Relative Clause Attachment in Bulgarian

Irina A. Sekerina ¹, Eva M. Fernández ²
and Krassimira A. Petrova³

¹ College of Staten Island, City University of New York
² Queens College, City University of New York
³ University of Sofia, Bulgaria

1 Introduction

Over the past 25 years of sentence processing research, hardly any other phenomenon has generated more experimental evidence and theoretical explanations than the apparent violations of Late Closure (Frazier and Fodor 1978) observed with the relative clause attachment ambiguity. Under the Late Closure principle, local attachments are preferred over non-local ones. Accordingly, the structural ambiguity illustrated in (1) should preferentially be resolved in favor of the Late Closure (local-attachment) interpretation. English speakers generally conform to this prediction, preferring an interpretation of the relative clause (RC), who was on the balcony, as a modifier of the second or low noun, actress (N2), despite the fact that the non-local attachment to the first or high noun, servant (N1), is also possible.

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

However, the low attachment preference is far from universal. Speakers of languages other than English prefer the non-local attachment of the RC, thus apparently violating Late Closure.

A substantial body of research on relative clause attachment addresses two important issues. The first has to do with the univer-

¹ Late Closure receives its name from its formulation as a principle about maintaining open and attaching inside a constituent currently being processed; we focus here on Late Closure’s describing the parser's preference for local attachments, elsewhere described as Recency Preference (Gibson et al. 1996) or Right Association (Kimball 1973).
² Henceforth, we will use “N2 attachment” interchangeably with “low attachment” and “local attachment”. Likewise, “N1 attachment”, “high attachment” and “non-local attachment” will be interchangeable.
sality of the preference predicted by Late Closure with respect to this construction. The second issue deals with the consistency of results within a given language: are the same preference patterns obtained when the methodology or the materials are varied?

Late Closure’s universality came under scrutiny very early on and still remains a topic of current investigations (e.g., Hemforth et al. submitted). Late Closure is proposed as a principle reflecting working memory limitations, under the assumption that local attachments are less computationally demanding than non-local ones (Kimball 1973, Frazier and Fodor 1978). This logically leads to the hypothesis that Late Closure, along with other principles employed in the parsing of natural language (e.g., Minimal Attachment, Minimal Chains), must be universal across languages. However, seminal work by Cuetos and Mitchell (1988) questioned the universality of Late Closure. Cuetos and Mitchell demonstrated that while English speakers preferred a relative clause as in (1) to be attached locally (to N2) some 60% of the time, Spanish speakers favored the non-local (N1) attachment some 60% of the time, with translation-equivalent materials in Spanish, like the example in (2).

(2) Juan disparó a la criada de la actriz que estaba en el balcón.

This cross-linguistic difference between English and Spanish has been replicated in a number of experimental investigations (e.g., Fernández 2003), and with a number of languages other than English and Spanish.\footnote{High-attaching languages include Afrikaans and Dutch (Mitchell et al. 2000), Croatian (Lovrić 2003), German (Hemforth et al. submitted), Polish (Nowak 2000), and Russian (Sekerina 2002), among others. Low-attaching languages include Norwegian, Romanian and Swedish (Ehrlich et al. 1999), and Egyptian Arabic (Abdelghany and Fodor 1999).} The two classes of language, high- versus low-attaching, are so heterogeneous that they defy any natural explanation for their different preferences, which are nevertheless fairly consistent. However, while a number of theoretical explanations exist, there is no general consensus yet about a conclusive explanation for the phenomenon. Alternative accounts include the Tuning Hypothesis (Mitchell and Cuetos 1991), the Two-Factor Model (Gibson et al. 1996), Construal (Frazier and Clifton 1996), Attachment-Binding (Hemforth et al. 1998), and the Implicit Pros-
ody Hypothesis (Fodor 1998, 2002). Among these, we will return to the Implicit Prosody Hypothesis later in this discussion.

Language-internal consistency in RC attachment has received relatively less attention in the experimental literature, but it is observed when variation is introduced by either the methodology or the materials. The cross-linguistic differences in attachment that are clearly present with unspeeded questionnaire tasks and have been found with some types of speeded response tasks (especially eye-tracking tasks) are not always replicated with all self-paced reading paradigms (De Vincenzi and Job 1993, Fernández 2003). Language-internal differences have also been examined along various dimensions of the materials. Language-internal effects have been found with manipulations of the host nouns in terms of their referentiality, animacy, frequency, and length (see discussion in Fernández 2003). The position of the complex NP, as subject or object of the matrix clause, has also been investigated (Hemforth et al. submitted), as has the type of relative pronoun (Sauerland and Gibson 1998), and the preposition in the NP (e.g., De Vincenzi and Job 1993).

Let us focus on one particular language-internal effect: RC length reliably shifts preferences, with speakers exhibiting a stronger preference for N1 when an RC is longer (e.g., Fernández 2003; Hemforth et al. submitted). Arguably, this effect is purely prosodic in origin (Bradley et al. 2003), despite the fact that adding prosodic weight to RC also alters the informational content of the sentence (Thornton et al. 2000). The prosodic explanation of RC length effects assumes that the prosody projected implicitly during silent reading can affect syntactic resolutions, in a system where major syntactic breaks preferentially align with major prosodic breaks (Fodor 2002). A long RC is more likely to trigger a pre-RC prosodic break than a short RC (Bradley et al. 2003), this prosodic discontinuity promoting the projection of a syntactic discontinuity that aligns with it: a high attachment.

The present study investigates language-internal consistency in relative clause attachment using a less-studied Slavic language, Bulgarian. Our main objective is to establish the pattern of attachment preference within this language using a standard questionnaire task and a task that was designed to address the problem of the semantic/pragmatic complexity of sentences presented in isolation and without immediate discourse referents. Within this second

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4 Language-internal effects have been found with manipulations of the host nouns in terms of their referentiality, animacy, frequency, and length (see discussion in Fernández 2003). The position of the complex NP, as subject or object of the matrix clause, has also been investigated (Hemforth et al. submitted), as has the type of relative pronoun (Sauerland and Gibson 1998), and the preposition in the NP (e.g., De Vincenzi and Job 1993).
task, we compare findings across two modalities, reading and listening. The modality issue is of significant methodological and theoretical importance, as it addresses the debate in the area of language production and syntactic priming concerning modality-neutral (Cleland and Pickering in preparation) versus modality-specific effects (Rapp and Caramazza 2002). Is the attachment preference involved in language comprehension common to different perceptual modalities within the same language? This concern arises because the overwhelming majority of relative clause attachment studies has used, and continues to use, written sentences as stimuli. In fact, we are not aware of a single study testing identical experimental materials in both written and spoken form. The methodological issue of modality effects has important theoretical implications. Finding the same attachment preference regardless of the perceptual modality would indicate that processing is modality-neutral. On the other hand, if we find that preference patterns within a language vary depending on the perceptual modality—i.e., if written materials elicit an attachment preference different from that elicited by materials presented auditorily—we will have to pursue explanations of RC attachment preferences based on demand for cognitive resources.

Effects of modality, if discovered, should be most dramatic in a language that exhibits a strong high attachment preference in a standard written questionnaire. Our test case is Bulgarian, a language characterized by its lack of case-marking morphology, unusual for a Slavic language. We report the results of three experiments. Experiment 1 employed materials similar to the examples in (1) and (2), only in Bulgarian. In such materials the lexical content has no direct referent in the immediate discourse context, but such combinations of lexical content result in sentences with intrinsic biases for attachment, given the semantic and pragmatic status of the two nouns vis-à-vis the RC. Experiments 2 and 3 employed novel materials designed to avoid the pitfalls brought about by

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5 The trend of using auditory rather than written stimuli is changing, particularly given that a number of recent investigations (e.g., Igoa and Teira 2003, Lovrič 2003, Salillas and Carreiras 2002, Schafer et al. 1996) have examined whether explicit prosody affects attachment preference.
such semantically and pragmatically complex nouns; instead, the materials in these experiments described abstract geometric shapes, and were accompanied with visual contexts. In Experiment 2 the linguistic stimuli were presented in written form, while in Experiment 3 identical linguistic stimuli were presented auditorily.

2 Experiment 1: Written Questionnaire

This experiment establishes the general preferences for relative clause attachment in Bulgarian. Its design follows the standard paper-and-pencil written questionnaire format that has been used previously in a variety of languages. This experiment therefore should identify the status of Bulgarian as a high or low attaching language, while also permitting us to explore two manipulations: relative clause length and word order.

Participants. Seventy-four participants, all native Bulgarian speakers, undergraduates at the University of Sofia, were each pseudo-randomly assigned to one of four versions of the experiment. The participants were naïve with respect to the purpose of the experiment and received the equivalent of $3 for their participation.

Design and Materials. The questionnaire booklets each contained 55 items: 3 practice, 36 filler, and 16 experimental. Each item in the questionnaire consisted of a complete sentence typed on one line, followed by a comprehension question and two potential answers arranged on a second line directly below. All experimental sentences and half of the fillers contained a complex NP with the reposition na ‘of’, modified by a relative clause.

Experimental sentences were constructed by a Bulgarian linguist (K. A. Petrova) to be globally ambiguous, allowing the RC to attach grammatically to either of the two nouns in the complex NP. The complex NP itself was always the direct object of a transitive verb. Six of the complex NPs were inanimate, and eight were animate, with N1 and N2 always matched in gender (relative pronouns in Bulgarian are gender-marked).

The target materials manipulated two factors, both in a within-items design: RC Length (short versus long) and Word Order (canonical versus scrambled); a complete example is provided in (3).
Short RCs consisted of the relative pronoun *kojato* ‘that+FEM’ or *kogoto* ‘that+MASC’ and a one- or two-word predicate (a simple verb or a complex verb with an auxiliary), e.g., *kogoto târseše* ‘that he was looking for’. Long RCs expanded the short RC with an additional two- to four-word phrase, e.g., *cjala sedmica* ‘the entire week’. The word order manipulation contrasted sentences with the object NP (containing the ambiguity) in the canonical position, (3a), and sentences with the object NP in a scrambled (pre-verbal) position, (3b). We expect that longer RCs will be more likely interpreted as attached to N1, as predicted by the Implicit Prosody Hypothesis (Fodor 1998, 2002). The Word Order manipulation is included to test whether changing the information structure via changes in word order has an effect, e.g., the ambiguity in scrambled position may be more likely to be resolved locally.

The question used to probe attachment preference in targets is illustrated in (3c). Binary-choice questions also followed fillers, but unlike the targets they had unambiguously correct answers.

(3) a. *Včera Petâr naj-nakraja sreščna brata na učitelja,*
*kojoto târseše (cjala sedmica).*

b. *Brata na učitelja, kogoto târseše (cjala sedmica),*
*naj-nakraja sreščna včera Petâr.*

‘Yesterday, Peter finally found the brother of the teacher that he was looking for (for the entire week).’

c. *Kogo târseše Petâr? brata učitelja*
*who+ACC looked for Peter? brother teacher*

‘Who was Peter looking for? the brother the teacher’

Four separate lists presented the materials in a fixed pseudo-randomization; presentation of the targets was counterbalanced across the four lists, such that no one subject would see more than one of the four versions of each experimental item.
Procedure. Each of the four lists was presented to a different group of participants in booklet form. Participants were instructed to read each sentence-and-question pair, and to indicate their response by circling one of the two provided answers for each item. Completion of the questionnaire typically took 20 minutes. The responses for the fillers were screened for errors, and two participants with more than 25% errors were rejected and replaced. Participants were highly accurate in responding to filler item questions (99%).

Subject- and item-based means of percent high (N1) attachment were used in the analyses of variance, which included the variables of RC Length (short versus long) and Word Order (canonical versus scrambled); an additional dummy factor (subject and item groups) was included to extract irrelevant variance but will not be reported here.

Results. Table 1 reports mean percent high attachment choices for the globally ambiguous sentences.

<table>
<thead>
<tr>
<th></th>
<th>Scrambled</th>
<th>Canonical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long RC</td>
<td>61.6</td>
<td>63.9</td>
</tr>
<tr>
<td>Short RC</td>
<td>52.4</td>
<td>56.4</td>
</tr>
</tbody>
</table>

The data clearly show a significant main effect of RC Length, with long RCs more likely to be interpreted as attached high (63%) than short RCs (54%), $F_{1}(1,68)=8.83$, $p<0.005$, $F_{2}(1,12)=15.08$, $p<0.005$. This replicates the RC length effect found previously for a different Slavic language, Croatian (Lovrić 2003). This effect has been explained by the Implicit Prosody Hypothesis (Fodor 1998, 2002), according to which, all other things being equal, prosodic phrasing projected during silent reading affects attachment preferences for ambiguous RCs. A long RC can be phrased independently, and it is such phrasing that can encourage high attachment, whereas a short RC is likely to be phrased in the same prosodic
constituent as N2, phrasing which would more likely result in a local attachment.

The data are also clear about the lack of effect of the Word Order manipulation, which failed to reach significance as a main effect, $F_1(1,68)=1.64$, $p>.20$, $F_2<1$, and which did not interact with RC Length, $F_1$, $F_2 < 1$. Resolution of the ambiguity when the complex NP was scrambled did not differ from when the complex NP was in canonical position. Despite the fact that N1 was less salient when it was scrambled, it remained the preferred host for the RC.

Overall, the Bulgarian speakers exhibited a high attachment preference, choosing N1 on average 59% of the time, a grand mean differing significantly from chance (50%), $t_1(71) = 3.69$, $p<.001$, $t_2(15) = 2.00$, $p=.064$. This finding is not surprising since other Slavic languages—Croatian (Lovrić 2003), Polish (Nowak 2000), and Russian (Sekerina 2002)—have also been found to exhibit a high attachment preference.

3 Experiment 2: Auditory Questionnaire with Abstract Shapes

Overall attachment preference within a given language has been found to vary from study to study, which suggests that speakers’ preferences can be shifted around by manipulating the linguistic properties of the materials, as discussed earlier and as shown through the RC length manipulation of Experiment 1. We now consider an additional property, the semantic/pragmatic complexity of the materials used in Experiment 1. Such materials, presented without immediate contextual referents, could conceivably bias the general attachment preference in Bulgarian. In an attempt to avoid this bias, Experiment 2 employs materials that do not depend on imagined context and thus are not semantically/pragmatically complex. Instead of using NPs, like the brother of the teacher, NPs referring to abstract geometric shapes, like the tip of the triangle, were used and presented with corresponding visual contexts. The experiment included globally ambiguous linguistic stimuli that were visually disambiguated or visually ambiguous, with two distinct predictions in mind. First, visually disambiguated items should result in ceiling accuracy, regardless of whether disambiguation is to the high or to the low site. Second,
visually ambiguous items should be preferentially interpreted according to the overall preference for the language: we expect to observe the same high attachment preference found in Experiment 1 with written stimuli in Experiment 2 with auditory stimuli, only perhaps now the preference will be strengthened, given that the visual contexts provide immediate referents for the sentences.

Participants. Twenty-one native Bulgarian speakers from the University of Sofia undergraduate population chose to participate in this experiment. They were naïve with respect to the purpose of the experiment and received the equivalent of $3 for participation.

Design and Materials. The complete materials consisted of 2 practice, 9 experimental, and 10 filler items. Each item included two preamble sentences followed by a comprehension question (a complete example is provided in (4)). The auditory stimuli, produced by a Bulgarian linguist (K. A. Petrova), were synchronized with the visual presentation, which introduced the visual components in their order of occurrence in the audio.

![Figure 1](image.png)

**Figure 1.** Sample visual stimuli used in Experiment 2. In all three pairs, the triangle on the left was yellow and had a green tip, the one on the right was pink and had a light blue tip.

(4) a. Eto edin rozov triâgâlnik i edin žâlt triâgâlnik.  
This one pink triangle and one yellow triangle

b. Vârxovete im sa različno ocveteni.  
The tips them are differently colored

‘This is a pink triangle and a yellow triangle.  
Their tips are different colors.’
c. Kakâv cvjat e vârxât na triâgâlnika, v kojto e narisuvan čadâr?
   ‘What color is the tip of the triangle that has an umbrella in the middle?’

The visual contexts, illustrated in Figure 1, were designed as pairs of identical geometric shapes, which differed only in terms of their features or components (color, texture, contents). For each of the three visual contexts illustrated in Figure 1, there are two large triangles with smaller triangles inside them, outlining the triangles’ top angles (their “tips”). The triangles and the tips differ in color and in type of the embedded object, an umbrella or a sun. The linguistic stimuli were always the same, irrespective of the visual stimuli they were paired with.

In combination with the question in (4c), each picture rendered one of the three experimental conditions: Ambiguous (Figure 1a), where both N1 vârxât ‘tip’ and N2 triâgâlnika ‘triangle’ contained an umbrella; Disambiguated Low (Figure 1b), where the umbrella was inside the triangle (N2) but not inside its tip; and Disambiguated High (Figure 1c), where the umbrella is inside the tip (N1). Thus, attachment was disambiguated (or left ambiguous) by means of the visual contexts, while the questions in the linguistic stimuli remained globally ambiguous.

Three separate lists presented the materials in a fixed pseudo-randomization; presentation of the targets was counterbalanced across the three lists, such that no one subject would see more than one of the three versions of each experimental item.

**Procedure.** Participants were seated in front of a laptop PC computer, which displayed the visual contexts on its screen and played the accompanying acoustic stimuli through external speakers at a loud but comfortable volume. Participants were given written instructions on the screen and were assisted by the experimenter during two practice items. The experimenter remained in the room with the participants throughout the duration of the experiment to record the responses, which participants were instructed to utter out loud. A 16-sec pause between items helped ensure that the ex-
Experiment moved at a pace rapid enough to retain participants’ interest but slow enough to allow them enough time to respond. Completion of the experiment typically took 15 minutes.

Within a given item, each auditory preamble was played automatically and synchronized with the variously-animated presentation of one picture component. For the example above, the first preamble sentence (4a) was played while the two triangles appeared in sequence, the one on the right (pink) followed by the one on the left (yellow). After a 500 msec delay, the second preamble sentence (4b) was played and the tips appeared on the screen, one after the other. All visual components remained on the screen while the question (4c) was played at the offset of the last animation. The participant was thus able to inspect the two alternative visual contexts while answering the questions.

The responses were screened for missing answers and for errors in the fillers, but no participants were rejected on these criteria. For the fillers and visually-disambiguated experimental items, participants’ responses were recorded as correct or incorrect, and for the ambiguous items, as indicating either high (N1) or low (N2) attachment preference. Subject- and item-based means of percent correct (for visually-disambiguated targets) were used in the analyses of variance, which included the variable Disambiguation Type (low versus high) and a dummy variable included to extract irrelevant variance, but which will not be reported here.

**Results.** Table 2 compares participants’ accuracy with fillers and with target items visually disambiguated to low or high attachment. Just like in Experiment 1, participants’ accuracy with fillers was at ceiling. Performance with experimental items visually disambiguated towards low attachment was also close to perfect. That is, participants named the color of the triangle correctly (‘yellow’ for the example in (4) and Figure (1b)) on average 98% of the time. Participants’ accuracy, however, fell dramatically for the experimental items that were visually disambiguated towards high attachment. Instead of the expected response, correctly naming the color of the tip (‘blue’ for the example above), participants named either the color of the triangle itself (‘pink’) or the color of the em-
bedded object 30% on average. When attachment was disambiguated high, the color of the triangle (N2) interferes with naming the color of its tip (N1). In terms of choosing the correct picture, participants behaved with accuracy comparable to that with items disambiguated low (94%), yet they lost track of which component of the picture should be named on almost one third of such trials. The main effect of Disambiguation Type was highly significant, $F_{1}(1,18)=27.90$, $p<0.001$, $F_{2}(1,6)=13.10$, $p<0.01$, with items visually disambiguated towards low attachment producing substantially better accuracy than items visually disambiguated towards high attachment.

Table 2. Experiment 2. Distribution of responses (%) as Correct (both picture and named component), Correct Picture (only), and No Answer, for Experiment 2.

<table>
<thead>
<tr>
<th>Disamb. Low</th>
<th>Disamb. High</th>
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</thead>
<tbody>
<tr>
<td>Correct</td>
<td>98.4</td>
</tr>
<tr>
<td>Correct Picture</td>
<td>1.6</td>
</tr>
<tr>
<td>No Answer</td>
<td>—</td>
</tr>
</tbody>
</table>

Turning now to the ambiguous items, we were surprised to find that the overall attachment preference was for N2, entirely contrary to the high attachment preference of Experiment 1. These participants—sampled from the same population as those who preferred high attachment of the ambiguous RC with the written sentences of Experiment 1 at a rate of 59%—exhibited entirely different overall preferences with the visual ambiguous materials in Experiment 2, choosing high attachment only 37% of the time.

How can we explain this case of the language-internal shift in overall attachment preference? Some existing work (De Vincenzi and Job 1993; Fernández 2003) has argued for a two-stage model for processing RC attachment ambiguities. In the first stage, the universal principle of Late Closure applies in all languages and the RC is initially attached low. This initial decision may be altered by non-syntactic considerations—such as pragmatic principles or prosodic phrasing preferences—made during a second processing stage. The overall preference for low attachment revealed by the
data for Experiment 2 suggests that this procedure taps the early phase of processing where only Late Closure is at play. The visual contexts for the linguistic stimuli employed in Experiment 2 were designed to minimize semantic/pragmatic complexity (since they provided immediate interpretative contexts). Thus, an initial low attachment decision would not be altered on such grounds. What’s puzzling, however, is that prosodic phrasing preferences are not biasing attachment toward N1 in this study. Not only were the RCs of similar length to the long RCs in Experiment 1, but we also note that the questions in Experiment 2 were recorded with a long pause (400 ms, on average) preceding RC. This kind of prosodic structure should have promoted high attachment (Lovrić 2003).

Instead of appealing to post-syntactic processing to explain the language-internal shift in attachment preference in Bulgarian, we may need to turn to the general architecture of human cognition. This explanation appeals to limitations of the human sentence processing mechanism, taking us beyond more constrained views approaching the phenomenon by examining factors inside the language processing mechanism. In addition to various linguistic properties of the stimuli, extralinguistic characteristics of the experimental design could contribute to the processing burden on working memory and cognitive resources.

The idea of a resource-limited processing system is not new; its implications have been investigated in several areas of psycholinguistics such as reading span in adults (Just and Carpenter 1992) and individual differences in spoken language acquisition (Adams and Gathercole 2000). The resource-limited processor will preferentially select the syntactic representation that is more easily computed: the local attachment. What complexity factors, modality, interpretative operations, visual properties, or a combination of those, are responsible for cognitive overload in the relative clause attachment ambiguity remains an open question.

However, before concluding that the effects observed in Experiment 2 are associated with a resource-limited processor, we explore one potential confound. A comparison of the experimental design between Experiments 1 and 2 reveals an additional difference besides the semantic/pragmatic complexity of the types of
NPs used. This additional difference has to do with modality: materials in Experiment 1 were presented to the participants in the written form while in Experiment 2 they were spoken. Recent work in language production has raised the question of modality-neutral versus modality-dependent effects in cross-modal priming (Cleland and Pickering in preparation; McLean et al. 2003). In contrast to Experiment 2’s auditory materials, the written presentation of materials in Experiment 3 should allow enough time for non-syntactic considerations to come into play, those considerations that produced the departure from low attachment in Experiment 1. Experiment 3 puts the modality question to direct empirical test, by presenting the visual contexts used in Experiment 2 with written rather than auditory linguistic stimuli.

4 Experiment 3: Written Questionnaire with Abstract Shapes

Participants. Twenty-one native speakers of Bulgarian who had not previously participated in either Experiment 1 or Experiment 2 took part in the experiment. They were naïve with respect to the purpose of the experiment and received $3 for their participation.

Design, Materials, and Procedure. The design, materials, and procedure (including the procedures for the data analyses) for Experiment 3 were identical to those for Experiment 2, with one critical difference: The linguistic stimuli presented auditorily in Experiment 2 were presented in the written form in Experiment 3. The written preambles and their corresponding questions were synchronized with the presentation of the visual components, appearing on the screen simultaneously with the visual components. Thus, the appearance of the pink triangle in Figure (1a) triggered the display of the first phrase in (4a), ‘This is a pink triangle’. The yellow triangle followed, together with the second phrase, ‘and a yellow triangle’. The second preamble sentence (4b) appeared simultaneously with the appearance of the first of the two tips. Both preamble sentences were displayed above the pictures and remained on the screen throughout the slide presentation. The experimental question (4c) appeared under the pictures after a 2-3 sec delay. Partici-
pants were asked to write down their responses on an answer sheet, before they triggered the display of the following item.

**Results.** Table 3 compares participants’ accuracy with targets disambiguated low and targets disambiguated high, for Experiment 3. (Responses to filler items were 99% accurate.) Accuracy in Experiment 3 is similar to accuracy in Experiment 2, with one exception: the participants were less accurate in naming the color correctly for the experimental items that were visually disambiguated towards low attachment (86%) than for the same items in Experiment 2 (98%). Just like in Experiment 2, responses to experimental items that were visually disambiguated towards high attachment were less accurate than responses to items visually disambiguated low; the main effect of Disambiguation Type was reliable, $F_1(1,18)=5.65$, $p<0.05$, $F_2(1,6)=4.62$, $p=0.068$. Still, the items visually disambiguated towards low attachment produced better accuracy than high attachment unambiguous items.

**Table 3.** Experiment 3. Distribution of responses (%) as Correct (both picture and named component), Correct Picture (only), and No Answer, for Experiment 2.

<table>
<thead>
<tr>
<th></th>
<th>Disamb. Low</th>
<th>Disamb. High</th>
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<tbody>
<tr>
<td>Correct</td>
<td>87.3</td>
<td>74.6</td>
</tr>
<tr>
<td>Correct Picture</td>
<td>12.7</td>
<td>25.4</td>
</tr>
<tr>
<td>No Answer</td>
<td>—</td>
<td>—</td>
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</table>

The overall preference with ambiguous items was again for low attachment, like Experiment 2 but unlike Experiment 1: the rate of N1 attachment with ambiguous materials was 22% in Experiment 3.

**Comparison of Experiments 2 and 3.** To compare directly accuracy rates for the visually disambiguated items across the two experiments, Analyses of Variance were performed combining the between-subjects factor of Modality (auditory versus written) and the within-subjects and -items factor of Disambiguation Type (low versus high); the data are displayed in Figure 2. These analyses confirm that, regardless of modality, it is easier to respond cor-
rectly in this task when the visual contexts disambiguate attachment to N2: the main effect of Disambiguation Type was highly significant, $F_1(1,18)=36.45$, $p<0.001$, $F_2(1,6)=10.35$, $p<0.02$. But this factor interacted significantly with Modality, $F_1(1,18)=6.00$, $p<0.025$, $F_2(1,6)=15.13$, $p<0.01$; as Figure 2 illustrates, the effect of disambiguation, a 34% difference for Experiment 2, is reduced in Experiment 3, where the difference is 12%.

In a comparison of the overall attachment preference with ambiguous items in Experiments 2 and 3, the main effect of Modality was not significant, $F_1(1,18)=2.99$, $p>0.1$, $F_2(1,6)=1.63$, $p>0.25$: participants were equally unlikely to choose the high-attachment interpretation, with rates of N1 attachment of 22% (Experiment 2) and 37% (Experiment 3). This shows that the overall low attachment preference with this task is present regardless of modality.

![Figure 2. Overall accuracy (%) in Experiments 2 (Auditory) and 3 (Written) with visually disambiguated items.](image)

5 General Discussion

The experiments reported here investigated relative clause attachment in Bulgarian. Using a traditional paper-and-pencil questionnaire in Experiment 1, we found that native Bulgarian speakers prefer to attach the RC to the non-local site, N1, with semantically/pragmatically complex globally-ambiguous sentences. This finding aligns Bulgarian with other high-attaching Slavic languages, including Croatian, Polish, and Russian.
The high attachment preference found in Experiment 1 was not replicated in Experiments 2 and 3. In the latter two experiments, semantically/pragmatically complex materials containing NPs such as the brother of the teacher were replaced with abstract materials containing immediate visual contexts. The presence of contextual support resulted in an overwhelming preference for low (local) attachment interpretations of the RC. This locality preference was present regardless of the modality of the linguistic stimuli, auditory (Experiment 2) or written (Experiment 3). Modality effects were nevertheless not entirely absent with these materials: the effect of disambiguation (more accuracy with N2 than with N1 visual disambiguation) was stronger in Experiment 2, with auditory materials, than in Experiment 3, with written materials.

We are left with the puzzle of understanding why the strong preference for Bulgarians to attach to N1 in Experiment 1 dramatically shifted to a preference to attach to N2 in Experiments 2 and 3. This N2 preference, which theoretically follows from application of the Late Closure Principle, could be seen as a consequence of the fact that low (local) attachments are less computationally demanding than high (non-local) attachments. This suggests that the color-identification task of Experiments 2 and 3 limits the resources of the processor in a way that the questionnaire of Experiment 1 does not. This work therefore adds to the record yet another way in which RC attachment is sensitive to variation in materials and in aspects of the method. It also points to a number of promising avenues for future work, including experimentation presenting the materials of Experiment 1 in auditory format, and the materials of Experiments 2 and 3 in a format more closely comparable to the protocol used in Experiment 1.

References


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(Sekerina)
College of Staten Island, City University of New York
Department of Psychology
2800 Victory Blvd.; Staten Island, NY 10314
sekerina@postbox.csi.cuny.edu

(Fernández)
Queens College, City University of New York
Department of Linguistics and Communication Disorders
65-30 Kissena Blvd.; Flushing, NY 11367
eva_fernandez@qc.edu

(Petrova)
Sofia University "St. Kliment Ochridski"
Department of Slavonic Languages, Chair of Russian Language
15, Tzar Osvoboditel Blvd.; 1504 Sofia, Bulgaria
krasi@slav.uni-sofia.bg