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**IMPLICIT PROSODY IN SILENT READING:
RELATIVE CLAUSE ATTACHMENT IN CROATIAN**

by

Nenad Lovrić

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

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Five major explanations have been proposed in the literature to account for cross-linguistic differences in RC-attachment: the Construal/Gricean account, Attachment-Binding Dualism, the Predicate Proximity/Recency model, the Tuning Hypothesis, and the Implicit Prosody Hypothesis (IPH).

This thesis examines RC-attachment preferences in Croatian. The data reported address four of the above proposals: they argue against the first three and support the fifth, the IPH. (The data do not bear on the Tuning Hypothesis, which holds that there is no principled parsing explanation for the cross-linguistic facts.) The IPH claims that a default prosodic pattern, which may differ across languages, is mentally computed during silent reading, influencing syntactic attachment decisions. Croatian has a distinctive pattern of prosodic phrasing in that in sentences comparable to (1), it favors a prosodic break before a long RC as compared with a short RC, and a prosodic break before the preposition in the complex NP construction as compared with the non-prepositional variant of the same construction. (Both variants of the construction, prepositional and non-prepositional, are acceptable in Croatian.) The experimental findings reported here document these prosodic characteristics, and show that they are reflected in syntactic attachment preferences in silent reading. This evidence is important because if the IPH is correct, then cross-language RC-attachment differences are attributable to independently demonstrable differences in the prosodic principles in the grammar. That is, they fall into line with other observed parsing preferences in that they do not reflect non-universal processing routines.

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In loving memory of my father, Slobodan.

New York, NY, June 2003

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CHAPTER 1

INTRODUCTION

1.1 Relative Clause Attachment in Croatian

This dissertation investigates Croatian speakers' understanding of complex noun phrases (NPs) which contain two nouns (N1, N2) followed by a modifying relative clause (RC). An English equivalent of the Croatian sentence types examined in this study is shown in (1). Croatian examples are introduced in Chapters 5 and 6, following discussion of theoretical issues.

- (1) Someone shot the servant of the actress who was on the balcony.
 N1 N2 ----- RC -----

Sentences like (1) are syntactically and semantically ambiguous, since either the first noun (*servant*) or the second noun (*actress*) could be understood as modified by the RC.¹ The construction is of particular interest to psycholinguistic research because experiments have shown that speakers of different languages exhibit different patterns

¹ Strictly speaking, when the first noun is modified by the RC, the RC is syntactically attached to the whole nominal complex headed by N1 (i.e., *servant of the actress* in (1)). However, for ease of exposition this will henceforth be referred to as modification of, or attachment to, N1.

of ambiguity resolution, even for translation-equivalent sentences (Cuetos & Mitchell, 1988). Speakers of English and Romanian and Egyptian Arabic, among other languages, tend to attach the RC to N2 (so (1) means that the actress was on the balcony), while the preference for Spanish, Dutch, German and other languages, is to interpret the RC as attaching to N1 (meaning that the servant was on the balcony).

This cross-linguistic variation, which has puzzled researchers for over 15 years now, is of theoretical concern because it is the only known counterevidence to the claim that the human sentence processing routines are universal. Universality is important because it is compatible with the hypothesis that the processing mechanism is innate, i.e., that language acquisition does not involve learning how to process sentences, learners being biologically equipped with this capacity and ready to apply it as soon as they have acquired some facts of the language. It is essential, therefore, to understand why cross-language variation occurs and whether it can still be reconciled with the innateness of the human sentence processing mechanism.

1.2 Overview

Chapter 2 of this dissertation reviews the existing evidence on relative clause attachment preferences in English, Spanish, and a number of other languages, and discusses theoretical issues surrounding the study of cross-linguistic differences in processing routines. Chapters 3 and 4 evaluate five influential explanations that have been proposed to date to account for cross-linguistic variation in RC-attachment preferences. The Construal/Gricean account, Attachment-Binding Dualism, the

Predicate Proximity/Recency model, and the Tuning Hypothesis are discussed in Chapter 3. The Implicit Prosody Hypothesis (IPH), the focus of this thesis, is discussed in Chapter 4. Chapter 5 explains why an investigation of Croatian, a language which has been studied very little from a psycholinguistic point of view, is particularly interesting when it comes to the study of RC-attachment. Grammatical characteristics of Croatian make it possible to test four of the five proposals mentioned above: the Construal/Gricean account, Attachment-Binding Dualism, the Predicate Proximity/Recency model, and the Implicit Prosody Hypothesis (IPH).

The experimental component of this research consists of five experiments designed to investigate RC-attachment in Croatian. Chapter 6 describes three reading experiments examining Croatian speakers' preferred interpretation of Croatian sentences similar to (1). The data from these experiments effectively eliminate the Construal/Gricean account, Attachment-Binding Dualism, and the Predicate Proximity/Recency model. (These data do not bear on the Tuning Hypothesis. It assumes that there is no principled explanation within the comprehension system for which languages exhibit which perceptual preference, but rather that speakers/hearers simply learn whichever attachment pattern is prevalent in their language; see Section 3.3.3 for discussion.)

The following chapter (Chapter 7) presents data from two experiments specifically designed to test aspects of the IPH. The IPH claims that even in silent reading (which is the procedure that has routinely been used in the experiments on RC-attachment), a prosodic contour is computed in the reader's mind and this implicit (mentally projected) prosodic contour, which may vary across languages, influences

the reader's attachment decisions in much the same way as explicit ("real") prosody affects hearers' attachment decisions in the comprehension of spoken sentences. Data from Experiment 4 (a reading-aloud study) and Experiment 5 (a parsing study with spoken stimuli), considered together with those from Experiment 3 (a parsing study with written input, involving silent reading), provide support for the IPH. The IPH attributes different RC-attachment preferences across languages not to different processing routines but rather to differences in the prosodic principles in the grammars of those languages, which can be independently documented. The Croatian data provide an especially well-controlled comparison, since they concern contrasts in attachment preferences across constructions within the same language, which can be ascribed to differences in the canonical prosodic contours for those constructions.

Finally, the findings of the five experiments are evaluated as a whole in Chapter 8, where we examine how the evidence presented in this dissertation contributes to current understanding of the human parsing mechanism and points to future investigations of variation in RC-attachment preferences.

CHAPTER 2

CROSS-LINGUISTIC DIFFERENCES IN SENTENCE PROCESSING: THE RELATIVE CLAUSE ATTACHMENT AMBIGUITY

2.1 A Universal Parser?

Much research on sentence comprehension has focused on questions concerning the architecture of the human sentence processing mechanism, and particularly on the principles that guide the structure-building component of that mechanism, the parser, in its assignment of structure to input word strings. According to the theory of parsing which has been most influential for the past 20-odd years, the Garden Path Theory (Frazier, 1978; Frazier & Clifton, 1996; Frazier & Fodor, 1978, among others), *all* parsing principles are universal: languages have different grammars, but the mental machinery that deploys the grammar to process sentences is the same, irrespective of the language of the input. On this account, the parser uses the grammar of the input language to structure word strings *incrementally*, as they are received. Any structural ambiguities are dealt with in a *serial* fashion: where the grammar allows more than one structure, the parser initially chooses one of them and ignores the rest, rather than computing multiple syntactic analyses (as in *parallel* models of processing) or delaying analysis of the input until disambiguating information becomes available (as in *delay*

models of processing). The parser's initial choice is not arbitrary but is determined by a set of parsing principles which are assumed to follow from the basic design of the mental parsing machinery.

Kimball (1973) was the first to propose specific parsing principles based on considerations related to the "hardware" of the human cognitive device, suggesting that certain principles serve to minimize storage requirements, thereby avoiding some of the difficulties associated with the limitations of human short-term memory. Frazier & Fodor (1978) followed along similar lines, reducing in number and refining Kimball's seven principles of parsing in their Sausage Machine model. Of all the principles that have been proposed over the years, the three that have featured most prominently in the literature are Minimal Attachment (Frazier & Fodor, 1978), Late Closure (Frazier, 1978) and the Minimal Chain Principle (De Vincenzi, 1991). All three have been argued to be computationally justified in that they serve to maximize the speed and efficiency of processing by favoring the analysis which requires the least effort and memory load on the part of the structure-building device. As such, they are assumed to be internally driven, reflecting general tendencies of the human cognitive system.

If arguments attributing all parsing strategies to the basic design of the parser (or of the human mind in general) are correct, then these strategies should apply universally across all constructions in all natural languages. This strong universalist approach, rooted in the Garden Path Theory, has the greatest potential explanatory power (there being no need to postulate *any* acquired, language-specific parsing principles). However, its descriptive consequence is that it leaves no room for *any* non-grammar-based cross-linguistic variation in parsing: if investigation uncovers differences between

languages with respect to how they are processed which cannot be attributed to differences in their grammars, then the notion of a universal parser would be seriously challenged.

For more than a decade now, the apparent failure of Late Closure to apply cross-linguistically has presented just such a challenge.

2.2 The Late Closure Crisis - Universality in Question

The Late Closure Principle was formulated by Frazier (1978) in these terms:

"When possible, attach incoming material into the clause or phrase currently being parsed."

At least in right-branching structures, this is equivalent to Kimball's (1973) principle of Right Association ("Terminal symbols optimally associate to the lowest nonterminal node."). What it entails for such structures is that when the parser is faced with a choice between high (or non-local/distant) and low (or local/recent) attachment, it should prefer to attach low (i.e., locally, to the nearest or most recent site). Among the familiar examples of this principle in action are the following:

- (1) Tom said that Bill left *yesterday*.
- (2) ...the gift for the boy *in the box*...

In both (1) and (2), the parser is faced with a structural ambiguity. In (1), the adjunct *yesterday* can be interpreted as modifying either the first verb *said* or the second verb

left; in (2), the PP *in the box* can be attached as a modifier either to the immediately preceding NP *the boy* or to the higher NP *the gift*. Late Closure correctly predicts the preferred readings: the ambiguously attached constituent (*yesterday* in (1), *in the box* in (2)) is easier to interpret as attaching low in both sentences (to *left* in (1) and to *the boy* in (2) despite a pragmatic bias to the contrary).

Late Closure has been shown to apply in a variety of constructions in English and in other languages as well. (Kimball, 1973, and Frazier, 1978, documented a number of constructions in English; see also Igoa, 1995, and Igoa, Carreiras & Meseguer, 1998, for PP-attachment to the VP in either the main or subordinate clause in Spanish; and Ferreira & Henderson, 1997, for object-attachment in subordinate clauses in English sentences like *While the boy scratched the big and hairy dog yawned loudly*.)

The only construction which to date has been shown to depart from Late Closure in some languages is the relative clause (RC) attachment construction of the type shown in (3):

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

Here the ambiguously attached RC (*who was on the balcony*) can be interpreted as modifying either N1 (*servant*) or N2 (*actress*).

Cuetos & Mitchell (1988) tested interpretation preferences for sentences like (3) in English and Spanish using an ambiguity-resolution questionnaire with written sentences. They found that when asked to make a choice between alternative interpretations (e.g., *Who was on the balcony?*), English-speaking subjects more often

chose the second noun (61% of the time²), indicating that they had preferred to interpret the RC as attaching at the lower site. Spanish speakers (given the equivalent sentences and questions in Spanish) more often chose the first noun (62% of the time³), indicating that they had preferred to attach the RC at the higher site. The low-attachment preference for English is predicted by the Late Closure strategy; however, the high-attachment preference exhibited by Spanish constitutes an apparent violation of Late Closure.

Cuetos and Mitchell further examined the attachment preference in Spanish by conducting a series of self-paced reading experiments. In RC-attachment experiments of this kind, subjects typically read sentences with the same structure as (3), but with disambiguating information added to force either high or low attachment of the RC (as shown below, where N1 and N2 differ in gender, and *con su marido* in the RC is intended to disambiguate the sentence toward high attachment in (4a) and low attachment in (4b)).

² This figure is for the 11 (of 24) target sentences in which both N1 and N2 were human (e.g., (3) above). For the remaining 13 targets, in which N2 was human but N1 was not (e.g., *Peter was looking at the book of the student that was in the living room*), English speakers chose N2 as the site of attachment only 32% of the time. Cuetos and Mitchell attributed this difference to the use of the complementizer *that* in the non-human/human sentences, which is likely to have introduced a bias in favor of the non-human N1 in these items, especially since the relative pronoun *who* was used in the human/human items.

³ This figure is for all 24 experimental sentences in Spanish. (The non-biasing animacy-neutral Spanish relative pronoun *que* was used in all Spanish target items, both human/human and non-human/human ones.)

(4a) Alguien disparó contra la criada del actor
 someone shot against the servant-[fem.] of-the actor-[masc.]
 que estaba en el balcón con su marido.
 that was on the balcony with [poss. pron.] husband

“Someone shot the servant of the actor who was on the balcony with his/her husband”

(4b) Alguien disparó contra el criado de la actriz
 someone shot against the servant-[masc.] of the actress-[fem.]
 que estaba en el balcón con su marido.
 that was on the balcony with [poss. pron.] husband

“Someone shot the servant of the actress who was on the balcony with his/her husband”

On-line experiments, including Cuetos and Mitchell's, have provided confirmation that Spanish RC-attachment departs from Late Closure: subjects take longer to read the disambiguating part of the sentence if it forces low attachment, as in (3b), than if it forces high attachment, as in (3a) (Carreiras & Clifton, 1993; Clifton, 1988; Mitchell & Cuetos, 1991; but see Fernández, 2000/2003, who reports contrary data for Spanish, using self-paced reading).

Since a single exception is sufficient to undermine the universality of a parsing principle, Cuetos and Mitchell's data for Spanish would appear to falsify the hypothesis that Late Closure is a parsing universal. Defenders of the universal parser have therefore taken up the challenge of explaining the data in a way that is compatible with the universality hypothesis.

Since Cuetos and Mitchell's seminal study, there has been a veritable explosion of research on the RC-attachment ambiguity. In addition to English and Spanish,

relevant data have been reported for a variety of languages. The appendix to Chapter 2 lists, by language, the experimental evidence to date concerning RC-attachment.

On the surface of it, languages fall into two groups: those that behave like English, in that they predominantly attach low (Egyptian Arabic, Norwegian, Romanian and Swedish), and those that behave like Spanish, in that they are reported to favor high attachment of the RC (Afrikaans, Dutch, French, German and Italian, among others). It should be noted, however, that the above division into low- and high-attaching languages is schematic at best, as the data are a good deal less clear than we might wish them to be, to support this kind of partitioning by language. In most cases, the preference is reliably different from chance (50%) but by only a small margin (e.g., approximately 60% low attachment in English, and 60% high attachment in Spanish; see discussion of Cuetos & Mitchell, 1988, above). Two languages in which the facts have been particularly hotly contested are Italian and French. Italian, in which measures based on post-sentential questions show the *final* attachment preference to be high, has been claimed to have a low-attachment preference *initially*, based on on-line reading times (De Vincenzi & Job, 1993, 1995). The methodology in these studies has, however, been disputed (Pynte, 1998; Frenck-Mestre & Pynte, 2000). Using materials closely matched to those used to test the attachment preference in Italian, Baccino, De Vincenzi & Job (2000) have in turn challenged the *initial* preference for French, reported to be high in a number of previous studies (Frenck-Mestre, 1997; Frenck-Mestre & Pynte, 2000; Zagar et al., 1997).

The controversy over attachment preferences in Italian and French instantiates a wider debate over the issue of initial RC-attachment preferences in general: Do they

vary cross-linguistically, like final attachment preferences, or do they obey structural principles such as Late Closure? Or are there no initial RC-attachment preferences at all (see discussion of Construal in Sections 3.2.1 and 3.2.2)? The position of De Vincenzi, Job and their colleagues, according to which Late Closure universally favors low attachment in early processing but may later be overridden by thematic and discourse influences post-syntactically, is supported by data from a number of other studies as well. Thus, for instance, on-line data presented by Fernández (2000/2003) challenge the initial attachment preference for Spanish, reported to be high in a number of previous studies (Carreiras & Clifton, 1993, 1999; Clifton, 1988; Cuetos & Mitchell, 1988; Gibson, Pearlmutter & Torrens, 1999; Mitchell & Cuetos, 1991; Mitchell, Cuetos & Zagar, 1990). Also, there are apparent discrepancies between the early and ultimate attachment preferences in Brazilian Portuguese. The preference for low attachment reported by Miyamoto (1999) using a version of the self-paced reading paradigm, has been challenged by questionnaire data from Maia & Maia (2001), Finger & Zimmer (2002) and Miyamoto & Finger (2002). Research is underway to elucidate this.

On the other hand, a host of studies have claimed a high-attachment preference for a number of languages even in what the authors take to be early processing, e.g., for Dutch (Brysbaert & Mitchell, 1996; Mitchell et al., 1995; Mitchell et al., 2000), German (Hemforth et al., 1998, 1999, 2000; Walter, Hemforth et al., 1999), and Spanish (Carreiras & Clifton, 1993, 1999; Cuetos & Mitchell, 1988; Gibson et al., 1999; Mitchell & Cuetos, 1991).

As the debate over initial attachment preferences continues, in particular for Italian and French, there has been occasional disagreement between studies examining

other languages as well. The high-attachment preference for German, repeatedly reported by Hemforth and colleagues (Hemforth et al., 1998, 1999, 2000; Walter et al., 1999), has also been challenged (Murray, Rahman & Heydel, 2000). Even the low-attachment preference for English, originally reported by Cuetos & Mitchell (1988) and replicated since then in numerous studies, using both off-line and on-line measures (Carreiras & Clifton, 1999; Clifton, 1988; Corley, 1996; Deevy, 1999; Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999; Fernández, 2000/2003; Frazier & Clifton, 1996; Henstra, 1996), has occasionally appeared not to be as robust as it is often taken to be. In an attempt to replicate Cuetos & Mitchell's findings, but with American English speakers (Cuetos & Mitchell's subjects were speakers of British English), Clifton (1988, reported in Frazier, 1990) failed to find a significant preference for either attachment. Clifton used a questionnaire technique, but data from some self-paced reading experiments have also indicated a null result for English (Carreiras & Clifton, 1993; Henstra, 1996).

The various discrepancies between studies may be due wholly or in part to differences in the methods and the materials used in the experiments. Studies on RC-attachment preferences have been carried out using a number of different experimental methods and a wide variety of experimental materials. The methods have included those traditionally regarded as tapping later (post-syntactic) processes (i.e., a number of variations on the off-line questionnaire task) and also methods believed to tap early stages of processing (i.e., speeded on-line tasks), such as several versions of the self-paced reading paradigm and eye-tracking. (For recent discussion of a number of methodological issues concerning research on RC-attachment, and particularly the

segmentation of visual displays and the method of disambiguation in on-line experiments, see Fernández, 2000/2003, Chapters 2 & 4, and the references therein.)

The materials tested have incorporated manipulation of various aspects of both the NP-complex host and the RC. Attachment preferences have been shown to be sensitive to a number of factors, many of which were overlooked in early studies: the length of the RC, the length of the host NPs, the number of nouns in the NP complex, the type of preposition(s) in the NP complex, the frequency of the host nouns, the definiteness and referentiality of the host nouns, the animacy/humanness of the host nouns, the type of relative pronoun introducing the RC, and the position of the complex NP in the sentence, among others. An additional source of within-language variation has been identified at the level of individual subjects (see Corley, 1996, and Corley & Cuthbert, 1997, for English, and Brysbaert & Mitchell, 1996, for Dutch; see also Hocking & Mitchell, 2000; however, see also Mendelsohn & Pearlmutter, 1999, for data contrary to those of Hocking & Mitchell), and there have been suggestions that attachment preferences may also vary at the level of dialect (Clifton, 1988; Corley & Cuthbert, 1997) as well as work indicating that there is variation based on the subjects' language history (e.g., whether they are monolingual or bilingual speakers of the language tested; see Fernández, 1998, 2000/2003; see also Maia & Maia, 2001; and Papadopoulou, 2002).

To summarize: after more than a decade of research, it is evident that the RC-attachment phenomenon is a good deal more complex than at first appeared. The literature is now ample, and there are numerous facts to account for. In addition to allowing for both *between-language* and *within-language* variation, an adequate model

of RC-attachment ambiguity resolution should also be able to explain what it is about this particular construction that makes it, as far as is known, the only exception to the operation of Late Closure.

In the next two chapters (Chapters 3 and 4) we discuss the various models of RC-attachment that have been proposed in the literature and evaluate how each fares with respect to the evidence available.

Appendix to Chapter 2: Sources of experimental evidence to date concerning RC-attachment, by language

<p>Afrikaans</p> <p>Mitchell, Brysbaert, Grondelaers & Swanepoel, 2000</p>
<p>Brazilian Portuguese</p> <p>Finger & Zimmer, 2002 Lourenço-Gomes, 2002 Maia & Maia, 2001 Miyamoto, 1999 Miyamoto & Finger, 2002</p>
<p>Bulgarian</p> <p>Sekerina, Petrova & Fernández, 2003</p>
<p>Dutch</p> <p>Brysbaert & Mitchell, 1996 Brysbaert, Desmet & Mitchell, 1999 De Baecke, Brysbaert & Desmet, 2000 De Baecke, Brysbaert, Desmet & Drieghe, 2002 Desmet, Brysbaert & De Baecke, in press Frazier & Vonk, 1997 Mitchell & Brysbaert, 1998 Mitchell, Brysbaert, Grondelaers & Swanepoel, 2000 Mitchell, Cuetos, Corley & Brysbaert, 1995 Wijnen, 1998, 2001, 2002 Wijnen, Troos & Quené, 1999 Wijnen & Quené, 2000</p>

Egyptian Arabic

Abdelghany & Fodor, 1999
 Quinn, Abdelghany & Fodor, 2000

English (including US, UK and non-native English)

Bradley, Fernández & Taylor, 2003
 Carreiras & Clifton, 1993, 1999
 Clifton, 1988
 Clifton, Carlson & Frazier, 2002
 Corley, 1996
 Corley & Cuthbert, 1997
 Cuetos, Mitchell & Corley, 1996
 Deevy, 1999
 Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999
 Felser, Marinis & Clahsen, 2002
 Fernández, 1998, 2000/2003
 (see also Fernández & Bradley, 1999, 2000; Fernández, Bradley & Fodor, 2000)
 Frazier & Clifton, 1996
 Gibson, Pearlmutter, Canseco-Gonzalez & Hickok, 1996
 Gibson, Pearlmutter & Torrens, 1999
 Gibson & Schütze, 1999
 Gibson, Schütze & Salomon, 1996
 Gilboy & Sopena, 1996
 Gilboy, Sopena, Clifton & Frazier, 1995
 Henstra, 1996
 Heydel & Murray, 2003
 Hocking & Mitchell, 2000
 Maia & Maia, 2001
 Mitchell & Cuetos 1991
 Murray, Rahman & Heydel, 2000
 Oria-Merino, Costantino, Heydel & Sainz, 2000
 Quinn, Abdelghany & Fodor, 2000
 Simoes, 2003
 Thornton, MacDonald & Gil, 1999
 Walter, Clifton, Frazier, Hemforth, Konieczny & Seelig, 1999

<p>French (including European and Canadian French)</p> <p>Baccino, De Vincenzi & Job, 2000 Colonna, Pynte & Mitchell, 2000 Fernández, Fodor, de Almeida, Bradley & Quinn, 2003 Frenck-Mestre, 1997 Frenck-Mestre & Pynte, 2000 Mitchell, Cuetos & Zagar, 1990 Pynte, 1998 Pynte & Colonna, 2000 Quinn, Abdelghany & Fodor, 2000 Schimke, Konieczny & Hemforth, 2002 Zagar, Pynte & Rativeau, 1997</p>
<p>Galician</p> <p>García-Orza, Fraga, Tejjido & Acuña, 2000</p>
<p>German</p> <p>Hemforth & Konieczny, 2002 Hemforth, Konieczny & Scheepers, 2000a, 2000b Hemforth, Konieczny, Scheepers & Strube, 1998 Hemforth, Konieczny, Seelig & Walter, 1999 Konieczny & Hemforth, 2000 Murray, Rahman & Heydel, 2000 Oria-Merino, Costantino, Heydel & Sainz, 2000 Walter, Clifton, Frazier, Hemforth, Konieczny & Seelig, 1999 Walter, Hemforth, Konieczny & Seelig, 1999</p>
<p>Greek</p> <p>Papadopoulou, 2002 Papadopoulou & Clahsen, 2002, 2003</p>
<p>Italian</p> <p>De Vincenzi & Job, 1993, 1995</p>
<p>Japanese</p> <p>Jun & Koike, 2003 Kamide, 1998 Kamide & Mitchell, 1997 Kamide, Mitchell, Fodor & Inoue, 1998</p>

<p>Norwegian</p> <p>Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999</p>
<p>Polish</p> <p>Nowak, 2000</p>
<p>Romanian</p> <p>Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999</p>
<p>Russian</p> <p>Sekerina, 1997</p>
<p>Spanish (including Peninsular, Latin American and US Spanish)</p> <p>Carreiras, 1992 Carreiras, Betancort & Meseguer, 2001 Carreiras & Clifton, 1993, 1999 Clifton, 1988 Cuetos, Mitchell & Corley, 1996 Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999; Fernández, 1998, 1999, 2000/2003 (see also Fernández & Bradley, 2000; Fernández, Bradley & Fodor, 2000) Gibson, Pearlmutter, Canseco-Gonzalez & Hickok, 1996 Gibson, Pearlmutter & Torrens, 1999 Gilboy & Sopena, 1996 Gilboy, Sopena, Clifton & Frazier, 1995 Igoa, 1995, 1996 Igoa, Carreiras & Meseguer, 1998 Mitchell & Cuetos 1991 Mitchell, Cuetos & Zagar, 1990 Oria-Merino, Costantino, Heydel & Sainz, 2000 Salillas, Carreiras, 2002 Simoes, 2003 Thornton, MacDonald & Gil, 1999</p>
<p>Swedish</p> <p>Ehrlich, Fernández, Fodor, Stenshoel & Vinereanu, 1999</p>

CHAPTER 3

PROPOSED EXPLANATIONS

3.1 Introduction

Four main proposed explanations of variation in RC-attachment preferences will be considered in this chapter⁴:

- 1) an explanation based on Construal Theory (Frazier & Clifton, 1996);
- 2) a dual-mechanism explanation (Hemforth and colleagues, e.g., Hemforth et al., 1998);
- 3) an explanation based on the Tuning Hypothesis (Cuetos, Mitchell and colleagues, e.g., Mitchell & Cuetos, 1991; Cuetos et al., 1996), and
- 4) an explanation based on parameter setting (Gibson and colleagues, e.g., Gibson et al., 1996).

The first two accounts fall into the class of explanations usually referred to as grammar-based: they propose that the observed variation in RC-attachment is attributable to differences in the grammars of the languages in question, thus leaving intact the

⁴ A number of other explanations have been either abandoned or disconfirmed by data, e.g., the Modifier Straddling hypothesis (Cuetos & Mitchell, 1988).

hypothesis that the parser is universal. In contrast with these accounts, the latter two are exposure-based: (3) proposes that attachment preferences are based on previous experience with the same construction, and (4) proposes a language-specific parsing parameter that learners of the language must set. We will start by examining the former (grammar-based) theories in Section 3.2, and return to the latter (exposure-based) theories in Section 3.3. The Implicit Prosody Hypothesis (Fodor, 1998, 2000; Quinn et al., 2000), a more recent addition to the class of grammar-based theories, and the focus of this thesis, will be discussed separately in Chapter 4.

3.2 Grammar-Based Explanations

3.2.1 Construal: The Proposal

Construal Theory (Frazier & Clifton, 1996) is a refinement of the Garden Path theory of sentence processing (Frazier, 1978, 1987; Frazier & Fodor, 1978; Frazier & Rayner, 1982). It draws a crucial distinction between primary phrases (subjects, predicates, complements, and other obligatory elements) and non-primary phrases (adjuncts and conjuncts), and it proposes that only primary phrases are subject to parsing principles such as Late Closure. In contrast, non-primary phrases are *associated* (rather than *attached*) to the current thematic domain, and then interpreted, i.e., *construed*. Construal is sensitive to a range of influences, including semantics and discourse as well as syntactic factors. Since relative clauses are adjuncts, relations of the kind involved in linking a relative clause to its head are classified as non-primary, and

are therefore *not* subject to Late Closure. Rather, RC processing is implemented as follows (Frazier & Clifton, 1996, pp. 31-32; italics in original):

Relative Clause Construal Hypothesis

- a. *Associate* a relative clause to the *current thematic processing domain* - the (extended) maximal projection of the last theta assigner.
- b. *Interpret* the relative clause with any grammatically permissible material in the associated domain using structural and semantic/pragmatic information.

In sentences like (3) in Chapter 2, repeated as (1a) below, N2 has been regarded as an argument of N1 and preposition *of* has been considered a case-marker that does not assign a thematic role⁵. N1 and N2 thus fall within the same *current thematic processing domain*, i.e., the N^{max} dominating N1, the last theta assigner. Clause (a) of the Construal account therefore predicts no *initial* preference to interpret the following RC as modifying either the higher or the lower attachment site. To explain the fact that languages ultimately *do* show a preference and to account for the cross-linguistic differences observed, Frazier and Clifton invoke two discourse-based principles, under Clause (b), as influences on RC construal: Relativized Relevance, and Grice's Maxim of Clarity.

Relativized Relevance, first postulated by Frazier (1990), states that the parser should "... preferentially construe a phrase as being relevant to the main assertion of the current sentence" (p. 321). As a result of the influence of Relativized Relevance, it is

⁵ See Gilboy et al. (1995), pp.138-140, and the references therein. There is, however, a narrower sense of 'argument' in which N2 counts as an argument of N1 in only a subset of *of*-constructions, such as those in which N1 is related to a verb which takes a direct object, e.g., *destruction of the city*, or *review of the poem*; see Table 1 in Chapter 5.

argued, there should be a general tendency in all languages to favor high attachment. To account for the low-attachment preference observed in languages like English, Frazier and Clifton posit a tendency that can override Relativized Relevance, one based on the Gricean Maxim of Clarity and the existence of unambiguous alternative genitive forms in a language. The argument, first set out in Frazier (1990), has as its starting point the observation that some languages have just one construction to express relationships of the 'servant of the actress' type, i.e., the 'Norman'⁶ genitive, as in *el criado de la actriz* in Spanish, whereas others, in addition to the Norman genitive (*the servant of the actress*), also have alternative constructions, such as the 'Saxon' genitive, as in *the actress's servant* in English. In contrast with the Norman form, which results in an ambiguous sentence when followed by an RC, as in (3) in Chapter 2, repeated below in (1a), the Saxon form is typically unambiguous: see (1b):

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

Interpretation I: the actress was on the balcony

Interpretation II: the servant was on the balcony

(1b) Someone shot the actress's servant who was on the balcony.

Interpretation: the servant was on the balcony

Two interpretations are possible for (1a), but in (1b) it is unquestionably *the servant*, and not *the actress*, who was on the balcony. Grice (1975) argued that perceivers assume that a cooperative interlocutor produces utterances following the Maxim of Clarity. This states, roughly: "Be clear", or, for our present purposes: "Be *unambiguous*

⁶ The terms 'Norman' and 'Saxon' were introduced in this context by Brysbaert & Mitchell (1996). They are applied now to languages to which they have no historical reference.

whenever you can". Thus, English perceivers, Frazier argues, tend to interpret the RC in the ambiguous sentence (1a) as modifying *the actress*. The rationale is that if the speaker had intended to convey the meaning that it was *the servant* who was on the balcony, he or she would have used the 'Saxon' variant (1b), which unambiguously expresses that meaning. The decision not to use (1b) thus reveals the speaker's intention to convey that *the actress* was on the balcony. In English, Frazier concludes, Relativized Relevance is overridden by the Gricean influence, ultimately resulting in a low-attachment preference for ambiguous sentences. In Spanish, however, where no alternative form for conveying unambiguous attachment to the higher noun (*servant*) is available, the principle of Relativized Relevance works alone, resulting in a high-attachment bias.⁷

Thus, under Construal it may not be necessary to postulate language-specific parsing strategies. If Gricean considerations explain the apparent exceptions, the parser can be fully innate and universal, and different languages will exhibit different RC-

⁷ A study by Oria-Merino, Costantino, Heydel & Sainz (2000) in Spanish, English and German can be regarded as providing an explicit test of writers' adherence to Grice's injunction. Do writers/speakers genuinely make differential use of the genitive forms available in their language? In these experiments, subjects read a short description (without any RC) of a situation that corresponded to either high RC-attachment (HA) or low RC-attachment (LA), as illustrated in (i) and (ii) below, and were then asked to rephrase the description by completing a sentence fragment requiring an RC, like (iii) below.

- (i) There is an actress, and she has a servant. The servant was on the balcony, and somebody shot him. (HA)
- (ii) There is an actress, and she has a servant. Somebody shot the servant, and the actress was on the balcony. (LA)
- (iii) Somebody shot.....that was on the balcony.

The results for English provided support for the Gricean claim regarding sentence production: English speakers mostly used Saxon genitives (*the actress's servant*) to express high attachment, i.e., for situation (i), and Norman genitives (*the servant of the actress*) to express low attachment, i.e., for situation (ii). (For the latest work on this approach, see Heydel & Murray, 2003.)

attachment preferences because of differences in their grammars. Languages in which alternative forms with unambiguous high attachment are available, such as English, should show a tendency to favor low attachment; those in which such alternatives are not available, such as Spanish, should show a tendency to favor high attachment. In addition, preferences (whether for low or high attachment) should manifest themselves only when discourse influences apply, i.e., in later stages of processing, since RC-attachment is a non-primary relation and not subject to structural principles such as Late Closure.

3.2.2 Construal: The Evidence

First we will examine implications of the distinction that Construal Theory draws between primary and non-primary phrases. We will then assess the Gricean component of Construal.

The distinction between primary and non-primary phrases, i.e., between those phrases that are attached in accord with Late Closure and those that are not, enables Construal to account for the fact that the RC-attachment ambiguity differs from other constructions, which are consistent with Late Closure. This account correctly predicts that even in Spanish, for which a high RC-attachment preference has been found, low attachment is preferred when the attachment in question is a primary relation. Using both off-line and on-line measures, Igoa, Carreiras & Meseguer (1998; see also Igoa, 1995) demonstrated this fact in ambiguous sentences like (2):

- (2) Raúl vendió el libro que había robado a su
 Raúl sold the book that (pro) had stolen [prep.] his
 amigo.
 friend

“Raul sold the book that he had stolen to/from his friend”

In (2), the PP *a su amigo* is preferentially interpreted as attaching to the more recent VP *había robado*, within the subordinate clause, rather than to *vendió* in the main clause.

This is as predicted by Late Closure, since the attachment of the PP to either VP constitutes a primary relation. This finding and its contrast with that for RC-attachment comports with the assumption made by Construal Theory that primary and non-primary phrases are processed differently.

Further evidence that RCs are interpreted in line with the Construal Principle is reported in a study by Gilboy, Sopena, Clifton & Frazier (1995). Using an off-line questionnaire, Gilboy et al. showed that the RC-attachment preference is similarly modulated in both English and Spanish by a variety of factors, including the referentiality of the host nouns⁸ and the thematicity of the preposition between N1 and N2. Gilboy et al. predicted the weakest low-attachment preference for complex NP types in which N2 is non-referential and the preposition between N1 and N2 is not a theta assigner (e.g., *a glass of wine*), and the strongest for complex NP types in which N2 is referential and in the domain of a theta-assigning preposition (e.g., *the notebook with the sticker*). That the thematic/non-thematic nature of the preposition should matter

⁸ Gilboy et al. (1995) define referential nouns as those "that introduce discourse entities (e.g., participants in events described in the discourse) into a discourse model (at least temporarily), or correspond to already existing discourse entities" (p. 136).

follows directly from the Construal Hypothesis, as formulated in Section 3.2.1 above: for a non-thematic preposition (e.g., *of*), the current thematic processing domain is the N^{\max} dominating N1, which includes both potential hosts, N1 and N2; by contrast, for a thematic preposition (e.g., *with*), the current thematic processing domain is the P^{\max} dominating the preposition, which includes only one potential host, N2. A stronger preference to attach the RC low when the preposition is *with* than when it is *of* is therefore predicted, and the pattern of results observed by Gilboy et al. is in accord with this prediction. Several other studies have confirmed this finding in a number of different languages (Baccino et al., 2000; Clifton, 1988; De Vincenzi & Job, 1993, 1995; Felser et al., 2002; Fernández, 1999; Frazier & Vonk, 1997; Frenck-Mestre & Pynte, 2000; Papadopoulou & Clahsen, 2002).⁹

However, Construal suffers from a number of limitations. It has difficulty accounting for the data which indicate that languages exhibit attachment preferences even at early stages of processing. Under the Construal Hypothesis, RC-attachment, being a non-primary relation, is predicted to show no immediate preferences since the discourse principles relevant to its interpretation should come into play only post-syntactically. However, experiments using paradigms which might be assumed to tap early phases of processing, such as self-paced reading and eye-tracking, apparently show that subjects *do* exhibit early tendencies either to attach high (e.g., in Spanish: Carreiras & Clifton, 1993, 1999; Cuetos & Mitchell, 1988; Gibson et al., 1999; Mitchell & Cuetos, 1991; but see Fernández, 2000/2003, for contrary data; in German: Hemforth

⁹ See Section 4.2 for a potential alternative explanation, based on prosodic phrasing in silent reading, of the finding that the type of preposition dominating N2 influences RC-attachment preferences.

et al., 1998, 1999, 2000; Walter, Hemforth et al., 1999) or to attach low (e.g., in English: Carreiras & Clifton, 1999; Deevy, 1999; Henstra, 1996; Fernández, 2000/2003).

The most problematic aspect of Construal's explanation of RC-attachment is the Gricean component of its account of cross-linguistic variation. On this account, languages which have alternative genitive forms to express unambiguous attachment to N1 (e.g., English) should attach low, uniformly, while all others should favor high attachment. While correctly predicting high attachment for Spanish and low attachment for English, the Gricean hypothesis faces difficulty in accounting for data from a number of other languages. Dutch and German, in which unambiguous high-attachment alternatives do exist, have repeatedly been shown to favor high attachment in parsing (Brysbaert & Mitchell, 1996; Hemforth et al., 1998, 1999, 2000; Mitchell, Cuetos, Corley & Brysbaert, 1995). On the other hand, Romanian, in which such alternative forms are not available, has been found to favor low attachment (Ehrlich et al., 1999). The same may be true of Brazilian Portuguese (Miyamoto, 1999). However, more recent studies indicate that the ultimate attachment preference for Brazilian Portuguese may in fact be high (Maia & Maia, 2001; Finger & Zimmer, 2002; Miyamoto & Finger, 2002).

In defense of this model, it has been suggested (Clifton, personal communication to Mitchell, 1996; see Mitchell & Brysbaert, 1998) that the Gricean hypothesis may be applied at several different levels of analysis, and not just at the level of entire languages. As a result, several different variants of the Gricean explanation may be imagined (as discussed in detail in Mitchell, Brysbaert, Grondelaers & Swanepoel, 2000; see also Mitchell & Brysbaert, 1998). In its simplest form, which we shall refer to as Variant 1, the Gricean argument proposes that the mere existence of an unambiguous

alternative form in a language triggers a low-attachment preference for ambiguous forms in that language. More refined versions propose that a Gricean influence favoring low attachment varies according to either the range of contexts in which alternative forms are acceptable in the language in general¹⁰ (Variant 2), or how felicitous the alternatives are for any particular sentence at issue (Variant 3). This last version of the Gricean account assumes what Clifton dubs the "Smart" Gricean Reasoner. It predicts a *negative correlation between the acceptability of the alternative forms for particular sentences, and the preference for high attachment in those sentences, i.e., as the acceptability of the unambiguous form increases, the tendency for high attachment should decrease.*

To recap: we have seen that the basic form of the Gricean explanation (Variant 1) is inadequate; it mispredicts the attachment preference for Dutch, German and Romanian, and possibly Brazilian Portuguese. We now turn to evidence that challenges the more refined versions of the model.

In a study designed to assess each of the versions of the Gricean hypothesis, Mitchell et al. (2000) analyzed eye-tracking data for Dutch sentences, considered individually. Subjects' judgments in a pre-test had indicated that the degree of acceptability of the alternative genitive forms varied over the materials set. Additionally, these authors tested attachment preference in Afrikaans, using a translation of the

¹⁰ E.g., in English, the Saxon possessive morpheme 's can attach to human and non-human NPs, singulars and plurals, even to a relative clause inside a complex NP. In some other languages, however, the range of contexts in which the non-Norman forms are acceptable is more restricted (e.g., German and Dutch; see Brysbaert & Mitchell, 1996).

original Cuetos & Mitchell (1988) questionnaire; see (3) below for an example

Afrikaans sentence.

- (3) Iemand het geskiet op die bediende van die aktrise wat
 someone has shot on the servant of the actress who
 op die balkon was.
 on the balcony was

“Someone shot the servant of the actress who was on the balcony”

A detailed sentence-by-sentence analysis of the Dutch data failed to find evidence of the negative correlation predicted by the "Smart" Gricean Reasoner (Variant 3 above), between the acceptability of the alternative genitive forms and the tendency to attach high.¹¹

The questionnaire data for Afrikaans further undermine the Gricean account. In Dutch (and German) the unambiguous alternative forms exist, but the contexts in which they are permissible are more restricted than for comparable English forms (Brysbaert & Mitchell, 1996). In Afrikaans, by contrast, the alternative form (marked by the particle *se*, as in, e.g., *die kind SE toontjie* (the child'S toe)) is permissible in an even wider variety of contexts than is the Saxon genitive in English (Mitchell et al., 2000, based on Donaldson, 1993). Mitchell et al. argue that if the Gricean influence is assumed to vary based on the range of contexts in which the alternative forms are acceptable in a language (Variant 2), then, given the grammatical facts, Afrikaans should show a low-

¹¹ Frazier & Vonk (1997) report a similar finding. Their comparison of Dutch sentences for which the Saxon alternative is available with those for which no such alternative exists, showed "... no greater tendency to attach to the lower NP in a complex NP such as *de vriend van mijn oom* 'the friend of my uncle', for which the alternative *mijn ooms vriend* exists (the attachment would be unambiguously to *vriend*), than in a complex NP where there is no such alternative available, such as in *de vriend van de actrice* 'the friend of the actress'" (p. 81).

attachment preference of at least the same magnitude as that in English. In fact, Mitchell et al.'s data show that Afrikaans has a *high*-attachment preference, similar to that for Dutch.

Taken together, the findings for Dutch and Afrikaans are difficult to accommodate under *any* version of the Gricean account.¹² To summarize: the Gricean explanation of cross-linguistic variation has been shown to be an unsatisfactory aspect of Construal Theory's account of RC-attachment preferences. A growing body of evidence suggests that this explanation, despite its flexibility to apply at several levels, cannot account for the facts. Mitchell et al.'s (2000) verdict is emphatic: "We have examined the Gricean hypothesis in every guise we can imagine and we conclude that in all variants without exception the proposal is consistently found wanting... We therefore conclude that the time has come to move on and resume the search for more productive suggestions concerning the mechanisms underlying cross-linguistic variation in RC-attachment" (p. 14).

¹² Mitchell et al. (2000) suggest that corpus data are needed to confirm that the unambiguous alternative form that is claimed to be widely *permissible* in Afrikaans is, indeed, *used* in the language as widely as both intuitions and grammars seem to suggest. However, any reformulation of the Gricean argument capitalizing on a potential discrepancy between the *permissibility* of the alternative forms, on the one hand, and their actual *usage* in the language, on the other, brings this supposedly grammar-based account perilously close to the assumptions of a statistics-based model, such as the Tuning Hypothesis (discussed below in Section 3.2.2): perceivers' attachment preference is determined on the basis of previous linguistic experience (i.e., the frequency of usage of particular structures in the language), rather than on any facts about the grammar of the language (i.e., the existence of particular grammatical options in the language).

3.2.3 Attachment-Binding Dualism: The Proposal

Hemforth and her colleagues (Hemforth, Konieczny & Scheepers, 2000; Hemforth, Konieczny, Scheepers & Strube, 1998; Hemforth, Konieczny, Seelig & Walter, 1999; Konieczny & Hemforth, 2000; Walter, Hemforth, Konieczny & Seelig, 1999) propose a model in which RC-attachment preferences are determined by competition between two mechanisms: structural attachment, on the one hand, and anaphoric binding of the relative pronoun, on the other. Structural attachment favors low attachment of the RC in response to syntactic recency, a structural principle akin to Late Closure. Anaphoric binding, in contrast, favors high attachment of the RC. The processes that resolve ambiguities of anaphoric reference preferentially bind an anaphor to a more salient potential antecedent, so the mechanism for relative pronoun binding favors the higher noun as the attachment site for the RC because the higher noun, being a discourse referent central to the main assertion, is the more salient of the two potential hosts.¹³

To account for the different attachment preferences observed across languages, Hemforth and her colleagues draw attention to the fact that the relative pronoun is frequently omitted from the RC in some languages, whereas deletion of this kind is impossible in others. For instance, the relative pronoun (*who*, *which*) in English RCs is often replaced by the complementizer *that*, or omitted altogether (as in object-gap RCs, e.g., *the daughter (whom/that) Peter visited*). This optional usage of the relative pronoun in English, Hemforth and her colleagues hypothesize, reduces the reliance on anaphoric

¹³ In this respect, the processes underlying relative pronoun binding are akin to Frazier's Relativized Relevance; see Section 3.2.1 above.

processes in finding a host for an RC, allowing structural principles to dominate; the result is a preference for low attachment.¹⁴ In contrast, relative pronouns are obligatorily present in German RCs.¹⁵ As a consequence, anaphoric influences in German are strong enough to outweigh syntactic recency, resulting in a high-attachment preference.

In its explanation of cross-linguistic RC-attachment differences, Attachment-Binding Dualism refers to grammatical differences between languages: languages like English, in which it is legitimate to drop the relative pronoun from the RC, should exhibit a tendency to attach low, while languages like German, in which relative pronouns are obligatory, should exhibit the opposite tendency.

3.2.4 Attachment-Binding Dualism: The Evidence

Like Construal, Attachment-Binding Dualism distinguishes between different types of attachment-ambiguous constituents (henceforth ‘attachees’, for brevity). On this account, the anaphoric processes which favor high attachment come into play for relative clauses, but they are not relevant to the attachment of adjuncts other than RCs, e.g., adjective phrases or prepositional phrases, which are not introduced by an anaphor. Thus, the fact that the RC-attachment construction is the only known exception to the

¹⁴ Hemforth et al. (1998) note that to strengthen this hypothesis it would be necessary to study attachment preferences in other languages which have optional relative pronouns or lack them altogether.

¹⁵ In addition, German relative pronouns are morphologically marked for case, and carry agreement features for number and gender. The latter may be important, since an argument not unlike that of Hemforth et al. could be made based on feature-checking rather than anaphoric binding. According to this line of thought, when the relative pronoun has agreement features, these must be checked against the two potential host nouns (either in a linguistic sense, e.g., Chomsky 1995, or as part of on-line processing, to see whether the features disambiguate the attachment). By logic similar to that of Hemforth et al., feature-checking might be expected to prefer N1 as the host site for the RC, in the case of ambiguous attachment, because N1 is a main discourse referent.

operation of syntactic recency principles such as Late Closure, is successfully accounted for.

Hemforth and her colleagues (Hemforth et al., 1998, 1999, 2000; Walter et al., 1999) have provided evidence in favor of their hypothesis by contrasting the attachment of RCs (where anaphoric processes apply) with the attachment of PPs (where anaphoric processes do not apply), in German.

- (4) Die Tochter der Lehrerin, die aus Deutschland kam,
 the daughter the teacher-[Gen] who from Germany came
 traf Klaus.
 met Klaus

“The daughter of the teacher who came from Germany met Klaus”

- (5) Die Tochter der Lehrerin aus Deutschland traf Klaus.
 the daughter the teacher-[Gen] from Germany met Klaus

“The daughter of the teacher from Germany met Klaus”

Under Attachment-Binding Dualism, the RC in a sentence like (4) is predicted to attach high because in German RCs the relative pronoun is obligatorily present (allowing syntactic recency to be overridden by anaphoric processes). In contrast, in (5), the ambiguously attached PP is predicted to be preferentially interpreted as attaching low, since PP attachment triggers no such anaphoric processes. The results of a number of experiments using both off-line and on-line measures have supported this prediction.¹⁶

Nevertheless, the Attachment-Binding proposal faces a number of problems.

¹⁶ A possible prosodic explanation of the data Hemforth and her colleagues report is discussed in Section 4.2.

While correctly predicting a high-attachment preference for German and a low-attachment preference for English, this account has difficulty accounting for RC-attachment data in several other languages. Abdelghany & Fodor (1999) tested the RC-attachment preference for Egyptian Arabic in an off-line questionnaire. See (6) below for an example sentence.

- (6) Yuthakiruni hatha alragul bi sadeeq almakhbir allathy
 reminds-me that man with friend detective who
 fusil.
 was-fired

“That man reminds me of the friend of the detective who was fired”

Abdelghany & Fodor (1999) reported a preference for low attachment of the RC, to N2, despite the fact that Egyptian Arabic, like German, has an obligatory relative pronoun. The questionnaire outcome is thus incompatible with the Attachment-Binding hypothesis, which predicts a high-attachment preference for languages in which the relative pronoun cannot be omitted.¹⁷

Romanian too has been reported to prefer low attachment of the RC. Using an off-line questionnaire, Ehrlich et al. (1999) tested ambiguous sentences containing the RC-attachment construction in Romanian. They give the example in (7) below. They

¹⁷ In Egyptian Arabic, relative pronouns carry agreement features for number and gender (e.g., *allathy* in (6) above is the masculine singular form). The low-attachment preference for Egyptian Arabic is thus also incompatible with the feature-checking hypothesis (see footnote 15 above). Other languages such as Spanish and French are similarly unexplained by it, since they have high attachment but no agreement features on the relative pronouns commonly used (*que* in Spanish, *que/qui* in French).

found a reliable low-attachment preference, despite the fact that relative pronouns are obligatorily present in Romanian RCs.¹⁸

- (7) Seful de birou vorbea cu asistentul contabilului care se manifesta ciudat.
 “The personnel supervisor was talking to the assistant of the accountant who was acting oddly”

If Miyamoto's (1999) conclusion of low-attachment for Brazilian Portuguese is sustained by future research, then Brazilian Portuguese too undermines the Attachment-Binding account, since Brazilian Portuguese has an obligatory relative pronoun. (For a sample of materials used by Miyamoto, see examples (10) and (11) in Section 3.3.2 below.) If, on the other hand, the questionnaire data indicating high attachment for Brazilian Portuguese (Maia & Maia, 2001; Finger & Zimmer, 2002; Miyamoto & Finger, 2002) prove more representative, then Brazilian Portuguese presents no problem for Attachment-Binding.¹⁹

In view of this evidence from Egyptian Arabic and Romanian, and possibly Brazilian Portuguese, it seems that the Attachment-Binding explanation of cross-linguistic variation in RC-attachment preferences cannot, at least as it now stands,

¹⁸ In Romanian, obligatory relative pronouns are morphologically marked for case (e.g., *care* in (7) above is the nominative form appropriate to (7)'s subject-extracted RC) but, as Ehrlich et al. (1999) point out, they carry no agreement features. The low-attachment preference observed in Romanian is thus incompatible with Hemforth et al.'s proposal but is not compatible with the feature-checking hypothesis.

¹⁹The relativizer, *que*, in Brazilian Portuguese carries no agreement features. Thus, a potential low-attachment preference for Brazilian Portuguese, while undermining Attachment-Binding Dualism, leaves the feature-checking approach unscathed. On the other hand, a potential high-attachment preference for Brazilian Portuguese does undermine the feature-checking proposal.

account for the full range of empirical findings.²⁰

3.2.5 Grammar-Based Explanations: Recap

There are a number of similarities between Construal Theory and Attachment-Binding Dualism. According to both these accounts, it is unnecessary to postulate learned, language-specific parsing routines; rather, variation among languages in the attachment of RCs to competing sites is to be attributed to differences in their grammars. Specifically, the Construal/Gricean model proposes that the cross-linguistic variation can be explained in terms of the availability of alternative syntactic devices for unambiguous expression of one of the two possible noun-modifier relations in the 'servant of the actress who' type of construction. Stressing a grammatical difference of another kind, Attachment-Binding Dualism bases its explanation of cross-linguistic attachment differences on the obligatoriness or otherwise of the relative pronoun in an RC.

Furthermore, both accounts have a way of explaining why the RC-attachment construction differs from other constructions with respect to the application of a recency principle. According to Construal, RC-attachment is not a primary relation, and, therefore, never subject to Late Closure. Under Attachment-Binding Dualism, RC-

²⁰ Hemforth and her colleagues have recently shifted away from Attachment-Binding Dualism because their own later experiments have demonstrated that relative pronouns do not behave in the way that other pronouns do. Their new proposal (Hemforth & Konieczny, 2002), based on pragmatic concerns such as informativeness, is discussed in Section 4.3.

attachment is simultaneously sensitive both to recency principles *and* to anaphoric processes, unlike other types of attachment where only the former apply.

On a less positive note, both proposals successfully account for data from some languages while failing to explain data from others. Thus, Dutch and Afrikaans present a problem for the Construal/Gricean hypothesis; Egyptian Arabic challenges attachment/binding dualism; and both accounts appear to be undermined by data from Romanian, and perhaps Brazilian Portuguese.

In addition, both accounts face problems in explaining findings of the kind reported by Corley (1996), Corley & Cuthbert (1997), Brysbaert & Mitchell (1996) and Fernández (1998, 2000/2003), which indicate that RC-attachment preferences differ among individual speakers of the same language, depending on such matters as their profession or language background. It is unclear how either of the above models can allow for individual differences among (native) speakers of the same language.

We now turn to models which, in their explanation of variation in RC-attachment preferences across languages, do not rely on facts about their grammars, but, rather, propose that factors external to the grammar play a crucial role in the parser's choice of a host for an ambiguously attached RC.

3.3 Exposure-Based Explanations

3.3.1 Predicate Proximity/Recency Model: The Proposal

Predicate Proximity/Recency Theory, put forward by Gibson and his colleagues (Gibson, Pearlmutter, Canseco-Gonzalez & Hickok, 1996; Gibson, Pearlmutter &

Torrens, 1999; Gibson & Schütze, 1999; Gibson, Schütze & Salomon, 1996; see also Miyamoto, 1999), is similar to Attachment-Binding Dualism in that it proposes that two competing factors play a role in selecting an attachment site for an ambiguous RC. Here, the two factors are Recency Preference and Predicate Proximity. Recency Preference, a principle similar to Late Closure, is formulated in these terms:

"Preferentially attach structures for incoming lexical items to structures built more recently" (Gibson et al., 1996, p. 26).

This factor would favor attaching the RC to the nearest potential host (i.e., N2), and is proposed to apply *universally*. Predicate Proximity is defined as:

"Attach as close as possible to the head of a predicate phrase" (Gibson et al., 1996, p. 41).

Predicate Proximity favors attachment of the RC to the site that is structurally nearest to the verb (i.e., N1), and unlike the universal Recency principle, is said to vary from language to language. Its relative strength is determined on the basis of exposure to the language in question, via a frequency-counting mechanism which computes "average distance from the head of a predicate (verb) to its arguments" (Gibson et al., 1996, p. 49).

Thus, the model accounts for cross-linguistic attachment differences by means of a parameter within the parsing mechanism: the strength of the Predicate Proximity factor, adjusted as a result of exposure to sentences of the language. It is assumed to be high in languages where the average distance between a verb and its arguments is great,

and low in languages in which a verb and its arguments must normally be adjacent, as in English. The idea is that in a language like Spanish, in which arguments are allowed to occur in positions non-adjacent to the verb, verbs have to be held in a state of stronger activation during processing than in a language like English, which almost guarantees that the verb and its arguments will be encountered in close succession because word order is more rigid. (For examples of relevant word-order differences between Spanish and English, see Gibson et al., 1996; see also Miyamoto, 1999, for discussion of word order in Brazilian Portuguese.) As a result, Predicate Proximity is strong enough in Spanish to outweigh Recency, resulting in a high-attachment preference, whereas the weak value of Predicate Proximity in English results in a low-attachment preference.

3.3.2 Predicate Proximity/Recency Theory: The Evidence

In support of their two-factor model, Gibson et al. (1996) provide evidence from self-paced reading experiments testing attachment preferences in fragments (rather than full sentences) containing three-site ambiguities like (8) and (9) in English and Spanish, respectively:

- (8) the cushion beside the cat with the kitten that was in the nearby park
- (9) los arboles junto a los gatos con los gatitos que fueron admirados por el niño
 “the trees next to the cats with the kittens that were admired by the child”

If Recency were the only factor at work in (8) and (9), Gibson et al. argued, then the pattern of preferences should be N3-N2-N1 (i.e., from most recent to least recent). On

the other hand, Predicate Proximity operating by itself should produce the opposite pattern, N1-N2-N3 (i.e., from closest to the verb, to farthest from the verb). In fact, the pattern of preferences observed showed N3 to be the preferred site for RC-attachment in both English and Spanish, with N1 being the second most preferred site. The middle site, N2, was least preferred in both English and Spanish, suggesting that the two factors, Recency and Predicate Proximity, interact in selecting a host for the RC.

Gibson et al.'s (1996) study had a number of methodological shortcomings: subjects were not presented with complete sentences, but, rather, sentence fragments like those in (8) and (9) above, in which the predicate hypothesized by Gibson and colleagues to activate Predicate Proximity was entirely absent. An additional questionable aspect of these experiments is the fact that Gibson et al. did not check, independently, that their Spanish speakers in fact tended to attach high when complex NPs contained two (rather than three) heads. It would have been appropriate to confirm this fact since these subjects were for the most part not speakers of European Spanish (as were those in the experiments by Cuetos & Mitchell, 1988), but were speakers of a variety of pan-American dialects of Spanish. Also, as noted by Fernández (2000/2003), these speakers were all bilingual to some extent (they were all also speakers of English as they were recruited from the academic community at Cambridge, MA); however, no effort was made to determine their degree of language dominance; see Fernández (2000/2003) for data indicating that language dominance affects attachment preferences. Furthermore, the triple-NP complexes in their materials most often contained thematic prepositions, e.g., *junto*, next to, and *con*, with, in addition to an occasional use of non-thematic prepositions *of* (English) and *de* (Spanish). In previous studies, manipulations

of this kind (e.g., contrasting *of* and *with* in the complex NP to which an RC is attached) have shown that the type of preposition affects attachment preference in all languages in which this has been tested (Gilboy et al., 1995; see also Baccino et al., 2000; Clifton, 1988; De Vincenzi & Job, 1993, 1995; Fernández, 1999; Frazier & Vonk, 1997; Frenck-Mestre & Pynte, 2000; Papadopoulou & Clahsen, 2002).²¹

Gibson, Pearlmutter & Torrens (1999) addressed the above issues in a subsequent study. They tested materials consisting of complete sentences in Spanish, and confirmed that Spanish speakers attached high with two NPs. The only preposition used in the NP complexes in these experiments was the non-thematic *de*. The pattern of preferences observed for the three-site ambiguity was the same as that found in Gibson et al. (1996).²²

Miyamoto (1999) has argued that his findings for Brazilian Portuguese are in accord with the Predicate Proximity/Recency account of RC-attachment preferences. He notes that Brazilian Portuguese is a language with rigid verb/object adjacency, like English. As a consequence, the Predicate Proximity factor is predicted to be weak in Brazilian Portuguese, allowing Recency to win out, resulting in a low-attachment preference. Using a non-cumulative word-by-word self-paced reading paradigm, Miyamoto tested sentences like (10) and (11) below, and found that subjects took

²¹ In particular, thematic prepositions favor low attachment. In Gibson et al.'s experiments the preposition between N2 and N3 was thematic in 15 of 18 English items, e.g., (8) above, and in 14 of 18 Spanish items, e.g., (9) above. This could explain the observed preference to attach the RC to N3 in both English and Spanish.

²² This pattern of preferences in three-site ambiguities may also be compatible with a prosodic explanation (see Section 4.2).

significantly longer to read items like (10), in which the attachment was forced high, than items like (11), in which the RC was unambiguously attached low.²³

- (10) A kombi trouxe os supervisores do engenheiro
 the van brought the supervisors-[pl.] of-the engineer-[sg.]
 que foram pagos pela empeiteira.
 that were paid-[pl.] by the-company

“The van brought the supervisors of the engineer who were paid by the company”

- (11) A kombi trouxe o supervisor dos engenheiros
 the van brought the supervisor-[sg.] of-the engineers-[pl.]
 que foram pagos pela empeiteira.
 that were paid-[pl.] by the-company

“The van brought the supervisor of the engineers who were paid by the company”

As mentioned earlier, however, the low-attachment preference reported by Miyamoto (1999) has recently been challenged by data from off-line questionnaires reported by Maia & Maia, 2001, Finger & Zimmer, 2002, and Miyamoto & Finger, 2002, indicating that speakers of Brazilian Portuguese prefer the higher noun as an attachment site for the RC, in final interpretations. Research is underway (e.g., by Maia and his colleagues) to elucidate these apparent discrepancies.

Like Construal, the Predicate Proximity/Recency model is able to explain findings indicating that RCs are more likely to attach to N2 when the preposition

²³ A second factor in Miyamoto’s experiment compared full relatives (e.g., (10) and (11) above) and reduced relatives (e.g., *A kombi trouxe os supervisores do engenheiro pagos pela empeiteira*. “The van brought the supervisors of the engineer paid by the company”). He found a stronger preference for low attachment with reduced relatives than with full relatives. Miyamoto (1999) argues that these data support the particular variant of Attachment-Binding Dualism which proposes that attachment preferences vary based on whether the actual sentences tested contain a relative pronoun or not (see Section 5.1.2 below).

between N1 and N2 is thematic *with* than when it is non-thematic *of*. According to Gibson's (1998) discourse-based formulation of Recency, thematic prepositions increase the effective distance between a modifier and its potential attachment site, increasing the pressure for attachment to N2, the more recent site, in the case of the RC-attachment ambiguity. No such pressure is predicted when the preposition between N1 and N2 is non-thematic because non-thematic prepositions are not hypothesized to increase modifier-host distances.

However, unlike Construal and Attachment-Binding Dualism, the Predicate Proximity/Recency model does not allow for differences between attachees. Thus the facts observed by Hemforth and her colleagues (see Section 3.2.4), such as different attachment preferences for RCs and PPs, have no account under this proposal.

Furthermore, the Predicate Proximity/Recency model in its present form has difficulty in accounting for some of the cross-linguistic variation in attachment preferences reported in the literature. It is not easy to imagine how "average distance" between a verb and its arguments could be computed in a way such as to predict a high-attachment preference for German (e.g., Hemforth et al., 1998) but a low-attachment preference for Swedish and Norwegian (Ehrlich et al., 1999), when verb-argument order appears to have comparable flexibility in the three languages. Nor is it clear why verbs should be activated more highly in Spanish (high attachment) than in Romanian (low attachment), when both languages allow verb/argument non-adjacency and in fact seem to exhibit rather similar word-order possibilities.

In this account, everything rests on the precise details of a theory-internal definition of verb/argument distance, and there is some freedom in this respect.

Different assumptions about verb/argument distance, or in the formula relating distance to parameter strength, may lead to different specific predictions about attachment preferences, within the same general framework. Or a different way of predicting Predicate Proximity strength might be proposed which does not tie it to verb/argument distance. But despite this leeway, it appears that no definition has so far been proposed that correctly sorts those languages for which data are available.

3.3.3 The Tuning Hypothesis: The Proposal

The Tuning Hypothesis (Brysbaert & Mitchell, 1996; Cuetos, Mitchell & Corley, 1996; Mitchell, 1994; Mitchell & Brysbaert, 1998; Mitchell & Cuetos, 1991; Mitchell, Cuetos, Corley & Brysbaert, 1995) proposes that initial parsing choices for ambiguous inputs are made exclusively on the basis of the relative frequencies with which alternative attachments (*high* vs. *low*) have been encountered in comparable structures in the past. According to this account, the parser resolves structural ambiguity by relying on a mechanism which records the frequencies of occurrence for various types of structures: if readers or listeners have been exposed to sentences with a higher frequency of unambiguous *low* attachments for a particular structure type, they should prefer to attach *low* when faced with ambiguous sentences containing the same structure type; and vice versa, if they have been exposed to input with more *high* attachments, they should prefer to attach *high* when processing ambiguous input.

Under this proposal, cross-linguistic variation in attachment preferences arises because different languages have different relative frequencies of occurrence of

unambiguous high and low attachments. Thus, Tuning predicts that a language should exhibit a low-attachment preference if the RC is more frequently attached to N2 when N1-of-N2-RC structures are used in the language; and high-attachment should be preferred in languages in which RCs have predominantly been linked to N1 in unambiguous sentences. Note that there need be no reason, as far as the comprehension device is concerned, why a language is high-attaching or low-attaching; this property is not expected to correlate with any other property of the language. (The question of why speakers and writers use these constructions with different frequencies may have some interesting explanation but it has not been addressed in the literature to date.²⁴)

3.3.4 The Tuning Hypothesis: The Evidence

In support of the Tuning account, there is some evidence that for languages in which high attachment prevails in sentence processing experiments, this preference is also found to dominate in unambiguous attachments found in corpora, while for languages in which low attachment prevails in experimental assessments of parsing, corpus samples show a preponderance of low attachments. Thus, in Spanish, the high-attachment preference found in comprehension studies parallels the predominance of high attachments in Spanish corpora (Cuetos et al., 1996, Igoa, 1996). Similarly, in English, low attachment prevails both in parsing experiments and in corpus samples (Corley, 1995; Cuetos et al., 1996). This correlation between parsing and corpus data,

²⁴One possibility would be a prosodically motivated explanation, see Section 7.3.

Mitchell and colleagues argue, suggests that the parser's choices may be based on the attachment patterns to which it has been exposed.

However, Gibson and his colleagues (Gibson & Schütze, 1999; Gibson, Schütze & Salomon, 1996) have presented evidence that the comprehension data do not always match the corpus facts. They examined the preferred order of attachment sites both in reading experiments and in corpora, for sentences in which an NP is *conjoined* (as illustrated in (12) below) to a complex NP with three stacked heads. They found that in texts, unambiguous attachments to the middle site (N2) significantly outnumber attachments to the highest site (N1).

- (12) The salesman ignored a customer with a child with a dirty face and ____.
- a. a wet diaper (N3 conjunction)
 - b. one with a wet diaper (N2 conjunction)
 - c. one with a baby with a wet diaper (N1 conjunction)

This distribution of corpus frequencies is at odds with both off-line and on-line data from their parsing studies, which show that readers prefer conjunction to N1, rather than to the middle site (N2). (The lowest site (N3) was most favored in both corpus analyses and parsing experiments.)²⁵

Further evidence against Tuning comes from comparisons between parsing and corpus data for Dutch. Several parsing studies, using both off-line and on-line measures,

²⁵ Gibson & Schütze (1999) explain this discrepancy by reference to differences between the production and the perception mechanisms: the Recency factor favoring low attachment is hypothesized to operate in both production and perception; by contrast, the Predicate Proximity factor favoring high attachment is a disambiguation mechanism, and as such is hypothesized to apply in perception but not in production (since the speaker knows the intended meaning; the perceiver does not).

have found a preference to attach the RC to the higher of two hosts in Dutch (Brysbaert & Mitchell, 1996; Mitchell et al., 1995; Mitchell et al., 2000). Brysbaert & Mitchell (1996) report an overall high-attachment preference of 62% for Dutch sentences translated directly from Cuetos & Mitchell's (1988) English/Spanish off-line questionnaire. In on-line studies (e.g., Brysbaert & Mitchell, 1996, Experiments II and III), subjects read disambiguated sentences of the type illustrated in (13) below:

- (13) De gangsters schoten op de zoon van de actrice
 the terrorists shot on the son-[masc.] of the actress-[fem.]
 die op het balkon zat met zijnhaar arm in het gips.
 that on the balcony was with his/her arm in a cast

“The terrorists shot the son of the actress who was on the balcony with his/her arm in a cast”

The results indicated that reading times for the portion of the sentence containing the disambiguating information, e.g., *his/her arm in a cast*, were longer for sentences disambiguated for low attachment than for those in which attachment was resolved in favor of N1.

To test the prediction of the Tuning Hypothesis that the high-attachment preference found in parsing experiments in Dutch should also be present in Dutch corpus samples, Brysbaert and Mitchell (1998) analyzed a sample of 675 sentences containing the N1-van-N2-RC construction, extracted from corpora based on four different Dutch newspapers and magazines. Of the 469 sentences in which the RC was clearly attached to either N1 or N2, it was attached to N2 in 325 cases (69%). This predominance of low attachment in Dutch corpora is completely unexpected on the

basis of Tuning, which claims that corpus biases are the source of preferences found in parsing.

Mitchell et al. (1995) originally proposed that Tuning's frequency record-keeping would be done at a relatively coarse grain, but recently attempts to rescue the Tuning hypothesis have sought to identify within the variety of N1-*van*-N2-RC structures in Dutch corpora, relevant subclasses for which high attachment is systematically more frequent. If such subclasses could be identified, it might be argued that the frequency-counting mechanism the parser relies on in resolving structural ambiguity keeps records at a sufficiently fine grain to classify constructions on the basis of many syntactic and semantic features. Recent finer-grain examinations of Dutch corpora (De Baecke, Brysbaert & Desmet, 2000a, b; Desmet, Brysbaert & De Baecke, in press) have uncovered a number of facts about attachment tendencies in language usage. Perhaps the most interesting of these is that the humanness of the noun hosts influences RC-attachment: when N1 refers to a human, high attachment of the RC is more frequent (just as in the reading experiments); however, when N1 does not refer to a human, low attachment of the RC is more frequent (whether or not N2 refers to a human). This may explain part of the mismatch between the reading data and corpus frequencies in Dutch: in the reading experiments, complex NPs with a human N1 prevailed, whereas the overwhelming majority of sentences in the corpora contained a non-human N1. Desmet et al. (in press) concluded that their results may "salvage the tuning hypothesis as there is a level of analysis (a grain) at which the reading data correspond to the corpus data. However, although the tuning hypothesis leaves open the possibility of such a grain (Mitchell et al., 1995), this is clearly a post-hoc adaptation",

one that "extends the tuning theory in ways which depart from its original conception", which is that the parser tunes "to frequencies of structures, not to characteristics of the individual words" (p. 28).

It is not clear why extending the original theory in this way should be regarded as a flaw, except that the finer the grain, the heavier the load on the memory for record-keeping purposes. A more serious problem for Tuning, however, is the finding (Desmet et al., in press) that for sentences in which N1 was non-human and N2 was human, the production data do not match the reading data: both corpus samples and sentence completion studies indicate a low-attachment tendency for this type of sentence, whereas in reading experiments in Dutch, a preference for high attachment has been found for this type. E.g., Brysbaert & Mitchell (1996) report results of a questionnaire based on that used by Cuetos & Mitchell (1988); for their non-human/human items (13 of the total 24 experimental items) they found a 67% high-attachment preference. The results of Brysbaert & Mitchell's (1996) on-line experiments, one using self-paced reading, and another eye-tracking, confirm this finding. Mitchell et al. (2000) also report a high-attachment bias for 12 non-human/human items (out of 36 total), in an eye-tracking study, though this tendency was not statistically reliable. These discrepancies between the production data and the reading data in Dutch still remain to be explained.

Unlike the grammar-based accounts discussed earlier, the Tuning Hypothesis has no way of explaining why the RC-attachment ambiguity differs with respect to Late Closure from all other constructions in all languages for which there are data so far. For Tuning, as given, there are no deeper explanations. Statistical factors are the sole determinants of initial attachments in ambiguity resolution. So the special status of the

RC-attachment construction is just an accident, and the general tendency toward Late Closure in all other constructions is a mere coincidence.

On the positive side, Tuning allows for individual differences in RC attachment preferences. A person's attachment bias is based on the accumulated record of relative frequencies of occurrence of the competing constructions, built up from experience. Thus, *individual variation in attachment preferences* would be attributed, in such an experience-based model, to differences in the input that different individuals have been exposed to, within the same language. (For findings indicating individual differences in RC-attachment preferences based on the individual's work environment and language background, among other things, see Corley, 1996; Corley & Cuthbert, 1997; Brysbaert & Mitchell, 1996; and Fernández, 1998, 2000/2003.)

3.3.5 Exposure-Based Explanations: Recap

In contrast with grammar-based accounts of RC-attachment, according to which the observed parsing differences across languages are to be attributed to differences in grammars, the Predicate Proximity/Recency model and the Tuning Hypothesis look for determinants of RC-attachment preferences outside of the grammar. Gibson and colleagues' two-factor model proposes that a parsing parameter, Predicate Proximity²⁶, whose language-specific value must be learned, governs the height of attachment through interaction with a universal principle, Recency. According to the Tuning

²⁶The strength of this parameter does depend on facts about what is grammatical in the language, but only as mediated by a mechanism external to the grammar, i.e., exposure-based frequency counts. It is not suggested that the average distance between a verb and its arguments can be deduced from knowledge of the grammar.

proposal, on the other hand, the parser favors whichever attachment it has encountered more frequently in actual language usage.

While there is some evidence in their favor, both of these accounts have been found to be deficient in several respects. In particular, Tuning faces difficulties in attempting to reconcile corpus statistics for Dutch with the corresponding evidence from parsing experiments. The Predicate Proximity/Recency account seems to face obstacles in defining the specifics of its parameter-setting procedure so as to correctly predict the preference ranking of attachment sites across languages.

In the next chapter, we discuss a grammar-based proposal which accounts for variation in RC-attachment preferences across languages by reference to the prosodic component of the grammar.

CHAPTER 4

THE IMPLICIT PROSODY HYPOTHESIS

4.1 The Implicit Prosody Hypothesis: The Proposal

Fodor and her colleagues (Fodor, 1998, 2000, 2002; Fodor et al., 2000; Quinn et al., 2000) have proposed that parsing preferences for ambiguous inputs may be influenced by silent prosody.

The Implicit Prosody Hypothesis (IPH):

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, p. 113).

This approach assumes that a prosodic contour is computed in the perceiver's mind even during silent reading, and that this implicit (mentally computed) prosody has an effect on the parser's choices in much the same way as explicit prosody affects the parser's preferences in the processing of spoken sentences. Bader (1998) and Hirose (1999) provide evidence for an effect of implicit prosody in the *reanalysis* of garden-paths in German and Japanese, respectively; see Section 4.2 below. The IPH differs from Bader's

and Hirose's proposals in that it supposes that implicit prosody influences parsing decisions *even on the first pass*.²⁷

The starting point for the proposal of Fodor and her colleagues is the observation, made within the framework of the Sausage Machine model (Frazier & Fodor, 1978), that constituent length influences parsing decisions. Frazier and Fodor noted what might be called an "anti-gravity law", a general tendency for heavier constituents to attach higher in the tree than lighter ones. Consider the following example:

- (1) a. She threw the bat, the ball and the glove down.
- b. She threw the bat, the ball and the glove down into the mud.

In (1a), there is a strong tendency for the short locative phrase *down* to attach low inside the *glove*-NP, as illustrated in (2), even though this results in an ungrammatical analysis. On the other hand, if the attaching constituent is lengthened, as in (1b), the sentence becomes easier to parse correctly, as illustrated in (3).

- (2) She threw [the bat, the ball and [the glove down]]
- (3) She threw [the bat, the ball and the glove] [down into the mud]

²⁷ The term 'first pass' is used in different ways in the literature - to refer to initial parsing decisions, as input is encountered, and to any decisions prior to syntactic reanalysis. The IPH, at its current stage of development, does not necessarily pick out the first of these. Henceforth, 'first pass' will be used to refer to any parsing decisions prior to encountering a syntactic trigger for reanalysis.

The observations that short constituents prefer to attach low while longer ones can more easily move up and attach higher in the tree, were initially attributed to short-term memory conservation by Frazier & Fodor (1978). Fodor (1998) offers a new interpretation, that these effects in parsing are prosodic in origin, in particular that they are a consequence of prosodic phrasing.

There is independent evidence in the phonological literature that constituent length has an impact on the pattern of prosodic phrasing. Prosodic phrasing has been shown to be influenced by a number of factors: syntactic structure, focus, and constituent length, among others (for reviews, see Shattuck-Hufnagel & Turk, 1996, and Cutler, Dahan & Donselaar, 1997). As regards syntax, researchers generally agree that there is a regular relationship, in large part, between syntactic and prosodic structure. Selkirk (1986) proposes that the relation between syntax and prosody is defined in terms of edge alignment between major prosodic phrases and lexical syntactic maximal projections (XPs), allowing alignment direction (left or right edge) to be parameterized for different languages (right edge for right-branching languages and left edge for left-branching languages). A formulation of the edge alignment constraint within the framework of Optimality Theory (OT) (Prince & Smolensky, 1993) is offered by Selkirk (1995, 2000) as follows:

Align XP: The edge of each lexical XP coincides with the edge of a major prosodic phrase.

Phrasal edge-alignment is a ranked and violable constraint in an OT grammar, and its effects may be suppressed by other constraints, e.g., constraints making prosodic

phrasing sensitive to the length of constituents. Selkirk (2000) has expressed this in terms of universal but violable constraints on the minimum and maximum size of prosodic constituents. The size constraints applying to the major phrase level are formalized as follows:

Binary Maximum (BinMax): A major phrase must consist of at most two minor phrases.

Binary Minimum (BinMin): A major phrase must consist of at least two minor phrases.

The Binary Minimum constraint requires that very short major phrases (such as, for instance, *down* in (1a) all by itself) are to be avoided if possible. So, obeying the BinMin constraint, the prosodic parser packages *down* together with *the glove*, even though the result is the ungrammatical structure shown in (2). In (1b), by contrast, the locative phrase *down into the mud* has sufficient prosodic weight (it consists of two minor phrases, *down* and *into the mud*) that it can constitute a major prosodic phrase by itself, as in *She threw (the bat, the ball and the glove) (down into the mud)*²⁸. (For present purposes one minor phrase can be taken to be one prosodic word; see Selkirk, 2000, for definition of terms.) The optimal-length principles are satisfied, and, as a result, there is no syntax-prosody mismatch.

An alternative length-sensitive theory of prosodic phrasing maintains that what is relevant is relative rather than absolute size, and proposes that there must be a length balance between successive major phrases. This prosodic preference for balance, or the

²⁸I follow Selkirk (2000) in using parentheses to indicate a major phonological phrase boundary and square brackets to indicate syntactic structure.

"bisection principle", has been endorsed by a number of studies on both English (Cooper & Paccia-Cooper, 1980; Gee & Grosjean, 1983; Bachenko & Fitzpatrick, 1990) and French (Monnin & Grosjean, 1993). Analyzing English sentences spoken aloud, Gee & Grosjean (1983) observed a strong tendency for prosodic breaks to divide the word string into units that "are more or less symmetrical (or balanced)" (p. 416). They further noted that syntactic and prosodic structure match when the major constituents of a sentence are roughly equal in length. However, when discrepancies in length threaten to throw constituents off balance, mismatches between syntax and prosody may occur. In other words, to achieve prosodic phrases of similar weight, thus resulting in a balance between constituents, prosodic phrasing may override syntactic structure. On this approach, the reason why *down* in (1a) is packaged together with *the glove* would be because the grouping of *the bat, the ball and the glove* (a long constituent) on the one hand, and *down* (a short constituent) on the other, as separate phrases, violates the prosodic balance principle; prosodic balance would prefer *(the bat, the ball) (and the glove down)*. By contrast, in (1b), a grouping with *the bat, the ball and the glove* as one prosodic phrase and *down into the mud* as another, divides the word string into segments that are more or less equal in length, thus satisfying the balance principle.

On the basis of his data for Italian, Ghini (1993) argues for *Uniformity*, a eurythmic constraint on prosodic phrasing which seems to capture both the notion of optimal length and of balance:

Uniformity and average weight:

A string is ideally parsed into same length units; the average weight of the \emptyset s²⁹ depends on tempo: at an average rate of speech (*moderato*), a \emptyset contains two phonological words; the number of Ws within a \emptyset increases or decreases by one by speeding up or slowing down the rate of speech.

Sandalo & Truckenbrodt (2002) adopt this notion in their analysis of phrasing in Brazilian Portuguese, recasting it in OT terms as two separate constraints:

Max-Bin: p-phrases consist of maximally two prosodic words; and

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

They give evidence that both constraints apply, with different effects, in Brazilian Portuguese. If this is correct, both absolute size and relative size of prosodic units are relevant to prosodic patterning, and where phrase length effects are observed, it will be necessary to determine (for Brazilian Portuguese or indeed for any language under investigation) whether what is at work is an optimal absolute size for a prosodic phrase, or instead an optimal balance (depending on relative size) between successive prosodic phrases, or indeed whether both types of length-sensitive constraints apply. We set this distinction aside here. For present purposes what matters is that researchers agree that constituent length affects prosodic phrasing, and that this may result in mismatches between syntactic and prosodic structure: prosodic phrasing may ignore syntactic structure in order to satisfy constraints on phrase length.

²⁹' \emptyset ' stands for 'phonological phrase', and 'W' stands for 'word'; in their work, discussed below, Sandalo and Truckenbrodt refer to phonological phrases as 'p-phrases'.

To summarize: Fodor and colleagues' Implicit Prosody Hypothesis brings together the observation that constituent length has an impact on syntactic parsing in silent reading, and the independent evidence from research on prosody which indicates that constituent length affects prosodic phrasing. Together, these suggest that length effects may occur in silent reading because prosodic phrasing is projected onto the sentence by the reader. If it is true that prosody influences parsing not only in the processing of spoken sentences but also in silent reading, then what appear to be syntactic parsing differences across languages and across constructions may in fact be reducible to effects of prosodic phrasing.

4.2 The IPH and RC-Attachment: A Preliminary Look

Before we turn to the evidence which indicates that prosody (both explicit *and* implicit) plays a role in parsing, let us first examine whether a model of parsing based on prosodic phrasing, such as the IPH, has the right sort of profile to account for the variety of data associated with the RC-attachment phenomenon.

Clearly, the IPH has the potential to explain *cross*-linguistic variation in RC-attachment preferences. Though there are some universal trends, prosodic principles do differ across languages (in OT terms, their ranking differs), and different characteristic prosodies could lead to different syntactic attachment preferences. If the IPH could account for all the observed contrasts, no parametrization of the parser would be necessary, and the parsing mechanism could be claimed to be fully innate and universal; variation in parsing preferences across languages would be attributed to differences in

the prosodic component of their grammars. A crucial question here is: What prosodic differences are relevant? Intuitively, boundary placement (as between a head noun and an RC) would be one natural candidate. In a preliminary discussion, Fodor (1998) reports her intuition that English (a low-attaching language) may differ prosodically from other languages such as French (a high-attaching language), in that it has a tendency to "glue" unstressed syllables onto the preceding prosodic phrase. This can result in phonological packages that do not match syntactic structure, e.g., a package in which the initial words of the RC "glue" to the second noun, in an N1-of-N2-RC structure. Data reported by Holmes (1995; see also discussion in Fodor et al., 2000) may be taken as providing some support for this intuition. Holmes compared the sites of hesitation pauses in spontaneous speech in English and French, and found that English speakers tended to hesitate *after* a clause-introducing word (such as a relative pronoun) to a significantly greater extent than French speakers did. Assuming substantial congruence between prosodic and syntactic structure (e.g., Selkirk, 2000), a prosodic grouping where the initial words of the RC "glue" to N2, prosodically, can be expected to encourage low attachment of the RC in an otherwise attachment-ambiguous N1-of-N2-RC construction. In other words, if two syntactic elements are close prosodically, it can be expected that they will be interpreted as being adjacent in the syntactic tree. In French, on the other hand, a stricter alignment of syntactic and prosodic boundaries in production, observed by Holmes, would arguably result in a pattern of prosodic phrasing which should favor high attachment for the RC in the corresponding French structure (illustrated in (4)).

- (4) ... la servante de l'actrice (qui était sur le balcon)
 "... the servant of the actress who was on the balcony"

In other words, a prosodic discontinuity between constituents can be expected to be interpreted as signalling syntactic distance. Maynell (1999, 2001) has provided experimental evidence that a prosodic break right before the RC does encourage a high-attachment interpretation in the processing of spoken sentences in English (see Section 4.3 below). The above observations are encouraging for the IPH, and are supported by pilot data obtained by Quinn (reported by Fodor et al., 2000, and Fodor, 2002) on differences in fundamental frequency (F0) contours between English and French examples, which may reflect the prosodic factors responsible for preferred low RC-attachment in English and preferred high RC-attachment in French.

Fodor (1998) notes that the prosodic proposal also has means of explaining *within*-language variation in RC-attachment preferences. For instance, individual differences in attachment preferences (e.g., Brysbaert & Mitchell, 1996) might be attributed to the extent to which particular perceivers rely on phonological memory in sentence processing. Individual subjects who do not robustly project prosody in silent reading should be largely insensitive to prosody-induced effects on attachment preferences. (They might exhibit no attachment preferences, or exhibit preferences which are consistent with syntax-based principles such as Late Closure/Recency.) This prediction has yet to be subjected to empirical test, however.

The finding (Gilboy et al., 1995; De Vincenzi & Job, 1993, 1995; Frazier & Vonk, 1997; Baccino et al., 2000; Fernández, 1999) that RCs are more likely to attach low when the preposition between N1 and N2 is *with* than when it is *of*, which has been

attributed to thematic factors, may also have a prosodic explanation. Intuitively, a prosodic break between N1 and *with* in an N1-with-N2 construction seems more likely than a break between N1 and *of* in an N1-of-N2 sequence (and similarly for the corresponding prepositions in other languages). This would result in a stronger tendency to package the RC phonologically with N2 when the preposition is *with* than when it is *of*, and a stronger tendency to group N2 with N1 when the preposition is *of* than when it is *with*; these patterns are illustrated in (5) below. In turn, these different patterns of prosodic phrasing, would likely favor lower attachment of the RC³⁰ in the *with*-construction as compared with the *of*-construction, given the results of Maynell (1999, 2001) mentioned above.³¹

- (5) a. N1) (*with* N2 RC
 b. N1 *of*N2) (RC

Thus, if the prosodic account is correct, it may be that no reference to the thematic or non-thematic nature of prepositions need be made in describing the parsing mechanism. The thematic difference may have its effect indirectly, via an association with different prosodic phrasings. This prediction has yet to be subjected to empirical test, however.

³⁰ For convenience, I will use expressions like ‘lower attachment (preference)’ as a shorthand for ‘a higher proportion of low-attachment choices’; ‘higher attachment (preference)’ will be used as a shorthand for ‘a higher proportion of high-attachment choices’.

³¹ Note also that Jun’s (2003) preliminary observations based on a number of languages, including English, indicate that hearers preferred to attach the RC low in spoken sentences with an overt prosodic break immediately following N1 and no break at the RC. Clifton et al (2002) report similar data for English: hearers preferred to attach the RC low when there was a large break right after N1 and only a small break before the RC.

The prosodic proposal may also be compatible with the finding (Gibson et al., 1996; Gibson et al., 1999) that in a three-site ambiguity (N1-N2-N3-RC) the middle noun (N2) is the least preferred attachment site for the RC, the preferred site being N3, with N1 being the second most preferred site. To explain the preference for N3, Fodor (1998) suggested that the three nouns and the RC are likely to divide into (N1-N2) (N3-RC), while N1 attachment would be favored by (N1-N2-N3) (RC). No grouping seems to be available to make N2 more accessible than N3 or N1, for RC-attachment. (Fodor also noted, however, that repetition of the nouns may lead to a list intonation with each of the three individual nouns treated as a singleton, not grouped together at all.) Wijnen and colleagues (Wijnen & Quené, 2000; Wijnen, Troos & Quené, 1999) have claimed that in Dutch there is no natural prosodic contour which would correspond to the interpretation in which the RC is attached to N2. In support of this they cite results of a production study by Wijnen & Quené (2000) in which subjects were asked to prosodically disambiguate Dutch N1-N2-N3-RC structures. It was found that speakers produced consistent prosodic phrasing for N1 and N3 attachments, but failed to do so for N2 attachments. A corresponding auditory questionnaire study, in which the three-site structures were presented with three different prosodic realizations representative of those most often observed in the production study, showed that overt prosodic phrasing significantly modulated perceived RC-attachments, but only in favor of either N1 or N3, not N2. Based on these findings, Wijnen and Quené argue for a prosodic explanation of the pattern of preferences observed in a three-site ambiguity: N2 is the least preferred attachment site because a prosodic structure compatible with N2-attachment is unavailable. (Notice that this presupposes the projection of *implicit* prosody in silent

reading, to explain the pattern of preferences, observed by Wijnen (1998) and Wijnen & Quené (2000), in Dutch sentences containing a three-site ambiguity construction.)

Finally, the prosodic explanation distinguishes not only between different types of host configurations but also between different types of *attachees*. In particular, the height of attachment is expected to differ across constructions, on this account, as a function of the heaviness/length of the *attachee* as well as that of its host configuration, as mediated by prosodic phrasing. This may explain what is special about the RC-attachment construction, and why it is less inclined toward low attachment than the other constructions studied. The *attachee* in this construction (RC) is usually ‘heavy’, in terms of both syntactic structure and length: it is a clause, i.e., a major syntactic constituent, and typically at least two minor phrases in length. Intuitively, the most natural place for a major prosodic break to occur is at the left edge of the RC. This site is compatible with the edge-alignment approach of Selkirk (2000, see above), though it does not follow from the particular alignment principles she applies to right-branching languages (right-edge alignment).³² It also accords with the optimal-length principles (see Selkirk, 2000, and Sandalo & Truckenbrodt, 2002, above). This prediction concerning production is reinforced by perceptual data. Watson & Gibson (2001) report that sentences are judged to be significantly more difficult to comprehend if they lack a prosodic break immediately before a long constituent such as an RC.

³² The Croatian data from Experiment 4, reported in Chapter 7, suggest that left-edge alignment of major prosodic phrase boundaries with syntactic XP (here, PP and RC following a noun head) boundaries can occur in a right-branching language. More data both from Croatian and other languages are needed before a full assessment can be made of the theoretical implications of this.

The result of a major break occurring right before the RC is a pattern of prosodic phrasing in which N1 and N2 are packaged together in one phrase, with the RC packaged separately as an independent prosodic unit; see (5b) above. (An additional major break between N1 and N2 is unlikely; N2 standing alone as a phonological package violates size constraints.) As a consequence, and assuming substantial congruence between syntactic and prosodic discontinuities (Selkirk, 2000; Maynell, 2001, for English), the RC is likely to be preferentially interpreted as modifying the whole complex NP whose head is the first noun, i.e., N1.

By contrast, in other constructions with a height-of-attachment ambiguity, the *attachee* is often light (e.g., a one-word adverb in (1) in Chapter 2, repeated below as (6), or a short PP in (2) in Chapter 2 and in (2) in Chapter 3, repeated below in (7) and (8), respectively).

- (6) Tom said that Bill left *yesterday*.
- (7) ...the gift for the boy *in the box*...
- (8) Raúl vendió el libro que había robado *a su amigo*.
 “Raúl sold the book that he had stolen to/from his friend”

As a result, the *attachee* is likely to be packaged together with a part of its host configuration, in accord with optimal-length principles. This pattern of prosodic phrasing should, in turn, favor a lower interpretation of the ambiguously attached constituent (a preference which coincides with the prediction of recency principles such as Late Closure).

Notice that this presupposes, like much of the literature on prosodic influences on parsing, that prosodic phrasing tends to be interpreted as signalling syntactic structure, even though its actual source might be some other factor such as phrase length, or focus, etc. This is what Fodor (2002) has called the *Structural Interpretation of Prosody Principle*. This is particularly relevant to implicit prosody phenomena, in which the same person might assign a prosodic pattern for reasons other than syntactic structure and then interpret it as signalling syntactic structure. (See Fodor, 2002, for discussion.)

Hemforth et al. (1998, 2000) have documented a contrast in German between attachment preferences for RCs and PPs in complex NPs, higher for the former than for the latter. As noted in Chapter 3, they attributed this divergence to the N1-favoring anaphoric binding which applies in RC-processing but not in PP-processing. But the prosodic account also has ways of explaining this (and similar) cross-construction differences. One explanation would be that an RC is often a longer attachee than a PP. This should result in a stronger tendency for an RC to be packaged as an independent prosodic unit, separate from the two nouns, compared with a PP in the same configuration. This pattern of prosodic phrasing would, in turn, favor higher attachment for the RC. However, this explanation is incompatible with the results of an experiment by Walter, Hemforth et al. (1999) in which the length of RCs and PPs was matched, and, nevertheless, PPs attached low more often than RCs.³³ Another possible prosodic explanation would be that principles of the prosodic component of the grammar favor

³³ However, all RCs were preceded by a comma (obligatory before RCs in German), unlike the PPs, and this might have increased the tendency to introduce a prosodic break immediately before RCs as compared to PPs.

prosodic boundaries edge-aligned with some syntactic categories rather than others (e.g., more strongly with clauses than with PPs). Note that such asymmetries could well be language-specific; see discussion of Croatian below. (For related discussion see Fodor, 2002, and Bradley et al., 2003.)

There is also substantial support for the IPH's prediction that in the RC-attachment construction, attachment preferences are modulated by the length of the attaching RC: short RCs have been shown to be less likely to attach high than long RCs in a number of languages: Brazilian Portuguese (Lourenço-Gomes, 2002), Dutch (Wijnen, 2001), English (Bradley et al., 2003; Fernández, 2000/2003; Hemforth & Konieczny, 2002; Walter et al., 1999), French (Fernández et al., 2003; Pynte & Colonna, 2000), German (Hemforth & Konieczny, 2002), Japanese (Kamide et al., 1998), Spanish (Fernández, 2000/2003; Hemforth & Konieczny, 2002). Consider the following example:

- (9) (a) ... the servant of the actress who smokes.
 (b) ... the servant of the actress who smokes two packs of cigarettes a day.

Under the IPH, if the RC is long (as in (9b)), it is more likely to be packaged separately as an independent prosodic unit, with a major break occurring between it and N2; by contrast, if the RC is short (e.g., one minor phrase, as in (9a)), it is more likely to be packaged with preceding material, with no major prosodic break intervening between it and N2. This prediction is supported by data reported in a study by Bradley et al. (2003), which examined prosodic phrasing in overt productions of RC sentences of English. Bradley and her colleagues found that mean N2 duration was significantly longer before

long RCs than before short RCs, suggesting a higher likelihood of a prosodic boundary immediately after N2 when the following RC is long than when it is short. Also, the perceptual data of Watson & Gibson (2001; see above) provide support for a higher probability of a break before a long constituent. Our assumption throughout this discussion, based on Selkirk (2000, discussed above) and Maynell (1999, 2001, discussed below), is that there is substantial congruence between syntactic structure and prosodic phrasing, i.e., that, for instance, strong prosodic breaks typically signal higher attachment of the following material in the syntactic tree, while prosodic continuity signals structural adjacency. Thus, the above patterns of prosodic phrasing can be expected to bias toward higher attachment for long RCs than for short RCs.

To summarize: potentially, the prosodic proposal offers a means to account both for cross-linguistic and within-language differences in RC-attachment preferences. It also offers an explanation of why RC-attachment is different from the many constructions for which a general tendency toward low attachment has been found. However, if the prosodic explanation is to gain full credibility, the above intuitions about how parsing preferences may be influenced by prosodic phrasing in silent reading need to be confirmed by evidence from experimental research explicitly designed to test them.

4.3 The IPH: The Evidence

A number of studies have shown that prosody in *spoken* sentences can guide hearers' interpretation of syntactically ambiguous RC-attachment sentences. Schafer,

Carter, Clifton & Frazier (1996) have documented an effect of focal pitch accent on the preferred interpretation of ambiguous RC-attachments in English. They presented subjects with spoken sentences which contained the RC-attachment ambiguity, and found that placing a focal pitch accent on N1 significantly increased the likelihood that listeners would interpret the RC as modifying N1, while a focal accent on N2 encouraged low attachment of the RC, i.e., to N2.³⁴ Maynell (1999, 2001) has presented evidence that breaks in overt prosody may influence the syntactic parse. She conducted a series of experiments using spoken English sentences which contained the RC-attachment ambiguity, and found that an intonational phrase break between N2 and the RC resulted in a preference to attach the RC high. This was so both when the RC was introduced by *that* and when it was introduced by *who/which*, regardless of which of N1 or N2 had a focal pitch accent, and both with and without a pause between N2 and the RC³⁵. By contrast, in the condition in which no prosodic break intervened between N2 and the RC, a low attachment preference was found (significant when the RC was introduced by *that*, non-significant when the RC was introduced by *who/which*).³⁶

³⁴ But see Jun (2003) for contrary data. Jun noted that focal accent on N1 favors a break right after N1, which favors N2-attachment.

³⁵ The intonational phrase breaks in Maynell's experiments were probably stronger than in normal speech. The stimuli were created artificially: a speaker first produced two clear intonational phrases, one corresponding to the matrix clause and one corresponding to the RC; these were then spliced together with either a 500ms silence between them, or with no intervening silence. In both conditions (500ms pause and 0ms pause), there was lengthening of N2 and a low boundary tone. In the no-boundary condition, the speaker only produced one single intonational phrase, with no prosodic boundary between N2 and the RC.

³⁶ In informal small-scale studies, Jun (2003) reports preliminary data for English and a number of other languages, to the same end: hearers preferred high RC-attachment when there was a break immediately preceding the RC. By contrast, they preferred low RC-attachment when there was a break right after N1. Also, in their study on English, Clifton et al. (2002) found a significant effect of prosodic phrasing: hearers preferred high attachment more often when there was a break right before the RC (and no prior break) than when there was a large break right after N1 and a smaller break before the RC.

The data from Schafer et al. (1996) and Maynell (1999, 2001) show that when sentences are *heard*, their prosody can affect parsing choices. However, almost all of the experiments examining attachment preferences across languages and across constructions have employed *written* materials, in which there is no explicit prosody which might bias structural disambiguation. The closest analogue to prosodic information in the input in reading experiments is the segmentation of sentences in visual displays for self-paced reading. Gilboy & Sopena (1996) have demonstrated that how the input is chunked in experimental presentations can influence the preferred interpretation of ambiguous RC-attachments in both English and Spanish. Presentation in small segments (with a break right before N1, immediately after N1, and between N2 and the RC) gave rise to no significant attachment preference, but presentation with a single break, right before the RC, resulted in a high attachment preference. This finding might be explained in various ways, but it is natural to surmise that visual chunking influenced prosodic phrasing. If so, it is compatible with the claim of the IPH that parsing preferences may be attributed to prosodic phrasing even in silent reading.³⁷ It may also be relevant that Carreiras (1992) observed a similar effect when there was a comma separating the complex NP from the RC. Schimke et al. (2002) obtained a similar result in French (but see Murray et al., 2000, for contrary evidence). However,

³⁷ Gilboy and Sopena noted that the observed segmentation effects in parsing may be mediated by a prosodic phrasing computed by the reader. However, their general theory is different from the IPH. They adopt the Construal assumption that arguments but not adjuncts are processed using structural parsing strategies, such as Late Closure. Also, they maintain that, in the absence of the segmentation artifacts, there should be no preference for either low or high attachment in either English or Spanish. Thus, in contrast with the IPH, they do not assume that readers *routinely* respond to prosodic contours imposed on sentences in silent reading.

the fact that a comma immediately before the RC increases the frequency of N1 interpretations may also be due to its inducing a non-restrictive interpretation of the RC.

The above data show how *direct* manipulation of the prosodic contour in auditory stimuli (Schafer et al., 1996; Maynell, 1999, 2001) and of segmentation patterns in written stimuli (Gilboy & Sopena, 1996) can affect structural preferences. Let us now consider evidence which indicates that prosody can influence syntactic parsing even when such direct prosodic/segmentation manipulations are *not* part of the stimulus. Bader (1998) has presented data from a series of three self-paced reading experiments in support of the claim that implicit prosody influences the reanalysis of garden-path sentences in German. He used focus particles (e.g., *sogar* ‘even’) to manipulate *indirectly* the placement of focal stress in locally ambiguous sentences of the type shown in (10) below.

- (10) a. Zu mir hat Maria gesagt, daß man ihr Geld anvertraut
 tu me has Maria said that one her money entrusted
 hat.
 has

“Maria said to me that someone entrusted money to her”

- b. Zu mir hat Maria gesagt, daß man sogar ihr Geld
 tu me has Maria said that one even her money
 anvertraut hat.
 entrusted has

“Maria said to me that someone entrusted money even to her”

- c. Zu mir hat Maria gesagt, daß man ihr Geld beschlagnahmt
 tu me has Maria said that one her money confiscated
 hat.
 has

“Maria said to me that someone confiscated her money”

- d. Zu mir hat Maria gesagt, daß man sogar ihr Geld
 tu me has Maria said that one even her money
 beschlagnahmt hat.
 confiscated has

“Maria said to me that someone confiscated even her money”

In (10), *ihr* (‘her’) can temporarily be interpreted either as a dative object or as a possessive adjective, the latter being the preferred analysis on-line in these contexts (as evidenced by Bader's other results). The sentences are disambiguated by their clause-final verbs: *anvertrauen* (‘entrust’) requires a dative object obligatorily, while *beschlagnahmen* (‘confiscate’) cannot be used with a dative object. Without the focus particle *sogar* (see (10a) and (10c) above), the situation is as follows: because the preferred analysis on-line is the possessive interpretation of *ihr*, where *Geld* is the head of the NP *ihr Geld*, *Geld* bears sentence stress by default (and *ihr* does not). When the verb is processed, syntactic reanalysis is required in (10a), the dispreferred (dative) interpretation. No *prosodic* reanalysis is necessary: the originally computed prosodic representation associated with the preferred (possessive) analysis (stress on *Geld*) is fully compatible with the correct (dative) analysis. Once *sogar* is inserted, however, the situation changes: sentence stress on *Geld* is still the intonation associated with the preferred (possessive) structure in (10d), but this intonation is no longer compatible with

the dispreferred (dative) structure in (10b). In (10b), where *ihr* and *Geld* fall into separate phrases, the only acceptable intonation has an accent on the pronoun *ihr*, thereby making it the focus of *sogar*. As a consequence, when the verb is processed, the reanalysis required in (10b), unlike that in (10a), in which only a revision of syntax is necessary, involves both a revision of the syntactic structure and a revision of the prosodic structure: the initially computed intonation with an accent on *Geld* has to be replaced by an intonation with an accent on *ihr*. On this basis Bader predicted that (10b) should be more difficult than (10a) (and also more difficult than (10c) and (10d), in which no reanalysis is required). This is captured in his Prosodic Constraint on Reanalysis:

"Revising a syntactic structure is difficult if it necessitates a concomitant reanalysis of the associated prosodic structure" (Bader, 1998, p. 8).

The results confirmed this prediction: (10b) was more difficult than (10a), i.e., reanalysis was more difficult when the placement of focal stress associated with the parser's preferred first-pass analysis differed from the focal stress position for the correct analysis.³⁸

On the basis of these data, Bader concluded that "readers do not only compute syntactic structures during reading but also prosodic structures. These prosodic

³⁸ It should be noted, however, that focus particles like *sogar*, in addition to affecting the prosodic contour of the sentence, also affect its focus structure. In a further experiment, Bader showed that reanalysis was easier with long focus particles than with short ones like *sogar*. He argues that particle length only affects the prosodic contour, thus countering possible criticism that the observed parsing difficulty discussed above may have been caused by revision of the focus structure of the sentence, rather than by revision of the first-pass prosody.

structures are a product of the process of phonological coding which normally accompanies silent reading" (p. 1). Furthermore, "at least for the *ihr*-ambiguity, the ease of revising an initial structure is completely determined by prosodic factors" (p. 40). Thus, prosody is assumed to play a role in parsing even when the input signal contains no overt (or "real") prosody, and when segmentation artifacts of the Gilboy and Sopena type are not present. (Bader presented his stimuli using a non-cumulative word-by-word self-paced reading paradigm, which he assumed introduced no bias toward either interpretation.) The only difference of consequence between Bader's proposal and Fodor's IPH is the stage of processing at which the structure imposed by the prosodic processor is assumed to affect syntactic parsing. While Bader's proposal is that implicit prosody has an effect on the course of reanalysis (on first-pass, the lexico-syntactic preference applies and *results* in a preferred prosodic assignment), the IPH posits an influence of implicit prosody even on the first-pass assignment of syntactic structure to ambiguous word strings.

Hirose (1999; see also Hirose, 2003) also presented evidence that implicit prosody plays a role in garden-path reanalysis. She tested Japanese sentences of the type shown in (11) below, which involve a temporary reanalysis ambiguity at the head noun.

- (11) Subj Obj-[Acc] Adv Verb head-Noun-[Dat] Adv main-Verb
 Subj new medicine truly trusted friends finally met

In (11), the occurrence of a post-verbal noun (here dative-marked) signals that the initially preferred single clause analysis developed to that point is wrong, and that the sentence-initial word string must be reanalyzed as including a relative clause. However,

it is only at the sentence-final matrix verb that it becomes clear what kind of relative clause that must be, i.e., the structure in (12a) or the structure in (12b) (or yet other structures not discussed here).

- (12) a. Subj_{RC}[e_i Obj Adv Verb] Noun_i Adv Verb (takes Dat only)
 “Subj finally met the friends who truly trusted the new medicine”
- b. Subj Obj_{RC}[*pro* e_i Adv Verb] Noun_i Adv Verb (takes Dat and Acc)
 “Subj finally showed the new medicine to the friends whom he truly trusted”

At the head noun, the reanalysis routines must choose which of these structures to adopt. For structures of this type, Hirose demonstrated that the length of the subject phrase can shift the parser's preferences in the reanalysis of these sentences during silent reading. For a long subject (conjunction of two names, each bearing a lexical accent, e.g., *Hosokawa-to Morisita-ga*), structure (12a) was preferred to structure (12b) (73% vs. 27%); for a short subject (a single name with lexical accent, e.g., *Morisita-ga*), there was a significant reduction in the preference for (12a) (73% vs. 55%). The data for the short subject showed no reliable preference for (12a) over (12b) (55% vs. 45%). Hirose also showed that subject length affects the *explicit* prosody of these sentences: reading aloud, speakers produced a stronger break (as indicated by measurements of pause duration and reset from downstep) after a long subject than after a short one. This suggests that when the subject is long (two minor phrases, compared with one minor phrase when it is short), it is more likely to be packaged as a major prosodic phrase on its own. This pattern of prosodic phrasing, in accord with optimal-length principles, correlates with the shift in syntactic phrasing preferences in reanalysis. Hirose

concluded that the shift in the parser's preferences in silent reading as a function of subject length is most likely an effect of implicit prosody that was computed silently during the first-pass, and later influenced syntactic ambiguity resolution in reanalysis. (Hirose, 2000, ruled out other properties of the long and short subjects, e.g., syntactic coordination, as the relevant factor.)

Bader (1998) and Hirose (1999) both argue for an effect of implicit prosody on garden-path reanalysis, for constructions other than the RC-attachment ambiguity. In studies examining the attachment of an RC to either the lower or the higher of two potential hosts, two types of evidence have been presented to date in support of the claim that implicit prosody has an effect on syntactic parsing *even on the first pass*.³⁹ We shall consider, in turn, within-language evidence on the effects of RC-length on attachment, and between-language evidence about characteristic prosodic phrasings in the complex NP-RC ambiguity.

The first type of evidence is based on experiments which involved manipulation of the length of the RC, contrasting short and long RCs (as illustrated in (9) above). As noted above, parsing experiments contrasting short and long RCs have consistently found a tendency, in all languages tested so far, for short RCs to attach lower than long ones, e.g., Brazilian Portuguese (Lourenço-Gomes, 2002), Dutch (Wijnen, 2001), English (Bradley et al., 2003; Fernández, 2000/2003; Hemforth & Konieczny, 2002; Walter et al., 1999), French (Fernández et al., 2003; Pynte & Colonna, 2000), German (Hemforth & Konieczny, 2002), Japanese (Kamide et al., 1998), Spanish (Fernández,

³⁹ Unlike the materials in Bader's and Hirose's experiments, target sentences used in the standard questionnaires examining RC-attachment preferences are globally ambiguous: there is no garden path, so there is no syntactic trigger for reanalysis.

2000/2003; Hemforth & Konieczny, 2002). This is exactly as predicted by the prosodic account. Under the IPH, constituent length affects prosodic phrasing, which in turn has an effect on syntactic parsing in silent reading. The ways in which the length of the RC may influence prosodic phrasing, and the effect this is likely to have on the parser's preferences, have already been discussed in detail (in Section 4.2 above): the prosodic break that is likely immediately before long RCs favors high attachment, and the decreased likelihood of a break before short RCs favors lower attachment. Empirical evidence indicating that these patterns of phrasing are actually used in spoken RC sentences of English is presented in the work of Bradley et al. (2003, see Section 4.2 above); see also Quinn and her colleagues' data for English and French (Quinn et al., 2000; Fodor et al., 2000; see discussion below).

Non-phonological accounts have been offered in the literature of the effect of RC-length on attachment. Pynte (1998) and Pynte & Colonna (2000) have proposed an explanation based on the timing of parsing decisions: while a long RC is being processed, the parser has enough time to complete building the whole N1-of-N2 construction to which the RC can attach, whereas when a short RC is processed and ready to be attached, the N1-of-N2 construction has not been (fully) built yet. This proposal, however, has no apparent way of explaining cross-linguistic differences in attachment preferences, i.e., why, despite the within-language length effect, some languages exhibit a high-attachment preference overall, while others prefer low attachment.

An account in altogether different terms has been proposed by Hemforth & Konieczny (2002). They note that increasing an RC's length increases at the same time

its information load, and they suggest that this greater information load carried by long RCs increases the pressure on them to be attached according to the principle of Relativized Relevance (Frazier, 1990), i.e., to the noun that is more central to the main assertion of the sentence (that is, N1). Like the proposal of Pynte and Colonna, however, this account has no obvious way of explaining cross-linguistic differences in attachment preferences for sentences with RCs carrying more or less the same information load (unless these can be attributed to the topic and focus structure of sentences, which has been suggested to differ across languages; see Hemforth & Konieczny, 2002). A direct blow to this account comes from data presented by Bradley et al. (2003), which indicate that the length of the RC and the length of the matrix subject have similar and purely additive effects on RC-attachment, in their materials. (See also Fernández et al., 2003, who present data for Canadian French showing that Hemforth and Konieczny's proposal needs formulating in such a way that it applies equally strongly at all levels of embedding in a sentence, including inside adverbial clauses, not just at the level of the main assertion.) In view of the difficulties these non-prosodic proposals have in accounting for the existing data, it seems fair to say that the IPH remains the proposal that provides the best coverage to date of the range of data indicating that RC-length affects syntactic tree-building in silent reading.

The second type of evidence concerning the IPH in RC-attachment, outside reanalysis, comes from cross-linguistic studies which examine specific prosodic characteristics of languages as a way of determining what particular language-specific prosodic features might be responsible for the inclination to attach high or low in that language. Quinn and her colleagues (Quinn et al., 2000; Fodor et al., 2000) have

attempted to establish the default prosody for N1-of-N2-RC constructions in French (high-attaching) and English (low-attaching) by studying the explicit prosody of these constructions in spoken sentences.⁴⁰ The logic behind Quinn and her colleagues' studies is the same as that of Hirose (1999): explicit prosody is taken as a guide to implicit prosody, the working hypothesis being that the implicit prosody computed during silent reading is the same as the (default) explicit prosody for the construction in question. In the experiments of Quinn and her colleagues, native speakers of French and English were recorded reading aloud disambiguated RC sentences. The materials in the two languages (based on those of Pynte & Colonna, 2000) were translation equivalents. There were four versions of each sentence, in a design simultaneously manipulating RC-Length (short or long) and RC-Attachment (forced low or high). Illustrations of the materials are shown in (13) for French.

- (13) Il respecte le voisin des dames qui sort/sortent
 he respects the neighbor of-the women who leaves/leave
 (du grand immeuble).
 from-the big building

“He respects the neighbor of the women who is/are leaving (the big building)”

Quinn measured fundamental frequency (F0) at the center-point of the accented vowels of N1, and of N2, and of the first accented word in the RC, i.e., the RC verb. These measurements points were selected on the basis of the following observation: typically,

⁴⁰ Quinn et al. (2000) also report data for Egyptian Arabic. The procedure and materials design was slightly different in the Arabic study from the English and French ones. The Arabic data will not be examined in detail here since the literature contains little discussion of the relevant principles of Arabic prosodic phonology.

declarative sentences are characterized by a gradual F0 declination over the course of the utterance (e.g., see Pierrehumbert, 1980; Liberman & Pierrehumbert, 1984), terminating with a particularly sharp utterance-final fall (e.g., see Cooper & Sorenson, 1981). Sentence-internally, an F0 for a given region that is higher than (or the same as) the F0 for the preceding region is indicative of a prosodic discontinuity, i.e., a prosodic boundary between the two regions. For example, an F0 reset at the start of an RC may signal a prosodic boundary between the RC and the preceding noun.

Quinn et al.'s data show that in sentences with very short RCs, there is generally no F0 reset on the RC, for both forced high and forced low attachment, in both English and French: short RCs fit into the sentence-final declination pattern, with no indication of prosodic discontinuity between N2 and the RC. The absence of a prosodic break between N2 and short RCs is compatible with the observed lower attachment preference for short RCs in silent reading in both English (Bradley et al., 2003; Hemforth & Konieczny, 2002; Walter et al., 1999) and French (Fernández et al., 2003; Pynte & Colonna, 2000). In sentences with long RCs, on the other hand, two different patterns emerged: in French, an F0 reset at the RC verb was observed whether attachment was forced high or low; in English, by contrast, an F0 reset at the RC verb was more likely when attachment was forced high. As noted above, a rise in F0 on the RC may be taken to indicate the presence of a major prosodic phrase boundary at the RC's left edge, separating it prosodically from N2⁴¹. This pattern of prosodic phrasing has been shown to favor high attachment (at least in English, Maynell, 1999, 2001; see also Jun's, 2003,

⁴¹ Some preliminary duration measures by Quinn suggested that this is so. Fernández et al. (2003) present data from Canadian French which support the prosodic boundary explanation, in contrast to a pure F0 influence on attachment.

preliminary observations for other languages, including French). The F0 patterns observed for long RCs thus suggest that an N1-favoring prosodic contour, i.e., (N1-P-N2) (RC), is used in English for high attachment only, in the materials of Quinn et al., but is more or less obligatory in French regardless of attachment site. Since the data for French indicate that a similar prosodic contour is used regardless of whether attachment is forced high or low, Quinn and her colleagues take this to be the *default* prosody for French RCs. Assuming that the implicit prosody computed during silent reading is the same as the default explicit prosody, they propose that implicit prosody *causes* the observed syntactic preferences: in French, the parser's preferences accord with the independently determinable prosodic pattern. The phonological rules of French apparently require a prosodic break immediately before long RCs regardless of the attachment height determined by the disambiguation, cf. no break immediately before short RCs. For ambiguous sentences these prosodic patterns would result in a tendency toward high attachment for long RCs and lower attachment for short RCs in French, as was observed by Fernández et al. (2003), Mitchell et al. (1990), Pynte & Colonna (2000), and Zagar et al. (1997).

In short, Quinn et al.'s data are compatible with the IPH, and a good case can be made that implicit prosody is the driving force behind the attachment preferences. However, this was only a small-scale preliminary study. The IPH would be strengthened by additional results along similar lines. That is, the interesting avenue for future research would be to assess the correlation between default patterns in overt prosody and attachment preferences in silent reading, not only in more languages but also in a range of different constructions within the same language (e.g., N1-*with*-N2 vs. N1-*of*-

N2, RC-attachment vs. PP-attachment, and so on). The advantage of within-language comparisons is that variability with respect to other factors that differ across languages (e.g., lexical items, segmental phonology) can be minimized.

4.4 The IPH: Recap

There is now a growing body of data indicating that implicit prosody plays a role in syntactic parsing during silent reading both in reanalysis (cf. Bader, 1998; and Hirose, 1999, above) and in first-pass parsing. In the latter case the evidence so far comes from studies of RC-attachment. Data from parsing experiments involving manipulation of the length of the RC (Bradley et al., 2003; Fernández, 2000/2003; Hemforth & Konieczny, 2002; Kamide et al., 1998; Pynte & Colonna, 2000) offer indirect support. Studies examining contrasting prosodic contours for short vs. long RCs (Bradley et al., 2003; Quinn et al., 2000) and for languages with different prosodic rules (Quinn et al., 2000; Fodor et al., 2000) provide more supporting evidence. Together, they suggest the viability of the claim that the observed variation in RC-attachment preferences may be reducible to effects of prosodic phrasing in silent reading. This is important because this is a grammar-based explanation, like the Construal/Gricean proposal and Attachment-Binding Dualism discussed in Chapter 3, though in the IPH the grammar is crucially taken to include an interface between syntactic and prosodic structure. If the IPH proves to be correct, and if it proves possible to attribute *all* syntactic parsing differences among languages to differences between the prosodic principles in their grammars, then

the hypothesis that the parser is fully universal and innate is preserved: there is no need to postulate language-specific parsing routines (see Section 2.1).

4.5 Proposed Explanations: Summary and Conclusion

In Chapter 3, we examined the four accounts of cross-linguistic variation in RC-attachment preferences that have featured most prominently in the literature. Two were grammar-based, i.e., the Construal/Gricean proposal and Attachment-Binding Dualism, and two were exposure-based, i.e., the Predicate Proximity/Recency model and the Tuning Hypothesis. Considered in the context of the data that have been presented so far, all these proposals have been shown to be inadequate. The latest in the class of grammar-based explanations, the Implicit Prosody Hypothesis, discussed separately in this chapter, is claimed to have the right sort of profile to explain the variation in RC-attachment preferences across languages and across variants of the construction. Because it holds this promise, it is important to put the IPH through its paces by means of experiments designed to test its predictions rigorously.

The set of experiments to be presented in Chapters 6 and 7 of this thesis, examining RC-attachment in Croatian, tests predictions of the IPH and also some predictions of the Construal/Gricean account, the Predicate Proximity/Recency model, and Attachment-Binding Dualism. However, before we turn to the experimental evidence, Chapter 5 describes the grammatical characteristics of Croatian which make it possible to test these proposals. Chapter 5 also presents a

preview of the five experiments comprising the experimental research reported in the dissertation.

CHAPTER 5

CROATIAN AND THE RC-ATTACHMENT AMBIGUITY

5.1 Characteristics of Croatian Relevant to RC-Attachment

The experimental research presented in this thesis (in particular, in Chapters 6 and 7) examines RC-attachment preferences in Croatian, the native language of the author. No data concerning RC-attachment have previously been reported for Croatian. The Croatian equivalent of the RC-attachment ambiguity construction is N1-N2[Gen]-RC. This construction is like the RC-attachment ambiguity construction in German, tested by Hemforth et al. (1998, 2000), in that there is no preposition linking the two nouns. (See Section 5.1.3 below for a prepositional genitive.)

Croatian is valuable because it has several grammatical characteristics that make it possible to test a number of proposed explanations of the observed variation in RC-attachment preferences. Croatian is basically a right-branching SVO language (though it has scrambling). Of interest is that Croatian has an unambiguous form for expressing high attachment; it also allows replacement of the relative pronoun in the RC with the uninflected complementizer *što*; and finally, it allows insertion of a non-thematic

preposition (*od*) between N1 and N2, which does not affect in any significant way the syntax or semantics of the sentence, but does affect its prosodic phrasing.

5.1.1 Unambiguous alternative form

First, Croatian has an unambiguous high-attachment alternative to the ambiguous N1-N2-RC construction. This alternative is a construction similar to the "Saxon" genitive in English, e.g., compare (2) to (1) below:

(1) AMBIGUOUS

Nazvali	smo	kóerku	političarke
phoned	are	daughter-[fem.sg.Acc]	politician-[fem.Gen]
koja	voli	pjevati.	
who	likes	sing	

“We phoned the daughter of the politician who likes to sing”

(2) UNAMBIGUOUS

Nazvali	smo	političarkinu	kóerku
phoned	are	politician-[fem.poss.adj.+fem.sg.Acc]	daughter-[fem.sg.Acc]
koja	voli	pjevati.	
who	likes	sing	

“We phoned the politician’s daughter who likes to sing”

In (2), unlike the ambiguous (1), it is unambiguously the *daughter* who likes to sing.

Note that this is the noun that was N1 in sentence (1). In both versions, *daughter* is the head noun of the complex NP.

Unlike the “Saxon” genitive in English, however, the possessive in Croatian sentences like (2) is adjectival. Like all adjectives in Croatian, it agrees in gender,

number and case with the noun it modifies (e.g., it is feminine, singular, and accusative in (2) above). In addition, the possessive adjective in Croatian is generally limited to singular, animate, single-word possessors. (For a detailed discussion of possessive adjectives in Croatian, see Matasović, 2000; see also Browne, 1993; Ivić, 1986; Kuna, 1999; Mićanović, 2000; among others.) In this respect, Croatian is similar to Dutch and German, where unambiguous alternative forms exist but the contexts in which they are permissible are more restricted than for the Saxon genitive form in English. Crucially, however, in Croatian, unlike Dutch, when the alternative form is permissible it is not only fully acceptable, but is also preferred to the genitive construction; indeed, when permitted, it is the possessive adjective that is regarded as the primary device for expressing possession, and the genitive form as its alternative (Kuna, 1999, and references therein; Mićanović, 2000, and references therein; Pranjković, 1998; among others).⁴²

As discussed earlier, the Construal/Gricean hypothesis (see Section 3.2.1 for details and references) maintains that since attachment to *daughter* can be expressed by (2), sentence (1) may be reserved (by cooperative speakers) to express attachment to *politician*. If perceivers take this into account, a low-attachment preference is predicted for sentences like (1) in languages which have an unambiguous high-attachment alternative, and a high-attachment preference is expected in languages without one. This is the basic form of the Gricean argument, i.e., Variant 1 (unambiguous alternative

⁴² Linguists have claimed that possessive adjectives are the primary device for expressing possession in a number of other Slavic languages as well, e.g., Czech, Bulgarian, Slovenian. Others, like Russian and Polish, had possessive adjectives, but have lost them, or nearly lost them, in favor of the postnominal possessive genitive (Corbett, 1987; Golovačeva et al., 1989; Marojević, 1983).

exists; see Mitchell et al., 2000, as well as 3.2.2 above). Clearly, this variant of the Gricean argument predicts a low-attachment preference for Croatian.

Let us now consider the two subtler variants of the Gricean account, as adapted here from Mitchell and colleagues, and the predictions they make about Croatian. The first of these, Variant 2, proposes that the Gricean influence favoring low attachment varies based on the proportion of contexts in which the alternative form is acceptable in the language. This variant predicts higher attachment for Croatian (alternative restricted to singular/animate/single-word NPs) than for, say, English (none of these restrictions), but lower than for, say, Spanish (no alternative). Finally, according to the most refined variant of the Gricean explanation, Variant 3, the Gricean influence favoring low attachment is hypothesized to vary depending on how felicitous the alternative form is for the particular sentences at issue. This variant therefore predicts that the existence or non-existence of an alternative should have an effect for individual Croatian sentences tested.

In Chapter 6, we report data from an experiment on Croatian which manipulated (among other factors) the existence or non-existence of an alternative form. In the ensuing discussion we assess how the individual variants of the Construal/Gricean account fare with respect to these Croatian data.

5.1.2 Relative pronoun vs. complementizer

Secondly, in addition to the relative pronoun *koji* (similar to English *who/which*, but marked for gender and number as well as case), relative clauses in Croatian may

also be introduced by the uninflected complementizer *što* (similar to English *that*).⁴³ Uninflected relativizers are part of standard usage in other Slavic languages as well (e.g., *što* in Russian, *ščo* in Ukrainian, *co* in Polish and Czech, *čo* in Slovak, *ki* in Slovenian, and *što* in Belarusian, Macedonian, Bulgarian and Serbian; see Gallis, 1956; Kurzová, 1981).⁴⁴ In a comprehensive study of Croatian relative clauses, Kordić (1995) qualifies the uninflected *što* as ‘a stylistic reserve for *koji*’ (pp. 58, 63, 163, 305) used to avoid excessive repetition of the more frequent relativizer, the relative pronoun.⁴⁵ This makes it clear (as do the numerous other studies referred to therein) that in Croatian sentences like (1), the two relativizers, *koji* and *što*, are fully interchangeable (except for their stylistic flavor), regardless of the properties of the head noun (unlike English, where some speakers balk at *that* with a human head noun).⁴⁶ Thus, Croatian may be used to test the Attachment-Binding Dualism hypothesis (see Section 3.2.3 in Chapter 3

⁴³ Note that in Croatian, a relativizer is obligatorily present in the RC, i.e., the relative pronoun and the complementizer cannot both be omitted from the RC, unlike English or Russian, for instance (e.g., compare the Croatian sentence *Gdje su jabuke KOJE_{rel} je Kostja kupio?* with its equivalent in English *Where are the apples Ø_{rel} Kostja bought?*, and Russian *Gde jabolki Ø_{rel} Kostja kupil?*; Weiss, 1993).

⁴⁴ The uninflected relativizer is used most frequently in Slovenian and Macedonian, and least frequently in Russian, Czech and Bulgarian, with Croatian, Serbian, Ukrainian, Belarusian and Polish falling roughly in the middle of the scale (Dmitriev, 1972).

⁴⁵ According to Kordić’s corpus data, based on written texts belonging to several different styles (e.g., literary, scientific, ‘journalese’, etc), the uninflected *što* was used, overall, to introduce 11% of RCs, compared with 59% introduced by *koji*; the remaining cases involved relativizers such as adjuncts (e.g., *gdje* ‘where’), not relevant to the construction under study here. She notes that an increased occurrence of *što* in a style is accompanied by a decreased occurrence of *koji* in the same style and vice versa - a clear indication that the two relativizers are stylistic alternatives; the occurrence of *što* was highest in literary style, 20% (cf. 49% for *koji*), and lowest in ‘journalese’, 4% (cf. 66% for *koji*). The uninflected relativizer was used more often to introduce restrictive RCs than non-restrictive ones (60% vs. 40%), while the relative pronoun was used more often to introduce non-restrictive RCs than restrictive ones (60% vs. 40%).

⁴⁶ See, however, Browne, 1986; and Pranjković, 1998; as well as Kordić, 1995, for a discussion of some restrictions on the use of *što*, as compared with *koji*, in contexts which are not directly relevant to the present research.

above for details and references). According to the Attachment-Binding proposal, cross-linguistic differences in RC-attachment preferences are attributable to the legitimacy of omitting the relative pronoun from the RC. In languages in which the relative pronoun is obligatorily present (e.g., German), the operation of binding the relative pronoun should preferentially associate it with the more salient noun, i.e., N1, which would result in a preference to attach the RC to N1, i.e., high. In languages in which the relative pronoun is not obligatorily present in the RC (e.g., English), this process of binding the relative pronoun to one of the nouns is said to be less important, so there is no preference for N1 (even in sentences where the RC is introduced by a relative pronoun) and a general locality preference favors low attachment. This, the basic form of Attachment-Binding Dualism, clearly predicts a low-attachment preference for Croatian (the relative pronoun is interchangeable with the complementizer *što*).

Let us, however, consider several other possible variants of Attachment-Binding Dualism, and the predictions they make about Croatian. (The variants below were chiefly modeled on Mitchell and colleagues' variants of the Construal/Gricean Hypothesis, see above.) A more exclusive form of Attachment-Binding (we shall dub this Variant 2) might propose that only languages which allow *omission* of the relativizer from the RC should attach low, while others should attach high. This variant of Attachment-Binding would predict a high-attachment preference for Croatian (omission not allowed). A further variant, Variant 3, might propose that if a language has a weak alternative to the relative pronoun (whether it be complementizer or null), attachment preferences should vary based on the proportion of contexts in which the alternative is acceptable. This variant of Attachment-Binding would predict a low-

attachment preference for Croatian (relative pronoun and complementizer are fully interchangeable) of at least the same magnitude as that for varieties of English which limit the use of the complementizer based on properties of the head noun. Finally, an even more refined variant of Attachment-Binding Dualism, Variant 4, might propose that if a language has a weak alternative to the relative pronoun, attachment preferences should vary depending on which relativizer (if any) is actually used in particular sentences.⁴⁷ This variant would therefore predict that whether the RC is introduced by a relative pronoun or by a complementizer should have an effect for individual Croatian sentences tested.

In Chapter 6, we present data for Croatian from an experiment which manipulated (among other factors) a Relativizer factor (RC introduced by a relative pronoun or by a complementizer). In the ensuing discussion we assess how the individual variants of Attachment-Binding Dualism fare with respect to these Croatian data.

5.1.3 Preposition *od*

Thirdly, in addition to the *non-prepositional* genitive construction, N1-N2[Gen], as in (1) above, Croatian also has a *prepositional* genitive construction with the preposition *od*, N1-*od*-N2[Gen]. (Note that the genitive case-marking on N2 is

⁴⁷ Maynell (2001, see Section 4.3 above) provides some support for this hypothesis: in English, hearers tended to interpret the RC as attaching high more often in sentences in which the RC was introduced by *who/which* than in those in which it was introduced by *that*. See also data from Miyamoto (1999, see Section 3.3.2 above): in Brazilian Portuguese, readers tended to attach full relatives (relative pronoun present) high more often than they did reduced relatives (relative pronoun omitted).

unchanged by the presence of *od*). In some N1-N2[Gen] complexes, the preposition *od* is obligatory, in others it is unacceptable; crucially, in some constructions involving ‘N1-of-N2’ type relations, the prepositional genitive with *od* can be used in alternation with the non-prepositional genitive, especially in colloquial speech.⁴⁸ Table 1 below describes the N1-N2[Gen] complexes in which *od* is acceptable (either optional or obligatory) and those in which it is not. The classification system below is derived in part from that of Gilboy et al. (1995).

Table 1: *od* in N1-N2[Gen] Complexes

Unacceptable	Optional ⁴⁹	Obligatory
1 <u>Quantity/Measure</u> <i>čaša vode</i> ‘glass of water’	1 <u>Kinship Relation</u> <i>kćerka (od) političarke</i> ‘daughter of the politician’	1 <u>Substance</u> <i>vesta od pamuka</i> ‘sweater of cotton’
2 <u>N2 Internal Arg’t of N1</u> <i>kritika pjesme</i> ‘review of the poem’	2 <u>Occupational Relation</u> <i>sekretarica (od) arhitektice</i> ‘secretary of the architect’	2 <u>N2 Theta-Role SOURCE</u> ⁵⁰ <i>pismo od doktora</i> ‘letter from the doctor’
	3 <u>Inherent Possession</u> <i>jarbol (od) broda</i> ‘mast of the ship’	3 <u>Idiomatic Non-Theta Use</u> <i>gigant od čovjeka</i> ‘giant of a man’
	4 <u>Alienable Possession</u> <i>kišobran (od) moje majke</i> ‘umbrella of my mother’	

⁴⁸ German also has a prepositional alternative to the standard non-prepositional genitive construction, N1-*von*-N2[Dat]; note that unlike the Croatian form with *od*, the German construction with *von* assigns dative case to N2 rather than genitive.

⁴⁹ When N2 is a single-word proper name, *od* is largely obligatory for kinship, occupation and inherent possession (e.g., *kćerka od Clintona* ‘daughter of Clinton’). When N2 is a single-word NP, *od* is obligatory for alienable possession (e.g., *bilježnica od studentice* ‘notebook of the student’).

⁵⁰ The German preposition *von* can also be thematic, meaning ‘from’, as can the prepositions which link N1 and N2 in the RC-attachment ambiguity construction in other languages (e.g., the Dutch *van*).

There is a general consensus in the literature that in the contexts in which its use is optional, the prepositional genitive with *od* is a syntactic translation from the Italian (see Hudeček, 2002, for a review); thus, for instance, *kuća od Marije* ‘the house of Mary’, *žena od Ivana* ‘the wife of John’ and *bog od mora* ‘the god of the sea’ correspond exactly to the Italian *la casa di Maria*, *la moglie di Giovanni* and *il Dio del mare*.⁵¹ Hudeček (2002) provides a detailed review of the usage of the possessive genitive with *od* up until the middle of the 19th century, documenting the extensive use made of this construction in Croatian literary texts, in alternation with the non-prepositional genitive construction. She also notes the discrepancy between the widespread use of the optional prepositional genitive, and the position of prescriptive grammars, which as early as the 18th century recommend that this construction should be avoided in favor of either the non-prepositional genitive or the possessive adjective. In a more recent grammar, however, Maretić (1963) points out that the prepositional genitive with *od* may be used to express possession in Croatian in free alternation with the non-prepositional genitive construction. He mentions no restrictions on the use of the prepositional form. This implies that the two genitive constructions, with and without *od*, may be regarded as synonyms. Interestingly, other grammars which discuss the prepositional genitive with *od* as a device for expressing possession restrict its use to

⁵¹ Feleszko (1995), in addition to Romance languages (Italian), also mentions German as a potential influence; the influence of the German construction with *von* would have been particularly strong in the *kajkavian* region of Croatia (Zagreb and the northeast); historically, the influence of Italian would have been the strongest in the coastal regions; see Hudeček, 2002.

inanimate possessors.⁵² In his discussion of possession in contemporary Croatian, Kuna (1999a) describes the attitude of prescriptive grammars toward the prepositional genitive with *od* as ‘at times negativistic’ (p. 117) and calls for its re-evaluation. He emphasizes that the prepositional genitive with animate possessors (e.g., *haljina od Ivane* ‘dress of Joan’, *tata od Marka* ‘dad of Mark’, *auto od tate* ‘car of dad’, *adresa od ćere* ‘address of the daughter’, *konji od Nijemaca* ‘horses of the Germans’) are simply ‘the reality’ (p. 110), especially in informal communication, as well as in regional usage and children’s speech. To this one can add that the construction with *od* is particularly popular with younger generations, and that, although still regarded as less than standard in some contexts, instances of its use can be found even in the standard media.⁵³ These facts about *od* could even be brought into connection with a wider process suggested by Gallis (1974). He claims that Croatian, like all Indo-European languages, may be subject to a general tendency toward change by which synthetic languages are becoming increasingly analytical, in the sense that a particular preposition may in future assume the role of a particular case. If this were to apply to Croatian prepositions, *od* would assume the role of the genitive case, making the case-marking redundant. While this is an interesting idea, such speculations fall outside of the scope of this dissertation.

⁵² Brabec et al. (1970) claims that *noga od stola* ‘leg of the table’ is correct in standard usage, but *suknja od moje majke* ‘skirt of my mother’ and *šešir od Ivana Milića* ‘hat of Ivan Milić’ are not. More recently, Raguž (1997) notes that the prepositional genitive with *od* is used to express possession; though he does not explicitly impose an inanimate-possessor requirement, all the examples he gives have an inanimate possessor (N2), e.g., *džep od kaputa* ‘pocket of the coat’.

⁵³ The following examples were collected recently from Croatia’s national TV networks in an interval of approximately half an hour: *trenner od Ivica* ‘coach of Johnny’, *sestra od Jean-Pierre Vidala* ‘sister of Jean-Pierre Vidal’, *obitelj i prijatelji od ročnika* ‘family and friends of the serviceman’, *od njene susjede pas* ‘of her neighbor the dog’, *otac od nesretne djevojke* ‘father of the unfortunate girl’, *žena od jednog mog prijatelja* ‘wife of a friend of mine’. Note that the possessor in all of these examples is animate; a more formal study of a representative corpus comprised of informal speech would certainly be useful.

To summarize, the prepositional genitive with *od* can be used in sentences like (1) in alternation with the non-prepositional genitive, especially in informal speech and in various Croatian dialects, e.g., the Zagreb dialect and the coastal dialects. Like English *of*, the preposition *od* is non-thematic in these sentences (see Gilboy et al., 1995, pp.138-140, and references therein). That is, *od* makes no semantic contribution here; the two forms of the construction, with and without *od*, mean exactly the same. Arguably, it makes no structural difference either, though this is a matter that deserves a fuller investigation.⁵⁴ This makes it possible to test the prediction of both the Construal/Gricean account and the Predicate Proximity/Recency model (see Chapter 3 above for details) that non-thematic prepositions should not have an impact on RC-attachment preferences. Under the Construal Hypothesis, if the preposition is non-thematic, the current thematic processing domain includes both potential hosts, N1 and N2; by contrast, if the preposition is thematic, the current thematic processing domain includes only one potential host, N2. Thematic prepositions are therefore predicted to lower the attachment preference; non-thematic prepositions are not. In Gibson's (1998) discourse-based formulation of Recency, thematic prepositions increase the distance (in the sense relevant to the model) between a modifier and its potential attachment site (in this case between the RC and N1), and thereby lower the attachment preference; non-thematic prepositions do not increase the distance and so do not lower attachment.

⁵⁴ It might be proposed that the structure with an overt preposition contains an additional syntactic node dominating the preposition. The analysis of these constructions has unfortunately received little attention in the syntactic literature. An exception is den Dikken et al., 1999, which proposes analyses for related constructions in Romanian and Norwegian. However, Croatian lacks the complexities which motivate the multiple movement derivations proposed by den Dikken et al. for these other languages. In the absence of a definitive account of *od*'s syntax, it is important to note that Experiment 5 (see Chapter 7) establishes that even if there are syntactic differences between the two constructions, these potential differences do not control attachment of the RC in ambiguous sentences.

Contrary to the prediction of both these accounts, intuitions suggest that the insertion of the non-thematic *od* in Croatian sentences like (1) results in a greater tendency to attach the RC low in these sentences than in those without *od*.

Intuitions suggest, furthermore, that the insertion of *od* (an unstressed proclitic) in Croatian RC sentences like (1) changes the prosody of the sentence in such a way as to make a prosodic break between N1 and the rest of the complex NP more likely than when *od* is absent⁵⁵; this pattern of prosodic phrasing can be expected to favor lower attachment of the RC for sentences with *od* as compared to those without *od* (see discussion in Section 4.2 above). Examination of the explicit prosody of Croatian RC sentences, both with and without *od*, and how it relates to the parser's attachment preferences in silent reading, is therefore a good way to test the Implicit Prosody Hypothesis (IPH). The IPH claims that even in silent reading a prosodic contour is computed in the reader's mind and that this mentally projected prosodic contour may influence the reader's attachment decisions. (For a detailed discussion of the IPH see Chapter 4 above.) So far the IPH has been tested in studies of overt prosody through manipulation of RC-length and through cross-linguistic comparison of languages with different prosodic rules. (For details see the discussion of Bradley et al., 2003, Quinn et al., 2000, and Fodor et al., 2000, in Chapter 4.) Croatian offers a third possibility: an opportunity to test the IPH within one language by comparing constructions which

⁵⁵ This should be so irrespective of whether the two nouns in the complex NP express a kinship relation, an occupational relation or inherent possession (see Table 1 above). In addition, that *od* favors a prosodic break at the left edge of the PP is probably not a fact peculiar to *od*, but a fact about Croatian prepositional phrases in general; this is suggested both by intuitions and by the discussion of the prosodic consequences of the proclitic status of prepositions, by Godjevac (2000). We shall, however, be conservative, and through the rest of the dissertation will limit our discussion of the prosodic rules concerning Croatian PPs to the N1-*od*-N2 construction in sentences like (1).

differ minimally with respect to lexical content; namely, constructions with and without a syntactically and semantically redundant preposition (*od*) between N1 and N2, in sentences like (1). A within-language investigation of this type is particularly valuable because, unlike tests involving manipulation of RC-length and/or comparison of languages with different prosodic rules, it makes it possible to minimize undesirable variability with respect to other factors (e.g., unavoidable differences in lexical content, segmental phonology, etc.). The *only* difference between the examples is *od*, yet intuitions suggest that both the prosodic phrasing and the attachment preference are altered by this.

Following the guidelines of Fodor (2000, 2002), four steps are needed to make a case for the IPH. The idea is to check for a correlation between attachment preferences in silent reading and patterns of phrasing in overt prosody, the working assumption being that the implicit prosody projected onto a sentence in silent reading is identical to the overt prosody for that sentence. In other words, the role of implicit prosody can only be inferred indirectly; here, on the basis of analogy with overt prosody. Applied to Croatian RC sentences with and without the preposition *od*, this entails:

- 1) showing that *od* impacts the parser's attachment preferences in silent reading;
- 2) showing that *od* measurably affects the *overt* prosody of RC sentences;
- 3) showing that this *overt* prosodic difference caused by *od* influences listeners' RC-attachment preferences in the processing of *spoken* sentences, in a way that is similar to the effect that *od* has on attachment in silent reading; and

- 4) establishing, as far as is possible, that *od* does not affect parsing via any means other than prosody (e.g., not by inducing a syntactic, semantic or discourse contrast).

While steps 1, 2 and 3 are needed to establish a correlation between attachment preferences in silent reading and phrasing patterns in overt prosody, step 4 is crucial for the IPH's claim that prosody is the *cause* of the parser's attachment preferences. Ideally, all other possible explanations of the data would be considered and ruled out.

Realistically, as Fodor (2002) notes, the aim is to establish that implicit prosody offers a better explanation of the facts than any other potential factor. Once all four steps of the research program are in place, the only reasonable inference for Croatian is that the effect of the preposition *od* on the parser's preferences in silent reading is mediated by implicit prosody, just as overt prosody mediates the effect of *od* on preferences in listening to spoken sentences. A similar logic applies to the effect on attachment of long versus short RCs, which is also addressed by the present research on Croatian.

5.2 The Experiments: Preview

The experimental component of this dissertation has three parts (presented in Chapters 6 and 7). Part 1 (Chapter 6) corresponds to the first step of the research program for evaluating the IPH (Fodor, 2000; 2002). One of the goals is to establish Croatian native speakers' attachment preferences for sentences like (1) in reading. Another aim is to explore what prosodic differences, if any, may be associated with RC-length differences, *+/-od* differences, and potential attachment differences. Part 1

contains three experiments. These experiments are designed to test aspects of the Construal/Gricean proposal, Attachment-Binding Dualism and the Predicate Proximity/Recency model. These experiments also provide an indirect test of the IPH by checking whether the length of the RC affects RC-attachment as it does in other languages (see Chapter 4 above). Experiments 1 and 2 employ a questionnaire procedure, in which subjects read ambiguous sentences like (1), first silently for comprehension, then aloud for recording, and then answer a comprehension question querying RC-attachment. **Experiment 1** uses items in which there is no preposition *od* between N1 and N2. Sentences for which an alternative form with unambiguous high attachment exists are contrasted with those for which an unambiguous alternative does not exist, and sentences containing a short RC are contrasted with those containing a long RC. In the materials read by one set of subjects, the RC is introduced by a relative pronoun (*koji*). In the materials read by another set of subjects, the RC is introduced by a complementizer (*što*). (For full details of Experiment 1, see Section 6.2 below.) In **Experiment 2**, yet another set of subjects reads sentences that have an RC introduced by the complementizer *što* and have the preposition *od* before the second noun. Attachment preferences for these sentences are compared with preferences for their Experiment 1 counterparts with *što* and without *od*. (For full details, see section 6.3 below.)

Experiment 3 is designed to establish Croatian speakers' attachment preferences for sentences like (1) in reading that is entirely silent. In this experiment, all sentences have an RC introduced by the complementizer *što*. One set of subjects reads sentences which have no preposition *od* before N2; another set of subjects reads sentences which

have the preposition *od* before N2. In both versions, sentences containing a short RC are contrasted with sentences containing a long RC. The procedures employed in Experiment 3 are identical to those employed in Experiments 1 and 2, except that the sentences are only read silently and not aloud. (For full details, see Section 6.4 below)

Parts 2 and 3 of the project (both presented in Chapter 7) are designed to carry out the additional steps that Fodor (2000, 2002) suggests are critical in establishing that the patterns of attachment preferences observed in Experiments 1-3 are truly attributable to implicit prosody. Part 2 corresponds to the second step of the four-step research program. It explores the prosody with which the type of sentences used in Part 1 are uttered. In **Experiment 4**, a reading-aloud study, prosodic break placement in sentences with *od* is compared with prosodic break placement in sentences without *od*, and the prosody of sentences with a short RC is compared with the prosody of sentences with a long RC. (For full details, see Chapter 7 below.) Subjects read sentences in which attachment of the RC is disambiguated by number agreement. That is, the RC's verb agrees in number (singular/plural) with only one of the nouns in the complex NP, as in the English examples below. The RC can only be attached to the first noun in (3) and to the second in (4).

(3) Someone shot the servants of the actress who were on the balcony.

(4) Someone shot the servants of the actress who was on the balcony.

Sentences are read silently for comprehension first and then aloud for voice recording.

Instrumental analyses of the recordings are then made, measuring the duration of N1 (including any following pause), and the duration of N2 (including any following

pause). A standard indicator of a prosodic phrase boundary is pre-boundary lengthening and/or pausing (Klatt, 1975; Lehiste et al., 1976; Selkirk, 1984; Ladd & Campbell, 1991; Wightman et al., 1992; Berkovits, 1993, 1993a). Thus, the durations of N1 and N2 provide evidence as to whether speakers have imposed a boundary right after N1 or right after N2.⁵⁶

Part 3 of the project corresponds to steps 3 and 4 of the research program (Fodor, 2000, 2002). It is designed to examine whether the *overt* prosodic effects typically induced by the presence of *od* (i.e., lengthening and/or pausing after N1, before *od*, as evidenced by the timing measurements from Experiment 4) and by long RCs (i.e., lengthening and/or pausing after N2, before the RC, as evidenced by the timing measurements from Experiment 4), measurably affect RC-attachment preferences in the processing of *spoken* sentences. In **Experiment 5**, subjects listen to syntactically ambiguous sentences like (1), both with and without *od*, spoken such that there is either a prosodic break after N1 and no break at the RC, or no break after N1 and a break at the RC. They then make judgments about the sentence's intended meaning. The issue is whether judgments will be influenced by the presence of the preposition, by the prosody, or by both. (See Chapter 7 for full details.)

We now turn to the experimental evidence, which provides substantial support for the IPH account of RC-attachment effects.

⁵⁶ Henceforth, 'boundary after N1' will be used as a shorthand for 'boundary at the left edge of the (*od*)-N2-RC complex; 'boundary after N2' will be used interchangeably with 'boundary at the RC', 'boundary between N2 and the RC' and 'boundary before the RC' as a shorthand for 'boundary at the left edge of the RC'.

CHAPTER 6

RC-ATTACHMENT PREFERENCES IN CROATIAN

6.1 Introduction

This chapter describes the aims, design, implementation, and results of three written questionnaires examining RC-attachment preferences in Croatian. The implications of the data from each experiment are discussed. Section 6.5 provides a summary of the findings and conclusions.

6.2 Experiment 1

Experiment 1 was designed to obtain RC-attachment data for Croatian, to test the Construal/Gricean and Attachment-Binding Dualism accounts, to check whether RC-length affects attachment, and to explore what prosodic differences, if any, may be associated with RC-length differences and/or attachment differences.

Method

Materials. The target construction was a complex NP of the form N1-N2[Gen]-RC (no preposition between N1 and N2). The complex NP (+RC) was in object position (sentence-final) in all the target sentences and the relative pronoun was always the subject within the RC.⁵⁷ To ensure the required ambiguity, the two nouns in the complex NP were always matched for gender and number, since Croatian relative pronouns are marked for gender and number, as well as for case. In addition, the nouns in the complex NP were either both animate (for 10 sentences, e.g., *kćerka političarke* ‘the daughter of the politician’, see (1a) below) or both inanimate (for 6 sentences, e.g., *predvorje svratišta* ‘the lobby of the hostel’, see (1c) below). Both noun types were included for variety in the materials, and to allow the results to be generalized over a wider set of item types.⁵⁸

In addition to fitting the specified structural description, the target sentences were constructed to be natural and to contain, as far as possible, a balanced ambiguity. That is, the aim of materials construction was to avoid any semantic content in the RC or the complex NP that might bias the attachment preference on plausibility grounds. A preliminary set of 16 sentences fulfilling the structural and design requirements, adapted from those used in the studies of Ehrlich et al. (1999), was pre-tested and then adjusted

⁵⁷ No context was used to make sure the RCs were interpreted as restrictive but there are good reasons to assume that they were, since it is virtually obligatory to use a comma before a non-restrictive RC in Croatian.

⁵⁸ Animacy of N1/N2 was not a design factor; however, informal inspection of the data indicated that whether the nouns in the complex NP were animate or inanimate had no influence on RC-attachment.

using feedback from three expert judges⁵⁹. Each item was revised until the judges agreed that it was natural and that the two alternative interpretations of the RC (i.e., attachment as modifier of either N1 or N2) were approximately equal in plausibility. No other normative assessment was undertaken.

The experimental materials (see Appendix A-1 for a full list) were constructed to instantiate a design with three factors: one factor (Alternative Form) related to the complex NP, and contrasted those items for which an unambiguous alternative exists with those for which it does not; a second factor (RC-Length) contrasted items with short versus long RCs; and the third factor (Relativizer) varied the element with which the RC was introduced, the relative pronoun *koji* or the complementizer *što*. The Alternative Form and RC-Length factors were manipulated between items (but within subjects); Relativizer was manipulated within items (but between subjects).

There were 16 basic items, 4 in each condition of the (between-items) Alternative Form x RC-Length component of the design; each basic item appeared in two variants, one with relative pronoun and the other with complementizer, to give a total of 32 targets in all. These materials were administered as part of a questionnaire in two versions, with any subject seeing only one version. The questionnaires were identical except that, in one version, the RC was always introduced by a form of the relative pronoun, appropriately inflected for gender and number; in the other version, the RC was always introduced by the uninflected complementizer.

⁵⁹ All three were native Croatian speakers: two were linguists (one from the University of Zagreb's Linguistics Department, the other from the Croatian Language Department), and one was a teacher of English as a second language in a private language school.

Eight of the 16 basic items had an unambiguous high-attachment alternative, e.g., (1a) below, for which the “N2’s N1” form shown in (1b) is well-formed. For the remainder, no such alternative was grammatically possible, e.g., (1c), for which the “N2’s N1” variant, (1d), is ungrammatical. Short RCs were 1 prosodic word⁶⁰ (average number of syllables = 4.8 for *koi*-relatives, 3.8 for *što*-relatives); long RCs averaged 3.5 prosodic words (average number of syllables = 14.8 for *koi*-relatives, 13.8 for *što*-relatives; see (1c) and (1a), respectively.^{61 62}

(1a) +ALTERNATIVE FORM (with LONG RC)

Pokušali	smo	nazvati	kćerku	političarke
tried	are	phone	daughter-[fem.sg.Acc]	politician-[fem.sg.Gen]
koja/što		voli	pjevati	u društvu.
who-[fem.sg.Nom]/that		likes	sing	in company

“We tried to phone the daughter of the politician who likes to sing when in company”

(1b)	... nazvati	političarkinu	kćerku ...
	... phone	politician-[fem.poss.adj.+fem.sg.Acc]	daughter-[fem.sg.Acc]

“... phone the politician’s daughter ...”

⁶⁰ A prosodic word (PWd) consists of an accent-bearing lexical (content) word (e.g., *uređuje* in (1c)) and whatever unaccented function words surround it (e.g., *koje/što* and *se* in (1c)). (For discussion of PWd as a level in phonological derivations, see for example Goldsmith, 1990.)

⁶¹ The ideal test of constituent-length effects contrasts two (or more) length conditions with identical content (up to the point of the end of the short RC), e.g., ... *who smokes*_{short} *a pack of cigarettes a day*_{long}. In this experiment, however, short and long RCs had different content, and were embedded in sentences that were not matched for their main clauses, as the examples in (1) indicate.

⁶² The case of N1 varied between the accusative in 11 items, the dative in 2 items, and the instrumental in 3 items. Although a case manipulation was not a design factor, informal inspection of the data gave no reason to believe that these case differences had any impact on RC-attachment. (See Sauerland & Gibson, 1998, for an account of RC-attachment based on case-matching; for evidence against this account see Hemforth et al., 1999, and Nowak, 2000.)

(1c) –ALTERNATIVE FORM (with SHORT RC)

Suzana je ušla u predvorje svratišta
 Suzana is enter in lobby-[neut.sg.Acc] hostel-[neut.sg.Gen]
 koje/što se uređuje.
 which-[neut.sg.Nom]/that self redecorate

“Suzana entered the lobby of the hostel which/that was being redecorated”

(1d) *... je ušla u svratištevo* predvorje ...
 ... is enter in hostel-[neut.poss.adj.+neut.sg.Acc] lobby ...

“... entered the hostel’s lobby ...”

The 16 target sentences were interleaved among 36 unambiguous filler sentences (see Appendix A-6 for a full list). The fillers were included in the materials to distract attention from the target structures being tested. In addition, error rates on the questions in the filler items were used as an indicator of reading accuracy, and were treated as criterial in determining whether a subject was included in the final analysis of the data. A proportion of the fillers contained the N1-N2-RC construction, but the majority of the fillers contained structures unrelated to the target construction. The fillers were identical across versions of the questionnaire, except that the relativizer used in any filler which contained a relative clause was always the same as that used in the target sentences.

The materials were arranged in a fixed pseudo-randomization, ensuring that the probability of the occurrence of any within-version condition (e.g., +Alternative Form with Long RC) was roughly uniform throughout the list sequence; condition runs were ruled out, while factor runs up to two were permitted (e.g., items N and N+1 could both have an unambiguous alternative if they differed in RC-length), and list-adjacent occurrences of design factors were balanced over the entire list. The pseudo-

randomization was the same in the two versions of the questionnaire. Three unambiguous practice items (see Appendix A-6), identical across versions of the questionnaire, preceded the presentation of the questionnaire proper.

The questionnaire's sentences were presented in a folder, one per page, arranged on a single line in the middle of the page. On the page following any sentence, a question was presented together with two answer choices. Targets were followed by a question about the attachment of the RC and two answer choices, i.e., N1 and N2 (see (2a) below). Practice and filler item sentences were followed by a question about some aspect of the meaning of the sentence, for which the choices represented one correct and one incorrect answer (see (2b) below).

(2a) Tijekom istrage upoznali smo nećaka detektiva koji puši.

“During the investigation, we met the nephew of the detective who smokes”

Tko puši?	nećak	detektiv
“Who smokes?”	the nephew	the detective

(2b) Turist je fotografirao staricu i magarca pokraj mosta.

“The tourist photographed the old woman and the donkey by the bridge”

Tko je fotografirao magarca?	turist	starica
“Who photographed the donkey?”	the tourist	the old woman

For the target sentences, in half the cases N1 was presented as an answer choice on the left, and in the other half, on the right. For the fillers, correct answers were equally likely to be located as the left or right member of the answer choice pair.

Procedure. Subjects were tested individually, in a quiet room, equipped with a Philips N2233 tape recorder and Hama DM15 microphone. They were first given a sheet of instructions (see Appendix B-1) providing guidelines on how to complete the questionnaire (read at a natural pace, give a spontaneous answer, do the test without interruptions, and so forth). After a short practice session (three sentence-and-question items), they were encouraged to ask any questions they might have about the procedure. They read each sentence silently for comprehension first, and then aloud for recording. They then turned the page, read the associated question and the two offered answers silently, and reported an answer aloud. The experimenter recorded the answers on a scoresheet. The questionnaire took 20-30 minutes to complete.

Subjects. Fifty-two subjects participated successfully in the experiment, 26 in each of the versions of the questionnaire. All the subjects were naïve with respect to the purposes of the experiment. They were all native speakers of Croatian, undergraduates in the Psychology Department of the University of Zagreb, who received course credit for their participation. An additional eight subjects were excluded from the analysis because they failed to meet a reading accuracy criterion (they made more than 10% errors on unambiguous fillers).

Data Treatment. Responses to target item questions were coded in terms of the attachment site (high or low) implied by the choice of noun answer (N1 or N2). In the preparation of a summary data matrix, values for each item were cast in terms of the proportion of responses indicating *high attachment*. Data were arranged for three-way

analyses of variance in accord with the Relativizer x Alternative Form x RC-Length design. Relativizer was treated as a within-items factor, and Alternative Form and RC-Length were treated as between-items factors. (The analysis of variance for Experiment 1 is provided in Appendix C-1.)⁶³

Results

Summary data for Experiment 1 are presented in Figure 1.

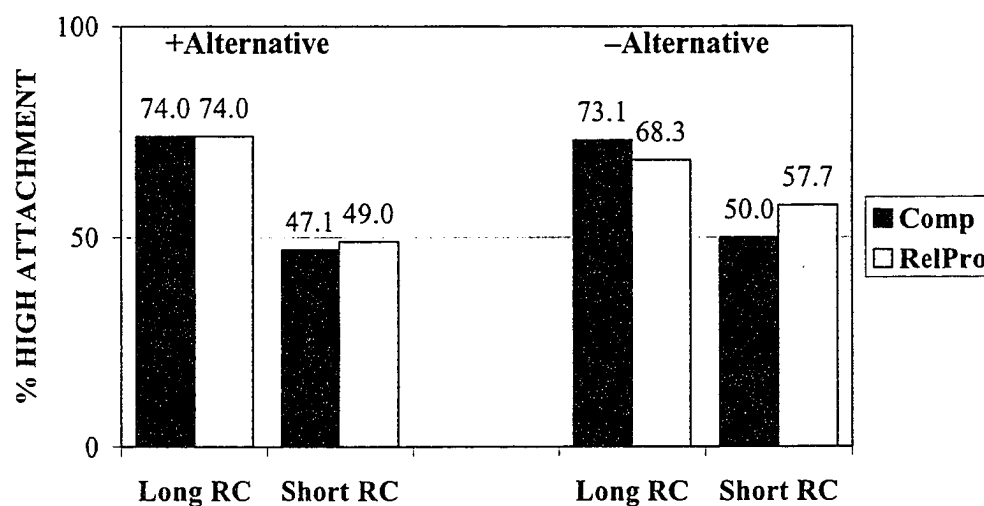


Figure 1: Mean percentage high attachment as a function of Alternative Form and RC-Length, for target sentences with complementizer (Comp) and relative pronoun (RelPro).

No main effect of Relativizer on attachment was found: the likelihood of high-attachment for sentences in which the RC was introduced by a relative pronoun (62.3%) did not differ from that for sentences in which the RC was introduced by the

⁶³ For Experiment 1, only the F_2 (item-based) analysis of variance is reported. A subject-based summary data matrix was not available, due to experimenter error.

complementizer *što* (61.2%), $F_2 < 1$. There was similarly no effect of the existence or non-existence of an unambiguous high-attachment alternative; high-attachment rates averaged 61.1% and 62.3%, respectively, $F_2 < 1$.

An effect of RC-Length on attachment was observed: subjects attached the RC high on 51.0% of occasions with short RCs, cf. 72.4% with long RCs, $F_2(1,12) = 12.87$, $p < .005$. No interactions among factors were observed, all p 's $> .25$.

An entirely separate analysis discarded all factors of the materials design, and looked simply at average rates of attachment, for subjects and for items. This analysis confirmed that Croatian speakers' overall preference for high attachment (61.7%) significantly exceeded chance, $t_1(51) = 3.82$, $p < .001$; $t_2(15) = 3.00$, $p < .01$.

Discussion

The Croatian data are incompatible with two of the three variants of the Gricean explanation (see Section 3.2.1 in Chapter 3 and Section 5.1.1 in Chapter 5), and cast doubt on the third. The basic form of the Gricean account (Variant 1) predicts a low-attachment preference for languages which have an unambiguous high-attachment alternative to the genitive construction, and a high-attachment preference for those which do not. Croatian has such an alternative, and yet Experiment 1 shows that Croatian speakers prefer overall to attach high. These data are therefore similar to those for Dutch and Afrikaans (Mitchell et al., 2000), and for German (Hemforth et al., 1998, 1999, 2000), discussed earlier in Section 3.2.2.

The data from Experiment 1 are also incompatible with a more refined form of the Gricean explanation (Variant 3). This variant proposes that the Gricean inference

favoring low attachment varies based on the availability of the alternative for the particular sentences under investigation. However, the data provided no evidence that the Alternative Form factor (unambiguous alternative does or does not exist) had any effect on attachment preference. Frazier & Vonk (1997) and Mitchell et al. (2000) drew the same conclusion for Dutch (see Section 3.2.2). However, the data reported here are more categorical since, in Croatian, the alternative form (possessive adjective), when permissible, is not only fully acceptable but is also preferred to the N1-N2 genitive construction (see Chapter 5). This apparently is not the case in Dutch. Mitchell et al. (2000) found no correlation between the acceptability of the alternative forms and RC-attachment preference, for individual sentences, and concluded that Variant 3 of the Gricean explanation does not work for Dutch. However, given the questionable acceptability of the unambiguous alternative forms for the Dutch sentences⁶⁴, it could be argued that the Gricean influence favoring low attachment is simply not strong enough in these sentences to manifest itself (and to outweigh the influence of N1-favoring Relativized Relevance; see Section 3.2.1). Our findings for Croatian, in which the unambiguous alternative is fully acceptable and even preferred when it exists, are impervious to such criticism.

The Croatian data thus effectively eliminate Variants 1 and 3 of the Gricean hypothesis. The remaining form of the account, Variant 2, proposes that attachment preferences vary based on the proportion of contexts in which the alternative form is

⁶⁴ Mitchell et al. (2000) administered a pre-test of acceptability of the alternative forms for the Dutch sentences which were subsequently used in the attachment experiment. The results indicated that the overall acceptability of the alternative forms was very low; on a scale from 1 (completely unacceptable) to 5 (completely acceptable) and depending on noun-type (human/non-human), it ranged from 1.3 to 3.5 (compared to 4.5 to 4.8 for the equivalent genitive forms).

acceptable in the language. This variant correctly predicts a higher attachment preference for Croatian than for, say, English, as the range of contexts in which the alternative is acceptable is more restricted in Croatian than in English (see Chapter 5). But it simultaneously also predicts a lower attachment preference for Croatian than for languages with no unambiguous high-attachment alternative at all, like Spanish. Contrary to this latter prediction, the tendency toward high attachment is, as best as can be judged, no less strong in Croatian than it is in Spanish (compare 61.7% overall preference for high attachment in Croatian with that in Spanish, e.g., 62% reported by Cuetos & Mitchell, 1988, and 56.7%, reported by Fernández, 2000/2003).⁶⁵ The Croatian data thus add to the existing body of evidence (from Afrikaans in particular, Mitchell et al., 2000; see Section 3.2.2) which suggests that even Variant 2 of the Gricean account is not viable.

The findings of Experiment 1 are also incompatible with three of the possible variants of the Attachment-Binding Dualism claim (see Chapter 5). The basic variant of Attachment-Binding predicts a high-attachment preference for languages in which relative pronouns are obligatorily present in the RC, and a low-attachment preference for languages in which they are not. In Croatian, the relative pronoun is interchangeable with the complementizer *što*, and yet, contrary to the predictions of this proposal, Croatian shows a high-attachment preference overall.

The Croatian data do not, however, falsify a variant of the account which proposes that only those languages permitting *omission* of the relativizer (relative

⁶⁵ For cross-linguistic comparisons of this kind to be other than impressionistic, studies must employ common materials, procedures, and criteria for subject selection.

pronoun or complementizer) from the RC should attach low, while all others should attach high (Variant 2). Croatian does not allow such omissions, and is thus correctly predicted to attach high. (See, however, Section 6.5 for a citation of languages which do disconfirm this variant of Attachment-Binding Dualism.)

A further variant of Attachment-Binding Dualism proposes that if a language has a weak alternative to the relative pronoun (whether it be complementizer or null), attachment preferences should vary based on the proportion of contexts in which the alternative is acceptable (Variant 3). Under this variant of Attachment-Binding, a low-attachment preference is predicted for Croatian (relative pronoun and complementizer are fully interchangeable) of at least the same magnitude as that for varieties of English which limit the use of the complementizer (see Chapter 5). The finding that Croatian speakers preferred overall to attach high shows this prediction to be incorrect. Finally, the most refined variant of Attachment-Binding Dualism, Variant 4, proposes that if a language has a weak alternative to the relative pronoun, attachment preferences vary depending on which relativizer (if any) is actually used in particular sentences. However, the data provided no evidence that the Relativizer factor (RC introduced by a relative pronoun or by a complementizer) had any impact on attachment preference.⁶⁶

The effect of RC-Length on attachment observed in Experiment 1 is consistent with that found in a number of other languages (Bradley et al., 2003; Hemforth & Konieczny, 2002; Fernández, 2000/2003; Kamide et al., 1998; Lourenço-Gomes, 2002;

⁶⁶ In addition to the implications for the Construal/Gricean account and Attachment-Binding Dualism, the data from Experiment 1 also bear on the Predicate Proximity/Recency model, in the following way: if the Predicate Proximity factor within the Predicate Proximity/Recency model is related to verb-object adjacency in a language (Miyamoto, 1999; see Section 3.3.2), the overall high-attachment preference observed for Croatian is compatible with this proposal, since Croatian has a relatively free word order.

Pynte & Colonna, 2000; Wijnen, 2001). As discussed earlier in Sections 4.2 and 4.3 above, the most developed proposal that can account for the data indicating that RC-length affects attachment is the IPH.⁶⁷ Under this proposal, a tendency to make a prosodic break before long RCs should favor higher attachment, while a lesser likelihood of a break before short RCs should favor lower attachment, both in spoken sentences and in silent reading. Preliminary evidence indicating that these patterns of phrasing are actually used in spoken sentences comes from Bradley et al.'s (2003) study of English, and Quinn and colleagues' study of English and French (Quinn et al., 2000; Fodor et al., 2000; see 4.3 above). Informal observations based on the recordings made in Experiment 1 suggested that similar differences in prosodic phrasing may be associated with RC-length differences in Croatian as well. This is investigated further in Experiment 4 (Chapter 7).

6.3 Experiment 2

Experiment 2 was designed to determine whether the preposition *od* affects attachment preferences, to test aspects of the Construal/Gricean and Predicate Proximity/Recency models, and to explore what prosodic differences, if any, accompany +/-*od* differences and/or attachment differences.

⁶⁷ For a discussion of the limitations of the alternative, non-prosodic explanations of the RC-length effect, see Section 4.3.; see also the discussion of the data for explicit prosody from Experiment 5 in Chapter 7.

Method

Materials. The materials (N=12, see Appendix A-2) were a subset of those used in the *što* version of Experiment 1, except that the preposition *od* was inserted between N1 and N2.⁶⁸ All the filler sentences which had complex NPs for which the use of *od* is felicitous underwent the same modification. (The use of *što* over *koji* in this experiment has the advantage that *što* is used more often with restrictive RCs; see Section 5.1.2.) The complex NP in all experimental sentences was of the type for which use of *od* is optional (see Table 1 in Section 5.1.3 above). Four sentences expressed a kinship relation (e.g., *daughter of the politician*); four expressed an occupational relation (e.g., *secretary of the architect*); four expressed inherent possession (e.g., *mast of the ship*). Six target items contained a short RC, and six contained a long RC. In the analysis, attachment preferences for sentences with *od* (Data Set 2) were compared with those for the corresponding 12 items without *od* in Experiment 1 (Data Set 1).

Procedure. Same as for Experiment 1.

Subjects. The data reported are from 52 subjects (26 new subjects for Data Set 2, and the 26 subjects from Experiment 1 for Data Set 1). The subjects were all naïve with respect to the purposes of the experiment. They were all native speakers of Croatian, undergraduates in the Psychology Department of the University of Zagreb, who

⁶⁸ For 3 (of 16) target sentences used in Experiment 1 the insertion of *od* was not felicitous (e.g., *kritika pjesme* ‘review of the poem’, where N2 is the internal argument of N1), and an additional item was excluded to achieve balance between the number of items with long and short RCs. (RC-Length was a between-items manipulation.) All four sentences were kept in the questionnaire as additional (but ambiguous) fillers.

received course credit for their participation. All subjects from Data Set 2 were screened to check that they spoke the Zagreb dialect. The subjects from Data Set 1 were not screened in this way; by informal estimate, some 80% were speakers of the Zagreb dialect. An additional six subjects (Data Set 2) were excluded from the analysis because they failed to meet the reading accuracy criterion which was set at the same value as for Experiment 1 (they incurred more than 10% errors on unambiguous fillers).

Data Treatment. The data were coded exactly as in Experiment 1. In the preparation of summary data matrices, subject- and item-based, values were cast in terms of the proportion of responses indicating *high attachment*. Data were arranged for two-way analyses of variance in accord with the Preposition x RC-Length design. In the subject-based analysis, Preposition was treated as a between-subjects factor, and RC-Length as within-subjects; this arrangement reversed for the item-based analysis. (All analyses of variance for Experiment 2 are provided in Appendix C-2.)

Results

Summary data for Experiment 2 are presented in Figure 2 below. Items with *od* showed, overall, a lower rate of high attachment (41.3%) than their corresponding variants without *od* (57.3%). This lowering of the preferred attachment due to inclusion of the preposition was reliable, $F_1(1,50) = 6.20, p < .025$, $F_2(1,10) = 10.95, p < .01$.

Lower attachment occurred across the board, $F_1, F_2 < 1$ for the interaction of Preposition and RC-Length.

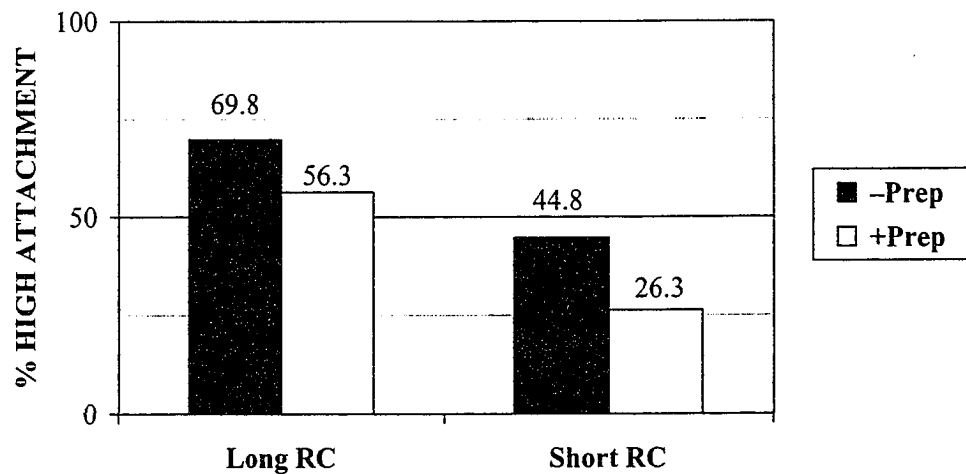


Figure 2: Mean percentage high attachment as a function of RC-Length, for target sentences with preposition *od* (+Prep) and without (-Prep).

The main effect of RC-Length on attachment found in Experiment 1 was replicated in this study: the subjects' overall rate of high attachment was 35.5% with short RCs versus 63.2% with long RCs, $F_1(1,50) = 50.60$, $p < .001$, $F_2(1,10) = 11.20$, $p < .01$.

Discussion

The effect on attachment of non-thematic *od* found in Experiment 2 is unexplained by both the Construal/Gricean account and the Predicate Proximity/Recency model. These proposals predict that only a thematic preposition should have an impact on RC-attachment preferences (see Section 3.3.2 in Chapter 3 and Section 5.1.3 in Chapter 5).

The *od* effect may, on the other hand, be compatible with the IPH.⁶⁹ Intuitions suggest that the preposition *od* alters the prosody of the sentences in these materials in such a way as to increase the likelihood of a prosodic break between N1 and the rest of the complex NP compared with when *od* is absent. Informal observations based on the recordings made in Experiment 2 suggested that the presence/absence of *od* may indeed be accompanied by a prosodic difference of this type. This is tested directly in Experiment 4. The pattern of prosodic phrasing described above should favor lower attachment of the RC in sentence comprehension for sentences with *od* as compared to those without *od* (see discussion in Chapter 4). This is tested for explicit prosody in Experiment 5.

6.4 Experiment 3

Experiment 3 was designed to establish Croatian speakers' RC-attachment preferences in silent reading. Part of the procedure in Experiments 1 and 2 involved subjects reading sentences aloud for recording, in addition to reading the sentences silently for comprehension first. This was included in order to explore the prosodic patterns used in spoken N1-N2-RC sentences in Croatian. However, this procedure raises a concern, which is well-founded, namely that the results may have been due in whole or in part to this aspect of the methodology. Specifically, the pattern of attachment preferences observed, which suggests the involvement of prosodic factors,

⁶⁹ The possibility of an alternative, non-IPH-based explanation of the effect of *od* on attachment will be discussed in Chapter 7. However, the data for overt prosody from Experiment 5, reported in Chapter 7, are incompatible with all but a prosodic approach.

may have arisen precisely because the sentences were read aloud. To build a case for *implicit* prosody, what is required is the kind of outcome observed in Experiments 1 and 2, in a situation in which subjects read the sentences only silently so that overt prosody is never at issue. Silent reading is the standard procedure used in experiments on RC-attachment. Experiment 3 addresses this point and a number of other methodological issues from the previous experiments (more uniform materials, more target items, full design, etc.; see below).

Method

Materials. A set of 20 basic ambiguous target items, each in 4 variants, manipulated the presence/absence of the preposition *od* and the length of the RC. (A full list of the experimental materials is provided in Appendix A-3.) For uniformity, the complex NPs included only animate nouns, and were selected to express either a kinship relation between the referents, e.g., *daughter of the politician*, or an occupational relation, e.g., *secretary of the architect*. They were therefore of the type for which *od* is optional (see Table 1 in 5.1.3).

The RC was always introduced by the complementizer *što*. Short RCs were all 1 prosodic word (average number of syllables = 3.3); long RCs were 3 prosodic words in 17 items, and 4 prosodic words in the remaining 3 items (average number of syllables = 10.3). As example (3) below illustrates, in this study, unlike in Experiments 1 and 2, the

long RC was a lengthened variant of the short RC, resulting in a more closely matched pair.⁷⁰

- (3) Nazvali smo klijenticu (od) odvjetnice
 phoned are client-[fem.sg.Acc] (of) lawyer-[fem.sg.Gen]
 što puši (paket cigareta dnevno).
 that smokes pack cigarettes daily

“We phoned the client of the lawyer that smokes (a pack of cigarettes a day)”

As in Experiments 1 and 2, the complex NP was in object position and sentence-final in all the target sentences, and the relative pronoun was always the subject within the RC. Additionally, the target items used in this study were more uniform in their structure than those used in the previous experiments. The complex NP was always the direct object of the matrix verb, making the case of N1 accusative in all instances. The sentence fragments preceding the complex NP were uniform, both structurally and prosodically. They began with a non-finite main verb (past participle, plural, number of syllables varying between three and four), followed by the enclitic *smo* (cliticized form of the auxiliary verb *biti* ‘be’, present tense, first person plural). The main verb and the clitic make up one prosodic word. There was no overt subject (Croatian is a null-subject language). Ten different verbs were used, each appearing in the list twice, with different complex NPs.

⁷⁰The long and short RC in a pair were identical up to the end of the short RC in all but two (of 20) items. In these two items, the long RC was a slightly modified variant of the short one, e.g., the long *što ponekad muca od uzbudjenja* (that sometimes stutters from excitement) versus the short *što muca* (that stutters); see Appendix A-3.

The target sentences underwent the same type of evaluation as those in Experiment 1: each was tested and revised until a panel of three expert judges agreed that it was natural and that the two alternative interpretations of the RC (attachment to N1, and to N2) were equally plausible.

The two factors, Preposition (*od* present or absent) and RC-Length (short or long), were fully crossed, and the resulting 80 target sentences (20 x 2 x 2) were arranged for presentation in a questionnaire in 4 versions, such that no subject saw more than one variant of any basic sentence. The length of the RC was manipulated in a within-subjects design. The presence/absence of *od* was manipulated in a between-subjects design, because of register differences between the prepositional and non-prepositional constructions.

The target sentences were interleaved with 50 unambiguous fillers (see Appendix A-6 for a full list of the fillers). A proportion of the fillers contained the N1- (*od*)-N2-RC construction, but the majority of the fillers contained structures unrelated to the target construction. The fillers were identical across versions of the questionnaire, except that in the *od* versions, the preposition *od* was inserted between N1 and N2 in the filler sentences which had complex NPs for which use of *od* is felicitous.

Sentences were arranged in a fixed pseudo-randomization, ensuring that the probability of occurrence of either a short or long RC was roughly uniform throughout the list sequence; list-adjacent occurrences of either a short or long RC were balanced over the entire list; runs up to two were permitted. The pseudo-randomization was the same in all four versions of the questionnaire. Three practice items, identical across

versions of the questionnaire, preceded the presentation of the questionnaire proper. The manner of presentation was the same as in the previous experiments.

Procedure. The procedures employed in Experiment 3 were identical to those employed in Experiments 1 and 2, except that the sentences were read *only silently*; the answers to the questions were also not spoken. The subjects indicated their answer by circling one of the two printed answers. The whole procedure took 30-40 minutes to complete.

Subjects. Fifty-six subjects participated successfully in the experiment, 14 in each of 4 versions of the questionnaire. The subjects were all naïve with respect to the purposes of the experiment. They were all native speakers of Croatian, undergraduates in the Psychology Department of the University of Zagreb, who received course credit for their participation. All were screened to check that they were speakers of the Zagreb dialect of Croatian. An additional 11 subjects were excluded from the data analysis because they failed to meet a reading accuracy criterion (they incurred more than 10% errors on unambiguous fillers).

Data Treatment. Responses to target items were coded in terms of the attachment site (high or low) implied by the choice of noun answer (N1 or N2). Subject- and item-based calculations of summary values were cast in terms of the proportion of responses indicating *high attachment*, for each of the cells of the design factorially combining Preposition and RC-Length. An additional dummy factor, Design Groups (subject groups in the subject-based analysis, item groups in the item-based analysis) takes into

account the assignment of subjects and items to versions of the questionnaire over which materials were counterbalanced. This factor is included in the analysis of variance design to extract irrelevant variance, but is not reported in what follows. (All analyses of variance for Experiment 3 are provided in Appendix C-3.)

Results and Discussion

Summary data for Experiment 3 are presented in Figure 3.

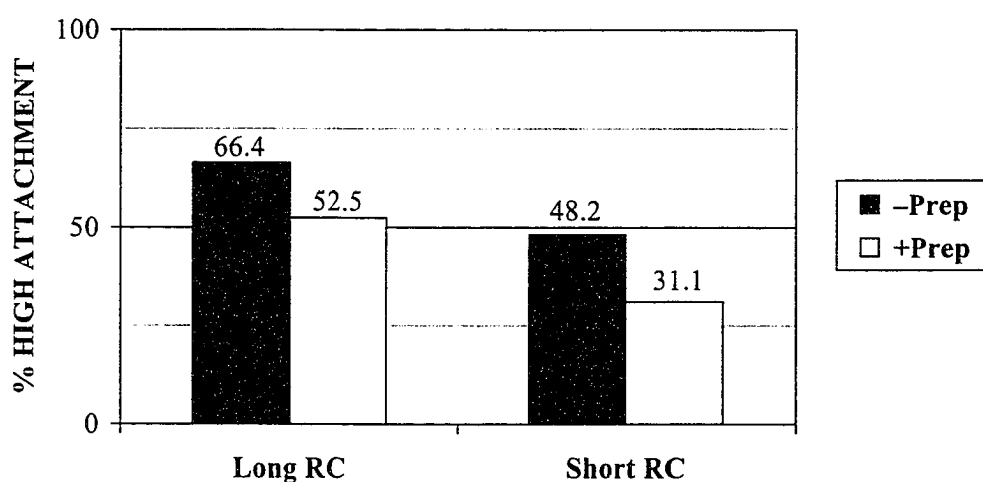


Figure 3: Mean percentage high attachment as a function of RC-Length, for target sentences with preposition *od* (+Prep) and without (-Prep).

Inspection of the figure suggests that the patterns of attachment preferences in this more carefully controlled experiment were very similar to those of Experiments 1 and 2, in which sentences were first read silently and then aloud. Analyses confirmed this impression: for items without *od*, the high-attachment preference was 57.3%, and for those with *od*, 41.8%. As in Experiment 2, the lowering effect of *od* on attachment was

highly reliable, $F_1(1,52) = 10.52$, $p < .001$, $F_2(1,18) = 42.02$, $p < .001$, and did not interact with RC-Length, $F_1, F_2 < 1$.

The effect of RC-Length on attachment found in Experiments 1 and 2 was replicated here: the rate of high attachment was 39.7% with short RCs, and 59.4% with long RCs. Although the difference observed here is numerically smaller than that found in the previous experiments, it was nonetheless highly significant, $F_1(1,52) = 40.27$, $p < .001$, $F_2(1,18) = 17.70$, $p < .001$.

6.5 Experiments 1-3: Summary

The results of Experiments 1-3 have implications for four of the five proposals discussed in detail in Chapters 3 and 4: the Construal/Gricean account, Attachment-Binding Dualism, the Predicate Proximity/Recency model, and the IPH. The data for Croatian undermine those aspects of the Construal and Predicate Proximity/Recency models that rely on the thematic/non-thematic nature of the preposition linking N1 and N2 to predict the preferred attachment of the RC in N1-Prep-N2-RC constructions. The lowering effect of non-thematic *od* on RC-attachment is unexplained by these approaches. The lowering effect of *od* is also unexplained by Attachment-Binding Dualism.

Similarly, the finding that RC-length affects attachment, with long RCs exhibiting a higher rate of high attachments than short RCs, observed in all three experiments reported above, is unexplained by the Construal/Gricean account, Attachment-Binding Dualism and the Predicate Proximity/Recency model.

Furthermore, the Croatian data either disconfirm or cast doubt on all variants of the Gricean explanation discussed here and three (of four) variants of Attachment-Binding Dualism. The only variant of the latter account left unscathed by the data is the one which relies on the legitimacy in the language of completely omitting the relativizer from the RC: languages which allow it should attach low, those that do not should attach high. There are, however, languages which do not allow omission of the relativizer from the RC, and yet, contrary to the above prediction, have been shown to exhibit a low-attachment preference, e.g., Egyptian Arabic (Abdelghany & Fodor, 1999), Romanian, Swedish, and Norwegian (Ehrlich et al., 1999).⁷¹

Thus, the only proposal left standing (apart from the Tuning Hypothesis, which these experiments are not designed to address) is the IPH. Notably, the IPH is the only current proposal that has the potential for explaining both the effect of RC-length and the effect of *od* on RC-attachment preferences in Croatian. The following chapter (Chapter 7) presents experimental data from two experiments (Experiments 4 and 5) designed specifically to test the IPH-based explanation of the effects of RC-length and *od* on attachment in silent reading of Croatian. These experiments correspond to steps 2, 3 and 4 of the four-step research program for evaluating the IPH (Fodor, 2000; 2002).

⁷¹ Also, Sekerina (1997) reports a high-attachment preference for Russian, a language which, like English, does allow omission of the relativizer from the RC (see Section 5.1.2).

CHAPTER 7

PROSODIC PHRASING AND ATTACHMENT PREFERENCES

7.1 Introduction

This chapter describes the aims, design, implementation, and results of two experiments: the first, Experiment 4, examined prosodic phrasing in spoken RC-sentences of Croatian; the second, Experiment 5, examined RC-attachment preferences in the parsing of spoken sentences of Croatian. A summary of the findings is presented in Section 7.5.

7.2 Experiment 4

Experiment 4 was designed to examine prosodic phrasing in overt productions of Croatian sentences in which an RC's attachment to one or the other host in a complex NP was disambiguated. Speakers were recorded as they read aloud sentences with and without *od*, with a short or long RC. Measurements were then made of N1 and N2 duration, each including any post-noun pausing. These timing measures were used to examine variation in duration at two possible prosodic break positions in the sentences

recorded. Both word-final lengthening and pausing are indicators of a prosodic phrase boundary (Klatt, 1975; Lehiste et al., 1976; Selkirk, 1984; Ladd & Campbell, 1991; Wightman et al., 1992; Berkovits, 1993, 1993a), so lengthening of N1 (and a following pause, if any) indicates a prosodic break immediately after N1, within the complex NP; lengthening of N2 (and a following pause, if any) indicates a prosodic break immediately after N2, at the RC.

The IPH was thus tested by comparing constructions within Croatian which have been shown to exhibit different attachment preferences in reading; specifically, N1-N2-RC constructions with and without the optional preposition *od* linking the two nouns, and with either a short or long RC. Experiment 4 was designed to answer whether these two factors, presence/absence of *od* and RC-length, interact with the prosodic rules of the language in a way that can be expected to be relevant for attachment. The greater tendency to attach the RC low in sentences with *od* as compared to sentences without *od*, observed in Experiments 2 and 3, can be explained by the IPH if a prosodic break immediately after N1, and no break at the RC, is more likely with *od* present than when *od* is absent. The RC-length effect observed in Experiments 1-3 can be explained by the IPH if a break at the RC is more likely with long RCs than with short RCs.⁷² In Experiment 4, these two points were examined for overt prosody. In discussing the implications of the results, it will be assumed that the implicit prosody projected onto these sentences in silent reading is similar to the prosody produced in reading them

⁷²The IPH makes no specific predictions about sentences containing both *od* and a long RC, and sentences without *od* and with a short RC. Prosodic phrasings potentially resulting from these cases, *N1) (N2) (RC* and *N1 N2 RC*, respectively, have yet to be tested for overt prosody. Experiment 5 tests hearers' attachment preferences for sentences with a prosodic phrasing *N1) (N2 RC* and for sentences with a prosodic phrasing *N1 N2) (RC*.

aloud. This cannot be proven directly, but it is a working assumption which, as will be seen, permits a coherent account of the data.

Method

Materials. The materials (see Appendix A-4 for a full list) consisted of 56 experimental sentences: 4 basic items, each in 14 different variants. The four basic items were drawn from the item set of Experiment 3, and modified only in that number disambiguation was introduced to force attachment of the RC either low as in (1a) below, or high as in (1b):

- (1a) Nazvali smo klijenticu (od) odvjetnica što puše (paket cigareta dnevno).
 “We phoned the client of the lawyers that smoke (a pack of cigarettes a day)”
- (1b) Nazvali smo klijenticu (od) odvjetnica što puši (paket cigareta dnevno).
 “We phoned the client of the lawyers that smokes (a pack of cigarettes a day)”

As the examples above illustrate, in addition to RC-Attachment (high or low), the other two factors independently manipulated were Preposition (*od* present or absent) and RC-Length (short or long). These three factors were combined factorially to create eight conditions, e.g., +Preposition with Long RC and High Attachment, +Preposition with Long RC and Low Attachment, and so on. In addition to these eight core variants of each basic sentence, another six control variants were used: a single noun followed by an RC (4 variants: N1/N2 + Short/Long RC, e.g., (2) below), and two nouns followed by

an adverbial modifying the predicate rather than an RC modifying one of the nouns (2 variants: –Prep/+Prep, e.g., (3) below)⁷³.

- (2) Nazvali smo klijenticu/odvjetnice što puši/puše (paket cigareta dnevno).
 “We phoned the client/lawyers that smokes/smoke (a pack of cigarettes a day)”
- (3) Nazvali smo klijenticu (od) odvjetnice jučer prijepodne.
 “We phoned the client of the lawyer yesterday morning”

The N2-RC cases were designed to show whether and how RC-length would affect the prosody in Croatian independent of whether the N2-RC was embedded in a complex NP. It is of interest to know whether Croatian grammar requires a prosodic break before *any* (long) RC regardless of its context. Furthermore, the mean duration of N2 in the N2-RC controls was compared with the corresponding data for the two-noun target sentences. The N1-RC cases were included in the materials to complete the design. The rationale behind the inclusion of the ‘adverbial’ cases was to see whether *od* would have a similar prosodic effect as in the more complex NPs in which the two nouns are followed by an RC. Thus, in all there were 12 relevant sentence types in the design.

As in Experiment 3, the RC was always introduced by the complementizer *što*. To facilitate accurate measurement, N1 was always consonant-initial; N2 was always vowel-initial, for comparability with *od*. In two items, N1 was singular and N2 plural; in the other two items, N1 was plural and N2 singular.

⁷³ In one item within the ‘adverbial’ condition, the complex NP was followed by an indirect object rather than by an adverbial, see Appendix A-4. This item will not be discussed separately since the adverbial/indirect object distinction had no perceptible impact on the results; see discussion of N1 timing data below. In all these sentences, the constituent following the RC was exactly two prosodic words, as illustrated in (3).

The sentences were presented to subjects, without fillers, in two blocks, first the –Prep block, followed by a short break, and then the +Prep block. The presentation of sentences with and without the preposition was blocked so as to avoid any potential effects due to register differences between the non-prepositional and prepositional constructions.⁷⁴

A single fixed pseudo-randomization was implemented in the item set, the same in the two blocks, ensuring that the probability of the occurrence of any within-block condition (e.g., Long RC with High Attachment) was uniform throughout the list sequence; list-adjacent occurrences of conditions were not permitted, while factor runs up to three were permitted (e.g., items N and N+1 could have a long RC if they differed in RC-attachment), and list-adjacent occurrences of design factors were balanced over the entire list. Because of the extent of materials repetition in the item set, subjects were told they would see several versions of each sentence, but that each version would be slightly different from all others. Two design features were adopted in order to avoid ‘repetition prosody’. Lexical content was distributed evenly over the item set. In addition, experimental items were separated by a formulaic sentence with a quite different prosody: "The next sentence is sentence number...". The sentences were presented to subjects in a folder, each on a separate page, typed on a single line in the middle of the page. Three practice sentences, which contained structures unrelated to the target N1-(od)-N2-RC construction, preceded the experiment proper, giving the subjects

⁷⁴ In their spontaneous comments following the experiment, many subjects asked, referring to the two blocks (+/–Prep) why they had been instructed to read ‘the same thing twice’, suggesting they were completely unaware of the +/–od contrast.

an opportunity to get used to speaking into the microphone. Each subject read aloud all 56 experimental sentences.

Procedure. Subjects were tested individually. They were first given a sheet of instructions (see Appendix B-2) providing guidelines on how to proceed (speak naturally but clearly, re-read the sentence if unhappy with their reading, refrain from going back to previous sentences, and so on.) After a short practice session (three sentences), the subjects were encouraged to ask any questions they might have about the procedure before the main experiment began. The subjects were tested in a quiet room, equipped with a Philips N2233 tape recorder and Hama DM15 microphone. They read each sentence silently for meaning first, and then aloud for voice recording. Including the short break between the two blocks (–Prep and +Prep), the experiment took 15-20 minutes to complete.

Acoustic analysis. The instrumental analyses of the recordings were carried out using Speech Analyzer software (from the Summer Institute of Linguistics). Measurements of N1 and N2 duration were made using the raw waveform to identify landmarks. The landmarks were selected to be detectable with high reliability across utterances, and were positioned to detect any final-syllable lengthening and following pause. The N1 measure started at the onset of N1 (always a consonant, e.g., *klijenticu* ‘client’), and ended at the onset of N2 (always vowel-initial) in sentences without *od*, and at the onset

of *od* in sentences with *od*. The N2 measure started at the onset of the first stressed syllable of N2 and ended at the *t*-burst of *što*.⁷⁵

Only duration data were used to estimate prosodic break positions. Croatian is a pitch-accent language (i.e., a language in which lexical pitch-accent contrasts differentiate word meanings) so its F0 contours are subject to a variety of influences. The reliability of duration as indicator of a prosodic boundary was checked against perceptual judgments (which presumably use both durational and boundary tone cues): two native-speaking judges (the experimenter and a Croatian linguist naïve as to the purpose of the experiment) listened to the recorded sentences and indicated when they heard a clear break or a clear absence of break immediately after each of N1 and N2.

Subjects. The data reported are based on the utterances of 10 subjects, all naïve with respect to the purposes of the experiment. The subjects were all native speakers of Croatian.⁷⁶ As in Experiment 3, all subjects were screened to check that they spoke the Zagreb dialect. One additional subject was excluded prior to data analysis, for failure to produce natural-sounding sentences in the judgment of the experimenter/author (a native speaker of the Zagreb dialect).⁷⁷

⁷⁵ To ensure accuracy, blind random partial rescoreing was undertaken by the experimenter a week after the original measurements were made. All the individual measurements in this sample (10% of all measurements) were within 15 ms of the original ones.

⁷⁶ Only female subjects were tested in case an F0 analysis of the utterances should prove to be required. Female speakers have higher F0 than male speakers, which facilitates tracking by the speech analysis program.

⁷⁷ This subject was very nervous throughout the recording session, never quite comfortable with speaking into the microphone. Her reading was marked by constant faltering and restarting. At the end of the recording session, she herself offered the comment that she did not believe she had managed to produce natural-sounding utterances.

N1 Timing Measures: Results and Discussion

Summary data for the duration of N1 are presented in Figures 4 and 5 below.

(For the numerical values, see Tables 7 and 8 in Appendix A to Chapter 7.) 'Duration' in this context encompasses both noun length and any following pause.

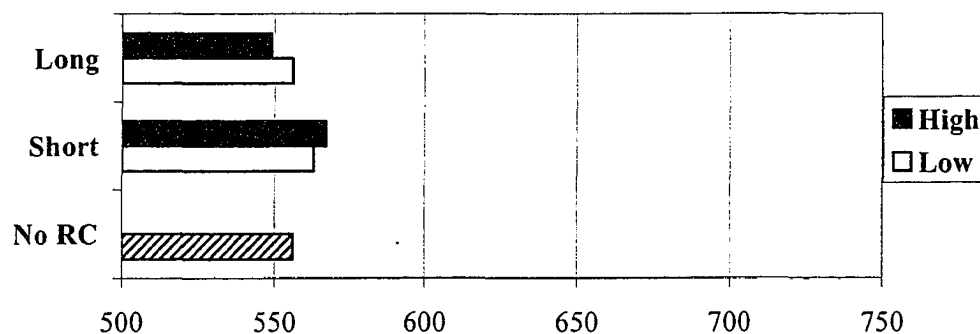


Figure 4: Mean duration (ms) of N1 in sentences without *od*, as a function of RC-Attachment and RC-Length, and for control sentences with no RC (i.e., N1-N2-ADV).

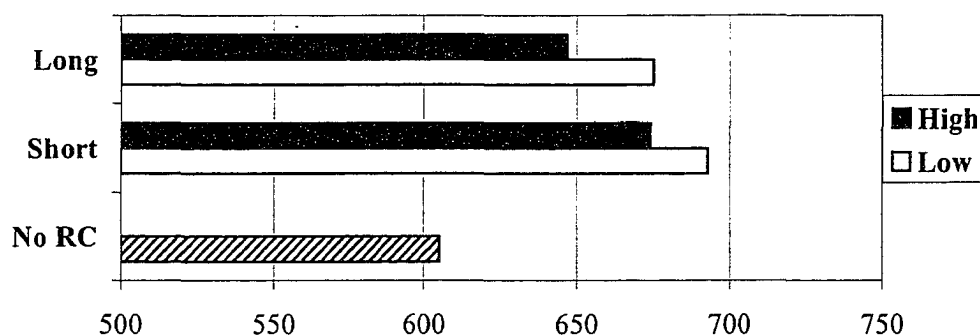


Figure 5: Mean duration (ms) of N1 in sentences with *od*, as a function of RC-Attachment and RC-Length, and for control sentences with no RC (i.e., N1-*od*-N2-ADV).

Timing data for N1 were analyzed using a three-way analysis of variance, in accord with the Preposition x RC-Length x RC-Attachment design. (The ‘no RC’ control data were analyzed separately from the target RC data, and are discussed later below.) Only a subject-based analysis was undertaken, as the number of items in each cell of the design was too small for an item-based analysis. (All analyses of variance for Experiment 4 are provided in Appendix C-4.)

There was no reliable effect of either RC-Length or RC-Attachment on N1 duration, nor were these factors involved in any interactions (all p 's > .20).⁷⁸ That there should be no reliable effect of RC-Attachment is somewhat surprising, the expectation being that speakers might want to indicate low attachment by making a break immediately after N1, contrasting it with no break in sentences with forced high attachment. This suggests that, as far as phrasing of N1-(*od*)-N2 in RC sentences is concerned, Croatian speakers use a similar prosodic pattern for both high and low attachment. This can reasonably be regarded as the default prosody for this sequence of elements regardless of how they are grouped syntactically.⁷⁹

⁷⁸ There was a numerical tendency in sentences without *od* toward greater mean N1 duration when the RC was long than when it was short (mean difference = 24 ms), and a tendency toward greater mean N1 duration when attachment was low than when it was high (mean difference = 23 ms). These tendencies were as expected, but they were not statistically reliable. They were swamped by the effect of *od* in sentences in which *od* was present.

⁷⁹ It may be worth noting here that on a number of occasions, subjects produced a pattern of prosodic phrasing (e.g., especially with a break before *od* and no break before the RC when attachment was forced high) and then indicated they were not satisfied with their reading (commenting: ‘Oh no, this came out wrong!’), only to produce the same pattern all over again when asked to try one more time.

The timing data indicate that average durations for N1 were significantly greater in sentences with *od* as compared with the sentences without *od*⁸⁰; the mean difference was 113 ms, $F_1(1,9) = 19.88$, $p < .01$. This suggests that a prosodic boundary immediately after N1 is more likely when *od* is present than when there is no *od*.⁸¹

The perceptual data corroborate the effect of Preposition on N1 duration suggested by the timing data. Perceptual judgments of presence or absence of a break immediately after N1 are presented in Table 2 below. Of the total 320 utterances, 296 (i.e., 92.5%) were judged to have either a clear break right after N1 or a clear absence of break right after N1. (Only utterances for which the two judges were in agreement were treated as 'clear' cases of either break or absence of break. These are the data reported here.) These data show that there were more clear breaks immediately after N1 with *od* present than when it was absent, and more utterances which clearly had no break when *od* was absent as compared with when it was present, $\chi^2(1) = 79.92$, $p < .001$.

Table 2: Number (and percentage) of perceptual judgments of clear presence (+break) or absence (-break) of a prosodic break immediately after N1 as a function of presence/absence of *od*

	<i>+od</i>	<i>-od</i>
+break	84 (56.8%)	12 (8.1%)
-break	64 (43.2%)	136 (91.9%)

⁸⁰ Measurements show that increased N1 durations were primarily due to lengthening. Pausing was rare: in 259 of 320 utterances, there was no pause immediately following N1; in the remaining 61 utterances, pause durations right after N1 measured up to 400 ms (the average being 105 ms).

⁸¹ In principle, these duration measurements cannot make it clear whether what is at issue here is the probability of a break or the extent of the break. This is of no consequence for our present purposes, though it is a question of theoretical interest.

Analysis of the timing data for the control sentences in which the two nouns were not followed by an RC but rather by an adverbial attached at the VP or clausal level, reveals that the mean N1 duration was not greater, statistically, for sentences with *od* than for those without *od* (i.e., the difference in mean duration of 49 ms was not reliable), $F(1,9) = 2.87$, $p > .10$. This suggests that in the adverbial variants, unlike the target RC sentences, a prosodic boundary right after N1 is not consistently more likely when *od* is present than when there is no *od*. This is not surprising since the adverbial in the adverbial variant of a sentence is outside the complex NP, and necessarily higher in the tree than the RC in the corresponding RC sentence. A prosodic boundary at the left edge of the adverbial is thus highly probable, and could suppress a tendency to break immediately before *od*, since the two breaks would be very close.

N2 Timing Measures: Results and Discussion

Summary data for N2 duration are presented in Figures 6 and 7 below. (For the numerical values, see Tables 9 and 10 in Appendix A to Chapter 7.) Timing data for N2 (as for N1; see above) were analyzed using a three-way analysis of variance, in accord with the Preposition x RC-Length x RC-Attachment design; only a subject-based analysis was undertaken. (The N2-RC control data were analyzed separately from the data for the two-noun targets, and are discussed later below.)

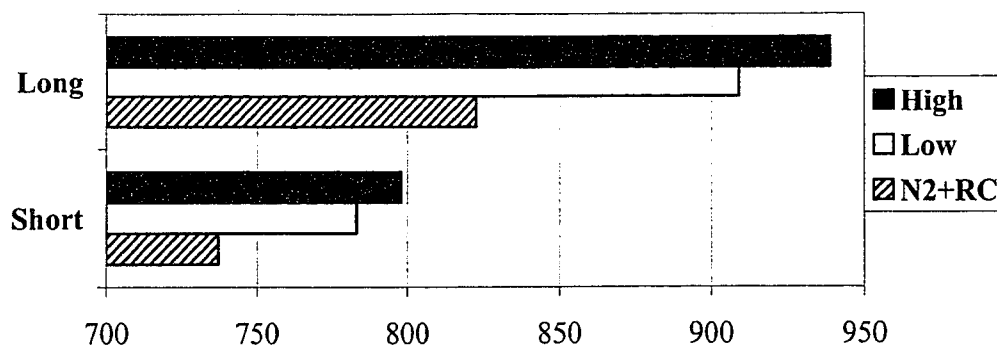


Figure 6: Mean duration (ms) of N2 in sentences without *od*, as a function of RC-Attachment and RC-Length, and for control N2-RC sentences.

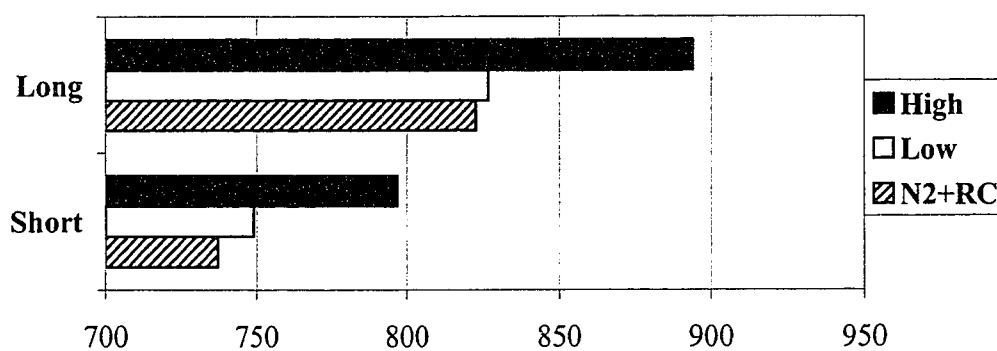


Figure 7: Mean duration (ms) of N2 in sentences with *od*, as a function of RC-Attachment and RC-Length, and for control N2-RC sentences.

The data pattern for N2 is more intricate than that for N1, since all three factors of the design showed reliable effects (cf. N1 data, where only the main effect of Preposition was significant). Briefly, mean N2 duration was greater (indicating a stronger tendency to break at the left edge of the RC) when the RC was long, when there was no *od*, and when the RC was attached high. Moreover, Preposition interacted with

RC-Attachment, and there was a suggestion of an interaction between Preposition and RC-Length; there was, however, no three-way interaction, $F_1 < 1$.

Let us first consider the main effect of Preposition. Mean N2 duration was significantly less in sentences with *od* as compared with sentences without *od*⁸²; the mean difference was 40 msec, $F_1(1,9) = 12.79$, $p < .01$. This finding indicates that a prosodic break immediately after N2 is less likely when *od* is present than when there is no *od*. Recall what the N1 data have shown us: the first effect of *od* is that it significantly increases the likelihood of a break right after N1 (perceptual data indicate a break in 56.8% of reliably classified cases when *od* is present, compared with 8.1% when there is no *od*). Once a speaker has made a break after N1, to break again right after N2 would violate one of the optimal-length constraints by making N2, a single prosodic word, into a major phrase by itself (see Selkirk, 2000, and our discussion in Chapter 4). Therefore, an expected downstream effect of the presence of *od* is to cause suppression of a prosodic break between N2 and the RC.

The Preposition factor interacted with the RC-Attachment factor, $F_1(1,9) = 5.21$, $p < .05$. When the RC was attached low, mean N2 duration was substantially less in sentences with *od* as compared with those without *od* (mean difference 58 ms) but the difference was less when the RC was attached high (mean difference 23 ms). This interaction is best understood by first considering the general impact of RC-Attachment on mean N2 duration.

Mean N2 duration was greater before an RC forced high than before an RC

⁸² As with N1, differences in the duration of N2 were also primarily due to lengthening. Pausing was rare: in 236 of 320 utterances, there was no pause immediately following N2; in the remaining 84 utterances, pause durations right after N2 measured up to 500 ms (the average being 138 ms).

forced low, the mean difference being 40 ms, $F_1(1,9) = 8.05$, $p < .025$. This finding implies that a prosodic boundary immediately after N2 is more likely before a high-attached RC than a low-attached RC.

We can now return to the interaction between Preposition and RC-Attachment. It is possible that the observed differences are a case of forced high attachment resisting the tendency of *od* to suppress a pre-RC break. Alternatively, it might be that the break-suppressing influence of *od* was reinforced by a preference for no break before a low-attaching RC. It is unclear at present which of these is the case.

The timing data for N2 further reveal a main effect of the RC-Length manipulation. Mean N2 duration was greater in sentences with a long RC as compared with those with a short RC; the difference in mean duration was 110 ms, $F_1(1,9) = 22.30$, $p < .01$. This finding indicates that the probability (or possibly, the strength) of a prosodic boundary immediately after N2 is greater before a long RC than a short RC.

RC-Length did not interact with RC-Attachment, $F_1(1,9) = 1.82$, $p > .20$. These appear to be independent factors. There was, however, a suggestion of an interaction between RC-Length and Preposition, not quite reaching conventional levels of significance, $F_1(1,9) = 3.01$, $p > .10$. When *od* was absent, mean N2 duration was substantially greater in sentences with a long RC as compared with those with a short RC (mean difference 134 ms), but the difference was less when *od* was present (mean difference 88 ms). This indicates that the presence of *od* not only reduces the overall incidence of breaks before the RC, as described above, but also reduces the contrast in the incidence of pre-RC breaks for long and short RCs. This is plausibly explained by the fact that a break before a short RC is already fairly unlikely, so the reduction due to

od's presence has its greatest impact on the long RCs. Thus the prosodic difference between long and short RCs is reduced compared to the versions without *od*.

Let us see if the perceptual data corroborate the duration data. Of the total 320 utterances, 236 (73.8%) were judged to have either a clear break right after N2 or a clear absence of break. (Only these cases are discussed here.) Perceptual judgments of presence of a break right after N2 for these 236 utterances are presented in Tables 3 and 4 below, broken down by Preposition. For clarity, we present here only a brief summary of the data, in the form of percentages of utterances with a clear break. The full data are provided in Tables 11 and 12 in Appendix B to Chapter 7.

Table 3: Percentage of perceptual judgments of clear presence of a break immediately after N2 in sentences without *od*, as a function of RC-Length and RC-Attachment

	Long RC	Short RC
High Attach't	100%	50%
Low Attach't	100%	12.5%

Table 4: Percentage of perceptual judgments of clear presence of a break immediately after N2 in sentences with *od*, as a function of RC-Length and RC-Attachment

	Long RC	Short RC
High Attach't	71.4%	55.6%
Low Attach't	16.7%	11.1%

In all cases, the comparisons of perceptual judgments across conditions comport with the patterns observed above in the duration data (three main effects and two interactions).

Finally, let us consider the timing data for the control cases in which N2 alone was followed by an RC. Analysis of these data reveals that, just as for the two-noun targets, mean N2 duration was greater in sentences with a long RC as compared with those with a short RC; the difference in mean duration being 86 ms, $F_1(1,9) = 9.45$, $p < .025$. This indicates a greater probability (or strength) of a break between a single noun and a long RC than between a single noun and a short RC. It can be inferred that there is some tendency to break immediately before an RC in Croatian, even if it is preceded by only one noun, as long as the RC satisfies the minimum length constraint on prosodic phrases.

Furthermore, informal comparison of the N2-RC data with the data for the two-noun targets shows that N2 duration for the N2-RC controls is most similar to that for the low-attachment targets with *od*. The similarity to low attachment is understandable, since the structural relationship between the RC and the preceding noun is the same; in both cases there is no discontinuity in the syntactic tree between the noun and the RC that modifies it. The similarity between N2-RC and the two-noun sentences with *od* is a little harder to understand. It depends to some extent on the relationship between the noun and what precedes it in the sentence; in all cases this was a main verb followed by an unaccented auxiliary, the whole constituting one prosodic word. In the two-noun targets with *od*, we have concluded that the prepositional phrase *od*-N2 is often immediately preceded by a prosodic break which tends to suppress a further break

between N2 and the RC. The similarity of the N2-RC data suggests the interpretation that a break between N2 and the RC was also suppressed in the N2-RC construction. For the N2-RC sentences with short RC this seems very plausible, since those sentences were just three prosodic words, which is permissible as a single prosodic phrase, so it is likely that speakers in fact made no breaks at all. For the N2-RC sentences with long RC, which had a total of six prosodic words, a break between N2 and the RC might be disfavored by a requirement for balanced phrases (see Section 4.1). However, a balance-compatible break in the middle would fall right after the RC verb, which is also less than fully natural as a prosodic pattern. Possibly, then, there was no clearly dominant pattern for these sentences.

Apart from this one case, whose explanation is somewhat speculative, all other prosodic differences and similarities across the 12 sentence types tested are fully explicable in terms of the interplay between RC-attachment, RC-length, and presence/absence of the preposition *od*. Furthermore, these prosodic data suggest a natural explanation of the effects of the latter two factors (RC-Length and Preposition) on RC-attachment choices in ambiguous sentences.

7.2.1 Summary and Conclusions for Experiment 4

These findings concerning overt prosody in spoken sentences of Croatian indicate that the preposition *od* changes the prosody of the target sentences in our materials in two ways: it increases the likelihood of a prosodic break immediately after N1, thus increasing the separation between N1 and N2; and it reduces the likelihood of a

prosodic break immediately after N2, resulting in a prosodic phrasing in which N2 is grouped together more closely with the RC. Let us now summarize the resultant patterns of prosodic phrasing. Two common patterns which are particularly relevant are shown in (4) and (5). The phrasing in (4) occurs more often for *+od* sentences and especially when the RC is short. When the RC is long, there is a greater tendency to break between N2 and the RC, as in (5), especially when there is no prior *od*-induced break between N1 and N2.

- (4) N1) (N2 RC typical of *+od* (especially for short RC)
 (5) N1 N2) (RC typical of long RC (especially for *-od*)

These findings for phrasing in overt productions of disambiguated Croatian RC-sentences have implications both for RC-attachment by hearers in ambiguous Croatian RC-sentences, and for the IPH-based explanation of the *od* and RC-length effects on attachment in these sentences in silent reading. In particular, the pattern of prosodic phrasing in (4), found to be more typical of *+od*, is of the kind that can be expected to encourage low attachment in listening; the phrasing in (5), on the other hand, found to be more typical of a long RC, is associated with high attachment in listening (see Maynell's, 2001, data for English, and Jun's, 2003, observations for a number of languages; see also Clifton et al., 2002, and our discussion in Section 4.3). This is tested for Croatian in our next experiment, Experiment 5, which examines whether Croatian hearers do tend to attach low in syntactically ambiguous sentences when there is an overt break immediately after N1 and no break at the RC, and prefer to attach high when there is a break at the RC only.

The results for overt phrasing in Croatian RC-sentences with and without *od* and with a short or long RC, are also correlated with the RC-attachment preferences for these sentences *in silent reading*. The greater chance of an overt prosodic break immediately after N1 and not at the RC when *od* is present than when it is absent, mirrors the lowering effect of *od* on RC-attachment in silent reading (as evidenced in Experiments 2 and 3). The greater chance of an overt prosodic break at the left edge of long RCs (though modulated by a prior *od*-induced break right after N1) as compared with short RCs, mirrors the greater tendency of long RCs to attach high in silent reading (as evidenced in Experiments 1-3).

So far, the data for Croatian are compatible with the IPH's explanation of RC-attachment preferences in silent reading: the presence/absence of *od* and RC-length measurably impact the parser's preferences in silent reading, and they affect the overt prosody of Croatian RC sentences in a way that is relevant for attachment. With steps 1 and 2 of the research program in place, we now turn to our final experiment, Experiment 5. This experiment was designed to examine whether the overt prosodic differences caused by manipulation of *+/-od* and RC-length measurably influence RC-attachment preferences in the processing of *spoken* sentences.

7.3 Experiment 5

If an implicit prosody account of attachment preferences in silent reading is to be viable, there is a crucial final step in the chain of inference. That is, it needs to be shown that the prosodic phrasing pattern which is typically associated with the presence of *od*,

and the pattern typically associated with long RCs (as observed in Experiment 4), in fact have the expected effects on attachment preference in listening, where they are an overt part of the input signal. The two patterns are repeated in (1) and (2) below:

- (1) N1) (N2 RC) typical of *+od* (especially for short RC)
- (2) N1 N2) (RC) typical of long RC (especially for *-od*)

The IPH-based explanation of RC-attachment preferences in silent reading presupposes that in listening the phrasing in (1) favors low attachment, whereas the phrasing in (2) favors high attachment. These preferences are expected on the basis of syntax-prosody congruence (Selkirk, 2000, see above). In addition, the latter has been shown to be true for English by Maynell (1999, 2001). (See also Jun's, 2003, preliminary observations for a number of languages, indicating that the phrasing in (1) favors low attachment and phrasing in (2) favors high attachment.) Experiment 5 was designed to test this for Croatian.

Furthermore, the implicit prosody explanation of the effect of *od* on attachment is that it is the *prosody* typically associated with *od* that lowers attachment in reading, rather than some other property (e.g., its syntactic, semantic or pragmatic properties). Similarly, the implicit prosody explanation of the effect of long RCs on attachment in reading assumes that it is the *prosody* typically associated with long RCs that induces higher attachment of long RCs as compared with short ones, rather than some other, non-prosodic property long RCs may have, e.g., a pragmatic property, such as increased information load (Hemforth & Konieczny, 2002), or the fact that long RCs give the

subject more time to recognize the high-attachment alternative (Pynte, 1998; Pynte & Colonna, 2000; see also the discussion in Chapter 4). Thus, for the IPH's explanation of attachment preferences in silent reading to be correct, it must be the case that the phrasing in (1) should result in a low RC-attachment preference for hearers, and the phrasing in (2) in a high RC-attachment preference for hearers, whether or not *od* is present, and whether or not the RC is long. These possibilities can indeed be tested. I report below an experiment that crosses the phrasing patterns with the presence or absence of *od*. This is possible since the phrasing in (1) without *od* and the phrasing in (2) with *od* are both acceptable in Croatian, though less typical than the alternatives. Moreover, if the material up to N1 contains one prosodic word (e.g., a verbal complex such as that used in the items for Experiments 3 and 4), and the length of the RC is kept constant at exactly two prosodic words, both patterns of phrasing should be felicitous (i.e., neither (3), nor (4) below violates any optimal-length constraints).

- | | | | | |
|-----|------------------------|-------------|--------------|---------------|
| (3) | Verbal Complex
1PWd | N1
1PWd) | (N2
(1PWd | RC
2PWds |
| (4) | Verbal Complex
1PWd | N1
1PWd | N2)
1PWd) | (RC
(2PWds |

A test like this is important because, as with RC-length, it is also possible to imagine non-prosodic explanations of the effect of *od* on RC-attachment in silent reading. Some of these explanations appear to be non-prosodic but may in fact turn out to be prosodically motivated at some deeper level. A kind of Gricean pragmatic explanation could be suggested: N1-N2-RC is used for high attachment, whereas N1-*od*-

N2-RC may be reserved for low attachment.⁸³ Unless it is completely arbitrary, on this account, which form is used for which attachment, this itself stands in need of some explanation. The likeliest explanation appears to be that it is favored by the syntax/prosody alignment rules of the language. A kind of tuning explanation of the *od* data may also be imagined: producers have trouble pronouncing the disfavored attachment (awkward prosody), so they avoid it (by paraphrasing); as a result, the frequency of the prosodically preferred attachment is higher in production, and this attachment is therefore preferred in comprehension.

One might contemplate also syntactic or semantic explanations of the effect of *od* on RC-attachment. As noted in Section 5.1.3, the exact facts of the linguistic status of *od* are yet to be clarified. It is possible nonetheless to show that any syntactic or semantic difference that might exist between the constructions with and without *od* cannot be what causes the attachment difference between them. Rather, it is the prosody associated with *od* that influences the attachment preference.

Experiment 5 was designed to test whether the effect of *od* on RC-attachment can be accounted for by any syntactic or semantic property of the *od* construction, or by any conventionalized association in the language community of *od* with low attachment. In an auditory questionnaire, the presence/absence of *od* was crossed with the two prosodic patterns in (1) and (2). If it is the prosody that influences attachment decisions, then sentences with the phrasing in (1) should be interpreted with low attachment of the RC, and sentences with the phrasing in (2) should be interpreted with high attachment,

⁸³This has been brought to our attention by Edson Miyamoto, in a personal communication. A similar suggestion has been made by Marcus Bader, based on his intuitions about the preposition *von* in German. We thank them both for their comments on this issue.

regardless of the presence or absence of *od*. If, on the other hand, it is non-prosodic properties of *od* that matter, then sentences with *od* should tend to be interpreted with low attachment of the RC, and sentences without *od* with high attachment, regardless of the presence or position of a prosodic break. Moreover if the length of the RC is kept constant, a difference in attachment preference between sentences with the phrasing in (1) and sentences with the phrasing in (2) is predicted by a prosodic account of RC-length effects on attachment but not by non-prosodic explanations of RC-length effects – at least, it is not predicted by non-prosodic accounts which have been proposed to date, viz. the information-load and decision-timing explanations.

Method

Materials. The materials (see Appendix A-5 for a full list) consisted of 32 syntactically ambiguous RC sentences: 8 basic items, each in 4 variants. These variants were created by the factorial combination of a Preposition factor (*od* present or absent) and a Prosody factor (Prosody 1/Prosody 2); see (5) and (6) below. The 8 basic items were identical to 8 (of 20) items used in Experiment 3, and included the 4 items subsequently adapted for Experiment 4, except that there was no RC-length contrast. All RCs consisted of exactly two prosodic words, for which both prosodic patterns are felicitous.

- (5) Prosody 1: Spacing indicates break after N1, no break after N2
 Nazvali smo klijenticu (*od*) odvjetnice što puši cigare.
 “We phoned the client of the lawyer that smokes cigars”

- (6) Prosody 2: Spacing indicates no break after N1, break after N2
 Nazvali smo klijenticu (*od*) odvjetnice što puši cigare.
 “We phoned the client of the lawyer that smokes cigars”

Because this length criterion required some modification of the content of the RCs in the items for Experiment 5 compared with those in Experiment 3, the sentences were subjected to re-evaluation. The same procedure was used as in Experiments 1 and 3: each sentence was examined and revised until a panel of three expert judges agreed that it sounded natural and that the two alternative interpretations of the RC (attachment to N1, and to N2) were equally plausible.

The sentences were recorded by a female native speaker of Croatian (Zagreb dialect), who had participated previously as a subject in Experiment 4. The speaker was selected because her recorded utterances in that experiment were notably natural and clear. For the recordings for Experiment 5, the speaker saw one sentence at a time, printed in the middle of the page, with the required position of a prosodic break indicated by inserted character spaces, as shown in (3) and (4) above. She read each sentence for recording, one or more times, until both she and the experimenter were satisfied that the utterance was produced as specified while sounding fully natural.

The recordings were acoustically analyzed in the same fashion as those in Experiment 4. Duration measurements pooled across the eight items, for each of N1 and N2, are presented in Tables 5 and 6 below.

Table 5: Mean N1 duration (ms), as a function of Preposition and Prosody

	<i>-od</i>	<i>+od</i>
Prosody 1	857	820
Prosody 2	549	535

Table 6: Mean N2 duration (ms), as a function of Preposition and Prosody

	<i>-od</i>	<i>+od</i>
Prosody 1	721	730
Prosody 2	976	977

Two-way analyses of variance revealed that, for N1, the difference of 297 ms in mean duration between Prosody 1 and Prosody 2 was significant, $F_2(1,7) = 81.12, p < .001$; there was, however, no effect of Preposition, nor was there an interaction between factors, F_2 's < 1 . Similarly, for N2, only the effect of Prosody was significant, the difference in mean duration being 251 ms, $F_2(1,7) = 113.65, p < .001$; $F_2 < 1$ for main effect of Preposition, and for the interaction of Preposition and Prosody.

Test of Naturalness of the Stimuli. Four (of 8) basic sentences used to generate the test stimuli in Experiment 5 were modifications of the four sentences used in Experiment 4; only the content of the RC was adjusted. This made it possible to compare the durations of N1 and N2 in the stimulus items in Experiment 5 with the durations of N1 and N2 in the same speaker's *naturally* produced utterances of the same sentences in Experiment 4 (i.e., when she had not been instructed to place any breaks). These data are summarized

in Figures 8 and 9, for N1 and N2 respectively. Figures 8 and 9 show that for the four items in question, the mean durations of N1 and N2 in the utterances used as stimuli in Experiment 5 fell within the envelope of mean durations in the same speaker's naturally produced utterances in Experiment 4.⁸⁴ We can therefore have confidence that Experiment 5's stimuli were not unnaturally exaggerated in the lengthening cues to boundary location.

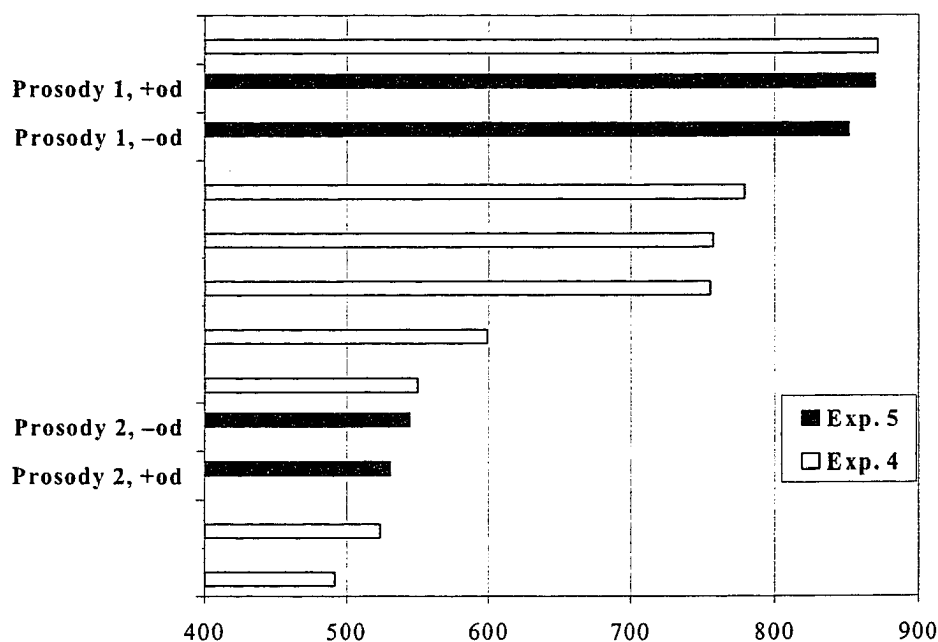


Figure 8: Mean N1 duration (ms) for the item types used in Experiment 4, and their counterparts as produced by the same speaker in Experiment 5.

⁸⁴ The same was also true of 81% of individual item durations.

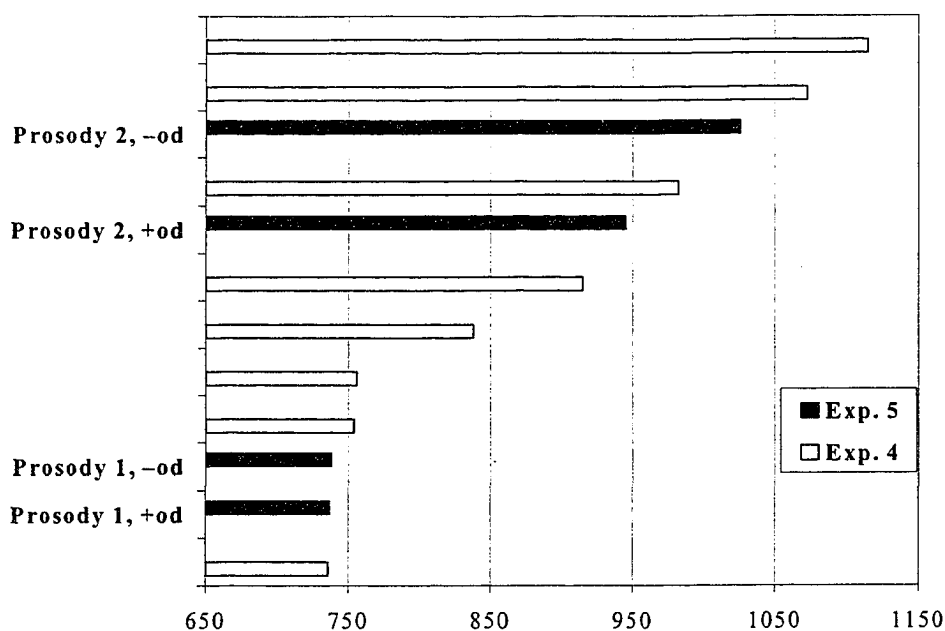


Figure 9: Mean N2 duration (ms) for the item types used in Experiment 4 and their counterparts as produced by the same speaker in Experiment 5.

Procedure. The utterances were arranged in a single fixed pseudo-randomization (with the same properties as that implemented in Experiment 4) and presented to subjects in an auditory questionnaire. No filler items were used.

Subjects were tested individually, in a quiet room. They were first given a sheet of instructions (see Appendix B-3) providing guidelines on how to proceed (listen to each sentence up to twice, choose whichever answer corresponds to the meaning you think that the speaker most likely had in mind, make a choice for every sentence, and so on). Because of the extent of materials repetition in the item set, subjects were told they would hear several versions of each sentence, but that each version would be slightly different from all others. The experiment proper was preceded by a short task-practice

session, in which subjects heard two globally ambiguous sentences unrelated to the RC-attachment ambiguity, and had to decide which of two possible meanings they thought that the speaker most likely had in mind. (The two practice items are provided in Appendix A-6.) After the practice session, the subjects were encouraged to ask any questions they might have about the procedure before beginning the main experiment. The utterances were played to subjects on an IBM Thinkpad laptop computer, through Philips AY3682 headphones. The subject had control over whether to repeat the presentation of the utterance. After the final (first or second) hearing of the utterance, subjects turned to a new page in a written booklet, and read a question about the attachment of the RC, with two answer choices, e.g., (7):

- | | | | |
|-----|----------------------|------------|------------|
| (7) | Tko puši cigare? | odvjetnica | klijentica |
| | “Who smokes cigars?” | the lawyer | the client |

As in the previous questionnaires, in half the items N1 was presented as an answer choice on the left, and in the other half, on the right. The subject then reported her/his chosen answer aloud. The experimenter recorded the subject’s answer on a scoresheet. The experiment took 15-20 minutes to complete.

Subjects. The data reported are from 16 subjects. The subjects were all naïve with respect to the purposes of the experiment. They were all native speakers of Croatian, undergraduates in the Psychology Department of the University of Zagreb, who received course credit for their participation. They were all screened to check that they were speakers of the Zagreb dialect of Croatian.

Data Treatment. Responses to the stimulus utterances were coded in terms of the attachment site (high or low) implied by the choice of noun answer (N1 or N2). Subject- and item-based calculations of summary values were cast in terms of the proportion of responses indicating *high attachment*, for each of the cells of a design factorially combining Preposition and Prosody. (All analyses of variance for Experiment 5 are provided in Appendix C-5.)

Results and Discussion

Summary data for Experiment 5 are presented in Figure 10.

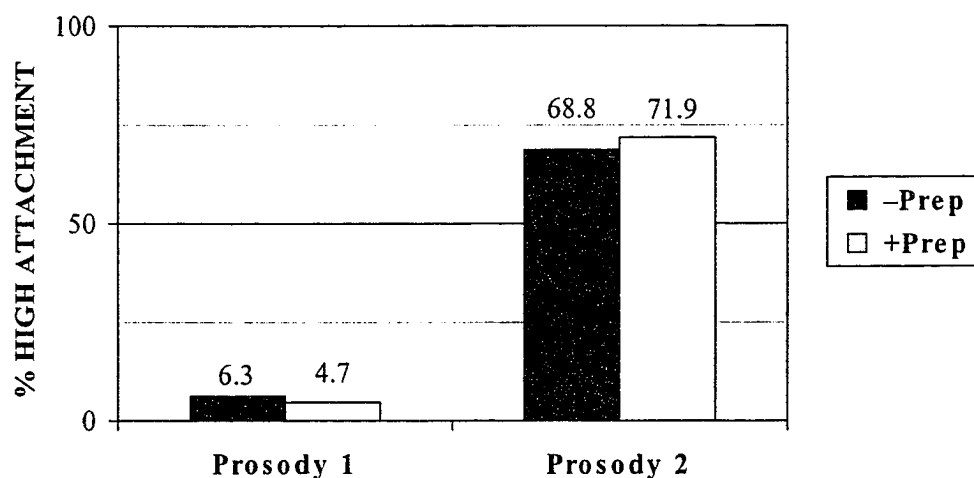


Figure 10: Mean percentage high attachment for spoken stimuli, as a function of Prosody and Preposition

The striking difference here, confirmed by the analysis, indicates that hearers preferred to attach the RC low (5.5% high attachment) when a sentence had Prosody 1, i.e.,

N1)(N2 RC, with a phrasing break immediately after N1 and no break at the RC; and they preferred to attach the RC high (70.4% high attachment) when a sentence had Prosody 2, i.e., N1 N2)(RC, with a phrasing break at the RC and no prior break, $F_1(1,15) = 114.44, p < .001$; $F_2(1,7) = 679.20, p < .001$. Crucially, these preferences were found to hold whether or not the preposition *od* was present, $F_1, F_2 < 1$ for main effect of Preposition, and for the interaction of Preposition and Prosody.

It could be suggested that these sharp differences in the interpretation of the RC as a function of Prosody arose only because subjects were hearing the very same sentences with contrasting prosodies (no fillers were used) and felt obliged to respond to them differently. This kind of ‘experimenter demand’ is, however, unlikely to be what is at work here. The subjects heard the same content with the same prosody except that *od* was either present or absent, and yet no effect of ‘experimenter demand’ is evident with respect to this Preposition factor. To the contrary, subjects were apparently entirely insensitive to the presence or absence of *od*.

Note also the apparent asymmetry in the data. Prosody 1 in effect forces low attachment, whereas Prosody 2 encourages but does not force high attachment. This may be related to Selkirk’s (2001) claim that a prosodic pattern in which a shorter phrase is followed by a longer phrase (e.g., here, two PWds followed by three PWds in Prosody 1) is more optimal than a pattern in which a longer phrase is followed by a shorter one (e.g., here, three PWds followed by two PWds in Prosody 2). An explanation based on a finding reported by Maynell (2001) may also be suggested. Maynell found that for English, in RC sentences with *no* prosodic boundary (either between N1 and N2 or between N2 and the RC) hearers preferred to interpret the RC as

attaching low, to N2. This pattern of phrasing has yet to be tested in Croatian. However, on the assumption that a similar result is obtained in Croatian, the above asymmetry may be explained as follows: the phrasing in which there is a break right after N1, in addition to there being no break between N2 and the RC, greatly *reinforces* the advantage that N2 might have held even with no break right after N1, thus clamping the interpretation of the RC low. By comparison, the phrasing in which there is a break between N2 and the RC and no prior break right after N1, does not clamp the interpretation of the RC high, to N1, but rather *allows* the interpretation to go high, arguably by nullifying the advantage that N2 might otherwise have held.

The data from Experiment 5 indicate that, as presupposed by the implicit prosody explanation, attachment responses are controlled by the prosody typically associated with *od*, and not by any other properties (syntactic, semantic, pragmatic, etc.) that *od* might have. Similarly, the overwhelming effect of Prosody on attachment even though RC-length was kept constant, is compatible with the IPH-based explanation of the effect of RC-length on attachment. On this account, it is the prosody typically associated with long versus short RCs that causes the attachment difference between them, and not any other properties with respect to which they might differ. The effect of Prosody is, however, unexplained by the non-prosodic account based on information-load (Hemforth & Konieczny, 2002), because the length and lexical content (and thus presumably the information load) of the RC was fixed across all versions of the questionnaire. The results of Experiment 5 are also unexplained by the non-prosodic account of Pynte & Colonna (2000), which, in its explanation of RC-length effects on attachment, invokes differences in the timing of parsing decisions between short and

long RC: the length of the RC, and thus presumably the time that the parser had to build the N1-of-N2 construction to which the RC could attach, was fixed across all versions of the questionnaire.

7.4 Experiments 4 and 5: Summary and Conclusions

Experiments 4 and 5 were designed to correspond to steps 2, 3 and 4 of the research program for testing the IPH. The timing measures from Experiment 4 showed that the inclusion of the preposition *od* between N1 and N2 in the Croatian N1-N2-RC sentences tested changes the prosodic phrasing of the sentence: *od* increases the likelihood of a prosodic break immediately after N1, thus grouping N2 more closely together with the RC. The timing measures for N2 showed that a prosodic break at the left edge of the RC is more likely preceding a long RC than a short RC, as usual, but this is modulated by a prior *od*-induced break immediately after N1: a higher probability of a break right after N1 implies a lower probability of a break right after N2.

The attachment data from Experiment 5 show that hearers preferred to attach the RC low in sentences which have prosodic phrasing with a break immediately after N1 (which is more typical of the *+od* construction), and prefer to attach the RC high in sentences which have prosodic phrasing with a break immediately before the RC (which is more typical of long RCs). The fact that these preferences were found to hold whether or not *od* was present in the sentence, and with RC-length fixed across versions, suggests that subjects' RC-attachment decisions are influenced by the prosody typically

associated with *od* and long RCs, and not by any other property that either *od* or long RCs might have.

Together, the results of Experiments 4 and 5 support the IPH-based explanation of the effects of *od* and RC-length on attachment in silent reading. The presence/absence of *od* and RC-length measurably affect the overt prosody of Croatian RC sentences (Experiment 4); the overt prosodic differences caused by manipulation of these two factors measurably influence RC-attachment preferences in the processing of *spoken* sentences (Experiment 5). In addition, we have seen in Experiment 3 that the presence/absence of *od* and the length of the RC affect the parser's RC-attachment preferences in a similar way *in silent reading* as well. Our method for testing the IPH has been to infer the role of implicit prosody on the basis of analogy with overt prosody. This is the most direct method known for examining implicit prosodic contours. Having ruled out as a relevant factor other properties of long RCs and of *od* (e.g., increased information load and syntactic / semantic / pragmatic properties of *od*, respectively; see Experiment 5), we conclude that the effects of *od* and RC-length on syntactic processing in silent reading must be mediated by the implicit prosody imposed on the sentence by the reader.

The final chapter of the thesis, Chapter 8, summarizes the complete set of experimental findings from Experiments 1-5, and points the way for future investigations.

Appendix A to Chapter 7: Mean durations of N1 and N2 in Experiment 4, numerical values

Table 7: Mean duration (ms) of N1 in sentences without *od*, as a function of RC-Attachment and RC-Length, and for control sentences with no RC (i.e., N1-N2-ADV).

	High Attach't	Low Attach't	
Long RC	549	556	
Short RC	567	563	
No RC			556

Table 8: Mean duration (ms) of N1 in sentences with *od*, as a function of RC-Attachment and RC-Length, and for control sentences with no RC (i.e., N1-N2-ADV).

	High Attach't	Low Attach't	
Long RC	647	675	
Short RC	674	693	
No RC			605

Table 9: Mean duration (ms) of N2 in sentences without *od*, as a function of RC-Attachment and RC-Length, and for control N2-RC sentences.

	High Attach't	Low Attach't	N2-RC
Long RC	939	909	823
Short RC	798	783	737

Table 10: Mean duration (ms) of N2 in sentences with *od*, as a function of RC-Attachment and RC-Length, and for control N2-RC sentences.

	High Attach't	Low Attach't	N2-RC
Long RC	894	827	823
Short RC	797	749	737

Appendix B to Chapter 7: Distribution of perceived prosodic breaks immediately after N2

Table 11: Number (and percentage) of perceptual judgments of clear presence (+break) or absence (–break) of a prosodic break immediately after N2 in sentences without *od*, as a function of RC-Length and RC-Attachment

	Long RC		Short RC	
	High Attach't	Low Attach't	High Attach't	Low Attach't
+break	24 (100%)	24 (100%)	16 (50%)	4 (12.5%)
–break	0 (0%)	0 (0%)	16 (50%)	28 (87.5%)

Table 12: Number (and percentage) of perceptual judgments of clear presence (+break) or absence (–break) of a prosodic break immediately after N2 in sentences with *od*, as a function of RC-Length and RC-Attachment

	Long RC		Short RC	
	High Attach't	Low Attach't	High Attach't	Low Attach't
+break	20 (71.4%)	4 (16.7%)	20 (55.6%)	4 (11.1%)
–break	8 (28.6%)	20 (83.3%)	16 (44.4%)	32 (88.9%)

CHAPTER 8

CONCLUSIONS

The original motivation for the research reported in this dissertation was to shed light on a phenomenon which has puzzled researchers for over 15 years now: cross-linguistic differences in RC-attachment preferences. Croatian, a language which has so far been the focus of little psycholinguistic research, has a number of grammatical characteristics which make it possible to test most of the major explanations that have been proposed to account for this phenomenon. In this chapter we recapitulate the central ideas presented in the preceding chapters, first by describing the general background considerations of the investigation, and then by briefly restating the primary results of the experiments conducted. The final section suggests possible avenues for future research in this area.

8.1 Background Considerations

When a relative clause (RC) follows two nouns (N1, N2) in a complex NP, as in (1):

- (1) Someone shot the servant of the actress who was on the balcony.
 N1 N2 ----- RC -----

the preferred interpretation has been found to differ across languages. In some languages (e.g., English, Egyptian Arabic, Romanian, etc.), readers preferentially interpret the RC as attaching to N2; in others (e.g., Spanish, German, Dutch, etc.), there is a preference for attachment to N1. This cross-linguistic variation is of theoretical importance because it is the only known counterevidence to the claim that the human sentence processing routines are universal, and could therefore be innate (see Chapter 2 for discussion).

Five major explanations (see Chapters 3 and 4 for a detailed discussion) have been proposed in the literature to account for the cross-linguistic differences in RC-attachment:

- 1) the Construal/Gricean account (Frazier & Clifton, 1996);
- 2) Attachment-Binding Dualism (Hemforth and her colleagues, e.g., Hemforth et al., 1998);
- 3) the Tuning Hypothesis (Cuetos, Mitchell and their colleagues, e.g., Mitchell & Cuetos, 1991; Cuetos et al., 1996);
- 4) the Predicate Proximity/Recency model (Gibson and his colleagues, e.g., Gibson et al., 1996);
- 5) the Implicit Prosody Hypothesis (Fodor and her colleagues, e.g., Fodor 2000).

According to the Construal/Gricean account, Attachment/Binding Dualism and the Implicit Prosody Hypothesis, it is unnecessary to postulate learned, language-specific

parsing routines: the observed variation in RC-attachment is attributable to differences in the grammars of the languages in question. Specifically, the Construal/Gricean account proposes that the cross-linguistic variation can be explained in terms of the availability of alternative syntactic devices for unambiguous expression of high attachment, while Attachment-Binding Dualism bases its explanation of cross-linguistic attachment differences on the legitimacy of omitting the relative pronoun from the RC. The Implicit Prosody Hypothesis, the focus of this dissertation, proposes that variation in RC-attachment preferences across languages is attributable to differences in the prosodic component of their grammars. In contrast to all of these grammar-based explanations, the Tuning theory proposes that attachment preferences are based on previous experience with the same construction, and the Predicate Proximity/Recency model proposes a language-specific parsing parameter that learners of the language must set.

Croatian has several grammatical characteristics that are relevant to RC-attachment (see Chapter 5 for a detailed discussion): it has an unambiguous form for expressing high attachment; it allows replacement of the relative pronoun in the RC with the uninflected complementizer *što*; and it tolerates the presence or absence of a non-thematic preposition (*od*) between N1 and N2, which does not affect in any significant way the syntax or semantics of the sentence, but does affect its prosodic phrasing. Croatian thus makes it possible to test four of the above proposals: the Construal/Gricean account, Attachment-Binding Dualism, the Predicate Proximity/Recency model, and the IPH. Experiments 1-5, presented in Chapters 6 and 7, were designed and implemented to accomplish this.

8.2 Summary of Experimental Findings

Let us first focus on the results of the three written questionnaires (Experiments 1-3, reported in Chapter 6). Experiment 3 involved purely silent reading; Experiments 1 and 2 involved reading each sentence silently first and then aloud for recording.

Example (2) illustrates the type of sentences tested:

- (2) Nazvali smo klijenticu (od) odvjetnice
 phoned are client-[fem.sg.Acc] (of) lawyer-[fem.sg.Gen]
 koja/što puši (paket cigareta dnevno).
 who-[fem.sg.Nom]/that smokes pack cigarettes daily

“We phoned the client of the lawyer that smokes (a pack of cigarettes a day)”

The data from all three questionnaires indicated that RC-length has an effect on the preferred interpretation of the RC: long RCs are more likely to be interpreted as attaching to N1 than short ones. This finding is unexplained by the Construal/Gricean account, Attachment-Binding Dualism, and the Predicate Proximity/Recency model. The data from Experiments 2 and 3 indicated that the presence of the preposition *od* between N1 and N2 in sentences like (2) lowers the preferred attachment of the RC. This finding too is unexplained by all three of the above proposals.

Furthermore, the data indicated a high-attachment preference overall in Croatian and no effect on attachment of either the Alternative Form factor (unambiguous alternative does or does not exist) or the Relativizer factor (RC introduced by a relative pronoun or by a complementizer). These findings are incompatible with all known variants of the Gricean explanation and three of four variants of Attachment-Binding

Dualism. (The one variant of Attachment-Binding Dualism left unscathed by the Croatian data is disconfirmed by data from other languages; see Section 6.5.)

Experiments 4 and 5 (reported in Chapter 7) were designed to test aspects of the IPH. The reading-aloud data from Experiment 4 indicated that RC-length and the presence/absence of *od* both measurably affect the overt prosody of Croatian RC sentences like (2). Presence of *od* increases the likelihood of a prosodic break immediately after N1, thus grouping N2 more closely together with the RC. Long RCs increase the likelihood of a prosodic break immediately before the RC, thus separating N2 and the RC. The listening data from Experiment 5 indicated that those overt prosodic differences which are caused by manipulation of RC-length and the presence/absence of *od* measurably influence RC-attachment preferences in the processing of *spoken* sentences. The RC was preferentially attached low in sentences pronounced with a prosodic break immediately after N1 (which is more typical of the +*od* construction), and was preferentially attached high in sentences pronounced with a prosodic break immediately after N2 (which is more typical of long RCs). These preferences were found to hold whether or not *od* was present in the spoken sentence, and with RC-length fixed across versions, suggesting that attachment decisions are influenced by the prosody that is typically associated with *od* and long RCs, and not by any other effects that either *od* or long RCs might have on sentences.

The results of Experiments 4 and 5, together with those from Experiment 3, support the IPH-based explanation of the effects of *od* and RC-length on attachment in silent reading. Our method for testing the IPH has been to infer the role of implicit prosody in silent reading on the basis of analogy with overt prosody. Independently

documented overt prosodic patterns (Experiment 4) affect the parser's attachment preferences in listening (Experiment 5). The parser's attachment preferences are affected in a similar way in silent reading as well (Experiment 3). In the absence of any other plausible account of this parallelism, we conclude that implicit prosodic patterns mediate the parser's preferences in silent reading, just as overt prosodic contours mediate them in listening to spoken sentences.

The disconfirmation of three influential theories of cross-language variation in sentence parsing is a useful outcome, which can re-channel the direction of future research in this area. The positive result in support of the IPH suggests that variation in RC-attachment preferences does have an explanation, and that this explanation is compatible with the innateness of the processing mechanism. If the IPH is correct, different attachment preferences observed for different languages and/or constructions are attributable to differences in prosodic phrasing, determined by the competence grammar, and not to different processing routines.

8.3 Issues for Future Investigation

Regarding RC-attachment in Croatian, one avenue for future research would be to examine the phrasing patterns in overt prosody and RC-attachment preferences in silent reading for sentences like (3):

- (3) Klijentica (od) odvjetnice što puši
 client-[fem.sg.Nom] (of) lawyer-[fem.sg.Gen] that smokes
 cigare nam je rekla da malo pričekamo.
 cigars to-us is told to little wait

“The client of the lawyer that smokes cigars told us to wait a moment”

In (3), the RC is ambiguously attached to a sentence-initial complex NP (compared with sentence-final in (2)). Intuitively, in (3), unlike in (2), the presence/absence of *od* should have no effect on the prosody of the sentence. A prosodic break at the left edge of the PP is unlikely because this would violate optimal-length constraints: N1, a single prosodic word, is too small to constitute a major prosodic phrase on its own. If this intuition concerning the overt prosody of sentences like (3) proves to be correct, the IPH would predict no effect of the presence/absence of *od* on attachment preferences for these sentences in silent reading. If this prediction regarding silent reading is confirmed, this will reinforce the existing evidence indicating that the effect of *od* on attachment in silent reading is mediated by the implicit prosody projected by the reader (rather than being caused by some possible syntactic, semantic or pragmatic property of *od*).⁸⁵

Both experiments involving spoken language in this dissertation employed reading tasks: in Experiment 4, subjects read the stimulus sentences; in Experiment 5, a native speaker's read utterances were recorded and used as stimuli in a comprehension questionnaire. This was appropriate since the experiments whose data we set out to explain (Experiments 1-3) also employed reading tasks. However, using reading in

⁸⁵ Intuitions also suggest that a prosodic break right before the RC may be less likely in (3) than in (2). Though less dramatic than the prediction concerning *od*, this too seems worth investigating.

production/comprehension studies of spoken language may attract criticism on the grounds that it lacks the spontaneity of typical conversation (Schafer et al., 2000). This is why it would be interesting to examine whether similar effects to those observed here are also found in spontaneous speech. The RC-attachment construction is, however, not an easy one to elicit. The elicitation protocol proposed by Bradley et al. (2003), in which subjects create a complex sentence containing N1-of-N2-RC by combining two simple sentences, may be a step in the right direction.

In addition to more studies on Croatian, future research should also investigate phrasing patterns in overt prosody, and their relation to known attachment preferences in silent reading, not only in other languages but also in a wider range of different constructions within the same language, e.g., comparing N1-*with*-N2-RC and N1-*of*-N2-RC in English (and the corresponding constructions in other languages), and contrasting RC-attachment and PP-attachment for length-matched attachées. This would subject to empirical test some of the intuitions discussed in Section 4.2, e.g., that the observed differences in attachment preferences between the construction with *with* and the construction with *of*, and between RCs and PPs, may be attributable to differences in the constructions' prosodic phrasing (rather than to the fact that *with* is thematic and *of* is not, and the fact that RCs are introduced by an anaphor whereas PPs are not).⁸⁶

⁸⁶ Within Croatian, a test involving contrasts between no preposition, non-thematic *od, s/sa* ('with') and thematic *od* would be particularly interesting. A manipulation of this kind would show to what extent the phenomena discussed here are only facts about non-thematic *od*, to what extent they are facts about *od* (whether thematic or non-thematic), and to what extent they are facts about Croatian PPs in general. As indicated in Section 4.2, this line of inquiry may lead to conclusions with wider theoretical implications concerning alignment principles between major prosodic phrase boundaries and syntactic XP boundaries, the key question being: Is it standard for both left- and right-edge alignment to occur in the same language?

Since differences in RC-attachment preferences have also been observed at the level of individual subjects (e.g., Brysbaert & Mitchell, 1996), it would be interesting to use these individual differences in a test of the IPH, by establishing a set of criteria for sorting subjects according to how robustly they project prosody in silent reading (Fodor 2002). Individual subjects who robustly project inner prosody should show strong prosody-induced effects in parsing; those who do not, should be largely insensitive to these effects. Sensitivity to explicit prosody (e.g., as established on the basis of a listening test similar to Experiment 5) may be a good criterion to use for classifying people as ‘prosodics’ and ‘non-prosodics’.

Finally, a few thoughts on how the IPH can be falsified. It would be interesting to undertake research in which implicit prosody is blocked, e.g., by testing the RC-attachment preferences of people who are clinically insensitive to prosody (if it is possible to identify aphasics with insensitivity to prosody and no other symptoms), or by testing the attachment preferences of subjects placed in conditions where they cannot be sensitive to prosody (e.g., by employing the technique used by Slowiaczek & Clifton, 1980, where subjects spoke nonsense syllables such as *colacolacola...* while reading silently). If effects on attachment similar to those observed here were found in such studies, this would disconfirm the IPH.

APPENDICES

Appendix A: Materials

Appendix A-1: Target Items in Experiment 1

This appendix lists the 16 experimental items used in Experiment 1 (reported in Chapter 6). Each item has a RelPro (*koji*) and Comp (*što*) variant, as illustrated in the first item. Within the 16 items, there are 4 items subsets: items 1-4 with a short RC and no alternative form with unambiguous high attachment, items 5-8 with a short RC and an alternative form, items 9-12 with a long RC and no alternative, and items 13-16 with a long RC and an unambiguous alternative form.

In all 16 items, N1, N2 and the relative pronoun agreed in gender and number. The first item contains the whole paradigm, including the question and two answers; for the remaining items, only the ambiguous target sentence is provided.

1. Željkin brat je jako želio prisustvovati probi predstave koja/što počinje.
Zeljka's brother is very-much wanted attend rehearsal show which/that begins
"Zeljka's brother really wanted to attend the rehearsal of the show which/that is beginning"

Što počinje?	predstava	proba
"What is beginning?"	the show	the rehearsal

2. Prešavši ulicu, Suzana je ušla u predvorje svratišta koje se uređuje.
Having crossed street, Suzanne is entered in lobby hostel which self redecorated
"Having crossed the street, Suzanne entered the lobby of the hostel which is being redecorated"
3. Gospodin Kos gledao je okvir akvarela koji propada.
Mister Kos looked is frame watercolor-painting which deteriorates
"Mister Kos was looking at the frame of the watercolor painting which was in bad shape"
4. Nakon sljedećeg pokusa, Tina će ukoriti koordinatore dobrovoljaca koji kasne.
After next rehearsal Tina will reprimand coordinators volunteers who are late
"After the next rehearsal, Tina will reprimand the coordinators of the volunteers who are late"

5. Sef kadrovskog morat će porazgovarati s pomoćnikom računovođe koji odlazi.
Chief of personnel must will speak to assistant accountant who leaves
“The chief of personnel will have to have a word with the assistant of the accountant who is leaving”
6. I nakon što su svi oslobođeni, rečeno nam je da ne intervjuiramo rođaka taoca koji stiže.
Even after that are everybody freed told us is that not interview relative hostage who arrives
“Even after everybody was freed, we were told not to interview the relative of the hostage who is arriving”
7. Ne gledajući kamo ide, Hana je gurnula sekretaricu arhitektice koja mumlja.
Not looking where going Hannah is pushed secretary architect who mumbles
“Not looking where she was going, Hannah pushed the secretary of the architect who mumbles”
8. Tijekom istrage upoznali smo nećaka detektiva koji puši.
During investigation met are nephew detective who smokes
“During the investigation we met the nephew of the detective who smokes”
9. Marija je trebala pročitati kritiku pjesme koja se nalazi na zadnjoj stranici knjige.
Mary is should read review poem which self finds on last page book
“Mary was supposed to read the review of the poem which was printed on the last page of the book”
10. Kuhar će baciti u smeće poklopac lonca koji stoji u ormariću kraj vrata.
Cook will throw in trash lid pot which stands in cupboard by door
“The cook will throw in the trash the lid of the pot which is kept in the cupboard by the door”
11. Mornar se popeo na jarbol broda koji treba hitne popravke nakon jučerašnje bure.
Sailor self climbed on mast ship which needs urgent repairs after yesterday’s storm
“The sailor climbed the mast of the ship which needs urgent repairs after yesterday’s storm”
12. Helena je plaćena da se brine o majkama kandidatkinja koje gledaju televiziju u salonu.
Helen is paid that self look after mothers candidates who watch television in parlor
“Helen is paid to look after the mothers of the candidates who are watching TV in the parlor”

13. Novinar je popričao s trenerom tenisača koji se zagonetno smješкао po završetku turnira.
Reporter is chatted with coach tennis-player who self enigmatically smiled after end tournament
“The reporter had a chat with the coach of the tennis-player who was smiling enigmatically after the tournament”
14. Jučer smo večerali s bratom učitelja koji se već dugo bavi sakupljanjem rijetkih leptira.
Yesterday are dined with brother teacher who self already long occupy collecting rare butterflies
“Yesterday we had dinner with the brother of the teacher who has for a long time been interested in collecting rare butterflies”
15. Pokušali smo nazvati kćerku političarke koja voli zapjevati u društvu.
Tried are call daughter politician who likes sing in company
“We tried to call the daughter of the politician who likes to sing when in company”
16. Bruno je pozdravio klijenticu odvjetnice koja je čekala u sobi za sastanke.
Bruno is greeted client lawyer who is waited in conference room
“Bruno greeted the client of the lawyer who was waiting in the conference room”

Appendix A-2: Target Items in Experiment 2

Experiment 2 (reported in Chapter 6) used 12 of the 16 experimental items in Experiment 1; the 4 items excluded are items 1, 4, 9 and 12 from Appendix A-1 above. Each item had a prepositional (+*od*) and a non-prepositional (-*od*) variant, as illustrated below in 1. All items had an RC introduced by the complementizer *što*.

1. Tijekom istrage upoznali smo nećaka (od) detektiva što puši.
 During investigation met are nephew (of) detective that smokes
 “During the investigation we met the nephew of the detective that smokes”

Tko puši?	nećak	detektiv
“Who smokes?”	the nephew	the detective

Appendix A-3: Target Items in Experiment 3

This appendix lists the 20 experimental items used in Experiment 3 (reported in Chapter 6). Each item has a short-RC and a long-RC variant, as well as a prepositional (+*od*) and a non-prepositional (–*od*) variant. All items have an RC introduced by the complementizer *što*.

The first item contains the whole paradigm, including the question and two answers; for the remaining items, only the ambiguous target sentence is provided.

1. Vidjeli smo prijatelje (od) arhitekata što plaču (kao kišna godina).
Saw are friends (of) architects that cry (like rainy year)
“We saw the friends of the architects that are crying (like a rainy year)”

Tko place? prijatelji arhitekti
“Who is crying?” the friends the architects
2. Nazvali smo klijenticu (od) odvjetnice što puši (paket cigareta dnevno).
Phoned are client (of) lawyer that smokes (pack cigarettes daily)
“We phoned the client of the lawyer that smokes (a pack of cigarettes a day)”
3. Upoznali smo kćerku (od) učiteljice što odlazi (na kraći put u inozemstvo).
Met are daughter (of) teacher that leaves (on short trip in abroad)
“We met the daughter of the teacher that is leaving (on a short trip abroad)”
4. Opisali smo majku (od) agenta što stiže (popodnevim avionom u Zagreb).
Described are mother (of) agent that arrives (afternoon plane in Zagreb)
“We described the mother of the agent that is arriving (in Zagreb on the afternoon flight)”
5. Pozdravili smo nećaka (od) detektiva što pije (čaj s limunom).
Greeted are nephew (of) detective that drinks (tea with lemon)
We greeted the nephew of the detective that drinks (tea with lemon)”
6. Susreli smo susjedu (od) glumice što putuje (na more za dan-dva).
Met are neighbor (of) actress that travels (on sea in day-two)
“We met the neighbor of the actress that is traveling (to the seaside in a day or two)”
7. Pozvali smo trenera (od) tenisačice što pjeva/ voli pjevati u društvu.
Called are coach (of) tennis-player that sings/likes sing in company
“We called the coach of the tennis-player that sings/likes to sing when in company”

8. Zapazili smo sekretaricu (od) računovodje što pliva (svaki dan prije posla).
Noticed are secretary (of) accountant that swims (every day before work)
“We noticed the secretary of the accountant that swims (every day before work)”
9. Promatrali smo tetu (od) kritičarke što mumlja (kao lik iz crtića).
Observed are aunt (of) critic that mumbles (like character from cartoons)
“We observed the aunt of the critic that mumbles (like a cartoon character)”
10. Pazili smo na sinove (od) delegata što jedu (voćnu salatu).
Looked-after are sons (of) delegates that eat (fruit salad)
“We looked after the sons of the delegates that were eating (fruit salad)”
11. Vidjeli smo brata (od) liječnice što muca/ ponekad muca od uzbuđenja.
Saw are brother (of) doctor that stutters/sometimes stutters from excitement
“We saw the brother of the doctor that stutters/sometimes stutters when excited”
12. Nazvali smo pomoćnicu (od) rukovoditelja što pati (zbog razvoda braka).
Phoned are aid (of) manager that suffers (because divorce marriage)
“We phoned the aid of the manager that is suffering (because of his/her divorce)”
13. Upoznali smo prevoditelja (od) veleposlanika što vježba (u novootvorenoj teretani).
Met are translator (of) ambassador that exercises (in newly-opened gym)
“We met the translator of the ambassador that works out (in the newly-opened gym)”
14. Opisali smo bratića (od) rukometaša što studira (na Odsjeku za arheologiju).
Described are cousin (of) handball-player that studies (on Department of archeology)
“We described the cousin of the handball-player that is a student (in the Department of Archeology)”
15. Pozdravili smo tjelohranitelja (od) političara što traća (kad god stigne).
Greeted are bodyguard (of) politician that gossips (when ever he-gets-a-chance)
“We greeted the bodyguard of the politician that gossips (whenever he gets a chance)”
16. Susreli smo sestru (od) novinara što sklada (u slobodno vrijeme).
Met are sister (of) journalist that composes (in free time)
“We met the sister of the journalist who composes music (in his free time)”

17. Pozvali smo oca (od) klizačice što se smješka (prije svakog natjecanja).
Called are father (of) skater that self smiles (before every competition)
“We called the father of the skater that is smiling/smiles before every competition”
18. Zapazili smo partnera (od) businessmana što kocka (u kasinima Monte Carla).
Noticed are partner (of) businessman that gambles (in casinos Monte Carlo)
“We noticed the partner of the businessman that gambles (in the casinos of Monte Carlo)”
19. Promatrali smo suparnicu (od) glasnogovornice što se odmara (nakon dugog puta).
Observed are opponent (of) spokeswoman that self rests (after long journey)
“We observed the opponent of the spokeswoman that was resting (after a long journey)”
20. Pazili smo na kolegice (od) kandidatkinja što uče (za državni ispit).
Looked-after colleagues (of) candidates that study (for state exam)
“We looked after the colleagues of the candidates that were studying (for the state exam)”

Appendix A-4: Target Items in Experiment 4

This appendix lists the four experimental items used in Experiment 4 (reported in Chapter 7). Each item has a short-RC and a long-RC variant, as well as a prepositional (+*od*) and a non-prepositional (–*od*) variant. Each item also has a high-attachment and a low-attachment variant, as illustrated in item 1; for items 2-4, only the high-attachment variant is provided. All items have an RC introduced by the complementizer *što*.

1. High-Attachment: Vidjeli smo prijatelje (od) arhitekta što plaču (kao kišna godina).
Saw are friends (of) architect that cry (like rainy year)
“We saw the friends of the architect that are crying (like a rainy year)”

- Low-Attachment: Vidjeli smo prijatelje (od) arhitekta što plače (kao kišna godina).
Saw are friends (of) architect that cries (like rainy year)
“We saw the friends of the architect that is crying (like a rainy year)”

2. Nazvali smo klijenticu (od) odvjetnica što puši (paket cigareta dnevno).
Phoned are client (of) lawyers that smokes (pack cigarettes daily)
“We phoned the client of the lawyers that smokes (a pack of cigarettes a day)”

3. Upoznali smo kćerke (od) učiteljice što odlaze (na kraći put u inozemstvo).
Met are daughters (of) teacher that leave (on short trip in abroad)
“We met the daughters of the teacher that are leaving (on a short trip abroad)”

4. Opisali smo majku (od) agenata što stiže (popodnevnim avionom u Zagreb).
Described are mother (of) agents that arrives (afternoon plane in Zagreb)
“We described the mother of the agents that is arriving (in Zagreb on the afternoon flight)”

CONTROLS

In addition to the above eight core variants, each basic sentence also has six control variants: a single noun followed by an RC (4 variants: N1/N2 + Short/Long RC, illustrated for item 1 in 1' below), and two nouns followed by an adverbial (or, in the case of item 4, by an indirect object) rather than an RC (2 variants: No Prep/+Prep, provided for all four basic items, in 1''-4'' below).

- 1.' Vidjeli smo prijatelje/arhitekta što plaču/plače (kao kišna godina).
Saw are friends/architect that cry/cries (like rainy year)
“We saw the friends/architect that are/is crying (like a rainy year)”
- 1.” Vidjeli smo prijatelje (od) arhitekta s vremena na vrijeme.
Saw are friends (of) architect from time to time
“We saw the friends of the architect from time to time”
- 2.” Nazvali smo klijenticu (od) odvjetnice jučer prijepodne.
Phoned are client (of) lawyers yesterday morning
“We phoned the client of the lawyer yesterday morning”
- 3.” Upoznali smo kćerke (od) učiteljice prekjučer na tulumu.
Met are daughters (of) teacher day-before-yesterday at party
“We met the daughters of the teacher the day before yesterday at a party”
- 4.” Opisali smo majku (od) agenata istražnom sucu.
Described are mother (of) agents investigation judge
“We described the mother of the agents to the investigation judge”

Appendix A-5: Target Items in Experiment 5

This appendix lists the eight experimental items used in Experiment 5 (reported in Chapter 7). Each item has a prepositional (+*od*) and a non-prepositional (–*od*) variant. Each item also has a Prosody 1 and a Prosody 2 variant, as illustrated in item 1; the slash signs indicate prosodic break positions.

The first item contains the whole paradigm, including the question and two answers; for the remaining items, only the syntactically ambiguous target sentence is provided.

1. Prosody 1: Vidjeli smo prijatelje/ (od) arhitekata što plaču od sreće.
 Saw are friends (of) architects that cry from joy
 “We saw the friends/ of the architects that are crying for joy”
 Prosody 2: Vidjeli smo prijatelje (od) arhitekata/ što plaču od sreće.
 Saw are friends (of) architects that cry from joy
 “We saw the friends of the architects/ that are crying for joy”
 Tko plače od sreće? prijatelji arhitekti
 “Who is crying for joy?” the friends the architects
2. Nazvali smo klijenticu (od) odvjetnice što puši cigare.
 Phoned are client (of) lawyer that smokes cigars
 “We phoned the client of the lawyer that smokes cigars
3. Upoznali smo kćerku (od) učiteljice što odlazi na put.
 Met are daughter (of) teacher that leaves on trip
 “We met the daughter of the teacher that is leaving on a trip”
4. Opisali smo majku (od) agenta što stiže iz inozemstva.
 Described are mother (of) agent that arrives from abroad
 “We described the mother of the agent that is arriving from abroad”
5. Pozdravili smo nećaka (od) detektiva što pije samo čaj.
 Greeted are nephew (of) detective that drinks only tea
 “We greeted the nephew of the detective that only drinks tea”
6. Susreli smo susjedu (od) glumice što putuje na more.
 Met are neighbor (of) actress that travels on sea
 “We met the neighbor of the actress that is traveling to the seaside”
7. Pozvali smo trenera (od) tenisačice što pjeva u društvu.
 Called are coach (of) tennis-player that sings in company
 “We called the coach of the tennis-player that sings when in company”

8. Zapazili smo sekretaricu (od) računovodje što pliva svaki dan.
Noticed are secretary (of) accountant that swims every day
“We noticed the secretary of the accountant that swims every day”

Appendix A-6: Fillers in Experiments 1, 2, 3, 4 and 5

This appendix lists the filler items used in the experiments reported in Chapters 6 and 7.

PRACTICE FILLERS

Items 1-3 were used in Experiments 1-3 at the beginning of the experimental task; these items were not counted towards subjects' score on fillers. Items 1-3 were also used in Experiment 4, where subjects only read the declarative sentence, but not the question. Items 4 and 5 were used in Experiment 5; they were recorded by the author, and subjects listened to them at the beginning of the experimental task; the slash signs indicate prosodic break positions.

1. Susjedov pas laje na našu mačku i grize poštara.
 "The neighbor's dog barks at our cat and bites the mailman"

Tko grize poštara?	pas	mačka
"Who bites the mailman?"	the dog	the cat

2. Gusar je bio sakrio svoje blago u špilju na otoku, a kartu je bio stavio u potpalublje gusarskog broda.
 "The pirate had hidden his treasure in the cave on the island, and put the map in the hull of his pirate ship"

Gdje je bila karta?	na otoku	na brodu
"Where was the map?"	on the island	on the ship

3. Ivan je nazvao prijatelje s kojima igra tenis kako bi im rekao da je uganuo gležanj.
 "John called the friends he plays tennis with to tell them he had sprained his ankle"

Tko je nazvao?	Ivan	Ivanovi prijatelji
"Who called?"	John	John's friends

4. Fotografirali smo muškarca/ i ženu pokraj mosta.
 "We photographed the man/ and the woman by the bridge"

Koliko smo fotografija napravili?	jednu	dvije
"How many photos did we take?"	one	two

5. Popričali smo s našim asistentom i fotografom/ Denisom Jurićem.
 "We chatted with our assistant and photographer/ Denis Jurić"

S koliko smo osoba popričali?	jednom	dvije
"How many people did we chat with?"	one	two

FILLERS PROPER

Items 1-36 were used in Experiments 1 and 2. All 50 items were used in Experiment 3.

1. Poznati se povjesničar pravio da ne vidi ljude što su zaspali za vrijeme njegovog dugog govora.
 "The eminent historian pretended not to notice the people who had fallen asleep during his long speech"
 Tko je zaspao za vrijeme govora? povjesničar publika
 "Who fell asleep during the speech?" the historian the public
2. Stanari su inzistirali da im kućevlasnik plati odštetu za njihov klavir koji je oštećen prilikom poplave u podrumu.
 "The tenants insisted that the landlord pay them for their piano which was damaged in the flood"
 Tko je bio vlasnik klavira? stanari kućevlasnik
 "Who owned the piano?" the tenants the landlord
3. Krešo je Ireni poslao razglednicu iz Rima.
 "Kreso sent Irene a postcard from Rome"
 Tko je primio razglednicu? Krešo Irena
 "Who received a postcard?" Kreso Irene
4. Dirigent je zamolio violinista koji je sjedio do klavira da ugodi svoj instrument.
 "The conductor asked the violinist next to the piano to tune his instrument"
 Koji instrument nije bio ugođen? violina klavir
 Which instrument was out of tune? the violin the piano
5. Ranko Vukas je objasnio da će Goran doći na prijem sa Sandrom.
 "Ranko Vukas explained that Goran was coming to the reception with Sandra"
 Tko će pratiti Sandru na prijem? Ranko Goran
 "Who was coming to the reception with Sandra?" Ranko Goran
6. Košara je sadržavala četiri svježa jaja, jednog fazana i dvije domaće pite od mesa.
 "The basket contained four fresh eggs, one pheasant and two home-made meat pies"
 Koliko je jaja bilo u košari? četiri dva
 "How many eggs were there in the basket?" four two

13. Kuća u kojoj Nina živi ima fasadu od cigli i drvena vrata.
 “The house Nina lives in has a brick façade and a wood door”
 Od čega su načinjena vrata Ninine kuće? cigle drva
 “What is the door on Nina’s house made of?” brick wood
14. Edo je pozvao Zvonkovog šefa da sutra dođe na večeru.
 “Edo invited Zvonko’s boss to come to dinner tomorrow”
 Tko je pozvan na večeru? šef Zvonko
 “Who was invited to dinner?” the boss Zvonko
15. Obojica carinskih službenika na aerodromu vrlo su sumnjičavi prema vlasniku kofera koji šepa.
 “Both customs officers at the airport are very suspicious toward the owner of the suitcase that has a limp”
 Koliko je ljudi sumnjičavo? jedan dva
 “How many people are suspicious?” one two
16. Taj starac nikad nije pričao priče svojoj djeci, a sada svojim unucima svaku večer ispriča jednu bajku.
 “That old man never used to tell stories to his children, and now he tells a fairytale to his grandchildren every night”
 Kome starac priča bajke? svojim unucima svojoj djeci
 “Who does the old man tell fairytales to?”
 his grandchildren his children
17. Turist je fotografirao staricu i magarca pokraj mosta.
 “The tourist took a photo of the old woman and the donkey by the bridge”
 Tko je fotografirao magarca? starica turist
 “Who took photos of the donkey?” the old woman the tourist
18. Dok uči, Kristina nikad ne sluša radio, ali kad čita romane, voli slušati klavirsku glazbu.
 “While she’s studying, Christine never listens to the radio, but when she’s reading novels, she likes listening to piano music”
 Da li Kristina sluša glazbu dok uči? nikad uvijek
 “Does Christine listen to music while she’s studying?” never always

19. Sudac je zatražio od sudskog službenika da ponovi iskaz svjedoka koji je lagao.
 “The judge asked the court clerk to repeat the testimony of the witness who had lied”
- Tko je zatražio da čuje iskaz? službenik sudac
 “Who asked to hear the testimony?” the clerk the judge
20. Pacijent se bojao ispričati svom psihijatru noćnu moru što ju je imao noć ranije.
 “The patient was afraid to tell his psychiatrist the nightmare he had had the night before”
- Tko je imao noćnu moru? pacijent psihijatar
 “Who had a nightmare?” the patient the psychiatrist
21. Ministar vanjskih poslova je imao prevoditelja koji savršeno vlada estonskim.
 “The Foreign Minister had a translator who was fluent in Estonian”
- Tko vlada estonskim? Ministar prevoditelj
 “Who is fluent in Estonian?” the Minister the translator
22. Zubar je rekao da je njegova sestra prije radila u misiji u Senegalu.
 “The dentist said his sister had previously worked in a mission in Senegal”
- Tko je radio u Senegalu? sestra zubar
 “Who worked in Senegal?” the sister the dentist
23. Sve natjecateljice su bile blatne i iscrpljene, ali liječnik se pobrinuo samo za pobjednicu utrke koja je kolabirala.
 “All the contestants were muddy and exhausted but the doctor only took care of the winner of the race who had collapsed”
- Tko je kolabirao? liječnik pobjednica
 “Who had collapsed?” the doctor the winner
24. Prodavač nije uspio uvjeriti kupca da kupi novu hi-fi liniju.
 “The salesman couldn’t persuade the buyer to buy a new stereo”
- Tko je smatrao da je nova linija dobra ideja? prodavač kupac
 “Who thought a new stereo was a good idea?” the salesman the buyer
25. Tigar je zaskočio antilopu dok su lešinari kružili po nebu.
 “The tiger pounced on the antelope while the vultures circled in the sky”
- Što je tigar ulovio? lešinara antilopu
 “What did the tiger catch?” a vulture an antelope

26. Dokumentarni je film smeo predavača koji ga je prikazao svojim studentima u razredu.
 “The documentary embarrassed the lecturer who showed it to his students in the classroom”
- Što je smelo predavača? film studenti
 “What embarrassed the lecturer?” the documentary the students
27. Ivica se nije mogao sjetiti riječi pjesama koje je sopranistica izvela na koncertu.
 “Johnny couldn’t remember the words of the songs that the soprano had performed at the concert”
- Što je Ivica zaboravio? pjesme riječi
 “What did Johnny forget?” the songs the words
28. Anita je nova, ali ostale sestre rade u ovoj bolnici više od deset godina.
 “Anita is new but the other nurses have worked in this hospital for over ten years”
- Koliko dugo Anita radi u bolnici? ne dugo deset godina
 “How long has Anita worked in the hospital?” not long ten years
29. Svilene rukavice što ih je glumica kupila u utorak slagale su se s njezinim šeširom.
 “The silk gloves that the actress bought Tuesday matched her hat”
- Što je glumica kupila u utorak? šešir rukavice
 “What did the actress buy Tuesday?” a hat gloves
30. Kad se magla digla, jutro je bilo tako vedro da se vidjelo svako drvo na dalekoj obali rijeke.
 “When the fog lifted, the morning was so bright that you could see every single tree on the distant river bank”
- Kakvo je bilo jutro? vedro maglovito
 “What was the morning like?” bright foggy
31. Vlasnik butika se prepirao s dizajnerom prstena koji je tražio više novaca.
 “The boutique owner was arguing with the designer who was asking for more money”
- Tko je tražio više novaca? vlasnik butika dizajner
 “Who was asking for more money?” the boutique owner the designer

32. Nakon što se skrene lijevo na semaforu, do sirotišta se dođe nakon oko kilometar i pol poslije crkve.
 “After turning left at the traffic light, one gets to the orphanage about a kilometer and a half after the church”
- Što je dalje? sirotište crkva
 “What is further?” the orphanage the church
33. Tost sa sirom i šunkom je naša omiljena užina za prohladnih večeri.
 “Toast with cheese and ham is our favorite snack on cold evenings”
- Što je naša omiljena užina? šunka tost
 “What is our favorite snack?” ham toast
34. Iako su prozori bili prljavi, a dimnjak nije radio, kućica je bila topla i udobna.
 “Although the windows were dirty and the chimney was out of order, the cottage was warm and comfortable”
- Što je bilo prljavo? prozori dimnjak
 “What was dirty?” the windows the chimney
35. Gotovo svi posjetitelji na izložbi pasa bili su impresionirani nastupom španijela što je pobijedio.
 “Almost all the spectators at the dog show were impressed by the performance of the spaniel that won”
- Koliko je posjetitelja bilo impresionirano? svi većina
 “How many spectators were impressed?” all most
36. Iako Davor obično na posao ide autobusom, danas je morao uzeti taksi.
 “Although Davor usually goes to work by bus, today he had to take a taxi”
- Kako Davor običava ići na posao? autobusom taksijem
 “How does Davor usually go to work?” by bus by taxi
37. Urednik nije objavio Lindino pismo u vezi sa člankom o dolazećoj Olimpijadi.
 “The editor didn’t publish Linda’s letter about the article on the upcoming Olympics”
- Tko je napisao pismo? urednik Linda
 “Who had written a letter?” the editor Linda
38. Nakon što su se okupala, djeca su sjela za večeru.
 “After they had their bath the children sat down to eat dinner”
- Što su djeca prije napravila? okupala se večerala
 “What did the children do first?” bathe eat

39. Služavka vojvotkinje je sjedila na trijemu i čitala knjigu.
 “The maid of the duchess sat in the patio reading a book”
- Tko je čitao knjigu? vojvotkinja služavka
 “Who was reading a book?” the duchess the maid
40. Krojačica je završila prepravke na haljini, ali cipele još nisu bile gotove.
 “The seamstress had finished the alterations on the dress, but the shoes were not ready yet”
- Je li haljina bila gotova? jeste nije
 “Was the dress ready?” yes no
41. Jolanda nije vidjela spasioca kako trči po plaži.
 “Yolanda didn’t see the lifeguard running on the beach”
- Tko je trčao po plaži? spasioc Jolanda
 “Who was running on the beach?” the lifeguard Yolanda
42. Marta je poslala pismo galeriji gdje su bile izložene Filipove slike.
 “Martha sent a letter to the gallery where Philip’s paintings had been shown”
- Čije slike su bile izložene u galeriji? Filipove Martine
 “Whose paintings were shown in the gallery?” Philip’s Martha’s
43. Menadžer je zamolio žene koje su radile cijeli dan da uzmu pauzu.
 “The manager asked the women who had been working all day to take a break”
- Tko je trebao na pauzu? menadžer žene
 “Who was supposed to take a break?” the manager the women
44. Sekretarica je poslala kurijera na aerodrom da pokupi paket.
 “The secretary sent a messenger to the airport to pick up the package”
- Tko će pokupiti paket? kurijer sekretarica
 “Who was going to pick up the package?” the messenger the secretary
45. Jedini način da se izađe iz zgrade je bio stepenicama jer je lift bio pokvaren.
 “The only way to exit the building was by the stairs because the elevator was not working”
- Kako se moglo izaći iz zgrade? liftom stepenicama
 “How could one exit the building?” on the elevator by the stairs

46. Saksofonistu se nije svidjela pjesma koju je napisao pjevač grupe.
 “The saxophonist didn’t like the song that the singer in the band wrote”
- | | | |
|------------------------|------------|-----------------|
| Tko je napisao pjesmu? | pjevač | saksofonist |
| “Who wrote the song?” | the singer | the saxophonist |
47. Djeca su stavila svoje rukavice u ladicu, a svoje kapute u ormar.
 “The kids put their gloves in the drawer and their coats in the closet”
- | | | |
|--|----------------|--------------|
| Što su djeca stavila u ormar? | svoje rukavice | svoje kapute |
| “What did the kids put in the closet?” | their gloves | their coats |
48. Knjižničar je dozvoljavao studentima da posude samo jedan po jedan tom enciklopedije.
 “The librarian would let the students take out only one volume of the encyclopedia at a time”
- | | | |
|--|----|-----|
| Jesu li studenti mogli posuditi dva toma enciklopedije? | ne | da |
| “Were the students allowed to take out two volumes of the encyclopedia?” | no | yes |
49. Tužitelj je dokazao da je branitelj ubio mehaničara.
 “The prosecutor proved that the defendant murdered the mechanic”
- | | | |
|------------------------------|----------------|---------------|
| Tko je ubio mehaničara? | tužitelj | branitelj |
| “Who murdered the mechanic?” | the prosecutor | the defendant |
50. Ivanova žena je objasnila svom svekru kako je pala u supermarketu.
 “John’s wife explained to her father-in-law how she fell at the supermarket”
- | | | |
|--------------------------------|----------|-------------------|
| Tko je pao u supermarketu? | žena | svekar |
| “Who fell at the supermarket?” | the wife | the father-in-law |

Appendix B: Instructions for the Experimental Tasks

Appendix B-1: Instructions for the off-line questionnaires (Experiments 1-3)

Croatian

UPUTE ISPITANIKU

U ovom uvezu naći ćete rečenice koje trebate pročitati, po jednu rečenicu na svakoj stranici. Za svaku rečenicu molimo Vas da:

- PRVO:** Pročitajte rečenicu u sebi, kako biste ju razumjeli.
- ZATIM:** Pročitajte rečenicu naglas, u mikrofon. Govorite prirodno, ali razgovjetno.
- NAPOSLIJETKU:** Okrenete stranicu. Vidjet ćete pitanje o značenju rečenice koju ste upravo pročitali i dva odgovora. Pitanje pročitajte u sebi. Zatim izaberite odgovor koji Vam se čini logičnim i izgovorite ga naglas u mikrofon.

PRODJITE REČENICE JEDNU PO JEDNU. NE VRAĆAJTE SE NA PRETHODNU STRANICU. NE PRESKAČITE REČENICE – ODGOVORITE NA PITANJE O SVAKOJ REČENICI.

Cijeli eksperiment traje ispod 35 minuta.

REČENICE ZA VJEŽBU: Prije samog eksperimenta, dobit ćete tri rečenice za vježbu, nakon kojih možete pitati istraživača sve što Vas zanima ili Vam nije jasno o samom postupku.

Kad eksperiment počne, najbolje bi bilo da ga prodjete do kraja bez prekidanja.

Opustite se i pokušajte se zabaviti. Ovo nije test. Eksperiment nije težak, a odgovori se ne boduju kao točni ili netočni.

Ono što nas zanima su Vaše intuicije o značenju rečenica koje ćete vidjeti. Najbolje bi bilo da čitate prirodno, brzinom koja Vama najbolje odgovara, i da odgovorite na pitanja spontano, bez previše razmišljanja.

Počnite sada s rečenicama za vježbu. Zaustavite se kada dodjete do žute stranice.

English translation

INSTRUCTIONS TO SUBJECTS

In this folder you will find sentences to read. Each one will be typed on a separate page. For each sentence, please:

- FIRST: Read the sentence silently to yourself, so that you understand it.
- THEN: Read the sentence aloud, into the microphone. Speak naturally, but clearly.
- FINALLY: Turn the page. You will see a question about the meaning of the sentence, with two answers. Read the question silently. Then select the answer that seems logical to you and say it into the microphone.

GO THROUGH THE FOLDER ONE SENTENCE AT A TIME. DO NOT GO BACK TO THE PREVIOUS PAGE. DO NOT SKIP SENTENCES – MAKE A CHOICE FOR EVERY SENTENCE.

The whole task takes no more than 35 minutes.

PRACTICE SESSION: Before the experiment begins, there will be three sentences for you to practice on. After trying out these sentences, you may ask the experimenter any questions you have about the procedure.

Once the experiment begins, it is best to go through it without interruption.

Relax and try to enjoy yourself. This is not a test.
The experiment isn't difficult, and we don't score answers as right or wrong .

We are interested in your intuitions about what the sentences mean. It will help us best if you read naturally, at whatever is your comfortable pace, and answer the questions spontaneously without thinking too long or hard.

You may begin the practice session now. Stop when you get to the yellow page.

Appendix B-2: Instructions for the reading-aloud experiment (Experiment 4)

Croatian

UPUTE ISPITANIKU

U ovom uvezu naći ćete rečenice koje trebate pročitati, po jednu rečenicu na svakoj stranici.

Vidjet ćete nekoliko verzija svake rečenice, ali svaka verzija će biti nešto drugačija od svih ostalih. Za svaku rečenicu molimo Vas da:

PRVO: Pročitajte rečenicu u sebi, kako biste ju razumjeli.

ZATIM: Pročitajte rečenicu naglas, u mikrofon. Govorite prirodno, ali razgovjetno.

(Ukoliko niste zadovoljni sa svojim čitanjem, možete rečenicu pročitati ponovno.)

PRODJITE REČENICE JEDNU PO JEDNU. NE VRAĆAJTE SE NA PRETHODNU STRANICU.

Cijeli eksperiment traje ispod 25 minuta.

REČENICE ZA VJEŽBU: Prije samog eksperimenta, dobit ćete tri rečenice za vježbu, nakon kojih možete pitati istraživača sve što Vas zanima ili Vam nije jasno o samom postupku.

Kad eksperiment počne, najbolje bi bilo da ga prodjete do kraja bez prekidanja.

Opustite se i pokušajte se zabaviti. Ovo nije test.
Eksperiment nije težak.

Najbolje bi bilo da čitajte prirodno, brzinom koja Vama najbolje odgovara.

Počnite sada s rečenicama za vježbu. Zaustavite se kada dodjete do žute stranice.

English translation

INSTRUCTIONS TO SUBJECTS

In this folder you will find sentences to read. Each one will be typed on a separate page.

You will see several versions of each sentence, but each version will be slightly different from all others. For each sentence, please:

FIRST: Read the sentence silently to yourself, so that you understand it.

THEN: Read the sentence aloud, into the microphone. Speak naturally, but clearly.

(If you are not satisfied with your reading, you may re-read the sentence.)

GO THROUGH THE FOLDER ONE SENTENCE AT A TIME. DO NOT GO BACK TO THE PREVIOUS PAGE.

The whole task takes no more than 25 minutes.

PRACTICE SESSION: Before the experiment begins, there will be three sentences for you to practice on. After trying out these sentences, you may ask the experimenter any questions you have about the procedure.

Once the experiment begins, it is best to go through it without interruption.

Relax and try to enjoy yourself. This is not a test.
The experiment isn't difficult.

It will help us best if you read naturally, at whatever is your comfortable pace.

You may begin the practice session now. Stop when you get to the yellow page.

Appendix B-3: Instructions for the auditory questionnaire (Experiment 5)

Croatian

UPUTE ISPITANIKU

U ovom audio uvezu naći ćete rečenice koje trebate poslušati, po jednu rečenicu u svakom file-u.

Svaku ćete rečenicu čuti u nekoliko verzija, ali svaka verzija će biti nešto drugačija od svih ostalih. Za svaku rečenicu molimo Vas da:

- PRVO: Poslušate rečenicu (jednom, ili dvaput, ako želite).
- ZATIM: Okrenete stranicu u uvezu ispred sebe. Vidjet ćete pitanje o značenju rečenice koju ste upravo čuli i dva odgovora. Pitanje pročitajte u sebi. Zatim izaberite odgovor koji Vam se čini da odgovara značenju koje je govornik želio prenijeti, i izgovorite ga naglas.

PRODJITE REČENICE JEDNU PO JEDNU. NE VRAĆAJTE SE NA PRETHODNU REČENICU. NE PRESKAČITE REČENICE - ODGOVORITE NA PITANJE O SVAKOJ REČENICI.

Cijeli eksperiment traje ispod 45 minuta.

REČENICE ZA VJEŽBU: Prije samog eksperimenta, dobit ćete dvije rečenice za vježbu, nakon kojih možete pitati istraživača sve što Vas zanima ili Vam nije jasno o samom postupku.

Kad eksperiment počne, najbolje bi bilo da ga prodjete do kraja bez prekidanja.

Opustite se i pokušajte se zabaviti. Ovo nije test.
Eksperiment nije težak, a odgovori se ne boduju kao točni ili netočni.

Ono što nas zanima je Vaša percepcija rečenica koje ćete čuti.

Počnite sada s rečenicama za vježbu.

English translation

INSTRUCTIONS TO SUBJECTS

In this audio folder you will find sentences to listen to. Each one will be saved in a separate file.

You will hear several versions of each sentence, but each version will be slightly different from all others. For each sentence, please:

FIRST: Listen to the sentence (once, or twice, if you wish).

THEN: Turn the page in the folder provided. You will see a question about the meaning of the sentence you have just heard, with two answers. Read the question silently. Then select the answer that corresponds to the meaning you think that the speaker most likely had in mind, and say it aloud.

GO THROUGH THE SENTENCES ONE AT A TIME. DO NOT GO BACK TO THE PREVIOUS SENTENCE. DO NOT SKIP SENTENCES - MAKE A CHOICE FOR EVERY SENTENCE.

The whole task takes no more than 45 minutes.

PRACTICE SESSION: Before the experiment begins, there will be two sentences for you to practice on. After trying out these sentences, you may ask the experimenter any questions you have about the procedure

Once the experiment begins, it is best to go through it without interruption.

Relax and try to enjoy yourself. This is not a test.

The experiment isn't difficult, and we don't score answers as right or wrong .

We are interested in your perception of the sentences.

You may begin the practice session now.

Appendix C: Summary Tables for Analyses of Variance

The symbols in the rightmost column indicate the significance of the p values, as follows: * = $p < .05$, ** = $p < .01$, *** = $p < .001$. No symbol following the p value indicates $p > .01$.

Appendix C-1: Experiment 1

Percent High Attachment, Written Questionnaire, Item-Based Only

The three factors are:

A: Relativizer (relative pronoun or complementizer)

B: Alternative Form (does or does not exist)

C: RC-Length (short or long)

Item-Based, % High Attachment

SV	SS	df	MSS	F	p
B	.78	1	.78	.04	0.50
C	247.53	1	247.53	12.87	0.005 **
BC	11.28	1	11.28	.59	0.25
S	230.88	12	19.24		
A	.78	1	.78	.13	0.50
AB	7.03	1	7.03	1.19	0.25
AC	.03	1	.03	.01	0.50
ABC	3.78	1	3.78	.64	0.25
S*A	70.88	12	5.91		

Appendix C-2: Experiment 2

Percent High Attachment, Written Questionnaire

The two factors are:

A: Preposition (*od* present or absent)

B: RC-Length (short or long)

Subject-Based, % High Attachment

SV	SS	df	MSS	F	p
A	24.04	1	24.04	6.20	0.025 *
S	193.81	50	3.88		
B	71.12	1	71.12	50.60	0.001 ***
AB	0.62	1	0.62	0.44	0.50
S*B	70.27	50	1.41		

Item-Based, % High Attachment

SV	SS	df	MSS	F	p
B	308.17	1	308.17	11.20	0.01 **
S	275.17	10	27.52		
A	104.17	1	104.17	10.95	0.01 **
AB	2.67	1	2.67	0.28	0.50
S*A	95.17	10	9.52		

Appendix C-3: Experiment 3

Percent High Attachment, Written Questionnaire

The three factors are:

A: Subject/Item Design Groups

B: Preposition (*od* present or absent)

C: RC-Length (short or long)

Subject-Based, % High Attachment

SV	SS	df	MSS	F	p
A	0.22	1	0.22	0.03	
B	67.58	1	67.58	10.52	0.0025 **
AB	0.44	1	0.44	0.07	
S	334.04	52	6.42		
C	110.01	1	110.01	40.27	0.001 ***
AC	1.51	1	1.51	0.55	
BC	0.72	1	0.72	0.26	0.50
ABC	0.22	1	0.22	0.08	
S*C	142.04	52	2.73		

Item-Based, % High Attachment

SV	SS	df	MSS	F	p
A	1.51	1	1.51	.59	
S	45.93	18	2.55		
B	94.61	1	94.61	42.02	0.001 ***
AB	.61	1	.61	.27	
S*B	40.53	18	2.25		
C	154.01	1	154.01	17.70	0.001 ***
AC	.11	1	.11	.01	
S*C	156.63	18	8.70		
BC	1.01	1	1.01	.46	0.50
ABC	.31	1	.31	.14	
S*BC	39.42	18	2.19		

Appendix C-4: Experiment 4

Mean duration of N1 and N2, Reading Aloud, RC Targets, Subject-Based Only

The three factors are:

A: Preposition (*od* present or absent)

B: RC-Length (short or long)

C: RC-Attachment (forced high or low)

Mean N1 Duration

	SV	SS	df	MSS	F	p
	S	214915.5	9	23879.51		
	A	256737.8	1	256737.8	19.88	0.0025 **
	S*A	116219.7	9	12913.30		
	B	5951.25	1	5951.25	1.60	0.25
	S*B	33578.75	9	3730.97		
	AB	540.80	1	540.80	1.93	0.25
	S*AB	2523.70	9	280.41		
	C	2952.45	1	2952.45	1.77	0.25
	S*C	15012.05	9	1668.01		
	AC	2464.20	1	2464.20	1.51	0.50
	S*AC	14704.80	9	1633.87		
	BC	594.05	1	594.05	.26	0.50
	S*BC	20211.45	9	2245.72		
	ABC	9.80	1	9.80	.00	0.50
	SABC	25659.20	9	2851.02		

Mean N2 Duration

	SV	SS	df	MSS	F	p
	S	592591.2	9	65843.47		
	A	32562.45	1	32562.45	12.79	0.01 **
	S*A	22922.05	9	2546.89		
	B	245089.8	1	245089.8	22.30	0.0025 **
	S*B	98895.70	9	10988.41		

AB	10811.25	1	10811.25	3.01	0.25
S*AB	32333.75	9	3592.64		
C	31769.45	1	31769.45	8.05	0.025 *
S*C	35516.55	9	3946.28		
AC	6125.00	1	6125.00	5.21	0.05 *
S*AC	10577.50	9	1175.28		
BC	1496.45	1	1496.45	1.82	0.25
S*BC	7385.05	9	820.56		
ABC	33.80	1	33.80	.03	0.50
SABC	10498.20	9	1166.47		

Independent Analyses of Controls, Subject-Based Only

Adverbial (i.e., N1-(*od*)-N2-ADV), Mean N1 Duration

The one factor is:

A: Preposition (*od* present or absent)

Mean N1 Duration, Adverbial

SV	SS	df	MSS	F	p
S	75876.05	9	8430.67		
A	12054.05	1	12054.05	2.87	0.25
S*A	37858.45	9	4206.49		

Single Noun (i.e., N2-RC), Mean N2 Duration

The one factor is:

A: RC-Length (short or long)

Mean N2 Duration, Single Noun

SV	SS	df	MSS	F	p
S	81115.8	9	9012.87		
A	35955.2	1	35955.2	9.45	0.025 *
S*A	34254.8	9	3806.09		

Appendix C-5: Experiment 5

Percent High Attachment, Auditory Questionnaire

The two factors are:

A: Prosody (Prosody 1 or Prosody 2)

B: Preposition (*od* present or absent)

Subject-Based, % High Attachment

SV	SS	df	MSS	F	p
S	54.94	15	3.66		
A	430.56	1	430.56	114.44	0.001 ***
S*A	56.44	15	3.76		
B	.06	1	.06	.06	0.50
S*B	14.94	15	1.00		
AB	.56	1	.56	.81	0.50
S*AB	10.44	15	.70		

Item-Based, % High Attachment

SV	SS	df	MSS	F	p
S	15.88	7	2.27		
A	861.13	1	861.13	679.20	0.001 ***
S*A	8.88	7	1.27		
B	.13	1	.13	.08	0.50
S*B	10.88	7	1.55		
AB	1.13	1	1.13	.66	0.50
S*AB	11.88	7	1.70		

Independent Analyses of Stimuli

Mean Duration of N1 and N2, Item-Based Only

The two factors are:

A: Prosody (Prosody 1 or Prosody 2)

B: Preposition (*od* present or absent)

Mean N1 Duration, Stimuli

	SV	SS	df	MSS	F	p
S	75872508		7	10838930		
A	70439548		1	70439548	81.12	0.001 ***
S*A	6078720		7	868388.6		
B	516890.3		1	516890.3	0.74	0.50
S*B	4914472		7	702067.5		
AB	109395		1	109395	0.31	0.50
S*AB	2507763		7	358251.8		

Mean N2 Duration, Stimuli

	SV	SS	df	MSS	F	p
S	11229331		7	1604190		
A	50378213		1	50378213	113.65	0.001 ***
S*A	3103018		7	443288.3		
B	20553.78		1	20553.78	0.03	0.50
S*B	5141268		7	734466.9		
AB	17251.53		1	17251.53	0.04	0.50
S*AB	2708162		7	386880.3		

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