.}$ dog-det.

‘They warned the father of the lunatic who fed the dog.’

Predeprediha pritesnenia baša na kvartalnata luda, koiato hraneše kučeto.
Warned$_{3p.pl.}$ anxious-det father(m) of neighborhood-det lunatic(f) who(f) fed$_{3p.sg.}$ dog-det.
‘They warned the anxious father of the neighborhood lunatic who fed the dog.’

Predeprediha pritesnenia baša na kvartalnata luda, kojto hraneše kučeto.
Warned$_{3p.pl}$ anxious-det father(m) of neighborhood-det lunatic(f) who(m) fed$_{3p.sg.}$ dog-det.
‘They warned the father of the lunatic who fed the dog.’

3. Pomneše diadoto na bulkata, koiato sabori tortata.
Remembered$_{3p.sg.}$ grandfather(m)-det of bride(f)-det who(f) knocked$_{3p.sg.}$ cake-det.
‘(S/he) remembered the grandfather of the bride who knocked down the cake.’

Pomneše diadoto na bulkata, kojto sabori tortata.
Remembered$_{3p.sg.}$ grandfather(m)-det of bride(f)-det who(m) knocked$_{3p.sg.}$ cake-det.
‘(S/he) remembered the grandfather of the bride who knocked down the cake.’

Pomneše podpijnalia diado na pritesnitelnata bulka, koiato sabori tortata.
Remembered$_{3p.sg.}$ tipsy-det grandfather(m) of shy-det bride(f) who(f) knocked$_{3p.sg.}$ cake-det.
‘(S/he) remembered the grandfather of the bride who knocked down the cake.’

Pomneše podpijnalia diado na pritesnitelnata bulka, kojto sabori tortata.
Remembered$_{3p.sg.}$ tipsy-det grandfather(m) of shy-det bride(f) who(m) knocked$_{3p.sg.}$ cake-det.
‘(S/he) remembered the grandfather of the bride who knocked down the cake.’

4. Podkupiha ikonoma na grafiniata, koiato pazeše pismata.
Bribed$_{3p.pl.}$ butler(m)-det of duchess(f)-det who(f) kept$_{3p.sg.}$ letters-det.
‘They bribed the butler of the duchess who was keeping the letters.’

Podkupiha ikonoma na grafiniata, kojto pazeše pismata.
Bribed$_{3p.pl.}$ butler(m)-det of duchess(f)-det who(m) kept$_{3p.sg.}$ letters-det.
‘They bribed the butler of the duchess who was keeping the letters.’

Podkupiha grohnalia ikonom na visokomernata grafinia, koiato pazeše pismata.
Bribed$_{3p.pl.}$ rickety-det butler(m) of arrogant-det duchess(f) who(f) kept$_{3p.sg.}$ letters-det.
‘They bribed the sickly butler of the arrogant duchess who was keeping the letters.’

Podkupiha grohnalia ikonom na visokomernata grafinia, kojto pazeše pismata.
Bribed$_{3p.pl}$ rickety-det butler(m) of arrogant-det duchess (f) who(m) kept$_{3p.sg.}$ letters-det.
‘They bribed the sickly butler of the arrogant duchess who was keeping the letters.’

5. Nagradiha šefa na brokerkata, koiato dvižeše sdelkata.
awarded$_{3p.pl.}$ boss(m)-det of broker(f)-det who(f) worked$_{3p.sg.}$ deal-det.
‘They promoted the boss of the broker who was working on the deal.’

Nagradiha šefa na brokerkata, kojto dvižeše sdelkata.
awarded$_{3p.pl.}$ boss(m)-det of broker(f)-det who(f) worked$_{3p.sg.}$ deal-det.
‘They promoted the boss of the broker who was working on the deal.’

Nagradiha nadutia šef na mladata brokerka, koiato dvižeše sdelkata.
awarded$_{3p.pl.}$ pompous-det boss(m) of young-det broker(f) who(f) worked$_{3p.sg.}$ deal-det.
'They promoted the pompous boss of the broker who was working on the deal.'

Nagradiha nadutia šef na mladata brokerka, kojto dvižeše sdelkata.
awarded$_{3p.pl.}$ pompous-det boss(m) of young-det broker(f) who(f) worked$_{3p.sg.}$ deal-det.
'They promoted the pompus boss of the young broker who was working on the deal.'

6. Čakaha bratovčeda na koležkata, koiato ureždaše vsičko.
waited$_{3p.pl.}$ cousin(m)-det of colleague(f)-det who(f) arranged$_{3p.sg.}$ all.
'They were waiting for the cousin of the colleague who made all the arrangements.'

Čakaha bratovčeda na koležkata, kojto ureždaše vsičko.
waited$_{3p.pl.}$ cousin(m)-det of colleague(f)-det who(m) arranged$_{3p.sg.}$ all.
'They were waiting for the cousin of the colleague who made all the arrangements.'

Čakaha proslovutia bratovčed na novata koležka, koiato ureždaše vsičko.
waited$_{3p.pl.}$ infamous-det cousin(m) of new-det colleague(f) who(f) arranged$_{3p.sg.}$ all.
'They were waiting for the infamous cousin of the new colleague who made all the arrangements.'

Čakaha proslovutia bratovčed na novata koležka, kojto ureždaše vsičko.
waited$_{3p.pl.}$ . infamous-det cousin(m) of new-det colleague(f) who(m) arranged$_{3p.sg.}$ all.
'They were waiting for the infamous cousin of the new colleague who made all the arrangements.'

7. Sabudiha hazaina na studentkata, koiato razbiraše frenski.
Woke$_{3p.pl.}$ landlord(m)-det of student(f)-det who(f) understood$_{3p.sg.}$ French.
'They woke the landlord of the student who understood French.'

Sabudiha hazaina na studentkata, kojto razbiraše frenski.
Woke$_{3p.pl.}$ landlord(m)-det of student(f)-det who(f) understood$_{3p.sg.}$ French.
'They woke the landlord of the student who understood French.'

Sabudiha vazrastnia hazain na uslužlivata studentka, koiato razbiraše frenski.
Woke$_{3p.pl.}$ elderly-det landlord(m) of student(f)-det who(f) understood$_{3p.sg.}$ French.
'They woke the elderly landlord of the helpful student who understood French.'

Sabudiha vazrastnia hazain na uslužlivata studentka, kojto razbiraše frenski.
Woke$_{3p.pl.}$ elderly-det landlord(m) of student(f)-det who(f) understood$_{3p.sg.}$ French.
'They woke the elderly landlord of the helpful student who understood French.'

8. Poznavaše pridružitelia na gospožitsata, koiato porača gaspačo.
knew$_{3p.sg.}$ companion(m)-det of lady(f)-det who(f) ordered$_{3p.sg.}$ gaspacho.
'S/he knew the companion of the lady who ordered gaspacho.'

Poznavaše pridružitelia na gospožitsata, kojto porača gaspačo.
knew$_{3p.sg.}$ companion(m)-det of lady(f)-det who(m) ordered$_{3p.sg.}$ gaspacho.
'S/he knew <u>the companion of the lady</u> who ordered gaspacho.'

Poznavaše edria pridružitel na svetskata gospožitsa, koiato porača gaspačo.
knew$_{3p.sg.}$ heavy-det companion(m) of society girl(f) who(f) ordered$_{3p.sg.}$ gaspacho.
'S/he knew the companion of <u>the lady</u> who ordered gaspacho.'

Poznavaše edria pridružitel na svetskata gospožitsa, kojto porača gaspačo.
knew$_{3p.sg.}$ heavy-det companion(m) of society girl(f) who(m) ordered$_{3p.sg.}$ gaspacho.
'S/he knew <u>the companion of the lady</u> who ordered gaspacho.'

9. Spomenaha učitelia na friziorkata, koiato otkrivaše salon.
Mentioned$_{3p.pl.}$ teacher(m)-det of hair-dresser(f)-det who(f) opened$_{3p.sg.}$ salon.
'They mentioned the mentor of <u>the hair-dresser</u> who was opening a salon.'

Spomenaha učitelia na friziorkata, koiato otkrivaše salon.
Mentioned$_{3p.pl.}$ teacher(m)-det of hair-dresser(f)-det who(m) opened$_{3p.sg.}$ salon.
'They mentioned <u>the mentor of the hair-dresser</u> who was opening a salon'

Spomenaha izvestnia učitel na talantlivata friziorka, koiato otkrivaše salon.
Mentioned$_{3p.pl.}$well-know-det teacher(m) of talented-det hair-dresser(f) who(f) opened$_{3p.sg.}$ salon.
'They mentioned the well-known mentor of <u>the talented hair-dresser</u> who was opening a salon.'

Spomenaha izvestnia učitel na talantlivata friziorka, koiato otkrivaše salon.
Mentioned$_{3p.pl.}$ well-known-det teacher(m) of talented hair-dresser(f)-det who(m) opened$_{3p.sg.}$ salon.
'They mentioned <u>the well-known mentor of</u> <u>the talented hair-dresser</u> who was opening a salon.'

10. Prosledi informatora na žurnalistkata, koiato provali sreštata.
Followed$_{3p.sg.}$ informer(m)-det of journalist(f)-det who(f) ruined$_{3p.sg.}$ meeting-det.
'S/he followed the informer of <u>the journalist</u> who ruined the meeting.'

Prosledi informatora na žurnalistkata, kojto provali sreštata.
Followed$_{3p.sg.}$ informer(m)-det of journalist(f)-det who(m) ruined$_{3p.sg.}$ meeting-det.
'S/he followed <u>the informer of the journalist</u> who ruined the meeting.'

Prosledi tainstvenia informator na skandalnata žurnalistka, koiato provali sreštata.
Followed$_{3p.sg.}$ secret-det nformer(m) of notorious journalist(f) who(f) ruined$_{3p.sg.}$ meeting-det.
'S/he followed the secret informer of <u>the notorious journalist</u> who ruined the meeting.'

Prosledi tainstvenia informator na skandalnata žurnalistka, kojto provali sreštata.
Followed$_{3p.sg.}$ secret-det nformer(m) of notorious journalist(f) who(m) ruined$_{3p.sg.}$ meeting-det.
'S/he followed <u>the secret informer of the notorious journalist</u> who ruined the meeting.'

11. Zaloviha saučstnika na kasierkata, koiato prizna izmamata.
Arrested$_{3p.pl.}$ partner(m)-det of cashier(f)-det who(f) admitted$_{3p.sg.}$ fraud-det.

‘They arrested the partner of the cashier who admitted the fraud.’

Zaloviha saučstnika na kasierkata, kojto prizna izmamata.
Arrested$_{3p.pl.}$ partner(m)-det of cashier(f)-det who(f) admitted$_{3p.sg.}$ fraud-det.
‘They arrested the partner of the cashier who admitted the fraud.’

Zaloviha drugia saučstnik na bankovat kasierkata, koiato prizna izmamata.
Arrested$_{3p.pl.}$ other-det partner(m) of bank-det cashier(f) who(f) admitted$_{3p.sg.}$ fraud-det.
‘They arrested the partner of the cashier who admitted the fraud.’

Zaloviha drugia saučstnik na bankovat kasierkata, kojto prizna izmamata.
Arrested$_{3p.pl.}$ other-det partner(m) of bank-det cashier(f) who(m) admitted$_{3p.sg.}$ fraud-det.
‘They arrested the partner of the cashier who admitted the fraud.’

12. Saboriha obožatelia na balerinata, koiato čakaše kolata.
Knocked down$_{3p.pl.}$ admirer(m)-det of balerina(f)-det who(f) waited$_{3p.sg.}$ car-det.
‘They knocked down the admirer of the ballerina who was waiting for the car.’

Saboriha obožatelia na balerinata, kojto čakaše kolata.
Knocked down$_{3p.pl.}$ admirer(m)-det of balerina(f)-det who(f) waited$_{3p.sg.}$ car-det.
‘They knocked down the admirer of the ballerina who was waiting for the car.’

Saboriha stroinia obožatel na iziašnata balerina, koiato čakaše kolata.
Knocked down$_{3p.pl.}$ slim-det admirer(m) of delicat-det balerina(f) who(f) waited$_{3p.sg.}$ car-det.
‘They knocked down the elegant admirer of the delicate ballerina who was waiting for the car.’

Saboriha stroinia obožatel na iziašnata balerina, kojto čakaše kolata.
Knocked down$_{3p.pl.}$ slim-det admirer(m) of delicat-det balerina(f) who(m) waited$_{3p.sg.}$ car-det.
‘They knocked down the elegant admirer of the delicate ballerina who was waiting for the car.’

13. Pokazaha vnučkata na poeta, kojto poluči nagrada.
Showed$_{3p.pl}$. grand-daughter(f)-det of poet(m)-det who(m) got$_{3p.sg.}$ reward.
‘They showed the grand-daughter of the poet who got the reward.’

Pokazaha vnučkata na poeta, koiato poluči nagrada.
Showed$_{3p.pl}$. grand-daughter(f)-det of poet(m)-det who(f) got reward.
‘They showed the grand-daughter of the poet who got the reward.’

Pokazaha kadrokosata vnučka na izvestnia poet, kojto poluči nagrada.
Showed$_{3p.pl}$. curly-haired grand-daughter(f)-det of famous poet(m)-det who(m) got$_{3p.sg.}$ reward.
‘They showed the curly-haired grand-daughter of the famous poet who got the reward.’

Pokazaha kadrokosata vnučka na izvestnia poet, koiato poluči nagrada.
Showed$_{3p.pl}$. . curly-haired grand-daughter(f)-det of famous poet(m)-det who(f) got reward.
‘They showed the curly-haired grand-daughter of the famous poet who got the reward.’

14. Haresvaše sestrata na aktiora, kojto snimaše reklami.
Liked$_{3p.sg.}$ sister(f)-det of actor(m)-det who(m) shot$_{3p.sg.}$ commercials
'S/he liked the sister of the actor who shot commercials.'

Haresvaše sestrata na aktiora, koiato snimaše reklami.
Liked$_{3p.sg.}$ sister(f)-det of actor(m)-det who(f) shot$_{3p.sg.}$ commercials
'S/he liked the sister of the actor who shot commercials.'

Haresvaše milovidnata sestra na mladia aktior, kojto snimaše reklami.
Liked$_{3p.sg.}$ sweet-looking sister(f)-det of young-det actor(m) who(m) shot$_{3p.sg.}$ commercials
'S/he liked the sweet-faced sister of the young actor who shot commercials.'

Haresvaše milovidnata sestra na mladia aktior, koiato snimaše reklami.
Liked$_{3p.sg.}$ sweet-looking sister(f)-det of young-det actor(m) who (f) shot$_{3p.sg.}$ commercials
'S/he liked the sweet-faced sister of the young actor who shot commercials.'

15. Informiraha klasnata na mladeža, kojto vodeše grupata.
Informed$_{3p.pl.}$ class teacher(f)-det of youngster(m)-det who(m) led$_{3p.sg.}$ group-det.
'They informed the teacher of the youngster who led the group.'

Informiraha klasnata na mladeža, kojto vodeše grupata.
Informed$_{3p.pl.}$ class teacher(f)-det of youngster(m)-det who(f) led$_{3p.sg.}$ group-det.
'They informed the teacher of the youngster who led the group.'

Informiraha strogata klasna na nepokornia mladež, kojto vodeše grupata.
Informed$_{3p.pl.}$ strict-det class teacher(f) of unruly-det youngster(m) who(m) led$_{3p.sg.}$ group-det.
'They informed the teacher of the youngster who led the group.'

Informiraha strogata klasna na nepokornia mladež, kojto vodeše grupata.
Informed$_{3p.pl.}$ strict-det class teacher(f) of unruly-det youngster(m) who(f) led$_{3p.sg.}$ group-det.
'They informed the teacher of the youngster who led the group.'

16. Raniha sasedkata na profesora, kojto običaše kotki.
injured$_{3p.pl.}$ neighbour(f)-det of professor(m)-det who(m) loved$_{3p.sg.}$ cats.
'They injured the neighbor of the professor who loved cats. '

Raniha sasedkata na profesora, koiato običaše kotki.
injured$_{3p.pl.}$ neighbour(f)-det of professor(m)-det who(f) loved$_{3p.sg.}$ cats.
'They injured the neighbor of the professor who loved cats.'

Raniha vazrastnata sasedka na razseiania profesor, kojto običaše kotki.
injured$_{3p.pl.}$ old-det neighbour(f) of absent-minded-det professor who(m) loved$_{3p.sg.}$ cats.
'They injured the elderly neighbor of the absent-minded professor who loved cats. '

Raniha vazrastnata sasedka na razseiania profesor, koiato običaše kotki.
injured$_{3p.pl.}$ old-det neighbour(f) of absent-minded-det professor who(f) loved$_{3p.sg.}$ cats.
'They injured the elderly neighbor of the absent-minded professor who loved cats.'

17. Razpozna gostenkata na hudožnika, kojto pišeše stihove.
recognized$_{3p.pl.}$ guest (f)-det of artist(m)-det who(m) wrote$_{3p.sg.}$ verse-det.
'S/he recognized the guest of the artist who wrote poetry. '

Razpozna gostenkata na hudožnika, kojto pišeše stihove.
recognized$_{3p.pl.}$ guest (f)-det of artist(m)-det who(f) wrote$_{3p.sg.}$ verse-det.
'S/he recognized the guest of the artist who wrote poetry.'

Razpozna čarovnata gostenka na ekstravagantnia hudožnik, kojto pišeše stihove.
recognized$_{3p.pl.}$ charming-det guest(f) of extravagant-det artist(m) who(m) wrote$_{3p.sg.}$ verse-det.
'S/he recognized the charming guest of the extravagant artist who wrote poetry. '

Razpozna čarovnata gostenka na ekstravagantnia hudožnik, kojto pišeše stihove.
recognized$_{3p.pl.}$ charming-det guest(f) of extravagant-det who(f) wrote$_{3p.sg.}$ verse-det.
'S/he recognized the charming guest of the extravagant artist who wrote poetry.'

18. Vidia saprugata na deputata, kojto imaše problemi.
Saw$_{3p.sg.}$ wife –(f)-det of polititian(m)-det who(m) had$_{3p.sg.}$ problems-det.
'S/he saw the wife of the polititian who was having problems.'

Vidia saprugata na deputata, koiato imaše problemi.
Saw$_{3p.sg.}$ wife –(f)-det of polititian(m)-det who(f) had$_{3p.sg.}$ problems-det.
'S/he saw the wife of the polititian who was having problems.'

Vidia prikazlivata saprugata na dostolepnia deput, kojto imaše problemi.
Saw$_{3p.sg.}$ talkative-det wife –(f) of stately-det polititian(m) who(m) had$_{3p.sg.}$ problems-det.
'S/he saw the wife of the polititian who was having problems.'

Vidia prikazlivata saprugata na dostolepnia deput, kojto imaše problemi.
Saw$_{3p.sg.}$ talkative-det wife –(f) of stately-det polititian(m) who(m) had$_{3p.sg.}$ problems-det.
'S/he saw the wife of the polititian who was having problems.'

19. Sreštna sluginiata na episkopa, kojto mrazeše prosiatsi.
Met$_{3p.pl.}$ servant(f)-det of bishop(m)-det who(m) hated$_{3p.sg.}$ beggars.
'S/he met the servant of the bishop was hated beggars.'

Sreštna sluginiata na episkopa, koiato mrazeše prosiatsi.
Met$_{3p.pl.}$ servant(f)-det of bishop(m)-det who(f) hated$_{3p.sg.}$ beggars.
'S/he met the servant of the bishop who hated beggars.'

Sreštna gramoglasnata sluginia na badeštia episkop, kojto mrazeše prosiatsi.
Met$_{3p.pl.}$ loud-det servant(f) of next-det bishop(m) who(m) hated$_{3p.sg.}$ beggars.
'S/he met the loud servant of the next bishop who hated beggars.'

Sreštna gramoglasnata sluginia na badeštia episkop, kojto mrazeše prosiatsi.
Met$_{3p.pl.}$ servant(f)-det of proest(m)-det who(f) hated$_{3p.sg.}$ beggars.
'S/he met the loud servant of the next bishop who hated beggars.'

20. Uvolniha treniorkata na tenisista, kojto izpusna poleta.
Dismissed$_{3p.pl.}$ trainer(f)-det of tennis player(m)-det who(m) missed$_{3p.sg.}$ flight-det.
'They let go the trainer of the tennis player who missed the flight.'

Uvolniha treniorkata na tenisista, koiato izpusna poleta.
Dismissed$_{3p.pl.}$ trainer(f)-det of tennis player(m)-det who(f) missed$_{3p.sg.}$ flight-det.
'They let go the trainer of the tennis player who missed the flight.'

Uvolniha neopitnata treniorka na obešavaštia tenisist, kojto izpusna poleta.
Dismissed$_{3p.pl.}$ inexperienced-det trainer(f) of promising-det tennis player(m) who(m) missed$_{3p.sg.}$ flight-det.
'They let go the inexperienced trainer of the promising tennis player who missed the flight.'

Uvolniha neopitnata treniorka na obešavaštia tenisist, koiato izpusna poleta.
Dismissed$_{3p.pl.}$ inexperienced-det trainer(f) of promising-det tennis player(m) who(f) missed$_{3p.sg.}$ flight-det.
'They let go the inexperienced trainer of the promising tennis player who missed the flight.'

21. Pričaka dašterriata na direktora, kojto tormozeše brat im.
waited$_{p.pl.}$ daughter(f)-det of principal(m)-det who(m) harrassed$_{3p.sg.}$ brother their.
'S/he waited for the daughter of the principal who harassed their brother.'

Pričaka dašterriata na direktora, koiato tormozeše brat im.
recognized$_{3p.pl.}$ daughter(f)-det of principal(m)-det who(f) harrassed$_{3p.sg.}$ brother their.
'S/he waited for the daughter of the principal who harassed their brother.'

Pričaka ehidnata dašterria na učilištnia direktor, kojto tormozeše brat im.
waited$_{p.pl.}$ sarcastic-det daughter(f) of school-det principal(m) who(m) harrassed$_{3p.sg.}$ brother their.
'S/he waited for the sarcastic daughter of the school principal who harassed their brother.'

Pričaka ehidnata dašterria na učilištnia direktor, koiato tormozeše brat im.
Waited$_{3p.pl.}$ sarcastic-det daughter(f) of school-det principal (m) who(f) harrassed$_{3p.sg.}$ brother their.
'S/he waited for the daughter of the principal who harassed their brother.'

22. Zaplašiha godenitsata na milionera, kojto sadeše vestnika.
Threaten$_{3p.pl.}$ fiancee(f)-det of millionnaire(m)-det who(m) sued$_{3p.sg.}$ paper-det.
'They threatened the fiancée of the millionaire who was suing the paper.'

Zaplašiha godenitsata na milionera, koiato sadeše vestnika.
Threaten$_{3p.pl.}$ fiancee(f)-det of millionnaire(m)-det who(f) sued$_{3p.sg.}$ paper-det.
'They threatened the fiancée of the millionaire who was suing the paper.'

Zaplašiha krasivata godenitsa na novoizliupenia milioner, kojto sadeše vestnika.
Threaten$_{3p.pl}$ beautiful-det fiancee(f) of newly-hatched-det millionnaire(m) who(m) sued$_{3p.sg.}$ paper-det.
'They threatened the beautiful fiancée of the new millionaire who was suing the paper.'

Zaplašiha krasivata godenitsa na novoizliupenia milioner, koiato sadeše vestnika.
Threaten$_{3p.pl}$ beautiful-det fiancee(f) of newly-hatched-det millionnaire(m) who(f) sued$_{3p.sg.}$ paper-det.
'They threatened the beautiful fiancée of the new millionaire who was suing the paper.'

23. Snimaha priatelkata na šampion a, kojto daržeše kupata.
Photographed$_{3p.pl.}$ girlfriend(f)-det of champion(m)-det who(m) held$_{3p.sg.}$ cup-det.
'They photographed the girlfriend of the champion who was holding the cup.'

Snimaha priatelkata na šampion, koiato daržeše kupata.
Photographed$_{3p.pl.}$ girlfriend(f)-det of champion (m)-det who(f) held$_{3p.sg.}$ cup-det.
'They photographed the girlfriend of the champion who drove a Toyota.'

Snimaha štastlivata priatelka novia na šampion, kojto daržeše kupata.
Photographed$_{3p.pl.}$ happy –det girlfriend(f) of new champion(m)-det who(m) held$_{3p.sg.}$ cup-det.
'They photographed the happy girlfriend of the new champion who was holding the cup.'

Snimaha štastlivata priatelka na novia šampion, koiato daržeše kupata.
Photographed$_{3p.pl.}$ happy$_{\text{-det}}$ girlfriend(f)-det of new champion(m)-det who(f) held$_{3p.sg.}$ cup-det.
'They photographed the happy girlfriend of the new champion who was holding the cup.'

24. Interviuiraha sadružničkata na hoteliera, kojto spečeli deloto.
Interviewed$_{3p.pl.}$ business partner(f)-det of hotel owner(m)-det who(m) won$_{3p.sg.}$ case-det.
'They interviewed the business partner of <u>the hotel owner</u> who won the case.'

Interviuiraha sadružničkata na hoteliera, koiato spečeli deloto.
Interviewed$_{3p.pl.}$ business partner(f)-det of hotel owner(m)-det who(m) won$_{3p.sg.}$ case-det.
'They interviewed <u>the business partner of the hotel owner</u> who won the case.'

Interviuiraha niakogašnata sadružnička na pročutia hotelier, kojto spečeli deloto.
Interviewed$_{3p.pl.}$ one-time-det business partner(f) of notorious hotel owner(m) who(m) won$_{3p.sg.}$ case-det.
'They interviewed the business partner of <u>the hotel owner</u> who won the case.'

Interviuiraha niakogašnata sadružnička na pročutia hotelier, koiato spečeli deloto.
Interviewed$_{3p.pl.}$ one-time-det business partner(f) of notorious hotel owner(m) who(m) won$_{3p.sg.}$ case-det.
'They interviewed <u>the business partner of the hotel owner</u> who won the case.'

**Appendix A-3: Pilot items in experiments 1-5: Accussative/possessive reflexive**

This appendix lists the 12 accusative/possessive reflexive items (sentence pairs) used as auditory stimuli in the phoneme restoration experiments reported in Chapters 3 and 4 and as visual (written) stimuli in the experiments reported in Chapter 6.

1. Običaše da se hvali. Detsata i te go znaeha.
   Loved to refl-acc praise children-det and they it knew
   'He liked to brag (about himself). The children even knew it.'

   Običaše da si hvali detsata. I te go znaeha.
   Loved to refl-poss praise children-det and they it knew
   'He liked to praise his children. And they knew it'

2. Planiraše da se premesti. Ofisat beše v loš kvartal i biznesat stradaše.
   planned to refl-acc move office was in bad area and business suffered
   'He planned to move. The office was in a bad area and business was not going well.'

   Planiraše da si premesti ofisa. Beše v loš kvartal i biznesat stradaše.
   planned to refl-poss move office was in bad area and business suffered
   'He planned to move his office. It was in a bad area and business was not going well.'

3. Zaklel se be da se varne. Liubimata žena čaka dalgo.
   Vowed refl was to refl-acc get back beloved woman waited long
   'He had vowed to come back. His beloved had waited a long time.'

   Zaklel se be da si varne liubimata žena. Čaka dalgo.
   Vowed refl was to refl-poss get back beloved woman waited long
   'He had vowed to get his beloved back. He had waited a long time.'

4. Pak uspia da se iznervi. Sakvartirantat naposledak go drazneše s vsiaka duma.
   Again managed to refl-acc annoyed roommate lately him annoyed with every word
   'He couldn't help getting annoyed again. Lately, his roommate annoyed him with every word.'

   Pak uspia da si iznervi sakvartiranta. Naposledak go drazneše s vsiaka duma.
   Again managed to refl-poss annoyed roommate lately him annoyed with every word
   'He managed to annoy his roommate again. Lately, every single word annoyed him.'

5. Varna se da se preobleče. Rokliata beše demode i i stoeše zle.
   Returned refl to refl-acc change dress-det was old-fashioned and her suited ill
   'She went back to change. The dress was old-fashioned and did not suit her.'

   Varna se da da si preobleče rokliata. Beše demode i i stoeše zle.
   Returned refl to refl-poss change dress-det was old-fashioned and her suited ill

‘She went back to change her dress. It was old-fashioned and did not suit her.’

6. Včera se beše izložil. Treniorat ne iskaše da se povtaria pri sledvaštia mač.
   Yesterday refl-acc was embarrassed Trainer not want to refl repeat at next game
   ‘He had embarrassed himself yesterday. His trainer did not want that to happen again at the next game.’

   Včera si beše izložil treniora. Ne iskaše da se povtaria pri sledvaštia mač.
   Yesterday refl-poss was embarrassed Trainer not want to refl repeat at next game
   ‘He had embarrassed his trainer yesterday. He did not want that to happen again at the next game.’

7. Uzažasno se izplaši. Sasedite biaha otvorili prozoretsa i koteto se šmugna prez nego.
   Terrible refl-acc scared Neighbours were open window and kitten refl sneak through it
   ‘He got a terrible fright. The neighbours had left a window open and the kitten sneaked throough it.’

   Uzažasno si izplaši sasedite. Biaha otvorili prozoretsa i koteto mu padna vatre.
   Terrible refl-poss scared Neighbours were open window and kitten refl sneak through it
   ‘He got his neighbours a terrible fright. They had left a window open and the kitten sneaked throough it.’

8. Edna žena triabva da se poddarža. Vanšnostta ne e bez značenie na tazi vazrast.
   One woman must to refl-acc care for appearance not is without importance at this age
   ‘A woman has to take care of herself. Looks are important at this age.’

   Edna žena triabva da si poddarža vanšnostta. Ne e bez značenie na tazi vazrast.
   One woman must to refl-poss care for appearance not is without importance at this age
   ‘A woman has to take care of her looks. That’s not trivial at this age.’

9. Imaše sklonnost da se podtseniava. Kolegite vse go ubeždavaha, če ne e prav.
   Had tendency to refl-acc underrate colleagues always him convince that not is right
   ‘He had a tendency to underestimate himself. His colleagues kept telling him he was wrong.’

   Imaše sklonnost da si podtseniava kolegite. Vse go ubeeždavaha, če ne e prav.
   Had tendency to refl-poss underrate colleagues always him convince that not is right
   ‘He had a tendency to underestimate his colleagues. They kept telling him he was wrong.’

10. Ne iskaše da se provalia. Šansovete i bez tova biaha mnogo malki.
   Not want to refl-acc fail chances and without that were very small
   ‘He didn’t want to make himself fail. His chances were not that good any way.’

   Ne iskaše da si provalia šansovete. I bez tova biaha mnogo malki.
   Not want to refl-poss ruin chances and without that were very small
   ‘He didn’t want to ruin his chances. They were not that good any way.’

11. Razbra, če naprazno se habi. Dumite iavno niamaše da ia vpečatliat.
    Understood that uselessly refl-acc waste words obviously not-fut to her impress
    'He understood that he was wasting his time. Obviously, words were not going to impress her.'
    Razbra, če naprazno si habi dumite. Iavno niamaše da ia vpečatliat.
    Understood that uselessly refl-poss waste words obviously not-fut to her impress
    'He understood that he was wasting his words. They were obviously not going to impress her.'

12. Mečtaeše da se izuči. Deteto niakoj den šteše da se gordee s nego.
    Dreamed to refl-acc school child-det some day would to refl pride with him
    'He dreamed of getting an education. One day his child will be proud of him.'
    Mečtaeše da si izuči deteto. Niakoj den šteše da se gordee s nego
    Dreamed to refl-poss school child-det some day would to refl pride with him
    'He dreamed of givinh his child an education. One day he will be proud of him.'

## Appendix B: Instructions to participants

### Appendix B-1: Instructions for the visual word choice experiments (Experiments 1a-c and Experiment 6)

Изследването, в което ще участвате проучва как хората възстановяват думи, които не са чули добре.

По време на теста ще слушате изречения, в които на места има страничен шум и не се чува добре. След всяко изречение ще виждате 2 думи на екрана. Вашата задача е да определите, коя от тях е била в изречението, което току що сте чули. Думите на екрана ще се повтарят периодично и винаги ще са в един и същ ред.

За да чуете изречението се натиска клавиш **<SPACE>.**
Лявата дума се избира с левия клавиш **<SHIFT>**, на който има червена лепенка.
Дясната дума се избира с десния клавиш, **<SHIFT>**, на който има синя лепенка.
Използвайте **<SPACE>** за да преминете, към следващо изречение.

Моля да отговаряте възможно най-бързо и възможно най- внимателно като избирате по усет ако не сте ситурни в отговора.

Първо ще видите на екрана надпис "**Ето няколко примера за упражнение**" и ще опитате примерите. На екрана ще се появи надпис "**Имате ли въпроси?**". Ако задачата Ви е затруднила, поискайте да Ви бъде обяснена и направете примерите отново преди да започнете теста.

После ще видите на екрана надпис "**Започвате теста!**". Като натиснете клавиш **<SPACE>** ще започне теста. Моля уверете се, че сте готови преди да започнете.

Самият тест отнема около 20 минути. След като започнете, ако е може направете теста до край. Това е важно за изследването. Ако прекратите теста, отговорите Ви не могат да бъдат използвани.

English translation

The research, in which you are participating, investigates on how people restore words that they do not hear well.

During the test you are going to listen to sentences where in places it is hard to hear because of noise. After each sentence you will see two words on the screen. Your task is to pick which of the words was in the sentence you have just heard. The word choices will be several pairs that will be repeated a number of times with the two words always in the same order.

To listen to a sentence press the <SPACE> bar.
The word on the left is selected by pressing the left <SHIFT> button, marked with a red sticker. The word on the right by pressing the right <SHIFT> button, marked with a blue sticker.
Pressing the <SPACE> bar when you are ready starts the next sentence.

Please try to answer as fast as you can and as best as you can. If you are not sure, make a guess.

First, you will see the words 'Here are some examples for practice' on the screen and you will try the practice items. The words 'Do you have questions?' will appear on the screen. If the task is not clear, you can ask that it be explained and go through the practice items again before starting the test.

Then you will see the words 'Starting the test' on the screen. When you press the <SPACE> bar you start the test. Please make sure you are ready before you start the actual test.

The actual test usually takes around 20 minutes to complete. Once you start, please if possible complete the test without interrupting. It is important for this research. If you stop and leave, your answers cannot be used.

**Appendix B-2: Instructions for the sentence repetition experiments (2a-b)**

Изследването, в което ще участвате проучва как хората възстановяват думи, които не са чули добре.

По време на теста ще слушате изречения, в които на места има страничен шум и не се чува добре. Вашата задача е да повторите всяко чуто изречение изцяло или колкото можете по-голяма част от него.

За да чуете изречението се натиска клавиш **<SPACE>.**
След края на всяко изречение, на екрана ще се появява микрофон. Моля да заповате да говорите възможно най-бързо щом видите микрофона.
След това използвайте **<SPACE>** за да преминете, към следващо изречение.

Първо ще видите на екрана надпис "**Ето няколко примера за упражнение**" и ще опитате примерите. На екрана ще се появи надпис "**Имате ли въпроси?**". Ако задачата Ви е затруднила, поискайте да Ви бъде обяснена и направете примерите отново преди да започнете теста.

После ще видите на екрана надпис "**Започвате теста!**". Като натиснете клавиш **<SPACE>** ще започне теста. Моля уверете се, че сте готови преди да започнете.

Самият тест отнема около 20 минути. След като започнете, ако е може направете теста до край. Това е важно за изследването. Ако прекратите теста, отговорите Ви не могат да бъдат използвани.

English translation

The research, in which you are participating, investigates on how people restore words that they do not hear well.

During the test you are going to listen to sentences where in places it is hard to hear because of noise. Your task is after listening to each sentence to repeat the whole sentence or as much of it as you can.

To listen to a sentence press the <SPACE> bar.
After each sentence you will see a microphone sign on the screen. Please start talking as soon as possible after you see the microphone.
After that press the <SPACE> bar when you are ready starts the next sentence.

First, you will see the words ‘Here are some examples for practice’ on the screen and you will try the practice items. The words ‘Do you have questions?’ will appear on the screen. If the task is not clear, you can ask that it be explained and go through the practice items again before starting the test.

Then you will see the words ‘Starting the test’ on the screen. When you press the <SPACE> bar you start the test. Please make sure you are ready before you start the actual test.

The actual test usually takes around 20 minutes to complete. Once you start, please if possible complete the test without interrupting. It is important for this research. If you stop and leave, your answers cannot be used.

**Appendix B-3: Instructions for the sentence shadowing experiments (3a-b)**

Изследването, в което ще участвате проучва как хората възстановяват думи, които не са чули добре.

По време на теста ще слушате изречения, в които на места има страничен шум и не се чува добре. Вашата задача е да възпроизведете изреченията още докато ги слушате по възможност изцяло или в колкото можете по-голяма част.

За да чуете изречението се натиска клавиш **<SPACE>.**
С всяко изречение, на екрана ще се появява микрофон. Моля да заповате да говорите възможно най-бързо щом видите микрофона. Опитвайте се да повтаряте на глас изречението докато го слушате с колкото може по-малко забавяне и да повторите колкото можете по-голяма част от него.
След това използвайте **<SPACE>** за да преминете, към следващо изречение.

Първо ще видите на екрана надпис "**Ето няколко примера за упражнение**" и ще опитате примерите. На екрана ще се появи надпис "**Имате ли въпроси?**". Ако задачата Ви е затруднила, поискайте да Ви бъде обяснена и направете примерите отново преди да започнете теста.

После ще видите на екрана надпис "**Започвате теста!**". Като натиснете клавиш **<SPACE>** ще започне теста. Моля уверете се, че сте готови преди да започнете.

Самият тест отнема около 20 минути. След като започнете, ако е може направете теста до край. Това е важно за изследването. Ако прекратите теста, отговорите Ви не могат да бъдат използвани.

English translation

The research, in which you are participating, investigates on how people restore words that they do not hear well.

During the test you are going to listen to sentences where in places it is hard to hear because of noise. Your task is to reproduce the sentence or as much of it as possible while you are still listening to it.

To listen to a sentence press the <SPACE> bar.
With each sentence you will see a microphone sign on the screen. Please start talking as soon as possible after you see the microphone. Try to follow as close as possible the sentence you are hearing and repeat as much of it as you can.
After that press the <SPACE> bar when you are ready starts the next sentence.

First, you will see the words ‘Here are some examples for practice’ on the screen and you will try the practice items. The words ‘Do you have questions?’ will appear on the screen. If the task is not clear, you can ask that it be explained and go through the practice items again before starting the test.

Then you will see the words ‘Starting the test’ on the screen. When you press the <SPACE> bar you start the test. Please make sure you are ready before you start the actual test.

The actual test usually takes around 20 minutes to complete. Once you start, please if possible complete the test without interrupting. It is important for this research. If you stop and leave, your answers cannot be used.

**Appendix B-4: Instructions for the silent reading visual word choice experiments (4a-b)**

Изследването, в което ще участвате проучва как хората възстановяват думи, които не са видяли добре при четене.

По време на теста ще четете на екрана изречения, в които по една дума не се вижда изцяло. След всяко изречение ще виждате 2 думи на екрана. Вашата задача е да определите, коя от тях е била в изречението. Думите на екрана ще се повтарят периодично и винаги ще са в един и същ ред.

За да прочетете изречението се натиска клавиш **<SPACE>.**
Лявата дума се избира с левия клавиш **<SHIFT>**, на който има червена лепенка.
Дясната дума се избира с десния клавиш, **<SHIFT>**, на който има синя лепенка.
Използвайте **<SPACE>** за да преминете, към следващо изречение.

Моля да отговаряте възможно най-бързо и възможно най-внимателно като избирате по усет ако не сте ситурни в отговора.

Първо ще видите на екрана надпис "**Ето няколко примера за упражнение**" и ще опитате примерите. На екрана ще се появи надпис "**Имате ли въпроси?**". Ако задачата Ви е затруднила, поискайте да Ви бъде обяснена и направете примерите отново преди да започнете теста.

После ще видите на екрана надпис "**Започвате теста!**". Като натиснете клавиш **<SPACE>** ще започне теста. Моля уверете се, че сте готови преди да започнете.

Самият тест отнема около 20 минути. След като започнете, ако е може направете теста до край. Това е важно за изследването. Ако прекратите теста, отговорите Ви не могат да бъдат използвани.

English translation

The research, in which you are participating, investigates on how people restore words that they do not hear well.

During the test you are going to read on the screen sentences in which one of the words cannot be seen entirely. After each sentence you will see two words on the screen. Your task is to pick which of the words was in the sentence you have just heard. The word choices will be several pairs that will be repeated a number of times with the two words always in the same order.

To see a sentence to read press the <SPACE> bar.
The word on the left is selected by pressing the left <SHIFT> button, marked with a red sticker. The word on the right by pressing the right <SHIFT> button, marked with a blue sticker.
Pressing the <SPACE> bar when you are ready starts the next sentence.

Please try to answer as fast as you can and as best as you can. If you are not sure, make a guess.

First, you will see the words ‘Here are some examples for practice’ on the screen and you will try the practice items. The words ‘Do you have questions?’ will appear on the screen. If the task is not clear, you can ask that it be explained and go through the practice items again before starting the test.

Then you will see the words ‘Starting the test’ on the screen. When you press the <SPACE> bar you start the test. Please make sure you are ready before you start the actual test.

The actual test usually takes around 20 minutes to complete. Once you start, please if possible complete the test without interrupting. It is important for this research. If you stop and leave, your answers cannot be used.

**Appendix B-5: Instructions for the silent reading with repetition experiments (5a-b)**

Изследването, в което ще участвате проучва как хората възстановяват думи, които не са видяли добре при четене.

По време на теста ще четете на екрана изречения, в които по една дума не се вижда изцяло. Вашата задача е да възпроизведете на глас всяко изречение по възможност изцяло или колкото можете по-голяма част от него.

За да прочетете изречението се натиска клавиш **<SPACE>.**
След края на всяко изречение, на екрана ще се появява микрофон. Моля да започвате да отговаряте възможно най-бързо щом видите микрофона.
След това използвайте **<SPACE>** за да преминете, към следващо изречение.

Първо ще видите на екрана надпис "**Ето няколко примера за упражнение**" и ще опитате примерите. На екрана ще се появи надпис "**Имате ли въпроси?**". Ако задачата Ви е затруднила, поискайте да Ви бъде обяснена и направете примерите отново преди да започнете теста.

После ще видите на екрана надпис "**Започвате теста!**". Като натиснете клавиш **<SPACE>** ще започне теста. Моля уверете се, че сте готови преди да започнете.

Самият тест отнема около 20 минути. След като започнете, ако е може направете теста до край. Това е важно за изследването. Ако прекратите теста, отговорите Ви не могат да бъдат използвани.

English translation

The research, in which you are participating, investigates on how people restore words that they do not hear well.

During the test you are going to read on the screen sentences in which one of the words cannot be seen entirely. After each sentence you will see

**Appendix C: Language background**

**ИНФОРМАЦИЯ ЗА ЕЗИЦИ, КОИТО ВЛАДЕЯ**

Код #: ……….

Информацията от лично естество в този въпросник няма да бъде разгласявана.

Възраст:........... Пол: ☐ мъж ☐ жена

Град на раждане: .................................. Професия: …………………

Родният Ви език български ли е? Да Не

Ако български не е родният Ви език, на каква възраст започнахте да го учите?.....

Какъв език (езици) се говори в дома Ви? …………………………..

Какъв език (езици) говори майка Ви? ……………………………..

Какъв език (езици) говори баща Ви? ……………………………...

Има ли друг език (езици) който да използвате редовно? Да Не

Ако да, моля посочете кой език (езици)…………………………………………

Можете ли да четете или пишете на друг език, макар по принцип да не говорите на него? Да Не

Ако да, моля посочете кой език (езици)…………………………………………

Случвало ли се е да прекарате повече от два месеца в среда където българският не е основен език? Да Не

Ако да, къде и за колко време? ……………………………………………

Българският ли е <u>основния</u> език в образованието Ви? Ако не, моля посочете основния език:

| | | | |
|---|---|---|---|
| Начално/Основно училище: | да | не | друг (посочете) …………. |
| Гимназия: | да | не | друг (посочете) …………. |
| Висше образувание: | да | не | друг (посочете) …………. |
| След висше образование: | да | не | друг (посочете) …………. |

С дясната или лявата ръка пишете? ☐ дясната ☐ лявата

Имате ли (кръвен) родственик, който да пише с лявата ръка? (Моля посочете)

………………………………………………………………………………………………..

**Благодаря Ви за съдействието!**

Ако желаете, моля добавете по-долу други факти свързани с езика, които считате за важни.

English translation

**LANGUAGE BACKGROUND INFORMATION**

Code No.: ……….

All personal information you will provide is confidential.

Age:........... Sex: ☐ male ☐ female

City/Country of origin: .................................. Occupation: …………………

Is English your native (first-learned) language? Yes No

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

What language(s) do you usually speak at home? …………………………..

What language(s) does your mother speak? ……………………………..

What language(s) does your father speak? ……………………………...

Are there any other languages that you use regularly? Yes No

If so, please specify which language(s) ………………………………………………

Can you read or write any other language, though you don't normally speak it? Yes No

If so, please specify which language(s) …………………………………………….

Have you ever spent any time longer than two months living in an environment where English is not the majority language? Yes No

If so, where, when and for how long? ……………………………………………

Has English has been the main language for your education? If not, please specify the main language:

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

Are you right-handed or left-handed? ☐ right-handed ☐ left-handed
Do you have any left-handed blood relatives (biologically related to you)? (Please list them)
…………………………………………………………………………………………

**Thank you for your cooperation!**
Please feel free to write beneath here if you have any
further language background facts you wish to add.

## REFERENCES


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, 77.* Leipzig.

Bashford, J. A. & Warren, R. M. (1979). Perceptual synthesis of deleted phonemes. In J. J. Wolf & D. H. Klatt (Eds.) *Speech Communication papers presented at the 97th meeting of the Acoustical Society of America* (pp. 423-426). New York, NY: Acoustical Society of America

Beach, C., Katz, W., & Skowronski, A. (1996). Children's processing of prosodic cues for phrasal interpretation**.** *Journal of the Acoustical Society of America*, 99, 1148-1160.

Beckman, M. E. (1996). The parsing of prosody. *Language and Cognitive Processes*, 11, 17-67.Beckman & Elam, 1997

Bever, T.G., Jandreau, S., Burwell, R., Kaplan, R., & Zaenen, A. (1990). Spacing printed text to isolate major phrases improves readability. *Visible Language* . v25 n1 p74-87 Win 1991

Bever, T.G., Straub, K., Shenkman, K., Kim, J.J., & Carrithers, C. (1990) The psychological reality of NP-trace. In Proceedings of the 1989 Meeting of the New England Linguistic Society

Bley-Vroman, R. & Chaudron, C. (1994). Elicited imitation as a measure of second-language competence. In E. Tarone, S. M. Gass, & A. D. Cohen (Eds.). *Research methodology in second-language acquisition*, Hillsdale, NJ: Lawrence Erlbaum Associates.

Blodgettt (2004). The interaction of prosodic phrasing, verb bias, and plausibility during spoken sentence comprehension. Unpublished doctoral dissertation. The Ohio State university.

Boersma P. & David Weenink (2009): Praat: doing phonetics by computer.

Caplan, D. (1972). Clause boundaries and recognition latencies for words in sentences. *Perception and Psychopysics*, 1972, Vol. 12(1B)

Carlson, K., Clifton, C., Jr., & Frazier, L. (2001). Prosodic boundaries in adjunct attachment. *Journal of Memory and Language*, 45, 58-81.

Christophe, A., Gout, A., Pepercamp, S. & Morgan, J. (2003). Discovering words in the continuous speech stream: The role of prosody. *Journal of Phonetics, 31, 585-598.*

Christophe, A., & Morton, J. (1998). Is Dutch native English? Linguistic analysis by 2-month-olds. *Developmental Science*, 1, 215-219Christovich (1960)

Clifton, C., Jr., Carlson, K., & Frazier, L. (2002). Informative prosodic boundaries. *Language and Speech*, 45, 87-114.

Clifton, C., Jr., Carlson, K., & Frazier, L. (2006). Tracking the what and why of speakers' choices: prosodic boundaries and the length of constituents. *Psychonomic Bulletin and Review, 13*, 854-861.

Cuetos, Fernando, & Mitchell, Don C. (1988). Cross-linguistic differences in parsing: Restrictions on the use of the Late Closure strategy in Spanish. *Cognition, 30,* 73-105.

Cutler, A., & Clifton, C., Jr. (2000). Blueprint of the listener. In P. Hagoort & C. Brown (Editors), *Neurocognition of language processing*, pp 123-166.

Cutler, A., & Fodor, J. A. (1979). Semantic focus and sentence comprehension. *Cognitio*n, 7, 49-59.

Cutler, A.,Dahan, D., van Donselaar, W. (1997). Prosody in the comprehension of spoken language: a literature review. *Language and Speech*, 40[2], 141-201.

Dahan, D., Tanenhaus, M., and Chambers, C.G. (2002). Accent and reference resolution in spoken-language comprehension. *Journal of Memory and Language*, 47, 292-314.

De Vincenzi, M., & Lombardo, V. (2000). Cross-Linguistic Perspectives on Language Processing. 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.

Fernández, E. M. (2007). How might a rapid serial visual presentation of text affect the prosody projected implicitly during silent reading? *Conferências do V Congresso Internacional da Associação Brasiliera de Lingüística, 5 (2007),* 117-154.

Fernández, E. M. & Bradley, D. (1999). Length effects in the attachment of relative clauses in English. Poster presented at the 12th Annual CUNY Conference on Human Sentence Processing, New York.

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,* 273-290.

Fodor, J. D. (1998). Learning to parse? *Journal of Psycholinguistic Research, 27*, 285-319.

Fodor, J. D. (2002). Prosodic disambiguation in silent reading. In M. Hirotani (Ed.), *Proceedings of the North East Linguistic Society 32, Vol 1* (pp. 113-132). Amherst, MA: GSLA, University of Massachusetts, Amherst.

Fodor, J.A., Bever, T.G. & Garrett, M.F. 1974. The Psychology of Language: An Introduction to Psycholinguistics and Generative Grammar, McGraw-Hill

Forster, K. I. & Forster, J. C. (2003). DMDX: a Windows display program with millisecond accuracy. *Behavior Research methods, Instruments, & Computers, 35 (1),* 116-124.

Frazier, L. (1978). *On comprehending sentences: Syntactic parsing strategies*. Unpublished doctoral dissertation, University of Connecticut.

Frazier, L. (1987). Syntactic processing: Evidence from Dutch. *Natural Language and Linguistic Theory*, **5,** 519–559.

Frazier, L, & Clifton, C., Jr. (1996). *Construal*. Cambridge, MA: MIT Press.

Frazier, L. & Rayner, K. (1982) Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology* 14, 178-210.

Frazier, L., Clifton, C. & Carlson, K. (2004). Don't break, or do: prosodic boundary preferences. *Lingua, 114(1),* 3-27.

Frenck-Mestre, C. & Pynte, J. (1997). Syn tactic ambiguity resolution while reading in second and native languages. *Quarterly J. of Experimental Psychology*, 50A, 119-148.

Gibson, E., Pearlmutter, N., Canseco-Gonzalez, E. and Hickok, G. (1996). "Cross-linguistic attachment preferences: Evidence from English and Spanish." *Cognition*, 59, 23-59.

Gibson, E., Piantadosi, S. & Fedorenko, K. (2011). Using Mechanical Turk to Obtain and Analyze English Acceptability Judgments. *Language and Linguistics Compass 5(8):509-524* (*2011*)

Gilboy, E. and Sopena, J. M. (1996). "Segmentation effects in the processing of complex noun pronouns with relative clauses." In M. Carreiras, J. E. Garcia-Albea and N. Sebastian (Eds.), *Language processing in Spanish.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Gordon, Peter C., Hendrick, Randall, and Foster, Kerry Ledoux "Language comprehension and probe list memory", *Journal of Experimental Psychology: Language, Memory, and Cognition* 26.3, 766-775

Hagoort, P., & Brown, C. M. (2000). ERP effects of listening to speech compared to reading: The P600/SPS to syntactic violations in spoken sentences and rapid serial visual presentation.

Hemforth, B. & Konieczny, L. (2000). *German sentence processing*.. Dordrecht, NL: Kluwer Academic Press.

Hemforth, B., Konieczny, L., Scheepers, C. & Strube, G. (1998). Syntactic ambiguity resolution in German. In D. Hillert: *Psycho-crosslinguistics*. San Diego: Academic Press. 293-311.

Hoeks, J. C. J., Vonk, W., & Schriefers, H. (2002). Processing coordinated structures in context: the effect of topic-structure on ambiguity resolution. Journal of Memory and Language, 46, 99-119.

Igoa, José Manuel, and Celia Teira. 2003. The contribution of prosody to relative clause attachment in spoken sentences in Spanish. Poster presented at *AMLaP (Architectures and Mechanisms for Language Processing) 2003*, Glasgow, UK.

Ito, K. & Speer, S. R. (2005). The effect of intonation on visual search: an eye-tracking study, Presentation at conference on *Experimental pragmatics: exploring the cognitive basis of conversation*. The British Academy, Cambridge, UK.

Jandreau, S. and Bever, T.G. (1992) Phrase-spaced formats improve comprehension in average readers. *Journal of Applied Psychology*, 77, 143 -146.

Jun. S-A. 2003. Prosodic Phrasing and Attachment Preferences. *Journal of Psycholinguistic Research*, 32, 2.

Kang, S.& Speer, S.R.(2004) Prosodic Disambiguation of Participle Constructions in English In B. Bel and I. Marlien, (Eds). Speech Prosody 2004 Proceedings, March, 2004. Nara, Japan

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.

Koizumi, 2009 Processing the *not-because* Ambiguity in English: The Role of Pragmatics and Prosody

Koizumi, Yukiko, Dianne Bradley, Eva M. Fernández and Janet Dean Fodor (2006). Explaining the Preference for Narrow-scope Negation in Not-because Sentences, A paper presented at The 19th Annual CUNY Conference on Human Sentence Processing, CUNY Graduate Center, New York, NY

Kraljic, T. & Brennan, S. E. (2005). Prosodic disambiguation of syntactic structure: for the speaker or for the addressee? *Cognitive Psychology, 50,* 194-231.

Lehiste, I. (1972). The timing of utterances and linguistic boundaries. *Journal of the Acoustic Society of America, 51,* 2018-24.

Lehiste, I., Olive, J. P., & Streeter, L. A. (1976). Role of duration in disambiguating syntactically ambiguous sentences. *Journal of the Acoustical Society of America, 40,* 1199-1202.

Li, W., Yang, Y. (2009). 'Perception of prosodic hierarchical boundaries in Mandarin Chinese sentences', *Neuroscience* 158(4): 1416-1425.

Lovrić, N. (2003). *Implicit prosody in silent reading: relative clause attachment in Croatian.* Doctoral dissertation, CUNY Graduate Center, New York, NY.

Lovrić, N., Bradley, D., & Fodor, J.D. (2000). RC attachment in Croatian with and without preposition. Poster presented at the 6th Annual Conference on Architectures and Mechanisms for Language Processing (AMLaP), Leiden, NL, September 21-23.

Lust, B., Flynn, S. & Foley, C. (1996). What children know about what they say: elicited imitation as a research method for assessing children's syntax. In D. McDaniel, C. McKee, & H. S. Cairns (Eds.) *Methods for assessing children's syntax*. Cambridge, MA: MIT Press, 55-76.

MacDonald, M.C. (1999). Distributional Information in Language Comprehension, Production and Acquisition: Three Puzzles and a Moral', in B. MacWhinney (ed.), The Emergence of Language. Mahwah, NJ: Erlbaum.

Marslen-Wilson, W. D. (1973). Linguistic structure and speech shadowing at very short latencies. *Nature, 244,* 522-523.

Marslen-Wilson, W. D. (1975). Sentence perception as an interactive parallel process. *Science, 189,* 226-228.

Marslen-Wilson, W. D. (1985). Speech shadowing and speech comprehension. *Speech Communication, 4,* 55-73.

Marslen-Wilson, W. D., Tyler, L. K., Warren, P., Grenier, P., & Lee, C. S. (1992). Prosodic effects in minimal attachment. *Quarterly Journal of Experimental Psychology, 45A,* 73-87.

Maynell, L. A. (1999). Effect of pitch accent placement on resolving relative clause ambiguity in English. Poster presented at the 12th Annual CUNY Conference on Human Sentence Processing, New York, NY, March 18-20.

Mazuka, R. (2007). The rhythm-based prosodic bootstrapping hypothesis of early language acquisition: does it work for learning for all languages? *Journal of the Linguistic Society of Japan*, 9 (132), 1-13.

Mendelssohn, A., & Pearlmutter, N. (1999). Individual differences in relative clause attachment preferences. Poster presented at the 12th Annual CUNY Conference on Human Sentence Processing, New York, NY, March 18-20.

Misheva, A. & Nikov, M. (1998). Intonation in Bulgarian. In D. Hirst & A. Di Cristo (Eds.) *Intonation systems. A survey of twenty languages* (pp. 275-287). Cambridge: Cambridge University Press.

Mitchell, D.C., & Brysbaert, M. (1998). Challenges to recent theories of cross linguistic variation in parsing: Evidence from Dutch. In D. Hillert (Ed.), *Sentence Processing:A Crosslinguistic Perspective* (pp. 313-335). San Diego, CA: Academic Press.

Mitchell, D. and Cuetos, F. (1991). The origins of parsing strategies. In *Current issues in* natural language processing, University of Texas.

Nespor, M. & I. Vogel (1986) *Prosodic phonology*. Foris, Dordrecht.

Newman, R.S. (2004). Phoneme restoration in infants. *Journal of the Acoustical Society of America, 107(5),* 2857

Pashov, P. (1999). Bulgarian grammar. Hermes.

Pauker, E., Itzhak, I., Baum, S. R., & Steinhauer, K. (2011). Co-operating and conflicting prosody in spoken English garden path sentences: Evidence from event-related potentials. *Journal of Cognitive Neuroscience*. 23, pp. 2731-2751

Penchev, Iordan. 1984. Structure of the sentence in Bulgarian. Nauka I Izkustvo. Sofia. 1984.

Peppe, S. and McCann, J. (2003). Assessing intonation and prosody in children with atypical language development: the PEPS-C test and the revised version. *Clinical Linguistics and Phonetics, 17/4-5,* 345-354

Peppé, S., McCann, J., Gibbon, F., O'Hare, A., Rutherford, M. (2007). Receptive and expressive prosodic ability in children with high-functioning autism. *Journal of Speech, Language and Hearing Research, 50,* 1015-1028.

Pierrehumbert, J. (1980). The Phonology and Phonetics of English Intonation.. Ph.D thesis, MIT

Pierrehumbert, J. and J. Hirschberg (1990) The Meaning of Intonational contours in the Interpretation of Discourse, in P. Cohen, J. Morgan, and M. Pollack, (eds) . Intentions in Communication, MIT Press, Cambridge MA. 271-311.

Price, P., Ostendorf, M., Shattuck-Hufnagel, S., & Fong, C. (1991). The use of prosody in syntactic disambiguation. *Journal of the Acoustical Society of America*, 90, 6, 2956-2970.

Pynte, J. & Colonna, S. (2000). Decoupling syntactic parsing from visual inspection: The case of relative clause attachment in French. In A. Kennedy, R. Radach, D. Heller, & J. Pynte (Eds.). *Reading as a perceptual process*. Oxford Elsevier, 529-547.

Quinn, D., Abdelghany, H., & Fodor, J.D. (2000). More evidence of implicit prosody in reading. French and Arabic relative clauses. Poster presented at the 13th Annual CUNY Conference on Human Sentence Processing, La Jolla, CA, March 30-April 1.

Samuel, A. G. (1981). Phonemic restoration: insights from a new methodology. *Journal of Experimental Psychology: General, 110,* 474-494.

Samuel, A. G. (1996). Phoneme restoration. *Language and Cognitive Processes, 11,* 647-653.

Schafer, A.J. (1997). Prosodic Parsing: The Role of Prosody in Sentence Comprehension. University of Massachusetts Doctoral Dissertation.

Schafer, A.J., Carter, J., Clifton, C. & Frazier, L. (1996). Focus in relative clause construal. *Language and Cognitive Processes, 11,* 135 - 163.

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.

Sekerina, I.A. 1997. The Late Closure Principle vs. the Balance Principle: Evidence from on-line processing of ambiguous Russian sentences. In P. Costa (Ed.), *The Proceedings of the Second European Conference on Formal Description of Slavic Languages*, Universität Potsdam, Germany.

Sekerina, I.A., Fernández, E.M., and Petrova, K.A. Relative Clause Attachment in Bulgarian. In Arnaudova, O., Browne, W., Rivero, M. L., & Stojanović, D. (Eds.), *The Proceedings of the 12th Annual Workshop on Formal Approaches to Slavic Linguistics*. *The Ottawa Meeting 2003*. (pp. 375-394.) Michigan Slavic Publications.

Sekerina, I.A. & Trueswell, J.C. 2012**.** Interactive processing of contrastive expressions by Russian children. *First Language*, 32 (1-2), 63-87.

Selkirk, Elisabeth. 1984. *Phonology and Syntax: The Relation between Sound and Structure*. Cambridge, MA: MIT Press.

Selkirk, Elisabeth. 1995. Sentence prosody: intonation, stress and phrasing. In *TheHandbook of Phonological Theory*, ed. John Goldsmith. London: Blackwell.

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.

Shaked, A. 2009. *Sentence processing of complex nominals in Hebrew*. Doctoral dissertation, CUNY Graduate Center, New York, NY.

Sherman, B.L. 1971. *Phonemic restoration: an insight into the mechanisms of speech perception.* Unpublished master's thesis, University of Wisconsin–Milwaukee.

Snedeker, J. & Trueswell, J. 2003. Using prosody to avoid ambiguity: effects of speaker awareness and referential context. *Journal of Memory and Language, 48,* 103-130.

Stanislaw, H. & N.Todorov. 1999. Calculation of signal detection theory measures. *Behavior Research Methods, Instruments, & Computers 1999, 31 (1), 137-149*

Stoyneshka, I., Fodor,, J.D. & Fernández  E. 2010. Phoneme restoration methods for investigating prosodic influences on syntactic processing, 1265-1293. In *Language and Cognitive Processes* 25 (7).

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.

Streeter, L. (1978).  Acoustic determinants of phrase boundary perception. *Journal of the Acoustical Society of America, 64,* 1582-92.

Teira, C., & Igoa, J.M. (2005). On the relation between prosodic structure and syntactic decisions in spoken sentence comprehension and production. Poster presented at the 18th Annual CUNY Conference on Human Sentence Processing, Tucson, AZ, March 31 - April 2.

Teira, C. & Igoa, J.M. (2007). The prosody-syntax relationship in sentence processing.  *Anuario de Psicología, 38, 1*, 45-69

Tilkov, D. 1981. Intonation in Bulgarian. Narodna Prosveta. Sofia.

Truckenbrodt, H. (1999). On the relation between syntactic phrases and phonological phrases. *Linguistic Inquiry*, 30, 219-255.

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, 285-318.

Trueswell, J. C**.,** Sekerina, I. A.**,** Hill, N. and Logrip, M. The Kindergarten-Path Effect: Studying On-Line Sentence Processing in Young Children.*Cognition 73*, 89-134.

Walley, A. C. (1988). Spoken word recognition by young children and adults. *Cognitive Development, 3,* 137-165

Warren, R. M. (1970). Perceptual restoration of missing speech sounds. *Science, 167,* 392-393.

Warren, R. M. (1999). Auditory demonstrations. Companion CD to *Auditory perception: a new analysis and synthesis, second edition*. Cambridge, UK: Cambridge University Press. Replication of CD available online; retrieved March 2009, from http://www4.uwm.edu/APL/demonstrations.html

Warren, R.M., & Obusek, C.J. Speech perception and phonemic restorations. *Perception & Psychophysics*, 1971, 9, 358-362.

Warren, R. M., & Warren, R. P. (1970). Auditory illusions and confusions. *Scientific American, 223,* 30-36.

Warren, R. M., & Sherman, G. L. (1974). Phonemic restorations based on subsequent context. *Perception &Psychophysics 1974, Vol.* 16, *No.1, 150·156*

Watson, D. G., Gunlogson, C. A., & Tanenhaus, M. K. (2006). Online methods for the investigation of prosody. In S. Sudhoff, D. Lenertova, R. Meyer, S. Pappert, P. Augurzky, I. Mleinek, N. Richter, J. Schlieber (Eds.) *Methods in empirical prosody research* (pp. 259-282). New York, NY: Walter de Gruyter.

Watson, D. & Gibson, E. (2004). The relationship between intonational phrasing and syntactic structure in language production. *Language and Cognitive Processes*, 19, 713-755.

Watson, D. & Gibson, E. (2005). Intonational phrasing and constituency in language production and comprehension. Studia Linguistica, 59, 279-300.

Webman Shafran, R. (2011) Prosody and parsing in a double PP construction in Hebrew, CUNY dissertn

Wijnen, F. (2004). The implicit prosody of jabberwocky and the relative clause attachment riddle. In H. Quené & V. van Heuven (Eds.*), On Speech and Language. Studies for Sieb G. Nooteboom* (pp.169-178). Utrecht: Landelijke Onderzoeksschool Taalwetenschap. (LOT Occasional Series 2).