Chapter 4

Future directions

As described in Chapter 2, relative clause (RC) attachment requires some parametric factor to be determined in order to explain the distinct preferences observed across languages. However, as seen in Chapter 3, cross-linguistic variations aside, RC attachment ambiguities are also interesting because they can be used to investigate properties of the human parser that may not be easily observable in other constructions. Two factors contribute to make RCs particularly suitable to test the types of factors to which the human parser is susceptible. First, RCs allow for a number of factors to be readily manipulated. Moreover, when not constrained by grammatical features (such as number or gender agreement) or by plausibility, RC attachment tends to have a weak bias for one of the available candidate sites, which can thus be overridden when appropriate features are manipulated.

The two sections in this chapter describe two on-going projects that take advantage of RC attachment ambiguities in order to explore general properties of the cognitive mechanisms underlying language processing.

4.1 Gender mismatch

The investigation of relative clause (RC) attachment as initiated by Cuetos & Mitchell (1988) led to the uncovering of a number of interesting phenomena (see Cuetos, Mitchell & Corley, 1996, for a recent overview). The present section reports a processing difficulty caused by a
local gender mismatch. This result has precedents in the work of Sauerland & Gibson (1997), who proposed that native German speakers prefer the case marking on a relative pronoun to be the same as on the noun that the RC modifies, even when the grammar itself does not impose such case matching constraints, as in the following sentences.

Example (1)

a. Local case matching

Der Brief ist für den Produzenten des Musikers [loc, dessen leg injured is].
The letter is for the producer of the musician whose leg is injured.

b. Non-local case matching

Der Brief ist für den Produzenten des Musikers [loc, den leg-injury from happening prevented].
The letter is for the producer of the musician who prevented a leg injury from happening.

c. No case matching

Der Brief ist für den Produzenten des Musikers [loc, der am leg injured is].
The letter is for the producer of the musician who is injured in the leg.

The sentences in Example (1) are ambiguous in that the RC can modify either the local noun (musician) or the non-local noun (producer). However, because case marking on the relative pronoun matches the local noun in Example (1a), the non-local noun in Example (1b) and neither noun in Example (1c), Sauerland and Gibson predicted that RC attachment would be biased towards the local noun in (a) and towards the non-local noun in (b), whereas (c) should provide a baseline preference. The predictions were only partially obtained in these authors’ off-line judgement study, in which native German speakers attached the RC to the local noun more often (73%) in (a) than in (b; 61%) and (c; 62%). But the difference in attachment preference between (b) and (c) was not statistically significant, which may suggest that the structural bias to attach the RC locally is too strong for case-matching in (b) to override.

Sauerland and Gibson’s results raise three questions. First, the overall local attachment preference observed in their study contrasts with previous results in which a non-local attachment bias was detected in eye-tracking experiments with similar German RC constructions (Hemforth, Konieczny & Scheepers, in press). Second, although these authors only consider
case marking, it is conceivable that the phenomenon at hand may extend to other types of feature matching. Third, there may be an alternative explanation for the phenomenon observed, namely, that only feature mismatch between adjacent constituents interferes with attachment, hence the lack of non-local attachment preference in Example (1b). The purpose of this section is to investigate the last two questions by conducting an on-line experiment with RCs in Brazilian Portuguese (BP) in which gender is the feature manipulated.

4.1.1 Gender agreement in RC attachment

As in the English translation, the RC in the following sentence in BP can be attached to either of the underlined nouns. However in BP, the relative pronoun whose\textsubscript{masc} has to agree in number and gender with the ensuing noun shoe\textsubscript{masc}, but not with the noun that the RC modifies (lawyer\textsubscript{fem} or prisoner\textsubscript{fem}).

Example (2)
\begin{itemize}
\item A\textsubscript{advogada} da\textsubscript{prisoneira} \textsubscript{\[\text{fem cujo sapato estava sujo}\]} conversou com o juiz.
\end{itemize}

"The lawyer of the prisoner whose shoe was dirty talked to the judge."

If there is a generalized tendency for the human parser to match features on a head noun with the features on the relative pronoun, then by manipulating gender on the head nouns (lawyer and prisoner) and on the relative pronoun, it should be possible to bias the attachment preference accordingly, even though there is no requirement for such gender matching in the grammar. However, if Sauerland and Gibson are correct and only case features are matched, then there should be no difference in attachment because the relative pronoun used will always have genitive case and hence it should always favour attachment to the local site, which also has genitive case. Note that in BP, as in English, case is usually not morphologically realized on noun phrases.

\footnote{The subscripts for feminine (\textsubscript{fem}) and masculine (\textsubscript{masc}) are only used if the BP word is inflected for gender but the corresponding English word does not indicate it.}
4.1.2 Method

The items in the present experiment were used as fillers for the experiment reported in Chapter 2, hence the participants, the procedure and the residual reading time analysis were as described previously.

Materials

There were three conditions as follows. (The two head nouns are underlined and the relative pronoun is in italics.)

Example (3)
a. Matching both sites
O advogado do prisioneiro cujo sapato estava sujo de barro conversou demoradamente com o juiz.

“The lawyer\textsubscript{masc} of the prisoner\textsubscript{masc} whose\textsubscript{masc} shoe was soiled with mud talked for a long time with the judge.”

b. Local matching
A advogada do prisioneiro cujo sapato estava sujo de barro conversou demoradamente com o juiz.

“The lawyer\textsubscript{fem} of the prisoner\textsubscript{masc} whose\textsubscript{masc} shoe was soiled with mud talked for a long time with the judge.”

c. Non-local matching
O advogado da prisioneira cujo sapato estava sujo de barro conversou demoradamente com o juiz.

“The lawyer\textsubscript{masc} of the prisoner\textsubscript{fem} whose\textsubscript{masc} shoe was soiled with mud talked for a long time with the judge.”

In Example (3a), the relative pronoun is masculine and matches both local and non-local head nouns. In Example (3b), the relative pronoun matches only the local noun, while in Example (3c), it matches only the non-local noun. Number was kept singular in all relevant constituents.

As observed earlier, if only case features are matched in RC attachment, then the three conditions should not differ in attachment pattern. However, if gender matching has the same effect as case matching, then the RC should attach locally more strongly in Example (3b) than in Example (3c). Moreover, if only the gender on the adjacent noun matters, then Example (3a) should pattern as (b). However, if gender on the non-local noun also influences
the outcome, then the non-local attachment should be stronger in (a) than in (b).

After each sentence, a comprehension question was presented querying about the attachment of the RC. No feedback was given in this experiment because both attachments are grammatical. This task would most closely resemble the judgement task in Sauerland & Gibson (1997). Moreover, residual as well as raw reading times were also analysed according to the attachment preference expressed in the comprehension question. For purposes of analysis only, the sentences were divided into three regions: region 1 contains the first four words (up to the local noun), region 2 contains the entire RC and the main verb (words 5 to 11), and region 3 contains the final words in the sentence. The crucial region for analysis was region 2.

There were a total of twelve items. In six items, the relative pronoun had masculine marking and in the other six, feminine marking. Each participant saw four items for each matching condition in a Latin Square design, intermixed with 82 unrelated items in pseudo-random order.

4.1.3 Results

Answers for the questions presented the following results. The local attachment preferences in the both-matching, local-matching and non-local-matching conditions were 62%, 64% and 67% respectively and did not differ significantly (Fs < 1).

The raw reading times presented the same numerical pattern as the residual reading times and will not be discussed further.

The results for the analyses with residual reading times were conducted as a 2 by 3 design: attachment site (local or non-local) and matching condition (both-matching, local-matching and non-local-matching). Note that the attachment site condition was based on each participant's response to the comprehension question, hence, the analysis by subjects could not be carried out as some participants consistently chose one attachment site for a given matching condition, thus not presenting data for the other attachment site. In region 1 and region 3, there was no interaction between attachment site and the matching conditions (F2 < 1). In region 2, the interaction was significant (F2(2,22) = 3.77, p < 0.05),

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which is due to the non-local attachment condition being significantly slower than the local attachment condition for non-local matching \((F_2(1,11) = 5.75, p < 0.05)\) but not in the other two matching conditions \((F_2 < 1.7)\).

No significant difference was observed between the items with feminine or masculine relative pronoun \((F_2 < 1)\).

### 4.1.4 Discussion

The reading time results suggest that the gender of the local noun may be the main cause for the interaction observed. In the both-matching and local-matching conditions, the local-noun gender matches the relative pronoun, and the reading times of the two conditions did not differ. In the non-local matching condition however, the local noun does not match the gender of the relative pronoun and here a significant slow-down is observed when the RC is attached to the non-local noun. The influence of the local noun would be further supported if a fourth condition, missing in the present experiment, in which neither noun matches the relative pronoun gender, also yielded a slow-down similar to the one observed in the non-local matching condition.

If supported by future work, intrusion of the local feature in the attachment of the RC to the non-local noun raises a rather interesting question, namely, why is the parser hindered by the mismatch of features which the grammar does not require to be matched. Moreover, considering grammar formalisms in which features are percolated along the structural organization of a sentence (e.g. Gazdar, Klein, Pullum & Sag, 1985), the features involved in the present case are not required to be matched by the grammar, but more importantly, they may not be matched. Note that the slow-down is observed when the RC is attached to the non-local noun, hence percolating the features from the local noun to the relative pronoun does not respect the structural relations of the components in the sentence.

This effect of a local feature mismatch is also observed when the agreement of a singular head noun and a verb is disrupted by an intervening plural noun (Bock & Miller 1991). But the comparison with the present result should be made with caution because the result with number was in a production task, while here the claim is about the comprehension stage.
Future work should also address the lack of effect of gender mismatch on attachment preference in the comprehension question response in contrast to the result obtained by Sauerland & Gibson (1997). Two possible explanations can be entertained at this point. First, case marking may interfere more strongly in parsing than gender features. Second, the internal structure of the RCs used by Sauerland and Gibson varies from condition to condition, hence possibly being an extra source for the attachment differences they observed.

4.2 Articulatory suppression

The present section is an attempt to bring three independent lines of research together. First, there have been recent proposals that during silent reading native speakers compute prosodic contours which in turn influence the way ambiguities are resolved (Bader, 1998; Fodor, 1998). Although plausible, evidence for such claims has been indirect by providing effects that are likely to derive from such implicit prosody, but no attempts have been made to show that prosodic contours are indeed computed during silent reading. A second line of research compared reading time patterns of two groups of native speakers, which were divided according to an independent memory span task, and its conclusion was that ambiguity resolution is affected by the amount of short term memory available during parsing (King and Just, 1991). Finally, within the working memory model, Baddeley and colleagues have shown that phonological effects (e.g., the phonological similarity effect and word length effect) in the recall of lists of words are eliminated when participants have to simultaneously perform a secondary task in which the articulatory loop is suppressed as participants continuously pronounce an irrelevant syllable (see Baddeley, 1990 for an overview; Coltheart, Avons & Trolley, 1990 for elimination of homonym effects during reading). Moreover, articulatory suppression has also been shown to decrease the amount of short-term memory available as participants recall fewer words when required to pronounce nonsense syllables at the same time.

Hence, given that articulatory suppression eliminates phonological effects (and possibly any prosodic effects as well) and decreases overall short-term memory available, then, according to the implicit prosody and the memory span proposals, articulatory suppression
should also interfere with ambiguity resolution. Of particular interest here is the claim that differences in prosodic contours are responsible for relative clause attachment preferences observed across languages (Fodor, 1998). More concretely, consider the following sentence in Spanish.

Example (4)  (Adapted from Gibson, Pearlmutter & Torrens, in press.)
Un alumno insultó a los profesores de las clases \(RC\) que no gustaron a los estudiantes.
“A pupil insulted the professors of the classes that were not fancied by the students.”

As discussed in Chapters 2 and 3, in constructions such as Example (4), native Spanish speakers prefer to attach the RC to the non-local noun (Cuetos & Mitchell, 1988; Gibson, Pearlmutter & Torrens, in press). If this attachment preference is due to the prosodic contours of this language, then articulatory suppression should affect the attachment pattern by either eliminating the preference altogether or by reverting attachment to the local site assuming that a locality effect may then be revealed. A crucial assumption here is that prosody is computed during silent reading through inner speech (Slowiaczek & Clifton, 1980), which presumably involves the articulatory loop.

In order to test this hypothesis, a self-paced reading experiment with a within-subject design is being conducted. In half of the trials, native Spanish speakers are required to pronounce irrelevant syllables (“ba” or “ta”), and in the other half they read silently. Order of the tasks is counterbalanced, thus half of the subjects read silently first, and the other half read while articulating in the first part of the experiment.

Initial results suggest that an interaction between articulation and attachment site takes place with the local attachment condition being read faster with simultaneous articulatory suppression. If this pattern of results is confirmed, this would be strong evidence that prosody is indeed being computed during silent reading. However, even in this case, interpretation of the result should be with caution as an alternative explanation may exist in that articulatory suppression decreases the amount of working memory available, therefore, potentially making the high site less available for attachment in the articulated condition.