Ergativity and the complexity of extraction: A view from Mayan

Lauren Eby Clemens,[a] Jessica Coon,[b] Pedro Mateo Pedro,[a] Adam Milton Morgan,[c] Maria Polinsky,[a] Gabrielle Tandet,[a] Matt Wagers[c]

Harvard University,[a] McGill University,[b] University of California at Santa Cruz [c]

Abstract: Researchers using different methods have converged on the result that subject relative clauses (RCs) are easier to process than object RCs. Cross-linguistic evidence for the subject processing advantage (SPA) has come mostly from accusative languages where grammatical function and case correspond, preventing researchers from investigating whether case or grammatical function underlies the SPA. Ergative languages allow for the separation of case and function, since more than one case is associated with the subject position. Prior results on the processing of ergative languages suggest that function and case are equally important in RC processing and differential effects are also visible. The ergative cues the projection the absolutive object, which gives preference to the absolutive, but the ergative is also preferred as subject. This paper tests these findings by examining the processing of RCs in Ch'ol and Q'anjob'al, two head-initial ergative languages that mark ergativity via agreement. The results again support the SPA but do not show any cueing by the ergative agreement marker. We conclude that case is superior to agreement in tracking grammatical function, and in the absence of case cues, structural preferences become more pronounced. Therefore the SPA is evident in both ergative and accusative languages.

Keywords: Ergativity, Mayan, Processing, Relative clauses, Subjects, Subject preference

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1. Introduction[1]

The division of languages into ergative and accusative is based on the alignment of the core arguments of a transitive clause with the single argument of an intransitive clause. Following the convention since Comrie (1978) and Dixon (1979), the three arguments in question are represented as S (sole argument of the intransitive clause), A (agent or most agent-like argument of a transitive clause), and O (theme or most theme-like argument of a transitive clause). For our purposes, two arguments are aligned if they bear the same case or are indexed by the same agreement maker in the verbal paradigm. If S aligns with A, the resulting system is accusative; if it aligns with O, the resulting system is ergative. Figure 1 shows a diagram illustrating the fundamental difference between these two types of alignment.

Figure 1. Alignment in accusative vs. ergative systems

Ergativity has long posed a challenge to theoretical linguistics, but it is a fresh topic in the experimental study of language (some recent work includes Carreiras et al. 2010, Choudhary et al. 2011, Polinsky et al. 2012). The introduction of ergative languages into processing studies is motivated by several considerations. It is only natural to extend the existing experimental paradigms—developed largely on the basis of English and other European languages—to less

[1] The authors of this paper are listed in alphabetical order. The work reported here was supported in part by the Max-Planck Institute for Evolutionary Anthropology, the Davis Center for Russian and Eurasian Studies (Harvard), the David Rockefeller Center for Latin American Studies (Harvard), the National Heritage Language Research Center, the Center for Advanced Study of Language at the University of Maryland, the National Science Foundation Grant BCS 2011876524 to Maria Polinsky, and the National Science Foundation Graduate Research Fellowship 2012136967 to Adam M. Morgan. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

We would also like to thank Judith Aissen, Olga Fedorova, Nicolás Arcos López, Peter Graff, Itziar Laka, Beth Levin, Emily Raykhman, and Svetlana Tchistiakova for their help in our work on this paper. Finally, we would like to thank the following individuals and groups in Chiapas and Santa Eulalia for their time, logistical support and hospitality: Diego Adalberto, Daniel Pedro Mateo, María Pedro, Pedro Gutiérrez Sánchez, the family of Nicolás Arcos López, Universidad Intercultural de Tabasco students and staff, Asociación de Mujeres Eulalenses para el Desarrollo Integral Pixan Konob, the Municipality of Santa Eulalia, Huehuetenango, and the participants in our experiments. The Ch'ol data in this paper are from Nicolás Arcos López; and the Q'anjob'al data are from Pedro Mateo Pedro.

Abbreviations: ADN—Adnominal; AF—Agent Focus; GER—Gerund(ive). All other abbreviations follow the Leipzig Glossing Rules. Roman numerals indicate noun class.

commonly studied languages, and ergative languages fit this description. Results from processing studies on ergative languages may contribute to our understanding of the central theoretical questions surrounding ergativity, namely case licensing and agreement. Finally, ergative languages allow researchers to study the processing of case alignment and grammatical function as independent phenomena in a way that accusative languages do not. Specifically, in an accusative language, the difference in case marking/agreement matches the distinction between subject and object; subject appears in the nominative case and determines verb agreement regardless of the transitivity of the clause. In an ergative language, the grammatical function 'subject' corresponds to two different case/agreement forms: absolutive (S) and ergative (A). Figure 2 illustrates that the subject of an intransitive clause (S) and the subject of a transitive clause (A) are associated with one case in an accusative language and two cases in an ergative language.

Figure 2. Case alignment and grammatical function in accusative vs. ergative systems

The grammatical function 'subject' has emerged as a pivotal category not only in theoretical linguistics but also in processing studies. A variety of processing studies using different experimental methods have converged on the result that languages show a strong subject processing advantage (SPA) in a number of language phenomena: relativization, wh-questions, coreference across clauses, and variable binding, to name a few. With most of the data coming from accusative languages, however, it is hard to tell if the observable subject advantage is truly a reflection of the grammatical function of subjects or an artifact of a more superficial preference for the nominative over the accusative. Ergative languages are critical in allowing us to determine whether the grammatical function or the case is the driving force behind the SPA.

The largest body of data on subject preference in processing is based on studies of relativization (see Kwon et al. 2010 for an overview and further references). Until recently, cross-linguistic evidence for the SPA in relatives was limited to accusative languages where grammatical function and case correspond, as shown in Figure 2. This limitation prevents researchers from investigating whether structural case, grammatical function or both underlie the SPA. Ergative languages, with their dissociation between morphological case marking and grammatical function, offer a particularly promising way of teasing these factors apart, which is the primary motivation behind this project.

So far, the processing of relative clauses has been investigated in two head-final ergative languages, Basque (Carreiras et al. 2010) and Avar (Polinsky et al. 2012). Both languages have prenominal relative clauses, and ergativity is overtly expressed in both by case marking. Furthermore, both languages have the relativization of the ergative and the absolutive on equal footing; regardless of the case marking, the extracted DP leaves a gap at the extraction site. This is unusual for morphologically ergative languages. Many morphologically ergative languages restrict relativization with a gap to the absolutive; the ergative cannot relativize leaving a gap at the extraction site. The restriction on relativization and possibly other A-bar movement processes which discriminates against the ergative is an example of what is more broadly known as "syntactic ergativity" (but see Kazenin 1994, Manning 1996 for a broader use of that term).

In this paper, we present and analyze the processing of relative clauses in two Mayan languages, Ch'ol and Q'anjob'al. Unlike Basque and Avar, both are head-initial and their ergative alignment is reflected in agreement, not in case marking. Ch'ol has no syntactic ergativity whatsoever, so it is directly comparable to Avar and Basque in that regard. Q'anjob'al has one type of construction where the ergative and the absolutive are relativized in a comparable manner (see Section 5.2), but is otherwise syntactically ergative. This brings us to the second reason to explore the processing of extraction in ergative languages. Accusative languages do not demonstrate a comparable asymmetry between the nominative and the accusative argument, i.e. both nominative and accusative arguments in accusative languages can undergo extraction. Why should this difference between ergative and accusative languages exist? One could imagine finding an answer in morphologically ergative languages that do not have syntactic ergativity, for instance, Avar, Basque or Ch'ol. If the processing of ergative extraction is somehow more difficult than the processing of absolutive extraction, we would have an explanation for syntactic ergativity: what surfaces as a processing limitation in some ergative languages may be grammaticalized as a hard constraint in syntactically ergative languages.

This paper is organized as follows. Section 2 presents a survey of the existing studies on processing of relative clauses in ergative languages. Section 3 explains the rationale behind our studies on Mayan languages. Section 4 introduces the experimental paradigm used for these studies and presents an independent test of that paradigm in a more familiar language. Section 5 provides a brief overview of the two Mayan languages investigated here. Section 6 presents the design and results of our experiments. Section 7 discusses the results of the two experiments generally and addresses broader implications of this study, and Section 8 presents our conclusions.

2. Processing of relative clauses in ergative languages

In this section we review previous processing studies of relative clauses in the ergative languages Avar (Polinsky et al. 2012) and Basque (Carreiras et al. 2010; Laka et al. 2012). Avar and Basque are both head-final languages with prenominal relative clauses. In both of these languages, any core argument can head a relative clause, i.e. they are not examples of syntactically ergative languages. We argue that for ergative languages with prenominal relatives, grammatical function and case are equally important in the processing of relative clauses.

2.1 Avar

Avar is a head-final language of the Nakh-Dagestanian family. It demonstrates morphological ergativity in case marking as well as agreement, where the verb agrees in number and noun class with the absolutive argument. The ergative argument has distinct subject properties: it binds the absolutive argument; it can appear as the implicit subject of the control complement; it can undergo raising; and it appears as the null pronominal of imperatives (Anderson 1984, Polinsky et al. 2012 and references therein). In Avar, relative clauses are prenominal and all core arguments relativize by leaving a gap at the extraction site:

1 a. Intransitive Subject Relative – Avar

[__$_i$	Artistka-yal-da	ask'o-y	č':u-n	y-ik'-ara-y]	yas$_i$.
	actress-OBL-LOC	near-II	standing-GER	II-be-PTCP-II	girl.ABS

'The girl that stood next to the actress.'

b. Transitive Subject Relative – Avar

[__$_i$	Yas	repetici-yal-de	y-ač:-un	y-ač'-ara-y]	artistka$_i$.
	girl.ABS	rehearsal-OBL-LOC	II-bring-GER	II-come-PTCP-II	actress.ABS

'The actress that brought the girl to a rehearsal.'

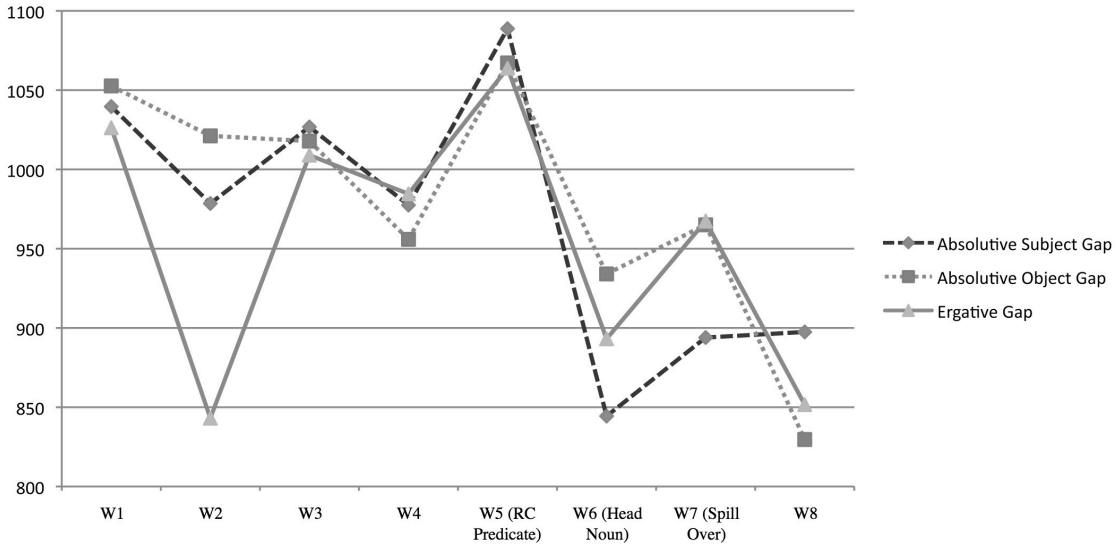
c. Object Relative – Avar

[Artistka-yał	__$_i$	repetici-yal-de	y-ač:-un	y-ač'-ara-y]	yas$_i$.
actress-ERG		rehearsal-OBL-LOC	II-bring-GER	II-come-PTCP-II	girl.ABS

'The girl that the actress brought to a rehearsal.'

In a self-paced reading study of Avar relative clauses, Polinsky et al. (2012) investigated the extraction of absolutive subjects (1a), the extraction of ergative subjects (1b), and the extraction of absolutive objects (1c).[2] They found that participants processed absolutive subjects faster than either ergative subjects or absolutive objects, but that there was no difference between the way participants processed the extraction of ergative subjects as compared to absolutive objects. Figure 3 shows the reading time data obtained in a self-paced reading experiment (from Polinsky et al. 2012).

Figure 3. Reading time (*ms*) for Avar relative clauses



The reading time data in Polinsky et al. (2012) suggest that the symmetry between the extraction of both core arguments in a transitive clause follows from the crossed effect of grammatical function and case. The Avar reading study presented evidence, observed locally (at the right edge of the first constituent of the relative clause—W2), that surface case also matters, in addition to the grammatical function. This case preference reflects the (in)ability of a particular case form to serve as a cue that another DP, in a different case form, has to be present. In Avar, the ergative can appear only in the presence of the absolutive;[3] this means that when the parser encounters the

[2] Note that both the intransitive and transitive stimuli contained two arguments. In the case of the intransitives, the arguments were absolutive and oblique.

[3] Avar does not have split intransitive ergativity of the type observed in Batsbi (Holisky 1987).

ergative, they can immediately project the entire transitive clause and predict that the absolutive will also be present in the structure. The appearance of the absolutive does not lead to specific predictions; it can be the sole argument of an intransitive or an argument of the transitive. Avar readers showed a significant slowdown when they encountered the ergative at W2.

Recall that Avar has prenominal relatives. As it turns out, we find a similar cueing effect in accusative languages with prenominal relatives. In Japanese and Korean, when the accusative appears in sentence-initial position (here, at the beginning of a relative clause) it is processed slower than the nominative (Miyamoto and Nakamura 2003; Ueno and Garnsey 2008: 665; Kwon et al. 2006). Just like the ergative, the appearance of the accusative means that the comprehender assumes the nominative will be projected, which leads to a local processing cost.[4] In other words, this slowdown follows from the extra processing work needed to project the argument cued by the dependent case form.

So far we have just stated the generalization concerning the cueing effect, as observed in Avar and in its accusative head-final counterparts such as Japanese or Korean. What possible theories can account for the cueing effect? This effect is compatible with theories of on-line complexity that relate processing difficulty to changes in predictability (Hale 2003, 2006; Levy 2008): in contrast to the absolutive, the presence of an ergative limits the possible analyses. This imposed limitation occupies the processing resources and increases the time it takes to process the material. This effect is equally compatible with licensing theories of comprehension (Aoshima et al. 2004; Wagers and Phillips 2009). According to this line of thought, comprehenders predictively construct a representation that will grammatically license the presence of a given feature or constituent. On such a view, encountering the ergative prompts the participant to project a structure for the remainder of the utterance, bogging down the parser and resulting in higher reading times.

To summarize, the complexity of extracting an ergative argument is shaped by at least two factors, SPA and cueing by case:

2a. SUBJECT PROCESSING ADVANTAGE. The ergative should be *easier* to process than the absolutive object but *as easy* to process as the absolutive subject.

b. CASE CUEING. The ergative should be *harder* to process than the absolutive, because the ergative is the dependent case, which evokes case cuing.

The net effect of these two factors depends on their relative weight and how they are resolved over time, but assuming equal weight, we come to understand why there was no difference in the reading times associated with extracted ergative subjects and absolutive objects in Avar relative clauses.[5] For the intransitive absolutive subjects, the SPA works in their favor and the case cueing is irrelevant, so the overall result is the extraction advantage we observe (W6 and W7, Figure 1).

Note that in an accusative language with prenominal relatives like Japanese and Korean, the two factors reinforce each other:

[4] In the Avar study, the slowdown occurs at the ergative (W2). In Japanese and Korean the slowdown is at the word following the accusative (Ueno and Garnsey 2008; Kwon et al. 2006).

[5] The notion of multiple pressures is of course not new. Our proposal is conceptually close to the one advanced in Bornkessel and Schlesewsky (2006), Bornkessel-Schlesewsky and Schlesewsky (2009), *according to which processing is shaped by several principles that can work at cross-purposes*. The overall conclusion is that processing is subject to a number of competing constraints and is streamlined when the relevant factors all line up in harmony, but is taxed more when the competing factors are at odds with each other.

3 a. SUBJECT PROCESSING ADVANTAGE. A nominative subject should always be *easier* to process than an accusative object.

b. CASE CUEING. The accusative should be *harder* to process than the nominative, because the accusative is the dependent case, which evokes case cuing.

In sum, data on the processing of relative clauses in Avar (Polinsky et al. 2012) suggest that function and case are equally important in the processing of relative clauses in ergative languages, or at least in those with prenominal relatives.

2.2 Basque

Basque is similar to Avar in that it also has prenominal, head-final relative clauses[6] and any constituent is amenable to relativization with a gap. As in Avar, the ergative argument behaves like the subject in a transitive clause, and there is ample evidence that ergative arguments are structurally higher than absolutive arguments (cf. Trask 2002; Arregi and Molina-Azaola 2004; Laka 2006; San Martin 2007, a.o.). Like Avar, Basque appears to have agreement with both the absolutive and the ergative arguments. Unlike Avar, however, closer examination of Basque reveals that at least the ergative markers are instances of clitic doubling (Nevins and Arregi 2012; Preminger 2009, 2012). Basque also has true intransitives with ergative subjects, which are not present in Avar (Preminger 2012, Režać et al. 2012 and further references there). Finally, Basque has substantial case homophony, something Avar lacks entirely, and it is this property of Basque that Carreiras et al. (2010) manipulate to experimental advantage.

Carreiras et al. (2010) ran a reading-time study that included two conditions: structures with ergative subject gaps and those with absolutive object gaps. Critically, their stimuli included DPs ending in the exponent(s) *–a-k/-ak*, which are ambiguous: *-a-* is the definite determiner, *-k* is the ergative marker, and *-ak* is the exponent of the absolutive plural. Therefore, when a participant encountered an argument ending in *–ak*, they could attribute one of two interpretations to the form: either singular ergative subject or plural absolutive object. By way of example, the sequence in (4a) could be interpreted as a subject relative (4b) or as an object relative (4c):

4 a. Ambiguous string – Basque
Irakasleak aipatu dituen ikaslea.
SR: 'The student who mentioned the teachers.' *or*
OR: 'The student whom the teacher mentioned.'

b. Subject relative – Basque
[$\_\__i$ Irakasle-ak aipatu ditu-en] ikasle-a_i.
teacher-ABS.PL mention AUX-ADN student-DET
'The student who mentioned the teachers.'

c. Object relative – Basque
[Irakasle-a-k $\_\__i$ aipatu ditu-en] ikasle-a_i.
teacher-DET-ERG mention AUX-ADN student-DET
'The student whom the teacher mentioned.'

[6] Basque also has post-nominal relative clauses with a relativizer (Hualde and Ortiz de Urbina 2003: 765ff.; Rebuschi 2009), but those are limited to a particular register and are beyond the scope of our discussion.

Carreiras et al.'s (2010) study made further use of the *–a-k/-ak* ambiguity: the head noun always ended in *–ak* as well, so that the disambiguation occurred only at the penultimate word of the sentence. Example (5), taken from Carreiras et al. (2010), shows that disambiguation point is W6.

5 a.	[__$_i$	Irakasle-ak	aipatu	ditu-en]	ikasle-a-k$_i$	lagunak	ditu	orain.
		teacher-ABS.PL	mention	AUX-ADN	student-DET-ERG	friends	has	now
		W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**

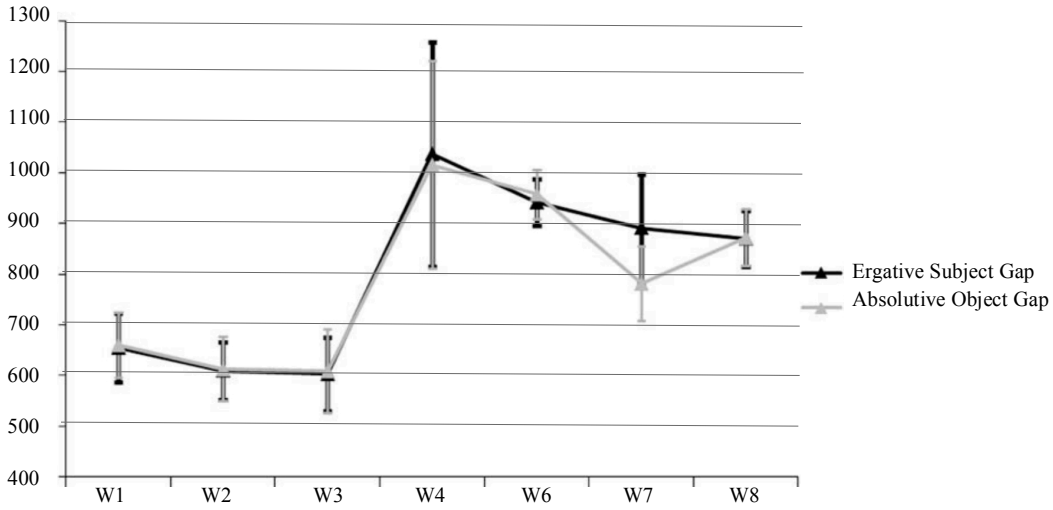
'The student that mentioned the teachers has friends now.'

b.	[Irakasle-a-k	__$_i$	aipatu	ditu-en]	ikasle-ak$_i$	lagunak	dira	orain.
	teacher-DET-ERG		mention	AUX-ADN	student-ABS.PL	friends	are	now
	W1		**W2**	**W3**	**W4**	**W5**	**W6**	**W7**

'The students that the teacher mentioned are friends now.'

As shown in Figure 4, the slowdown for the ergative subject gap was much longer than that for the absolutive object gap at the disambiguation point.

Figure 4. Reading times (*ms*) for the transitive subject and object relatives in Basque (Adapted from Carreiras et al. 2010)



These results appear to suggest a strong disadvantage in the processing of an ergative gap as opposed to an absolutive gap, which is quite a different result than those reported for Avar. We are concerned, however, that this result may reflect experimental design more than actual processing effect. First, at the point of disambiguation, the difference between *ditu* 'has' (5a) and *dira* 'are' (5b) is one of transitivity. We just saw the effect of transitivity in the Avar results, and although the exact mechanism of this effect still needs to be explained, it may be playing a role in Basque as well.

Second, the results may reflect interpretation biases and ambiguity resolution. The Basque stimuli all start with a noun which is ambiguous between the ergative singular and the absolutive plural, which keeps the items maximally similar. Research on lexical ambiguity, however, shows that the parser does not stall at lexical ambiguities, but makes an early commitment to a particular interpretation. Many existing studies demonstrate this early commitment, particularly with number ambiguities (Duffy et al. 1988; Frazier and Rayner 1987,

1990; Frazier et al. 1999; Fodor and Inoue 2000; Bader and Häussler 2009, a.o.). The initial commitment is largely affected by prior experience, and it is reasonable to assume that prior experience would incorporate statistical preferences and lexical biases for combining with particular predicates. We do not have access to the complete list of the Basque stimuli, but since the ambiguous word is the first word of the sentence, we would expect that the first time it is reassessed would be at the predicate of the relative clause (W2 in Figure 4). Such a reassessment does not happen, and, therefore, there is no reason to believe that the lexical biases played any role in the disambiguation.

In terms of prior experience, there is evidence suggesting that the parser is more likely to interpret the first word (the word ending in *–ak*) as the ergative DP rather than the absolutive plural. First, statistically the ergative singular is more common than the absolutive plural: in 1,496 utterances of adult speech examined in Austin (2007), there were 92 instances of the ergative singular and 46 instances of the absolutive plural.[7] In the EPG online corpus of Basque (http://www.ehu.es/euskara-orria/euskara/ereduzkoa/), we find the following statistics: in the books published in 2002, out of approximately 1 million sentences, there were 39,037 sentences containing one or more ergative singular *-(a)k* and 30,184 sentences containing one or more absolutive plural *-(a)k*.[8] Thus the statistical prevalence of the ergative form in discourse is likely to affect the initial commitment to the ergative interpretation made by the reader.

Finally, although the experiment was conducted using standard Basque, there may still have been some interference from the spoken variety. In spoken Basque, object forms of animate nouns are often marked dative, not absolutive, and trigger dative agreement on the verb (Austin 2006).[9] Since the object can appear in the dative in the spoken variety, it is more likely that participants would interpret the first word in the sentence to be an ergative subject.

These factors converge in favoring an initial commitment to the interpretation of the word ending in *–ak* as the ergative singular. That in turn favors the interpretation of the relative clause as having an absolutive object gap. Once the reader gets to the disambiguation point, the object relative interpretation requires no revision of the initial commitment. The subject relative interpretation, on the other hand, requires a revision of the earlier parse, and such a revision is associated with higher processing costs (see Duffy et al. 1988, Bader and Häussler 2009 for a discussion of such costs and processing models associated with them).[10]

If our explanation is on the right track, then these results may be most relevant for understanding ambiguity resolution and transitivity effects, but not to the processing of ergative and absolutive gaps in relative clauses. Moreover, in a later study of near-native speakers of Basque, Laka et al. (2012) found that the processing of the ergative and the absolutive were very similar, which is consistent with the Avar results. To recapitulate, these results suggest that grammatical function and case marking both affect relative clause processing in ergative languages. However, languages with prenominal relatives do not allow us to control for the case cueing effect discussed in Section 2.1. In the next section we turn to two ergative languages with postnominal relatives.

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[7] The ergative data are reported in Austin (2007); the statistics on the absolutive are courtesy of Jennifer Austin (p.c.).

[8] We would like to thank Asier Alcazar for help with these statistics.

[9] Speakers see it as Spanish influence, but nevertheless this feature seems very common, at least in the spoken language. We are grateful to Karlos Arregi for bringing this to our attention.

[10] A sentence completion task may be a good way of further testing the proposal made here: subjects see the form ending in –ak and compete the sentence in such a way that this form is interpreted as ergative or as absolutive. That would provide an independent measure of the comprehension bias that we have discussed.

3. Beyond case marking

Up to now we have considered ergative languages which show ergativity in case marking (and concomitantly, in agreement). In Avar, the pattern of agreement matches the alignment in case marking. In both domains, the ergative differs from the absolutive: the verb does not show agreement with the ergative, and the ergative is a special case form. In Basque, case marking distinguishes ergative and absolutive, and agreement does too: the ergative and the absolutive arguments have separate exponents.[11]

Mayan languages allow us to investigate whether the processing of ergative languages that have agreement but no case marking is different from those ergative languages with case marking or both case marking and agreement. The answer to this question goes beyond the specific theoretical and experimental issues in ergative languages and potentially bears more generally on our conception of case and agreement − specifically, it bears on the level(s) of representation that case vs. agreement belong to and the licensing mechanisms that are responsible for case vs. agreement.

In order to evaluate the relationship between case marking and agreement, we need to find languages that differ with respect to the placement of the relative clause (prenominal or postnominal) and the employment of case- vs. agreement-marking (one or both). Of course, we also need to consider languages which allow both subject and object extraction with a gap, i.e. languages without syntactic ergativity in at least some structures. Several Mayan languages meet these requirements.

We hypothesize that Mayan languages may show the same processing effects as Avar. Putting aside the difference between case marking and agreement for a moment, we start with the general notion of alignment (accusative vs. ergative). We assume that the ergative argument has subject status; Section 5 contains evidence in support of this claim. In light of this assumption, we should expect that the processing of ergative and absolutive object gaps will be similar. The ergative will serve as a cue to project the absolutive, which will nullify its advantage in phrase structure, and the cueing effect will cancel out the relative disadvantage of the absolutive as object.

We also predict that the distinction between alignment based on case-marking and alignment based on agreement-marking will affect our results. Two known observations underlie this prediction. First, it has been noted that potential targets for establishing agreement relationships are selected based on their case (Moravcsik 1974, 1978; Bobaljik 2008, Preminger 2011: Ch. 4); thus, agreement depends on case, not vice versa. Next, unlike case, agreement does not *directly* track grammatical functions. Instead, it tracks phi-feature probes located in particular structural positions. This in turn suggests that agreement plays less of a role in determining grammatical functions and, consequently, in processing preferences. Structure building based on agreement is expected to be slower and more costly than structure building based on case. Therefore, the parser does not allocate substantial processing resources to it.

Based on this reasoning, we can expect languages that encode ergativity through agreement to show less sensitivity to this alignment in processing compared to languages that encode ergativity via case marking. In the absence of case marking in relative clauses, such languages are then likely to resort to an SPA based on grammatical function, as other languages are known to do when other processing strategies fail.

The reliance on an SPA based on grammatical function in the absence of other cues has been demonstrated in more familiar languages. For example, subject preference is observed in

[11] Note that some researchers suggest that the indexing of the ergative in Basque is cliticization, not agreement (Nevins and Arregi 2012; Preminger 2009, 2012). If so, Basque becomes even more similar to Avar in terms of case marking and agreement. For us, nothing hinges on the status of ergative marking on Basque verbs.

ambiguous contexts such as the nominative and accusative of feminine and neuter nouns in German (Fanselow and Frisch 2006; Schwarz 2007) or the nominative and accusative of neuter and masculine inanimates in Russian, which we will discuss in Section 4 (see example 9). Our predictions are summarized below.

8. Predictions concerning the processing of relative clauses in Mayan

a. Agreement is equal to case in determining processing preference: ERG = ABS_{Obj}
Ergative extraction is comparable to absolutive *object* extraction (processing is based on morphological cues).
b. Case is superior to agreement in tracking grammatical function: ERG > ABS_{Obj}
Ergative extraction is easier than absolutive *object* extraction, due to subject preference (phrase structure-based processing underlies the processing preference in the absence of morphological cues).

Sections 5-6 pertain to our study of relative clauses in Ch'ol and Q'anjob'al. Before discussing our study, however, we would like to discuss our methodology. We will address concerns about gathering data from reading-based studies when there is little-to-no culture of literacy in the language of interest. We will also consider the validity of comparing results from reading-based and picture-matching studies.

4. Behavioral studies of unwritten languages

Looking back at the self-paced reading data from Basque and Avar presented above, one is struck by the observation that reading times on individual words are quite high, roughly from 700 to 1200 ms per word. This is almost twice as much time as speakers of Korean, a language with comparable wordlength, spend on their word reading (cf. Kwon et al. 2010). There is also significant variance in the self-paced reading times, which can be seen in the large SEM spreads in Figure 2. This suggests that self-paced reading is not a very natural paradigm for speakers of Basque or Avar.[12]

With respect to Basque, there is actually some research on the tension between orality and literacy. Researchers underscore that Basque is primarily a spoken language whose speakers tend not to read Basque frequently (see Martí 2005, Irujo Ametzaga 2009, Arozamena 2010, and references therein). There is no comparable research for Avar (see Kirkwood 1990: Ch. 1; Grenoble 2003: 130 for some general observations), but there are at least two tangible indications that Avar is mainly used for oral communication. First, in a pretest questionnaire for the self-paced reading experiment, all the subjects reported a strong preference for speaking in Avar but for reading in Russian. Second, there are publication data for the multilingual biweekly "As-Salam" published in Dagestan:[13] the number of copies printed in Avar is 24 thousand, in Russian, 31.5 thousand.

Thus, Basque and Avar represent two languages whose speakers do not use its writing system on a regular basis or are more comfortable reading and writing in another language. Choosing to pursue reading-based studies of these languages means making a number of extra assumptions that include the transferability of literacy skills from one language to another and the

[12] Indeed, there are concerns about the naturalness of self-paced reading even for highly literate people, such as college students, on whom such methods have been traditionally used by scores of researchers (Witzel et al. 2012).
[13] Ас-Салам (As-Salam). (n.d.). In Википедия (Wikipedia) Retrieved June 25, 2012, from http://ru.wikipedia.org/wiki/Ас-Салам.

ability of our statistical methods to compensate for speaker variability with regard to reading proficiency.

Our concerns about using reading-based methods to investigate languages that speakers do not generally read, coupled with knowledge that the Mayan language literacy rate is generally low (Holbrock 2004; French 2010: Ch. 1), led us to look for a different experimental paradigm that assesses processing load without reading. We believe that one solution, based on cross-modal decision making, can be found in online sentence-picture matching (SPM) tasks. Tests of sentence comprehension based on picture matching where a subject hears a sentence/word and matches it to a picture are quite common in aphasiology (Caplan et al. 1997; Wassenaar and Hagoort 2007; a.o.), child language acquisition (Weist 1991; Weissenborn et al. 1990, a.o.), specific language impairment and second language learning (Grüter 2005 and references therein), and the visual-world paradigm (Witzel et al. 2012 and references therein). If used behaviorally or with a portable eye-tracker, this paradigm is easily transferable to use in the field.

In order to ascertain whether the SPM paradigm is actually comparable to self-paced reading in providing evidence on processing difficulty, we conducted a comparative study of self-paced reading (SPR) and sentence-picture matching (SPM) using Russian. Russian is a particularly apt test case, both because speakers use Russian in both spoken and written communication and because Russian has a subject-object ambiguity in relative clauses with inanimate DPs in the masculine and neuter as a result of scrambling. For example, the sequence in (9a) has two parses: a subject relative (9b) and an object relative (9c).

9 a. Ambiguous string – Russian
Akvarium kotoryj zagoraživaet jaščik.
SR: 'The fish tank which is blocking the box…' *or*
OR: 'The fish tank which the box is blocking…'

b. Subject relative – Russian
Akvarium$_i$ [kotoryj __$_i$ zagoraživaet jaščik]
fish.tank which.M.NOM blocks box.M.ACC
'The fish tank which is blocking the box...'

c. Object relative – Russian[14]
Akvarium$_i$ [kotoryj [zagoraživaet]$_k$ jaščik t_k __$_i$]
fish.tank which.M.ACC blocks box.M.NOM
'The fish tank which the box is blocking...'

[14] In this relative clause, the subject stays in the base position (spec,v) and the verb moves to a higher projection, presumably AspP (as indicated by the trace); for details, see Bailyn 2004 and Kallestinova 2007. Nothing hinges on the specific analysis of this construction for our purposes.

In an SPR study, Russian subjects read sentences like the ones in (9) and then answer the question 'Which object appears in front?' by clicking on one of two pictures (in the case of (9), either a box or a fish tank). They also read and chose pictures corresponding to unambiguous relative clauses with either a subject or an object gap (all the head nouns were masculine for equal comparison). 33 participants completed the survey, which included 12 items under 3 conditions (ambiguous, subject relative (SR), object relative (OR)). In a second study, 31 new participants listened to auditory versions of the same stimuli as in the SPR study and chose corresponding pictures. The measures included the reading times at each word (for the SPR study only), the percentage of relative clause interpretations as subject or object relative (both studies), and the time between the completion of the initial task (reading or listening) and the picture choice. Figure 5 provides a comparison of participant accuracy with unambiguous subject and object relatives as well as the percentage of ambiguous items interpreted as subject relatives.

Figure 5. Comparison of Russian relative clause SPR and auditory studies: Accuracy with unambiguous items and subject preference in ambiguous cases.

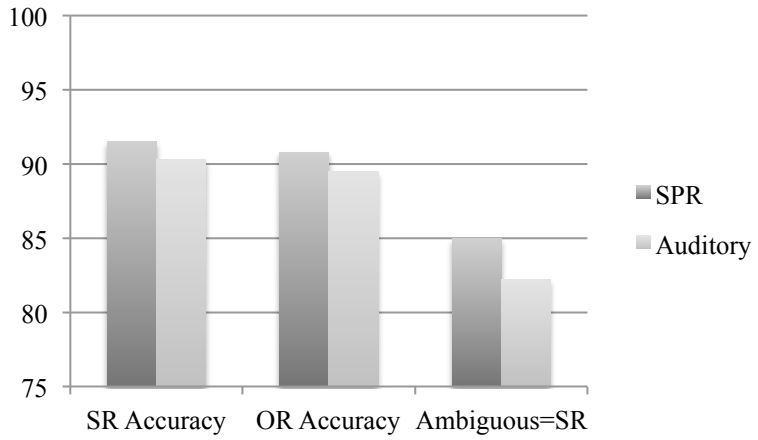
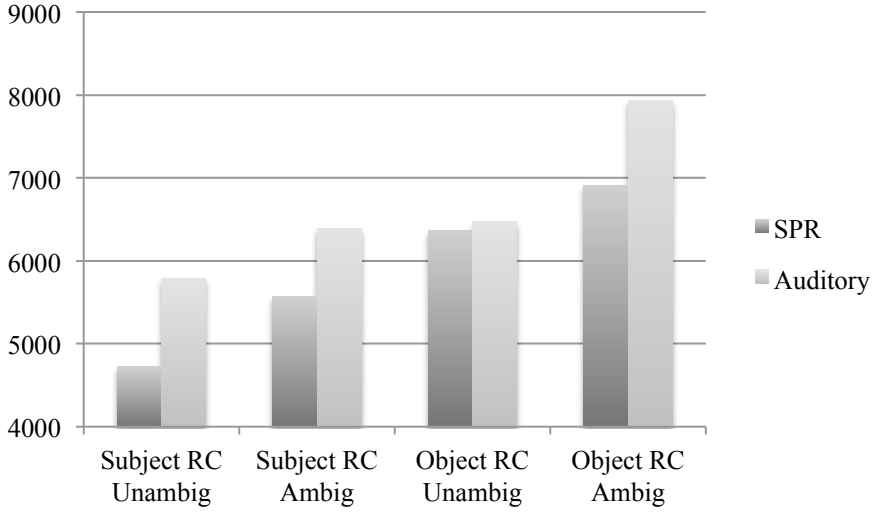


Figure 5 shows a significant subject preference under the ambiguous condition as measured by picture choice in both the SPR study (p <.001) and the auditory version (p < .05). Figure 6 provides a side-by-side comparison of time it took participants to decide whether they had just encountered a subject relative or an object relative. In the case of the SPR study, response time begins when the last word of the item appears on the screen; in the case of the auditory version of the study, response time begins when the sound file plays to completion.

Figure 6. Comparison of Russian relative clause SPR and auditory studies: Response time (*ms*) for picture choice



The results look extremely comparable, indicating that the two methodologies are equally able to capture the processing effect we are considering. We take this to give us the necessary proof of principle that sentence-picture matching can be successfully used in lieu of self-paced reading, when self-paced reading is deemed inappropriate. We are now ready to address the Mayan languages we investigated using the sentence-picture matching paradigm.

5. Ch'ol and Q'anjobal

The Mayan language family consists of about thirty languages spoken throughout southern Mexico, Guatemala, and Belize. The number of speakers varies from language to language: while speakers of K'ichee' number in the millions, Itzaj only has a handful of elderly speakers. Of the two languages compared in this study, Ch'ol belongs to the Tseltalan branch of the family and is spoken in Chiapas, Mexico. The data in this paper come from the Tumbalá variety (Ch'ol), as opposed to the Tila variety (Chol), (Vazquez Alvarez 2011). Q'anjob'al belongs to the Q'anjob'alan branch and is spoken primarily in Huehuetenango, Guatemala.

Mayan languages share many commonalities across the family. Most of the languages show verb-initial word order (see England 1991) and a morphologically ergative system of head-marking grammatical relations on the predicate (Larsen and Norman 1979). Mayan languages are robustly pro-drop, but when overt DP arguments are present, they generally follow the verb. In addition, they may be fronted to pre-verbal positions for topic and/or focus (Aissen 1992). In the vast majority of Mayan languages, a basic transitive verb stem has the structure of (10):

10. ASPECT–{ABS} ERG-[**verb.root**-(VOICE)-STATUS.SUFFIX]–{ABS}

Eventive predicates typically require one of a series of aspectual particles (possibly tense in some languages). The verb stem consists of the root, possibly voice or valence-changing morphology, and in many cases a "status suffix" which varies with transitivity and possibly aspect. In all of the

languages, the ergative marker, which cross-references transitive subjects, precedes the stem.[15] Absolutive morphemes cross-reference transitive objects and intransitive subjects. The location of absolutive is subject to variation within the family, but either it follows the aspect marker (as in Q'anjob'al), or it comes at the end of the verb stem (as in Ch'ol). Interestingly, the location of the absolutive morpheme appears to correlate with the presence of syntactic ergativity (Tada 1993; Coon et al. 2012). In Ch'ol, all core arguments may freely A-bar extract for wh-question formation, relativization, and topic (we illustrate this below with relativization), while in Q'anjob'al, A-bar extraction is limited to absolutive arguments.

The ergative argument is structurally superior to the absolutive argument of transitive clauses in all Mayan languages. Since the premise of this paper is that ergative languages uniquely allow us to investigate the role of grammatical function and case independently in the processing of relative clauses, we will provide two arguments that in transitive clauses, the ergative argument is structurally superior to the absolutive in Ch'ol and Q'anjob'al: the arguments come from binding and control.

In Ch'ol and Q'anjob'al reflexives, the ergative argument binds the reflexive. In both of these languages, reflexives are possessed nominals (the possessive markers and ergative markers are homophonous). The reflexive nominal has 3rd person features, and this nominal is indexed by the 3rd person absolutive marker on the verb (11a and 12a), which is consistently null in Mayan. If the reflexive could appear in the ergative, we would predict the ungrammatical structures shown in (11b) and (12b). Thus the absolutive reflexive is bound by the ergative argument, but not vice versa. This shows that the ergative argument must be structurally superior to the absolutive argument.

11a. Ch'ol reflexives
Ta' k-jats'-ä-ø k-bä
PRFV ERG.1-hit-TV-ABS.3 POSS.1-self
"I hit myself"

b. *Ta' i-jats'-ä-oñ k-bä
PRFV ERG.3-hit-TV-ABS.1 POSS.1-self
Intended: "I hit myself."

12a. Q'anjob'al reflexives
X-ø-w-il hin-b'a
PRFV-ABS.3-ERG.1-see POSS.1-self
'I saw myself.'

b. *X-in-s-il hin-b'a
PRFV-ABS.1-ERG.3-see POSS.1-self
Intended: 'I saw myself.'

For Ch'ol, we have a further diagnostic: obligatory control. In some nonfinite environments, it is the embedded ergative, not the absolutive object,t that is obligatorily controlled. (12a) shows a grammatical control structure where the controllee corresponds to the subject of the matrix verb 'want'. Though both matrix and embedded subjects are expressed, coreference is obligatory in the aspectless embedded environments. As (12b) shows, it is impossible for the controllee to be the absolutive object. (12c) proves that the construction instantiates obligatory control, as it does not

[15] Ergative morphemes are homophonous with possessor agreement morphemes, and they are both typically referred to in Mayan linguistics with the theory-neutral label "set A". Absolutive is commonly referred to as "set B".

allow a non-c-commanding antecedent:

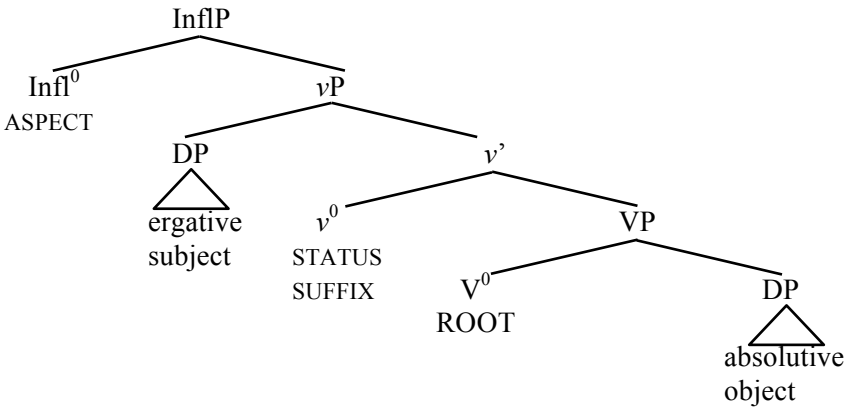
13a. Ch'ol obligatory control
K-om [k-mek'-ety.]
ERG.1-want ERG.1-hug-ABS.2
'I want to hug you.'

b. *K-om [i-mek'-ety.]
ERG.1-want ERG.3-hug-ABS.2
Intended: 'I want him to hug you.'

c. *K-om [a-mek'-oñ.]
ERG.1-want ERG.2-hug-ABS.2
Intended: 'I want you to hug me.'

These diagnostics confirm that the ergative is structurally superior to the absolutive. The basic outline of Ch'ol and Q'anjob'al clause structure is presented below:

Figure 7. General structure of transitives in Ch'ol and Q'anjob'al



5.1 Ch'ol relativization

As noted above, grammatical relations are encoded in Ch'ol via head-marking on the predicate. Ergative morphemes mark subjects of transitive verbs, while absolutive morphemes mark transitive objects and intransitive subjects. As in other Mayan languages, the third person absolutive marker is null; this null marker is represented here with "ø" for illustrative purposes, but is omitted elsewhere in the paper. These basic facts are illustrated in (14).

14a. Transitive clause – Ch'ol

Ta'	i-jap-ä-ø	kajpej	jiñi	x'ixik.
PRFV	3.ERG-drink-TV-3.ABS	coffee	DET	woman

'The woman drank coffee.'

b. Intransitive clause – Ch'ol

Ta'	wäy-i-ø	jiñi	x'ixik.
PRFV	sleep-ITV-3.ABS	DET	woman

'The woman slept.'

All core arguments freely relativize with a gap, as illustrated in (15a) for subject relative and in (15b) for object relative. Relative clauses in Ch'ol are marked with a second position clitic, *-bä*. This clitic attaches to the aspect marker in eventive predicates, and to the predicate itself in non-eventive predicates. This morpheme is absent from relative clauses in other Mayan languages, and is thought to be a borrowing from the neighboring Zoquean languages (see Vázquez Álvarez 2011 for discussion).

15a. Subject relative – Ch'ol

Ta'	jul-i	jiñi	x'ixik$_i$	[ta'-bä	y-il-ä-yety	__$_i$]
PRFV	arrive-ITV	DET	woman	PRFV-REL	3.ERG-see-TV-2.ABS	

'The woman who saw you arrived.'

b. Object relative – Ch'ol

Ta'	jul-i	jiñi	x'ixik$_i$	[ta'-bä	aw-il-ä	__$_i$]
PRFV	arrive-ITV	DET	woman	PRFV-REL	2.ERG-see-TV	

'The woman who you saw arrived.'

From the examples above we see that, because only one of the arguments in the clause is third person, an ambiguity is prevented: in (15a) the second person triggers absolutive, indicating that the object is second person; in (15b) the second person triggers ergative, indicating that it is the subject. However, ambiguity results when both DPs are third person, as shown in (16). Because both DPs appear post-verbally, and no case is marked on nouns, it is possible to interpret the gap in either subject or object position.

16a. Ambiguous string – Ch'ol

Ta' juli jiñi x'ixik ta'bä itsäk'ä jiñi wiñik.

SR: 'The woman who cured the man arrived' *or*

OR: 'The woman who the man cured arrived.'

b. Subject relative – Ch'ol

Ta'	jul-i	jiñi	x'ixik$_i$	[ta'-bä	i-tsäk'-ä	jiñi	wiñik	__$_i$]
PRFV	arrive-ITV	DET	woman	PRFV-REL	3.ERG-cure-TV	DET	man	

'The woman who cured the man arrived.'

c. Object relative – Ch'ol

Ta'	jul-i	jiñi	x'ixik$_i$	[ta'-bä	i-tsäk'-ä	__$_i$	jiñi	wiñik.]
PRFV	arrive-ITV	DET	woman	PRFV-REL	3.ERG-cure-TV		DET	man

'The woman who the man cured arrived.'

In practice, context may disambiguate between the two, but given the appropriate context, speakers report both readings to be available; i.e., neither interpretation is reported to be marginal or unnatural. Thus Ch'ol ambiguous relative clauses are similar to the Basque and Russian relatives above (see (4a) and (9) respectively). The possible ambiguity here provides a unique opportunity to determine whether speakers prefer to interpret the gap as ergative or absolutive, and whether one of these is easier.

5.2. Q'anjob'al relativization

Q'anjob'al shows two distinct environments with respect to relativization. In perfective and imperfective aspects, only absolutive arguments may relativize with a gap; a special construction

is required to relativize the ergative. In progressive constructions, however, an ambiguity arises similar to the one seen in Ch'ol. We examine both environments in turn.

5.2.1 Q'anjob'al perfective: syntactic ergativity

Basic word order in Q'anjob'al is VSO/VS, as seen in the examples in (17).[16] Note that while in Ch'ol, the absolutive markers appear at the end of the verb stem, in Q'anjob'al, they appear affixed to the clause-initial aspect morpheme. Here too, the third person absolutive marker is null.

17a. Transitive clause – Q'anjob'al
Max-ø y-uk' ix ix kapey.
PRFV-3ABS 3.ERG-drink DET woman coffee
'The woman drank coffee.'

b. Intransitive clause – Q'anjob'al
Max-ø way ix ix.
PRFV-3.ABS sleep DET woman
'The woman slept.'

In Q'anjob'al, absolutive arguments, i.e. transitive objects and intransitive subjects, are freely relativized with a gap. This is illustrated in (18).

18a. Object relative – Q'anjob'al
Max jay ix ix_i [max h-el-a' $\_\__i$]
PRFV arrive DET woman PRFV 2.ERG-see-TV
'The woman who you saw arrived.'

b. Intransitive subject relative – Q'anjob'al
Max jay ix ix_i [max way $\_\__i$]
PRFV arrive DET woman PRFV sleep
'The woman who slept arrived.'

In contrast to Ch'ol, ergative arguments do not relativize with a gap in Q'anjob'al, as shown by the ungrammaticality of (19).

19. Ungrammatical subject relative – Q'anjob'al
*Max jay ix ix_i [max-ach y-il-a' $\_\__i$]
PRFV arrive DET woman PRFV-2.ABS 3.ERG-see-TV
(*intended:* 'The woman who saw you arrived.')

Simple transitive sentences with two third person arguments are thus not ambiguous in Q'anjob'al, as they are in Ch'ol: in a basic transitive construction, only an object relative interpretation is available. In order to relativize, wh-question, or focus an ergative argument, i.e. a transitive subject, a special construction must be used which is known in Mayan literature as "Agent Focus" (henceforth AF) (see e.g. Stiebels 2006; Coon et al. 2012). AF transitives differ from regular transitives in several important respects: (i) the transitive subject no longer triggers

[16] Q'anjob'al has verb stem-final status suffixes, as in Ch'ol, but they are generally deleted when not phrase final. While Ch'ol has a single determiner *jiñi*, Q'anjob'al has a series of noun class markers, such as *ix* used for female humans, which change form depending on the noun. We gloss them all as "DET" for simplicity.

ergative agreement on the verb stem, (ii) the suffix *-on* appears suffixed to the root; (iii) the verb appears with the intransitive, rather than transitive, status suffix (compare *–i* in (20)).

20. Grammatical subject relative with AF – Q'anjob'al

Max	jay	ix	ix_i	[max-ach	il-**on**-i	$\_\__i$]
PRFV	arrive	DET	woman	PRFV-2.ABS	see-AF-ITV	

'The woman who saw you arrived.'

Despite the intransitive morphology, the AF structure is not an antipassive, as it might first appear (Aissen 1992, Craig 1979, Smith-Stark 1978, Stiebels 2006, Tonhauser 2007; also Ayres 1983). While there is no ergative agreement on the verb stem in (20), the absolutive still tracks the object, not the relativized subject. Compare the grammaticality of (20) to the ungrammaticality of (21), where the absolutive agreement (null marker) ungrammatically indexes the person of the relativized subject, and not of the object.

21.

*Max	jay	ix	ix_i	[max-ø	il-**on**-i	$\_\__i$]
PRFV	arrive	DET	woman	PRFV-3.ABS	see-AF-ITV	

'The woman who saw you arrived.'

In effect, the absolutive marker in (21) behaves as though it were part of a simple transitive clause and not as a member of an intransitive clause, which would be expected if AF were an instance of the antipassive.

Finally, the object in AF constructions is not oblique, in contrast to the object in antipassives, and may not be omitted. Oblique arguments in Q'anjob'al are introduced by relational nouns; no relational noun is present in example (20), which indicates that the AF object is not oblique. Even when the object itself is unpronounced, this is simply an instance of pro-drop because the agreement marker indexing that object remains present in the verb.

5.2.2 Q'anjob'al progressive: Ambiguity

In matrix clauses, the AF construction is reserved to environments in which the transitive subject has been A-bar extracted. However, the AF morphology is also found in *all* non-finite embedded transitives in the language, regardless of whether or not a DP has undergone extraction (Pascual 2007; see Coon et al. 2012 for analysis). This is illustrated in the embedded transitives in (22). Notice that we assume that (22b), despite its English translation, is a biclausal structure with the matrix verb *lanan* encoding the progressive aspect. The progressive *lanan* has been argued elsewhere to be a predicate, which embeds a non-finite clause (see Bricker 1981 on Yucatec; Mateo Pedro 2009 on Q'anjob'al; Coon in press, on Ch'ol). For a discussion of the crosslinguistic tendency to express progressive with complex constructions see Bybee et al (1994), Laka (2006) and Coon (in press). Note also that while the stem appears with the AF and intransitive status suffixes, as in (21) above, here the ergative prefix is again present.[17]

22. Embedded nonfinite clause – Q'anjob'al

a.

Chi	uj	[hach	y-il-on-i.]
IMPF	be.able.to	2.ABS	3.ERG-see-AF-ITV

'She can see you.'

[17] In other work (e.g., Mateo Pedro 2010; Coon et al. 2012), the ergative is analyzed as the *possessive marker,* and the corresponding embedded clauses are argued to be nominalizations. In Q'anjob'al even embedded intransitive subjects are marked with the ergative prefix, supporting the idea that these are formally possessed nominalizations.

b. Lanan [hach y-il-on-i.]
PROG 2.ABS 3.ERG-see-AF-ITV
'She is seeing you.'

Since the AF form of the verb stem is required in all embedded transitives, it is precisely in these environments that extraction ambiguities arise in Q'anjob'al.

23a. Ambiguous string – Q'anjob'al
Max wil ix ix lanan yanten naq winaq.
SR: 'I saw the woman who was treating/curing the man.' *or*
OR: 'I saw the woman who the man was treating/curing.'

b. Subject relative – Q'anjob'al

Max	w-il	ix	ix_i	[lanan	[y-ante-n	$\_\__i$	naq	winaq.]]
PRFV	3.ERG-see	DET	woman	PROG	3.ERG-cure-AF		DET	man

'I saw the woman who was treating/curing the man.'

c. Object relative – Q'anjob'al

Max	w-il	ix	ix_i	[lanan	[y-ante-n	naq	winaq $\_\__i$]]
PRFV	3.ERG-see	DET	woman	PROG	3.ERG-cure-AF	DET	man

'I saw the woman who the man was treating/curing.'

5.3 Interim summary

To recapitulate, Ch'ol freely permits relativization of all core arguments. The fact that both DPs originate post-verbally and that no case is marked on the nominals themselves results in ambiguity when both DPs are third person (i.e. when agreement on the verb does not differentiate); the aspect of the verb does not play an important role.

Q'anjob'al, in contrast, can be described as syntactically ergative: absolutive arguments freely extract, but ergative DPs do not. In order to extract a transitive subject, a special AF verb form must be used. However, due to special properties of progressive constructions (namely, that they involve syntactic embedding, and that the AF form of the verb is required *regardless* of whether an argument has extracted), we find ambiguity in the progressive when both DPs are third person. We will use the ambiguities that arise in Ch'ol and Q'anjob'al as one way to explore the processing of relative clauses.

6. The processing of relative clauses in Ch'ol and Q'anjob'al

The majority of cross-linguistic evidence for the subject processing advantage (SPA) in relatives comes from accusative languages where grammatical function and case correspond. Ergative languages uniquely allow us to investigate the role of grammatical function and case in the processing of relative clauses independently, and therefore allow us to investigate whether case or function underlies the SPA.

If the SPA were driven by case prominence, then we would expect more accurate responses on object extractions in stimuli semantically biased for object interpretation as compared to subject extractions in stimuli semantically biased for subject interpretation. We would also expect fewer subject-compatible responses in ambiguous stimuli. This pattern would reflect absolutive gaps being processed more successfully or being more easily accessible in ambiguity resolution. If the SPA were instead controlled exclusively by phrase structure prominence, i.e. grammatical function, then we would expect more accurate responses on subject

extractions in stimuli semantically biased for subject interpretation as compared to object extractions in stimuli semantically biased for object interpretation. We would also expect fewer object-compatible responses in ambiguous stimuli. This pattern would reflect subject gaps being processed more successfully or being more easily accessible in ambiguity resolution.

6.1 Ch'ol: Materials, methods, and participants

In the Ch'ol experiment, we compared the processing of four gap types: absolutive subject gaps (24a), gaps ambiguous between ergative subject and absolutive object (24b), ambiguous gaps semantically biased towards ergative subject (24c), and ambiguous gaps semantically biased towards absolutive object (24d).

Recall that in Ch'ol, all relatives based on transitive clauses are syntactically ambiguous. To create relative clauses with a bias towards subject or object interpretation, then, we systematically manipulated the animacy of the arguments with respect to one another. Thus, while 'Find the boy that the beans are picking' is a possible translation of (24c), this and the corresponding implausible interpretation for (24d) represent unlikely interpretations for pragmatic reasons. Other factors we manipulated within relative clauses across stimuli include aspect (perfective and progressive), morphological form of the verb (derived vs. non-derived), and type of intransitive verb (unergative vs. unaccusative).

24. Example stimuli – Ch'ol

a. Intransitive:
Yajkañ jiñi mis$_i$ [tsa'-bä i-cha'l-e xämbal tyi __$_i$ i-ty'ej kabayu.]
choose DET cat PRFV-REL 3.ERG-do-TV walk PRP 3.ERG-side horse
'Choose the cat that walked next to the horse.'

b. Ambiguous transitive, Condition (a):
Päsbeñ jiñi poli$_i$ [wol-bä i-käch (__$_i$) jiñi solraru (__$_i$)]
show DET police [PROG-REL 3.ERG-tie.up DET soldier
'Show me the police officer that is tying up the soldier.' *Or*
'Show me the police officer that the soldier is tying up.'

Ambiguous transitive, Condition (b):
Päsbeñ jiñi solraru$_i$ [wol-bä i-käch (__$_i$) jiñi poli (__$_i$)]
show DET soldier [PROG-REL 3.ERG-tie.up DET police
'Show me the soldier that is tying up the police officer.' *Or*
'Show me the soldier that the police officer is tying up.'

c. Biased transitive:
Tyaja jiñi alob$_i$ [wol-bä i-k'ok jiñi bu'ul __$_i$]
find DET boy PROG-REL 3.ERG-pick DET bean
'Find the boy that is picking beans.'
Implausible: 'Find the boy that the beans are picking.'

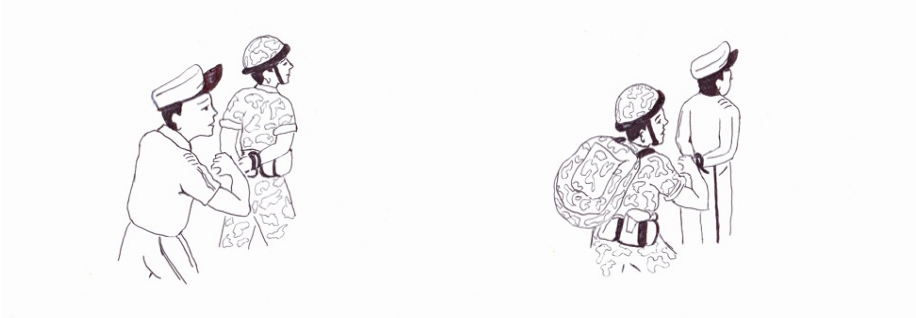
d. Biased transitive:
Baki añ jiñi kajpej$_i$ wol-bä i-jap __$_i$ jiñi solraru?]
where LOC DET coffee PROG-REL 3.ERG-drink DET soldier
'Where is the coffee that the soldier is drinking?'
Implausible: 'Where is the coffee that is drinking the soldier?'

The images used in our experiment were commissioned from an artist who is a native speaker of Q'anjob'al, and all stimuli involved objects, professions, and activities common in Mayan communities.

Our stimuli were constructed in collaboration with a native Ch'ol speaker who recorded them in the Harvard Phonetics Lab. After recording and before testing, we verified, using our consultant's intuitions as well as acoustic analysis of pitch and phrasing, that the syntactically ambiguous stimuli were not prosodically disambiguated.

The experiment was run using Linger (Rohde 2007). Participants watched a short introductory video in Ch'ol (recorded by the same native speaker). Participants were instructed to listen to each item to completion and then select the picture that best represented the item that they had just heard. For the intransitive stimuli there was a correct representation and an incorrect representation, i.e., one where the subject and PP argument were switched. For the biased stimuli, the options included only the plausible reading: for an example like (24d), participants would be given the choice of an image of a man drinking coffee or a man eating tortillas. For the ambiguous stimuli, the two possible parsing interpretations were represented. An example set of pictures is given below.

Figure 8. Example screenshot from experiment: This screenshot corresponds to the stimulus item in (24b). On the left, a police officer is depicted tying up a soldier. On the right, a soldier is depicted tying up a police officer.



Participants indicated their selection with a binary button box. They were told that the experiment was not a test and that there was not necessarily a correct answer. After the practice phase, further explanation was given in Ch'ol or Spanish before the experimental phase began.

63 native Ch'ol speakers completed the study. 16 participants were undergraduate students studying at *Universidad Intercultural de Tabasco* in Tabasco, Mexico. 41 were run in Comunidad San Miguel, Chiapas, Mexico, and the remaining 6 in Tila, Chiapas, Mexico. 28 participants were female and 28 were male. 40 participants reported being Ch'ol-Spanish bilinguals; the remaining 16 reported to be monolingual speakers of Ch'ol. Seven participants were excluded before data analysis when it was determined that they had not understood the instructions. Two more participants were taken out during the analysis due to low accuracy on unambiguous tokens.[18] Of the participants whose data were used, the age range was 15 to 54, with a mean of 29.

6.2 Ch'ol results

[18] Accuracy on the two biased relative clause types was computed as d-prime scores. We scaled the accuracy on subject extractions from semantically biased transitives or subject extractions from intransitives against the error rate on semantically disambiguated object extractions. Each participant was then assigned the average of these scores. Participants whose average d-prime score was less than twice the standard deviation below the mean (2.1, s.d. = 0.87) were excluded; in our case it was only two subjects.

With respect to semantically biased relative clauses, participants are both more accurate and faster with ergative subject relatives than absolutive object relatives (see 6.2.1 below). In the case of ambiguous relatives, we find that participants are more likely to resolve the ambiguity with an ergative subject interpretation; when they instead choose absolutive object interpretations, they take longer to do so (6.2.2). Finally, we report other effects, and in particular, those pertaining to language experience: Ch'ol monolinguals and Ch'ol-Spanish bilinguals display similar response patterns, however, the results are more pronounced in the case of the bilinguals (6.2.3).

6.2.1 Forced choice task

*Unambiguous and biased relative clauses***.** Table 1 reports accuracy for the syntactically unambiguous (intransitive) and the syntactically ambiguous but semantically biased transitive stimuli. For unambiguous stimuli, we report the percentage of correct picture choices. Similarly, for syntactically ambiguous stimuli with a strong semantic bias toward either a subject or object interpretation we report the percentage of picture choices that reflect a response congruent with the bias. In this table and in subsequent tables, the standard error, computed over participant means, is given in parentheses.

Table 1. Participant accuracy on unambiguous and semantically biased RCs

GAP TYPE	**ACCURACY** (*n*=51)
Intransitive Absolutive Subject	72 (2)
Transitive Ergative Subject	96 (1)
Transitive Absolutive Object	86 (3)

Looking at the crucial comparison between subject and object extractions in transitive clauses, we find that participants gave more accurate responses to sentences containing ergative/subject extractions than to sentences with absolutive/object extractions (β: 0.06 ± 0.02, $p < .05$). Participants were more accurate on extractions from transitive clauses than on extractions from intransitive clauses (β: 1.33 ± 0.17, $p < .001$).

Ambiguous relative clauses. For gaps ambiguous between ergative subject and absolutive object, participants showed a preference for subject-compatible responses 68% of the time (s.e.: 2%).

6.2.2 Response times

We also examined response times (RTs), with transitives split according to the interpretations participants assigned.[19] Response times were long (2-6 seconds; median RT: 3.1 seconds, IQR: 1.7-5.4 seconds), probably both because there was no deadline and because many of our participants had little or no experience with computers. Table 2 reports the mean reaction times and standard error for each condition (with RTs reported only for correct/bias-congruent responses, where applicable). For the biased stimuli, only the RTs for responses congruent with the direction of the bias were used to determine the mean. For the intransitives, only correct responses were used.

[19] In this analysis, we transformed the RTs by the natural log. In doing so, we ensured that the residuals were normally distributed. We thus minimized the impact of potential outlier observations. We compared this transformation to an inverse transformation, and found that only

Table 2. Mean RTs (*ms*) for intransitives, biased transitives and ambiguous transitives

GAP TYPE		**MEAN RT** in *ms*
Intransitive Absolutive Subject		3574 (108)
Biased Transitive	*Ergative Subject*	2207 (140)
	Absolutive Object	2890 (261)
Ambiguous Transitive	*Ergative Subject*	3914 (133)
	Absolutive Object	4340 (269)

Subject-compatible responses were reliably shorter than object-compatible responses (β: -0.10 ± 0.05 log sec, t = -2.1, $p < .05$).

6.2.3 Other effects

*Unambiguous and biased relative clauses***.** Table 3 reports accuracy by extraction type for unambiguous relative clauses and fluency in Spanish (Ch'ol-Spanish bilinguals vs. Ch'ol monolinguals). In the case of the intransitives, there was a significant effect of language experience, with bilingual speakers giving more accurate responses (β: 0.44 ± 0.18, $p < .05$).

Table 3. Accuracy on unambiguous and biased RCs according to language experience

	LANGUAGE EXPERIENCE	
GAP TYPE	*Monolingual* (n = 11)	*Bilingual* (n = 36)
Intransitive	65 (4)	74 (2)
Biased to Object RC	83 (6)	87 (3)
Biased to Subject RC	95 (3)	96 (1)

Ambiguous relative clauses. For the unbiased ambiguous stimuli (Tables 4 and 5), bilingual participants (n=36) gave more subject-interpretation responses than monolingual speakers (n=11) (β: 0.72 ± 0.25, $p < .005$). We found two additional main patterns in features that were not manipulated as a controlled factor in our experiments, i.e., they varied across items in our stimuli and not across conditions within items. First, root (non-derived) transitives led to a higher percentage of subject-interpretation responses (β: 0.22 ± 0.07, $p < .001$). Second, progressive aspect led to more subject-interpretation responses (β: 0.30 ± 0.14, $p < .05$).

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the log transformation led to normal residuals (see Ratcliff 1993; Baayen and Milin 2010). In all analyses, the pattern of results and significance were the same.

Table 4. Percentage subject-compatible responses to unbiased ambiguous stimuli according to morphological form, aspect, and language experience

MORPHOLOGICAL FORM AND ASPECT		LANGUAGE EXPERIENCE	
		Monolingual (n = 11)	*Bilingual* (n = 36)
Root Transitive	*Perfective*	53 (7)	77 (3)
	Progressive	75 (6)	78 (3)
Derived Transitive	*Perfective*	51 (5)	66 (3)
	Progressive	58 (6)	72 (4)

In Table 5, predictors are centered and scaled to unit differences between the 2 levels. The positive level for each coefficient (corresponding to +0.5) is given in parentheses.

Table 5. Fixed effects, logistic regression over subject-compatible responses

Coefficient	***Estimate***	***Standard Error***	***z-value***	***P(>|z|)***	
INTERCEPT	0.913	0.108	8.42	< 2e-16	***
MORPHOLOGICAL FORM (*Root)*	0.222	0.069	3.20	0.001	**
ASPECT *(Progressive)*	0.304	0.138	2.20	0.028	*
FLUENT IN SPANISH? (*Yes*)	0.720	0.249	2.89	0.004	**

The effect of language experience was strong: Ch'ol speakers who were also fluent in Spanish showed a greater tendency to interpret the ambiguous relative clauses as subject-extracted relative clauses. We conducted a further analysis, restricted to just the 11 speakers who were not fluent in Spanish. For these speakers, there was a significant tendency to interpret relative clauses as subject-extractions (β: 0.36 ± 0.16, $p < .05$) and a significant effect of aspect (β: 0.60 ± 0.26, $p < .05$). The effect of morphological form did not achieve significance (β: 0.20 ± 0.13, $p \sim 0.14$), though it was in the same direction and of the same magnitude as the effect in the entire sample. Thus Ch'ol speakers who were not fluent in Spanish showed the same pattern as speakers who were fluent in Spanish, but their base-rate of choosing subject interpretations was lower.

In a final analysis, we divided experimental participants by their subject-preference rate for the unbiased ambiguous stimuli. The goal of this analysis was to quantify the prevalence of participants who might have an object preference. In Table 6, we report how many participants fall into each of 5 categories: 0-20% subject preference, 21-40%, 41-60%, 61-80% and 81-100%. Participants were split by language experience. It's clear that more participants in the bilingual group had near-total subject preference rates. Monolingual participants tended to show a subject preference, but not an extreme one. Note that for either language experience group, no more than 2 individuals fell below 40% in subject preference rates.

Table 6. Participants by subject preference rates

LANGUAGE EXPERIENCE	0-20%	21-40%	41-60%	61%-80%	81% - 100%
Monolingual	0	1	3	7	0
Bilingual	0	2	3	19	12

Response times. With regard to response time, there was no reliable effect of language experience or of the derived/root status of the verb. The effect of aspect was clear, though; responses to progressive stimuli were significantly shorter than responses to perfective stimuli (β: -0.36 ± 0.04 log sec, t = -8.5, $p < .001$).

6.3 Discussion of Ch'ol results

Participants are faster and more accurate with transitive stimuli generally than they are with intransitive stimuli. The difference between the transitives and intransitives is likely to follow from the duration of the stimuli; our intransitive stimuli were much longer than our transitive stimuli. The mean duration of intransitive stimuli was 4.0 s, but it was only 2.8 s for transitive stimuli.

When we consider the transitives to the exclusion of intransitives, we find that participants are more accurate with subject-biased stimuli than with object-biased stimuli. Participants are also faster to choose subject-compatible responses to subject-biased transitive stimuli than they were to give object-compatible responses to object-biased stimuli. We also find that participants demonstrate a preference for the subject interpretation in the resolution of unbiased ambiguous items, and that RTs are lower for subject-compatible responses than for object-compatible responses. The subject preference is greater for the stimuli which contained root transitives as opposed to derived transitives, and for the stimuli whose verb is in the progressive aspect as opposed to perfective aspect. This result is not important for our driving question, but it is worth mentioning that overall the particular root transitives in our stimuli are likely more commonly used than the derived ones. It is therefore likely that the overall effect of subject preference is magnified in stimuli containing the more frequent lexical items.[20]

We conclude that, for speakers of Ch'ol, subject extractions are less complex than object extractions. Data from patterns of choice and response times support this conclusion. This preference is modulated by language experience; it is less pronounced in monolingual speakers. The effect of language experience is discussed in Section 7, since the Q'anjob'al data display a similar pattern.

6.4 Q'anjob'al: Materials, methods, and participants

In the Q'anjob'al experiment, we compared the processing of the four gap types that matched the gaps investigated in Ch'ol: absolutive subject gaps (25a), gaps ambiguous between ergative subject and absolutive object (25b), ambiguous gaps semantically biased towards ergative subject (25c), and ambiguous gaps semantically biased towards absolutive object (25d). In addition, we included syntactically unambiguous subject (25e) and object relatives (25f). Syntactically unambiguous subject and object relatives are possible in Q'anjob'al but not in Ch'ol, because only Q'anjob'al is syntactically ergative (see Section 5.2). Note that in (25e), the predicate of the

[20] There are no frequency data for Ch'ol, so this is just a conjecture on our part, although it is supported by native speakers' intuitions.

relative clause is in the AF form, which entails that only the subject can be extracted. Conversely, in (25f) the only argument that can be extracted is the absolutive object.

Other factors manipulated within relative clauses were morphological form of the verb (derived vs. non-derived), and type of intransitive verb (unergative vs. unaccusative).

25 Example stimuli -- Q'anjob'al

a. Intransitive:
Tx'ox ayin no' oq$_i$ [lanan [s-way __$_i$ s-pak'ilal no' chej]].
show 1.SG DET coyote PROG 3.ERG-sleep 3.ERG-side DET horse
'Show me the coyote that is sleeping next to the horse.'

b. Ambiguous transitive, Condition (a):
Say no' chej$_i$ [lanan [s-tek'on (__$_i$) no' wakax (__$_i$)]]
find DET horse PROG 3.ERG-kick-AF DET cow
'Find the horse that is kicking the cow.' *Or*
'Find the horse that the cow is kicking.'

Ambiguous transitive, Condition (b)
Say no' wakax$_i$ [lanan [s-tek'on (__$_i$) no' chej (__$_i$)]]
find DET cow PROG 3.ERG-kick-AF DET horse
'Find the cow that is kicking the horse.' *Or*
'Find the cow that horse is kicking.'

c. Biased transitive, subject relative:
Tx'ox ayin naq winaq$_i$ [lanan [s-lo-hon __$_i$ an keney.]]
show 1.SG DET man PROG 3.ERG-eat-AF DET banana
'Show me the man who is eating the banana.'
Implausible: 'Show me the man whom the banana is eating.'

d. Biased transitive, object relative:
B'aytalil ay te' kapey$_i$ [lanan [y-uk'-on cham pale __$_i$?]]
where LOC DET coffee PROG 3.ERG-drink-AF DET priest
'Where is the coffee that the priest is drinking?'
Implausible: 'Where is the coffee that is drinking the priest?'

e. Unambiguous transitive subject relative:
Tx'ox ayin xal ixnam$_i$ [max jeq-on __$_i$ cham icham.]
show 1.SG DET old.woman PRFV massage-AF DET old.man
'Show me the old woman that massaged the old man.'

f. Unambiguous transitive object relative:
Tx'ox ayin cham doctor$_i$ [max y-iq cham mexhtol __$_i$].
show 1.SG DET doctor PRFV 3.ERG-carry DET teacher
'Show me the doctor that the teacher carried.'

Our stimuli were constructed by a Q'anjob'al native speaker, and recorded at the Harvard Phonetics Lab. As with Ch'ol, we verified that the syntactically ambiguous stimuli were not prosodically disambiguated. The images used in the Q'anjob'al version of the experiment were the same as those used for Ch'ol.

This experiment was also run in Linger. Participants watched a short introductory video where instructions were given in Q'anjob'al. For more information about our methodology, see Section 6.1, as the Q'anjob'al experiment was conducted in the same way as the Ch'ol experiment. 100 native speakers of Q'anjob'al completed the study in Santa Eulalia, Huehuetenango, Guatemala. Data from four participants was removed from the study before analysis when it was determined they had misunderstood the instructions. Two additional participants' data were excluded from the analysis due to low accuracy on unambiguous subject extractions.[21] Of the participants whose data were used, the age range was 16 to 65 with a mean of 30. 44 participants were female and 50 were male. 47 participants reported to be Q'anjob'al-Spanish bilingual; the remaining 47 were monolingual speakers of Q'anjob'al.

6.5 Q'anjob'al results

With respect to unambiguous and biased relative clauses, Q'anjob'al participants are more accurate with subject gaps than with object gaps (6.5.1). In the case of ambiguous relatives, participants prefer the subject interpretation (6.2.2). Finally, we report other effects, and in particular, those pertaining to language experience: Q'anjob'al monolinguals and Q'anjob'al-Spanish bilinguals display similar response patterns, however the results are more pronounced in the bilingual pool (6.2.3).

6.5.1 Forced choice task

Unambiguous and biased relative clauses. Table 7 gives the overall accuracy for unambiguous (25a, e, f) and semantically biased (25c, d) stimuli. For unambiguous stimuli, we report the percentage of correct picture choices. For the semantically biased stimuli, we report the percentage of responses congruent with the bias. In this and subsequent tables, the standard error is given in parentheses.

Table 7. Participant accuracy for unambiguous and semantically biased RCs

GAP TYPE		**ACCURACY** (*n*=94)
Intransitive Absolutive Subject		83 (1)
Unambiguous Transitive	*Subject of AF*	75 (2)
	Absolutive Object	51 (5)
Biased Transitive	*Ergative Subject*	79 (3)
	Absolutive Object	88 (2)

The overall accuracy on unambiguous tokens was 77% (s.e. by participant: 1%). Looking at subject and object extractions in unambiguous transitive clauses, we see that responses to subject extractions were more often correct than responses to object extractions (β: 0.50 ± 0.12, $p < .001$). This is not the case, however, for the biased stimuli, where object extractions are more often correct than subject extractions. For the semantically biased relative clauses, the effect of bias

[21] Accuracy on unambiguous object extractions was low (51%), therefore we do not use it as a reasonable basis on which to identify outlier participants (as we did for the Ch'ol data, by including it in a *d*-prime calculation). Instead we examined each participant's average percentage correct on unambiguous subject extractions (both transitive and intransitive), and excluded those whose average, expressed as a *z*-score, was less than twice the standard deviation below the mean (0.99 [==83%], s.d.: 0.30). There were two participants excluded by this criterion.

was significant, and in the expected direction: subject bias led to more subject interpretations (β: 3.72 ± 0.25, p <.001). We can therefore look at the semantically biased and unambiguous transitives together; taken together, responses to subject extractions are indeed more often correct (β: 0.50 ± 0.12, p <.001). Finally, participants were less accurate on extractions from transitive clauses than they were on extractions from intransitive clauses (β: 0.52 ± 0.09, p <.001).

Ambiguous relative clauses. The percentage of subject-interpretation compatible responses for ambiguous stimuli with no semantic bias (25b) was 74% (s.e.: 2%). Participants thus showed a preference to interpret ambiguous transitive relative clause extractions as subject extractions.

6.5.2 Response times

We examined response times, with transitives split according to the interpretations participants assigned. Response times were not as slow as in the previous experiment, though most were over one second (median RT: 1.2 seconds, IQR: 0.74-2.2 seconds).Table 9 gives mean RT by gap type. Among transitives, we find one nearly reliable pattern for semantically unbiased stimuli: subject-compatible responses were shorter than object-compatible responses (β: -0.08 ± 0.04 log sec, t = -1.9, p < .10).

Table 8. Mean Q'anjob'al RT by gap type (standard error in parentheses)

GAP TYPE		**MEAN RT** in *ms*
Intransitive Absolutive Subject		1472 (83)
Unbiased Transitive	*Subject of AF*	2059 (117)
	Absolutive Object	2501 (182)
Biased Transitive	*Ergative Subject*	1377 (77)
	Absolutive Object	1513 (120)
Ambiguous Transitive	*Ergative Subject*	1938 (114)
	Absolutive Object	2240 (158)

For the object-biased transitives, the shortest response times were observed when the response was compatible with the bias. However, this numerical trend did not achieve significance.

6.5.3 Other effects

Unambiguous and biased relative clauses. Table 9 reports accuracy by extraction type for unambigous and biased relative clauses and fluency in Spanish (Q'anjob'al-Spanish bilinguals vs. Q'anjob'al monolinguals). For unambiguous transitives and for intransitives, there was a significant effect of language experience, with bilinguals giving more accurate responses (β: 0.52 ± 0.09, p <.001). The effect of semantic bias was also sharper among Spanish-fluent speakers, reflected in a significant interaction of bias and language experience (β: 2.36 ± 0.50, p <.001). In other words, bilinguals were more likely to respond to biased stimuli in the direction of the bias.

Table 9. Accuracy on unambiguous and biased RCs according to language experience

		LANGUAGE EXPERIENCE	
GAP TYPE		*Monolingual* (*n* = 47)	*Bilingual* (*n* = 45)
Intransitive Absolutive Subject		73 (2)	83 (1)
Unambiguous Transitive	*Subject of AF*	70 (3)	70 (2)
	Absolutive Object	50 (5)	53 (4)
Biased Transitive	*Ergative Subject*	74 (3)	86 (3)
	Absolutive Object	82 (3)	96 (2)

Recall that participants were less accurate on extractions from transitive clauses overall. There was a marginal interaction of transitivity and language experience, such that the difference in accuracy on the two clause types was narrowed for speakers fluent in Spanish (β: -0.24 ± 0.05, p <.10). We observe that transitive extractions were easier for Ch'ol participants; the opposite effect of transitivity in the Q'anjob'al data is dominated by the low accuracy on object extractions. If we remove object extractions altogether, then the effect of transitivity becomes non-significant.

Ambiguous relative clauses. There are two main patterns for the semantically unbiased, syntactically ambiguous relative clauses. First, bilingual speakers showed a stronger subject preference (β: 0.73 ± 0.18, p <.001). Second, derived transitives led to more subject-interpretation responses than non-derived transitives (β: -0.42 ± 0.16, p <.01). Table 10 reports the percentage of subject-compatible responses to ambiguous stimuli according to language experience and to the morphological form of the verb. Table 11 is a fixed effects, logistic regression over subject-compatible responses. The *estimate* indicates the strength of the effect, and the low p values indicate that all of these effects were significant.

Table 10. Percentage subject-compatible responses to unbiased ambiguous stimuli according to morphological form and language experience

	LANGUAGE EXPERIENCE	
Morphological Form	*Monolingual* (n = 47)	*Bilingual* (n = 45)
Nonderived	64 (3)	76 (3)
Derived	70 (3)	84 (2)

Table 11. Fixed effects, logistic regression over subject-compatible responses[22]

Coefficient	***Estimate***	***Standard Error***	***z-value***	***P(>|z|)***	
INTERCEPT	1.12	0.089	12.69	< 2e-16	***

[22] For the fixed effects logistic regression over subject-compatible responses in Table 11, predictors are centered and scaled to unit differences between the 2 levels. The positive level for each coefficient (corresponding to +0.5) is given in parentheses.

MORPHOLOGICAL FORM *(Root)*	-0.42	0.158	-2.70	0.007	**
FLUENT IN SPANISH? *(Yes)*	0.73	0.178	4.09	4.28e-05	***

Response times. In Table 12, reaction times are broken down by derivation and language experience. There were no simple effects of language experience or morphological derivation on response times. As mentioned above, the shortest response times for biased stimuli seemed tendentially to be those congruent with the direction of the bias. Splitting participants by language experience revealed that this effect was only consistent in bilingual speakers and was reflected in the three-way interaction coefficient between bias, response type, and language experience (β: -0.45 ± 0.15, t=-3.1, p <.005).

Table 12. Response time for ambiguous stimuli according to morphological form, bias and language experience

MORPHOLOGICAL FORM AND BIAS		**MONOLINGUAL** (n = 47)		**BILINGUAL** (n = 45)	
		Subject Compatible	*Object Compatible*	*Subject Compatible*	*Object Compatible*
Ambiguous	*Root*	1893 (194)	2126 (320)	2220 (188)	2670 (264)
	Derived	1897 (172)	1979 (199)	1858 (148)	2474 (267)
Semantically Biased	*Subject*	1460 (122)	1236 (120)	1287 (90)	1822 (243)
	Object	1619 (151)	1609 (191)	3633 (534)	1407 (139)

6.6 Discussion of Q'anjob'al results

The results show that participants are generally more accurate on subject extraction than on object extraction in transitive clauses. In particular, in ambiguous stimuli with no semantic bias, participants favored responses consistent with the subject interpretation. This preference is most apparent in bilingual speakers (see Section 7.2 for a discussion of language experience). We also find that derived transitives led to more subject-interpretation responses than did root transitives, which is the opposite of what we found for Ch'ol. The verbs used in the Ch'ol stimuli and the verbs used in the Q'anjob'al stimuli were different; there is no one-to-one correspondence between the verbs across the two experiments. As is the case for Ch'ol, however, we suspect that the difference between root transitives and derived transitives could be an effect of the particular lexical items in our stimuli and/or general lexical frequency of root and derived transitives. This conjecture brings us to a testable hypothesis; however, without information about lexical frequency, we must leave this question for future work.

Two other trends in the data deserve further discussion. In *semantically biased relative clauses*, participants are more accurate with object extractions (25d) than they are with subject extractions (25c). In contrast, participants show lower scores for *syntactically unambiguous stimuli*, and particularly low scores with unambiguous object extraction (25f).[23]

[23] The accuracy for unambiguous subject extractions is so low that it suggests that participants may have been performing at chance. Given the high standard error on these trials and the

Recall that semantically biased stimuli have two arguments differing in animacy, with an animate subject and inanimate object. Studies of English relativization show that object relatives with inanimate head nouns are particularly easily interpreted (Traxler et al. 2002; Gennari and MacDonald 2008). The Q'anjob'al result is therefore consistent with the strategy of favoring inanimate objects modified by a relative clause, in the presence of the animate subject. In such cases, it stands to reason that the participants' interpretive strategy relies more on world knowledge (i.e., the more animate of two transitive arguments is likely to be the subject) than on structural cues; the latter may be relied on as the last resort.

As for the low scores on the unambiguous objects, this can be explained by the participants' expectations. Q'anjob'al employs many strategies for relativizing objects. While extractions from active voice constructions (like those in our stimuli, cf. (25f)) are licit object extractions, objects may also be extracted from passive constructions as in (26). Thus, since Q'anjob'al speakers have an alternative strategy for object extraction, their expectation of an object extraction from a given construction is lower, and this leads to greater noise in the data.

26. Passive relative clause – Q'anjob'al

cham	doctor$_i$ [max	iq–lay	y-uj	cham	mexhtol	__$_i$].
DET	doctor PRFV	carry-PASS	ERG3-REL_NOUN	DET	teacher	

'the doctor that was carried by the teacher'

In summary, the Q'anjob'al experiment shows higher accuracy on unambiguous subject extraction as compared to unambiguous object extraction and a subject preference in ambiguous relative clauses with no semantic bias. We conclude that for speakers of Q'anjob'al, subject extractions are less complex.

7. General discussion of Ch'ol and Q'anjob'al results

7.1. Subject preference

In both Mayan languages, we find that participants are more accurate and respond more quickly to subject relative clauses than to object relative clauses in the absence of ambiguity. We also find that participants in both languages demonstrate a preference for subject interpretation in the resolution of unbiased ambiguous items, and that the time it takes them to respond to the stimuli is lower for subject-compatible responses than for object-compatible responses. This means that both languages show the SPA effects unmitigated by any predictive properties that the presence of the ergative marker on the verb could have contributed. Therefore, we see no cueing by agreement, which would be the Mayan equivalent to cueing by case.

Recall that we established two possible scenarios concerning the processing of ergative and absolutive gaps in Mayan languages with regard to case and agreement: either case and agreement are equally likely to trigger cueing effects or they are not. On the assumption that agreement and case have equal predictive power, ergative gaps should be parsed in about the same amount of time as absolutive object gaps. Specifically, the presence of the ergative agreement marker on the predicate of the relative clause in Mayan languages should serve as a cue for the parser to project the absolutive argument and the rest of the clause. The extraction of the absolutive gets a boost from the agreement cue; and the extraction of the ergative gets the normal subject boost. The two would cancel each other out, and we would end up with the Avar scenario, where the extraction of either argument would require about the same processing effort.

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slightly higher than 50% success rate, though, we treat this result as a low score with great noise instead.

The second scenario is that agreement does not provide the same predictive information to the parser that case does, in which case the parser would rely on other available cues. In the context of Mayan, where there is no case marking, word order is also not useful: relative clauses based on transitive clauses where the subject is extracted have the same order as object relative clauses, as both subjects and objects follow the verb. The remaining option is to rely on grammatical function. Thus the second scenario is one in which ergative subject extraction would be easier than absolutive object extraction due to the structural superiority of subjects. In other words, phrase structure-based processing underlies the processing preference in the absence of morphological cues. The resolution of ambiguous clauses and accuracy and response time in unambiguous (or semantically disambiguated) clauses are the relevant measures for both of these hypotheses.

Our results strongly support the second scenario; the extraction of the ergative subject is significantly faster and more accurate than the extraction of the absolutive object and ambiguous clauses are significantly more likely to be parsed as subject relative clauses. This has several immediate implications. First, this result confirms the conclusion drawn from primary data that the ergative argument is structurally superior to the absolutive in transitive clauses (see Section 5). Second, this result shows that subject preference is a psychological reality that serves as a processing strategy when other cues are absent. Ch'ol and Q'anjob'al speakers treat ambiguous clauses in the same manner that Russian and German speakers treat relative clauses that are structurally ambiguous between subject and object relatives (see Section 4 for Russian and Schwarz 2007 for German and more references).

While we are confident in these first two conclusions, we remain cautious in our third conclusion, which pertains to whether agreement serves as a processing cue. We hypothesize that agreement does not provide the same predictive information that case does, but hope to stimulate more work on the role of agreement as a cue for argument tracking in processing.[24]

That being said, our results suggest that agreement is qualitatively different from case in terms of cueing effects. Unlike case, agreement does not provide direct processing cues but is parasitic on other syntactic relations. Perhaps the parser ignores agreement because computing grammatical functions based on agreement cues would impose too much processing load for too little information. The disregard of agreement in processing is particularly expedient in third person configurations, where there tend to be many null exponents and quite a bit of homophony. This tends to be true for Mayan languages, as well as many other languages (for instance, in a study of the exponency of verbal categories of 50 languages, Bybee (1985) shows that there is a particularly strong tendency to have a zero exponent for the third person singular agreement marker). Instead of tracking agreement, the parser makes an early decision based on other available evidence; if revisions are necessary they will be made further down the road.

Our cause for caution in pursuing the agreement-is-not-as-informative-as-case interpretation is that there is an alternative explanation, which we cannot rule out in the absence of empirical data. This alternative explanation has to do with headedness. Our background data are based on Avar which has prenominal relatives (inasmuch as the Basque data are relevant, they are also based on prenominal relatives). Meanwhile, these Mayan languages have postnominal relatives. A possible explanation as to why Avar shows a strong tension between morphological cueing and subject preference and Mayan languages show only the latter may have to do with the order of the head noun and relative clause.[25]

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[24] There is a good amount of processing work on such issues as agreement attraction (Wagers et al. 2009 and references therein) or closest conjunct agreement (Lorimor 2007) but not enough on the role of agreement as an argument-cueing device.

[25] Basque has both pre- and postnominal relatives, and the postnominal relatives reveal subject preference (Carreiras et al. 2010); however, those relative clauses do not have ambiguity, so the comparison with prenominal RCs is more difficult.

In order to rule out this alternative explanation we need to complete the paradigm by collecting data from ergative languages with postnominal relatives that have case marking instead of agreement or in addition to agreement. An additional requirement is that such languages have to allow extraction of the ergative with a gap, which rules out a sizeable number of syntactically ergative languages. Once all these requirements are met, we end up with a relatively restricted sample of languages. Table 13 lists ergative languages that do not display syntactic ergativity that fit each of the following categories: headedness, case, agreement.

Table 13. Case, agreement, and headedness in morphologically ergative languages

HEADEDNESS	**CASE**	**AGREEMENT**	**BOTH**
Prenominal RC	Shipibo-Konibo (Valenzuela 2002)	Unattested[26]	Avar, Basque (references above)
Postnominal RC	Niuean (Seiter 1980)	Mayan languages without AF[27]	Georgian (Hewitt 2005)

Of these languages, Niuean is particularly relevant for comparison to the Mayan languages without agent focus; it is also verb-initial, it has case marking distinguishing ergative and absolutive arguments but no agreement, and it allows equally the ergative and absolutive extraction with a gap—compare (27a) and (27b) respectively:

27a. Subject relative clause -- Niuean

E	leoleo	[ne	lagomatai	__	e	faiaoga.]
ABS	policeman	NON-FUT	help		ABS	teacher

'The policeman who helped the teacher.'

b. Object relative clause -- Niuean

E	faiaoga	[ne	lagomatai	he	leoleo	__]
ABS	teacher	NON-FUT	help	ERG	policeman	

'The teacher whom the policeman helped.'

Unlike Georgian, which is in the same row of the table, Niuean does not have a case-marked relative pronoun (such a pronoun would provide an early cue as to which argument has been extracted).

The processing of relative clauses in Niuean is yet to be studied; the Niuean results would allow us to determine whether the relative order of the subordinate clause and relativized nominal affects processing preferences. If the results from a similar study in Niuean were to look like the Avar results, then we could conclude that the order of the relative clause and head noun does not matter, and the reason why the results of this study pattern differently from those of the Avar study would in fact be due to differences in the processing effects of agreement vs. case. If, however, Niuean were to pattern with Ch'ol and Q'anjob'al, i.e. if participants were to demonstrate SPA effects without case-cueing effects, the significance of the relative order of the

[26]Prenominal relatives are found in head-final languages only, and such languages rarely lack case-marking (Mallinson and Blake 1981: 179, 332). Among ergative languages, only Abkhaz seems to fit that profile, but it is syntactically ergative; only the absolutive argument can extract leaving a gap at the extraction site. The ergative requires resumption in the verb form (Hewitt 1979).

[27]See Section 5 for a discussion of agent focus (AF) in Mayan.

subordinate clause and relativized nominal would need to be re-evaluated for both ergative and accusative languages.

7.2. Language experience and psycholinguistic work in the field

Another finding that applies to both Ch'ol and Q'anjob'al is that bilingual and monolingual speakers pattern in the same ways in terms of trends in the data and significant findings, but the effects are often stronger for bilingual speakers than they are for monolingual speakers. The question is whether the difference between the two groups is primarily the result of linguistic or extralinguistic variation. We cannot say with certainty, but we suspect the latter. An alternative explanation may appeal to transfer effects; Spanish has strong subject preference (Betancort et al. 2009), and due to bilingualism, this preference could be transferred to Ch'ol and Q'anjob'al. There are at least two reasons to reject this explanation. First, monolingual speakers were significantly less accurate than bilingual speakers even on the syntactically unambiguous clauses. Second, the standard error is greater for monolingual speakers than bilingual speakers in each of our analyses. This indicates that the differences between the two groups stem from the extra challenges monolingual speakers may have had completing the task rather than from interference from Spanish in the case of the bilingual speakers.

Until recently, experimental work has been confined to the university setting, with researchers testing obliging undergraduates very familiar with experiment-type settings (i.e. use of computers or test-taking in general). Their data may include some individual differences but the sheer rate of experimental replication on familiar topics such as passives, past tense or our own relative clauses suggests that such individual differences are negligible in light of more general patterns. Once researchers leave the college campus and venture into different settings, things can change dramatically. For example, response rates on most measures are slower than what we would expect from populations in which a higher percentage of the population has access to formal education. The level of noise in our data is greater than what one would expect from speakers of English, Russian, or Japanese. Furthermore, the level of noise and slow response time increases when we consider only monolingual speakers of Ch'ol or Q'anjob'al. Similar concerns about the level of noise in the data arise in experimental work on Tsez (Gagliardi 2012). This issue will become more familiar as researchers attempt to conduct experimental work on increasingly diverse populations of speakers.

There are many philosophical and ethical questions that arise as experimental methods move into the field, but discussion of these issues belongs in a different paper. Here we will try to restrict ourselves to methodological considerations. First, we return to our finding that the data we gathered from bilingual speakers are cleaner than those we gathered from monolingual speakers. This contributes to the fact that the significant effects that we report are stronger for bilingual speakers. Bilingualism is correlated to the level of formal education (Spanish is overwhelmingly the only language used in schools in Guatemala), and we believe that the difference between the two groups has primarily to do with formal education.[28]

Perhaps it seems improbable that speakers would need a formal education to have the skills necessary to easily complete a sentence-picture matching task in their native language. After all, we ensured that literacy would not be an obstacle for task completion, but there are concerns relating to educational experience that do not involve linguistic competence: familiarity with following instructions with less context than one receives in the 'real world,' comfort with the framework of a test and test-taking skills, familiarity with technology, experience interpreting

[28] Similar patterns, where subjects with higher levels of formal education produce cleaner data in an experimental setting, have been reported for English as well (cf. Dąbrowska and Street 2006), so one does not need to travel to Dagestan or Santa Eulalia to observe noisy data.

abstract images, etc. Such skills include the desire to cooperate with the experimenter. These skills are often assumed when preparing experiments, but these skills are likely to be less developed in monolingual speakers, since they are skills one develops in school.

Another result that supports our observation has to do with the performance on longer sentences. Recall that all our results deteriorated as the sound stimulus became longer in duration. This pattern was observed both in the bilinguals and monolinguals but it was again greater in the monolinguals. We hypothesize that it has to do with working memory capacity. There is independent evidence that educational experience correlates with working memory capacity (Gathercole et al. 2004). A longer stimulus imposes a greater memory load. Thus, the intransitive stimuli are expected to tax working memory more. This increase would have been negligible in a population more skilled at test-taking, but it played a negative role in our pool, even with the bilinguals.

Every testing situation is different and every population is different. When investigating minority languages, monolingual speakers do not present the confound of interference from the dominant language; bilingual speakers, who presumably learned the dominant language in school, are likely to be more comfortable with the framework of the experiment, but that does not mean that they will test in exactly the same way as the traditional populations of experimental linguistic studies. The general expectation that we can develop on the basis of our results and results from studies that faced similar challenges is that everyone should be prepared for a greater level of noise in this sort of study. As the field gets more accustomed to working with a wider variety of populations, we can expect to develop new methodologies, which may minimize the role of test-taking skills. For now we can make three suggestions: be aware of noise in the data; keep track of demographic information; and test large pools of speakers. In comparing the Ch'ol and the Q'anjobal results, we find that there were more subjects in Q'anjobal, and although the data still had a fair amount of noise, the statistical effects were stronger.

8. Conclusions

We started this paper with a set of questions that relate ergativity to extraction phenomena from a processing perspective, which we will now review. First, the validity of the phrase-structural preferences in processing is threatened by the overlap of case and grammatical function in accusative languages. A large body of literature, beginning with the accessibility hierarchy (Keenan and Comrie 1977) and including numerous experimental studies, has advanced the idea that subjects are special because of phrase-structural dominance, i.e. they c-command objects. The essential idea is that the parser reaches the subject first, giving rise to subject processing advantage (SPA). Yet, this conclusion has been reached solely on the basis of accusative languages, where a preference for the nominative over the accusative would look exactly like a phrase-structural preference for the highest argument. These two factors, one morphosyntactic and one syntactic, may conspire to give a special advantage to the subject in accusative languages. In contrast, subjects in ergative languages have different cases depending on the valency of the predicate, and so ergative languages offer an opportunity to tease apart the effects of case marking and grammatical function effects in processing. Our results support the view that it is in fact grammatical function that underlies SPA effects.

The second reason to explore the processing of extraction in ergative languages has to do with the widespread phenomenon of syntactic ergativity. Accusative languages do not demonstrate "syntactic accusativity," since they allow both nominative and accusative arguments to extract with a gap. If we had found that the processing of the ergative argument was somehow more difficult than the processing of the absolutive argument, we would have had the beginning of a processing explanation for syntactic ergativity: the speakers of morphologically ergative languages demonstrate processing limitations where speakers of syntactically ergative languages display a hard constraint. Our results do not indicate that the extraction of an ergative argument

increases processing load, however; in fact, they show the opposite. Therefore, an explanation for syntactic ergativity should be sought outside of processing, in the grammatical design of ergative languages.

A final motivation for this study has been to contribute to the small but growing body of experimental literature on understudied languages. Ergative languages have been generally underrepresented in the psycholinguistic literature. Ideally, linguistic theory strives to account for a representative body of language families; psycholinguistic theories should also continue to broaden their scope with data from diverse languages. We find it independently motivating to participate in the recent trend for researchers to apply experimental methods to the study of languages that have not previously featured in psycholinguistic work.

Two existing studies on the processing of extraction in ergative languages (Carreiras et al. 2010 and Polinsky et al. 2012) provided more questions than answers to the specific questions of our project. For example, the Avar study provided positive evidence for the SPA in ergative languages, but these results were mediated by an orthogonal cueing effect: the ergative serves as a cue for projecting the absolutive object and the entire transitive clause, which causes a local slowdown at the ergative argument and facilitates the processing of the absolutive object. As a result, the processing of the ergative subject gap and the processing of the absolutive object gap took about the same response time, albeit with a different time course. For this reason, we turned to the processing of relative clauses in two Mayan languages where ergativity is expressed by agreement markers on the verb, rather than by case markers affiliated with the arguments.

The Mayan results strongly support the SPA. At the same time, they do not show any evidence of the cueing function of the ergative agreement marker. Unlike Avar, where ergative case served as a strong cue for projecting the absolutive object, the ergative agreement marker in Mayan does not help the parser to project the absolutive. This leads us to conclude that case is superior to agreement in tracking grammatical functions, and in the absence of case cues, structural preferences become more pronounced. Speakers of both ergative and accusative languages therefore exhibit subject preference in relative clauses. These results provide novel support for the psychological validity of the concept of grammatical subject. They also indicate that subject preference is best observed in the absence of surface cues—in that sense, Mayan languages appear to be one such "clean" case, on par with the ambiguous German and Russian relative clauses that we discussed above.

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