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Ergativity and the complexity of extraction: a view from Mayan

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Abstract Researchers using different methods have converged on the result that subject relative clauses are easier to process than object relative clauses. Cross-linguistic evidence for the subject processing advantage (SPA) has come mostly from accusative languages, where the covariance of grammatical function and case prevents researchers from determining which of these two factors underlies the SPA. Languages with morphological ergativity allow for the separation of case and grammatical function, since the subject position is associated with two cases: absolutive (intransitive subjects) and ergative (transitive subjects). Prior experimental results on the processing of ergative languages suggest that grammatical function and surface case may be equally important in relative clause processing. On the one hand, as a syntactic subject, the ergative DP has a processing advantage over the absolutive object. On the other hand, the appearance of an ergative serves as a cue for the projection of the absolutive object, which gives processing preference to that object. This paper further tests these findings by examining the processing of relative clauses in Ch'ol and Q'anjob'al, two languages that mark ergativity via agreement on the predicate (head-marking). We address two main questions: (a) does the SPA hold in ergative languages? And (b) are case and agreement equally able to license grammatical functions, and if so, is this reflected in processing? With regard to (a), our results support the SPA, suggesting that it is present in both ergative and accusative languages. With

We dedicate this paper to the memory of the Q'anjob'al community activist and artist Daniel Pedro Mateo (1969–2013), who was kidnapped and killed in Guatemala during the course of this work.

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respect to (b), we do not find evidence for a cueing effect associated with the ergative agreement marker. We conclude that dependent-marking is superior to head-marking in tracking grammatical function; in the absence of case cues, universal structural preferences such as the SPA become more pronounced. We also consider and reject a processing explanation for syntactic ergativity, according to which some languages categorically avoid A-bar movement of the ergative with a gap because it imposes a heavy processing load. Our results show that the processing of ergative gaps is not associated with greater cost than the processing of absolutive object gaps; this suggests that an explanation for syntactic ergativity should be sought outside processing.

Keywords Ergativity · Mayan · Head-marking · Dependent-marking · Processing · Relative clauses · Subject preference

1 Introduction[1]

In a range of languages, subject relative clauses have been found to be easier to process than object relative clauses (see Gibson 1998 and Kwon et al. 2010 for a review of extensive literature on this finding). This is known as the subject processing advantage (SPA). However, cross-linguistic evidence for the (SPA) has come mostly from accusative languages, where grammatical function and morphological case/agreement go hand in hand, making it impossible to tease the effects of these factors apart. Languages with morphological ergativity—such as those in the Mayan family—allow for the separation of case and grammatical function, since the subject position is associated with two cases: absolutive (intransitive subjects) and ergative (transitive subjects). In this paper, we investigate the processing and interpretation of relative clauses in two morphologically ergative Mayan languages, Ch'ol and Q'anjob'al. We find that the SPA is attested in these languages and thus is not limited to accusative languages.

As with other members of the Mayan family, Ch'ol and Q'anjob'al exhibit morphological ergativity in the form of person morphemes on the predicate; nominals do not show any case morphology. Using the terminology of Nichols (1986), Mayan languages are thus "head-marking" (grammatical relations marked on the verb), rather than "dependent-marking" (grammatical relations marked on nominals). Since the relatively small amount of work on ergative language processing done to date has focused on dependent-marking (i.e., case-based) languages, the head-marking languages of the Mayan family are a useful testing ground to determine whether case and agreement marking make comparable contributions to the identification of grammatical function. Our results lead us to conclude that dependent-marking (case) is

[1] Abbreviations: 1—First person; 2—Second person; 3—Third person; ABS—Absolutive; ACC—Accusative; ADN—Adnominal; AF—Agent Focus; AUX—Auxiliary; DET—Determiner; ERG—Ergative; GEN—Genitive; GER—Gerund(ive); IMPF—Imperfective; IQR—Interquartile range; ITV—Intransitive; LOC—Locative; M—Masculine; NOM—Nominative; NON-FUT—Non-future; OBL—Oblique; OR—Object relative clause; PASS—Passive; PL—Plural; POSS—Possessive; PRFV—Perfective; PRP—Preposition; PROG—Progressive; PTCP—Participle; REL—Relative; REL_NOUN—Relational noun; RT—Response time; SG—Singular; SR—Subject relative clause; TV—Transitive. Roman numerals in the glosses indicate noun class (gender).

Fig. 1 Alignment in accusative vs. ergative systems

superior to head-marking (agreement) in tracking grammatical functions, and that in the absence of case cues, the structural preference for subjects emerges most strongly.

Before we embark on the discussion of our focal languages, we set the stage for our study by addressing the more general context of ergativity.

1.1 The appeal of ergativity

The division of languages into "ergative" and "accusative" is based on the relationship between the two arguments of a transitive clause and the single argument of an intransitive clause in terms of their overt marking.[1] According to the convention established in Comrie (1978) and Dixon (1979), these three core arguments 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 marker in the verbal paradigm. If S aligns with A (="nominative") in opposition with O ("accusative"), the resulting system is accusative. If S aligns with O ("absolutive") in opposition to A ("ergative"), the resulting system is ergative. Figure 1 shows a diagram illustrating the fundamental difference between these two types of alignment.

Accounting for ergativity has long been a challenge in theoretical linguistics (see Coon and Adar 2013 and works cited therein for an overview), but it is a fresh topic in the experimental study of language structure and processing. We advocate an approach which links theory and experimental work through a feedback relationship: theory offers relevant questions to experimentalists, and experimental results inform changes in theory.

The appeal of investigating ergative languages from a processing perspective is threefold. First, ergative languages allow researchers to study the processing of case and grammatical function (that is, the syntactic position of an argument in clause structure) as independent phenomena in a way that accusative languages do not. In an accusative language, differences in case marking and/or agreement co-vary with the distinction between subject and object; subjects trigger nominative morphology (case or agreement) regardless of the transitivity of the clause. In an ergative language, on the other hand, the grammatical function "subject" corresponds to two different case/agreement forms: absolutive (S) and ergative (A). In studying accusative

[1] As has been frequently noted, it is often inaccurate to characterize an entire language as "ergative" or "accusative", since most, if not all, languages exhibit some reflexes of more than one alignment type (e.g., Dixon 1979). Neutral alignments (in which all core arguments are marked alike) or tripartite alignments (in which each core argument is marked distinctly) are also attested and not discussed here.

languages, it is not possible to tease apart grammatical function and morphological marking, but in an ergative language the two concepts are distinguishable. An experimental study of ergative language processing may be relevant to testing the theoretical proposals of Zaenen et al. (1985), Sigurðsson (1989/1996), and Marantz (1991), who have argued for the treatment of grammatical function and argument marking as two separate elements. If ergative languages are sensitive to differences between subjects and objects (regardless of case or agreement marking), this will provide strong and novel evidence that subjects constitute an independent concept in grammar.

By allowing us to tease apart morphological marking and grammatical function the study of ergative languages will permit us to more deeply assess the relative contributions of each of these elements in the grammar. As already noted, differences in alignment, shown in Fig. 1, can be expressed either by nominal case or by agreement (or by a combination of the two). It is not yet clear whether these two types of marking play equal roles in licensing particular grammatical functions. The relative contributions of case and agreement have to be evaluated both theoretically and experimentally; this is another area where experimental results can feed back into syntactic theory.

A further motivation for conducting experimental work on ergative languages has to do with the phenomenon of *syntactic ergativity*. In a subset of morphologically-ergative languages, ergative subjects cannot undergo extraction with a gap under relativization, focusing, wh-question formation, or topicalization (e.g., Dixon 1979, 1994; Marantz 1984, and discussion in Coon and Adar 2013). This is known as syntactic ergativity, a phenomenon which reflects a restriction on A-bar movement of the ergative expression.[2] In such languages, relativization with a gap is limited to intransitive subjects and transitive objects (absolutive arguments). Accusative languages do not demonstrate a comparable asymmetry between the nominative and the accusative arguments; both nominative and accusative arguments in accusative languages can usually undergo extraction.

Theoretical explanations for syntactic ergativity have been varied, and no consensus has been achieved so far (see e.g. Aldridge 2004; Campana 1992; Coon et al. in press; Manning 1996; Polinsky 2013 for proposals). What if the phenomenon of syntactic ergativity follows from language processing? It is known that grammatical structures that impose a heavy processing load and tax working memory tend to be avoided (de Vincenzi 1991; Townsend and Bever 2001, a.o.). If structures involving ergative A-bar movement are more difficult to process than structures involving absolutive A-bar movement, we can expect that the former will be used less and avoided more. If this prediction holds, we can then expect that some languages will take this avoidance to its logical extreme and stop using structures with the ergative gap altogether. In other words, a soft, gradient processing-based constraint in one language ("ergative gaps are hard to process; do not use them often") may become a hard categorical constraint ("no ergative gaps") in another. This leads to the

[2]Though A-bar extraction restrictions are the prototypical instance of syntactic ergativity, some researchers (in particular, Kazenin 1994 and Manning 1996) use the label "syntactic ergativity" to refer to a wider range of syntactic phenomena which distinguish ergative from absolutive arguments. In this paper we use the term to refer specifically to asymmetries in A-bar extraction.

expectation that, in morphologically ergative languages *without* syntactic ergativity, structures with ergative gaps should be more difficult to process than structures with absolutive gaps, even if they are still grammatical. If ergative extractions turn out to be universally more difficult, this would suggest that syntactic ergativity develops from the conventionalization of a processing difficulty (the source of which would remain to be elaborated). Initial empirical support for this idea can be found in the fact that, in many languages, the ban on A-bar extraction is limited to certain types of constructions. Stiebels (2006) emphasizes this point in her survey of Mayan languages.

1.2 Studies of relative clause processing

The grammatical function "subject" has emerged as a pivotal category not only in theoretical linguistics but also in psycholinguistic theory. A variety of processing studies using different experimental methods have found that languages privilege subjects in a number of contexts, including relativization, wh-questions, coreference across clauses, and variable binding. The largest body of data on subject preference in processing comes from studies of relativization (see Kwon et al. 2010 for an overview).

Research on the processing of relative clauses has established two distinct but related findings: (i) a comprehension preference asymmetry in ambiguous expressions (speakers prefer to interpret ambiguous relative clauses as subject relatives); and (ii) a processing asymmetry in unambiguous expressions (subject relatives are generally easier to process than object relatives). We assume that the comprehension preference results from an underlying processing asymmetry, and will therefore subsume both findings under a single label: the subject processing advantage (SPA). At the same time, many linguistic and contextual factors combine to shape an individuals' response to any given sentence. For example, in English, the SPA can be lessened or eliminated by manipulating the relative animacy of the NP arguments involved (Traxler et al. 2002; Gennari and MacDonald 2008, a.o.) or by changing the NPs' referring type (Gordon et al. 2004). Therefore in asking whether the grammatical function per se of the relative clause pivot plays a role in shaping the complexity of relative clauses—as we will do in Mayan—it is necessary to control for many features of arguments that are often correlated with subject/object distinctions (like animacy or definiteness).

Until recently, cross-linguistic evidence for the SPA in relative clauses was only available for accusative languages. Since both transitive and intransitive subjects trigger nominative morphology in these languages, grammatical function and surface marking necessarily co-vary. Recently, the processing of relative clauses has been investigated in two head-final ergative languages: Basque (Carreiras et al. 2010; Gutierrez-Mangado 2011; Laka et al. 2012) and Avar (Polinsky et al. 2012).[3] Both languages have prenominal relative clauses and express ergativity overtly through case marking. Furthermore, both languages employ the same strategy to relativize

[3] Other work on processing in ergative languages include Nevins et al. (2007), Erdocia et al. (2009), Choudhary et al. (2009), Díaz et al. (2011), and Zawiszewski et al. (2011).

ergative and absolutive DPs: regardless of the case of the extracted DP, the relative clause contains a gap at the extraction site. Ch'ol and Q'anjob'al, the Mayan languages we will investigate in this paper, differ from Basque and Avar in two important ways. First, Ch'ol and Q'anjob'al are head-initial; second, their ergative alignment is expressed through head-marking (agreement) rather than dependent-marking (case). If we find that these Mayan languages show a preference for the processing of absolutive object gap (as compared to the processing of the ergative gap) that will support the notion that syntactic ergativity may derive from a processing preference. The idea is as follows: the dispreference for ergative extraction may be a gradient, soft constraint in some languages, but gets grammaticized as a hard constraint in others. (This reasoning about the emergence of grammatical principles from processing preferences follows the general spirit of Hawkins 1999, 2004.)

The rest of this paper is organized as follows. Section 2 presents a survey of the existing studies on the processing of relative clauses in ergative languages. Section 3 explains the rationale behind on the use of Mayan languages in our study. 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 Sect. 8 concludes.

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, meaning that these languages do *not* exhibit syntactic ergativity. We will argue that, for ergative languages with prenominal relatives, grammatical function and argument marking (as expressed by surface 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 exhibits morphological ergativity in agreement as well as in case marking: 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 (see Anderson 1984; Polinsky et al. 2012, and further references therein). Relative clauses are prenominal and all core arguments relativize by leaving a gap at the extraction site:[4]

[4] Avar does not have overt determiners, so in the translations below we provide both definite and indefinite interpretations.

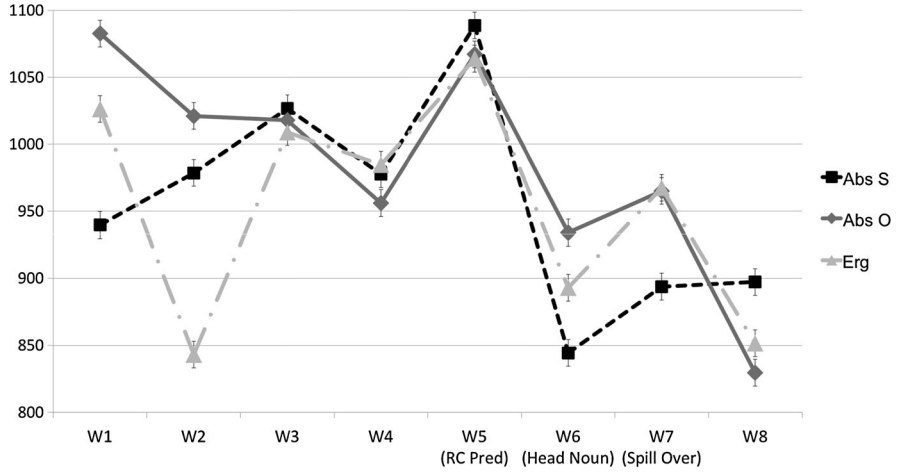


Fig. 2 Reading time (*ms*) for transitive and intransitive relative clauses in Avar (adapted from Polinsky et al. 2012)

(1) a. INTRANSITIVE SUBJECT RELATIVE—AVAR
[__$_i$ bercinay artistka-yal-da ask'o-y č':u-n y-ik'-ara-y]
beautiful actress-OBL-LOC near-II standing-GER II-be-PTCP-II
yas$_i$
girl.ABS
'the girl that stood next to a/the beautiful actress'

b. TRANSITIVE SUBJECT RELATIVE—AVAR
[__$_i$ bercinay yas repetici-yal-de y-ač:-un
beautiful girl.ABS rehearsal-OBL-LOC II-bring-GER
y-ač'-ara-y] artistka$_i$
II-come-PTCP-II actress.ABS
'the actress that brought a/the beautiful girl to a rehearsal'

c. OBJECT RELATIVE—AVAR
[bercinay artistka-yał __$_i$ repetici-yal-de y-ač:-un
beautiful actress-ERG rehearsal-OBL-LOC II-bring-GER
y-ač'-ara-y] yas$_i$
II-come-PTCP-II girl.ABS
'the girl that a/the beautiful 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).[5] Figure 2 shows the reading time data from that self-paced reading experiment. The authors found that participants read the heads of relative clauses with absolutive subject gaps faster than those

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

with either ergative subject gaps or absolutive object gaps. This difference is particularly reflected at words 6 and 7 below. Note, however, that there was no difference between ergative subject gap conditions and absolutive object gap conditions at W6 and W7.

Polinsky et al. (2012) suggest that the symmetrical extraction behavior of both core arguments in a transitive clause follows from the combined effects of grammatical function and case. Unlike some other Nakh-Dagestanian languages, Avar does not have split intransitivity, so the ergative can appear only in the presence of the absolutive. This means that when the parser encounters the ergative argument, it can immediately predict that an absolutive argument will also be present in the structure. In the experiment reported here, Avar readers slow down significantly when they encounter the ergative at W2, the first word inflected for case. An ergative at W2 serves as a cue allowing the reader to project a transitive clause with an absolutive object. The significant slowdown at W2 in this context follows from the extra processing work needed to project the argument cued by the dependent (=ergative) case form. On the other hand, the appearance of an absolutive at W2 does not lead to specific predictions; the absolutive might be the sole core argument of an intransitive clause or the object argument of a transitive clause. The effect of grammatical function, in which the subject has advantage over the object, is observed at the head noun of the relative clause (W6) and the following word (W7). Thus the Avar reading study presents evidence, observed locally (at the right edge of the first constituent of the relative clause—W2), that surface case and grammatical function matter roughly equally in the interpretation of relative clauses.

What theories might be able to account for such a cueing effect? The observed pattern is compatible with theories of on-line complexity that relate processing difficulty to changes in predictability (Jurafsky 1996; Hale 2003, 2006; Levy 2008): the presence of an ergative at W2 restricts the possible continuations of the sentence more than the presence of an absolutive in this position does. The effect is likewise compatible with licensing theories of comprehension (Aoshima et al. 2004; Wagers and Phillips 2009), in which comprehenders predictively construct a representation that will grammatically license the presence of a given feature or constituent. On either view, the parser's accommodation of the change in licensing requirements or change in expectations is likely to require reallocation or consumption of resources. Thus, presence of the ergative results in longer reading times.

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

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

b. CASE CUEING. The ergative gap should be *harder* to process than the absolutive gap, because the absolutive DP inside a relative clause does not evoke case cueing.

The net effects of these two factors may depend on their relative weight and how they are resolved over time. Assuming similar weighting for the two factors, we can understand why there was no difference in the reading times associated with extracted

ergative subjects and absolutive objects in transitive Avar relative clauses: in both cases, the advantage conveyed by one factor was balanced by the disadvantage conveyed by the other factor. Thus, the ergative gap gained an advantage from the SPA but a disadvantage from case cueing, while the absolutive object gap produced the opposite effects. Only the intransitive absolutive subject gap resulted in a net extraction advantage (W6 and W7, Fig. 1): since case cueing was not pertinent in this case, the advantage conveyed by the SPA was the only relevant factor. These results 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.

The notion of multiple competing processing pressures is of course not new. Our proposal is conceptually close to the one advanced in Bornkessel and Schlesewsky (2006) and Bornkessel-Schlesewsky and Schlesewsky (2009), according to which processing is shaped by several principles that can work at cross-purposes. Processing is subject to a number of competing constraints, and is thus streamlined when the relevant factors all line up in harmony, but taxed more when the competing factors are at odds with each other (see also Tanenhaus and Trueswell 1995; Altmann 1997; Gibson and Perlmutter 1998).

Let us now compare these results with the processing of prenominal relative clauses in accusative languages such as Japanese and Korean. Consider the subject and object relative clauses in Korean:

(3) a. SUBJECT RELATIVE—KOREAN
[__$_i$ sinmwunsa-uy sacang-**ul** cengchicekulo iyongha-n]
newspaper-GEN publisher-**ACC** politically exploit-ADN
uywon-i
senator-NOM
'the senator who exploited the newspaper publisher for political purposes'

b. OBJECT RELATIVE—KOREAN
[sinmwunsa-uy sacang-**i** __$_i$ cengchicekulo iyongha-n]
newspaper-GEN publisher-**NOM** politically exploit-ADN
uywon-i
senator-NOM
'the senator whom the newspaper publisher exploited for political purposes'

According to the SPA, the nominative subject gap in (3a) should be easier to process than the object gap in (3b). In addition, the presence of the accusative DP (*sacang-**ul*** 'publisher') in (3a) serves as a strong cue which helps the parser predict that the verb is transitive and that the nominative subject needs to be projected (even if it is not expressed). The presence of the nominative (as in (3b)) does not offer a cue for projecting the accusative, since nominative subjects can occur in both intransitive and transitive clauses. Empirical evidence in favor of the cueing effect of the accusative comes from the slowdown following the accusative DP inside the relative clause in Korean (Kwon et al. 2006:8). Similarly, in Japanese, which has relative clauses that are structurally similar to those in Korean, there is a slowdown following the ac-

cusative, but no slowdown following the nominative inside a relative clause (Ueno and Garnsey 2008:665).

Thus, in an accusative language with prenominal relatives, like Korean or Japanese, the SPA and case cueing reinforce each other:

(4) a. SUBJECT PROCESSING ADVANTAGE. A nominative subject gap should always be *easier* to process than an accusative object.

b. CASE CUEING. A nominative transitive subject gap should be *easier* to process than an accusative gap, because the accusative serves as a cue predicting the presence of the nominative DP inside the relative clause.

This reinforced effect means that the apparent effect of the SPA may in fact be a cumulative effect of two separate factors, SPA and case cueing. In an ergative language like Avar, these same two factors work at cross-purposes, essentially canceling each other out.

2.2 Basque

Basque is similar to Avar in a variety of ways: it is a dependent-marking language with prenominal, head-final relative clauses;[6] it allows any constituent to undergo relativization with a gap; its ergative argument behaves like the subject in a transitive clause; 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; however, closer examination of Basque reveals that at least the ergative markers are instances of clitic doubling (Preminger 2009, 2012; Nevins and Arregi 2012). Basque also has true intransitives with ergative subjects, which are not present in Avar (Preminger 2012; Režać et al. 2012 and further references therein). Finally, Basque has substantial case homophony, something Avar lacks entirely. It is this property of Basque that Carreiras et al. (2010) manipulate to experimental advantage.

Carreiras et al. (2010) conducted a reading-time study that included two structural conditions: ergative subject gaps and 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 participants encountered an argument ending in *-ak*, they could attribute one of two interpretations to the form: it might be either a singular ergative subject or a plural absolutive object. For instance, the sequence in (5a) could be interpreted as a subject relative (5b) or as an object relative (5c):

(5) a. AMBIGUOUS STRING—BASQUE
irakasleak aipatu dituen ikasleak.
SR: 'The student who mentioned the teachers.' *or*
OR: 'The students 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 these are limited to a particular register and are beyond the scope of our discussion.

b. SUBJECT RELATIVE—BASQUE
[__$_i$ irakasle-ak aipatu ditu-en] ikasle-a-k$_i$
teacher-ABS.PL mention AUX-ADN student-DET-ERG
'the student who mentioned the teachers'

c. OBJECT RELATIVE—BASQUE
[irakasle-a-k __$_i$ aipatu ditu-en] ikasle-ak$_i$
teacher-DET-ERG mention AUX-ADN student-ABS.PL
'the students whom the teacher mentioned'

Carreiras et al.'s (2010) study made further use of the *-a-k*/*-ak* ambiguity: the head noun of the relative clause in the study always ended in *-ak* as well, so that disambiguation occurred only at the penultimate word of the sentence. Examples (6a, b), taken from Carreiras et al. (2010), show that disambiguation occurs at W6, close to the end of the matrix clause.

(6) a. [__$_i$ Irakasle-ak aipatu ditu-en] ikasle-a-k$_i$ lagunak ditu
teacher-ABS.PL mention AUX-ADN student-DET-ERG friends has
W1 **W2** **W3** **W4** **W5** **W6**
orain.
now
W7
'The student that mentioned the teachers has friends now.'
(ergative gap)

b. [Irakasle-a-k __$_i$ aipatu ditu-en] ikasle-ak$_i$ lagunak dira
teacher-DET-ERG mention AUX-ADN student-ABS.PL friends are
W1 **W2** **W3** **W4** **W5** **W6**
orain.
now
W7
'The students that the teacher mentioned are friends now.'
(absolutive gap)

The results are presented in Fig. 3. The time course for each reading was the same up to W6, since the conditions were identical. At W6, the slowdown for the ergative subject gap was much longer than the slowdown for the absolutive object gap. This result appears to suggest a disadvantage in the processing of an ergative gap as opposed to an absolutive gap—quite a different result from that reported for Avar.

We are concerned, however, that factors other than the case marking on the extracted argument may have contributed to the observed experimental effect. First, the disambiguating words differed in transitivity: compare *ditu* 'has' (6a) versus *dira* 'are' (6b). The precise effect of transitivity on processing still needs to be explored, as it may be adding a confound to the Basque experimental results.[7]

[7]Outside Basque, there is preliminary evidence that transitivity differences may play a role in processing, as such differences require the parser to manipulate fewer or more arguments associated with each pred-

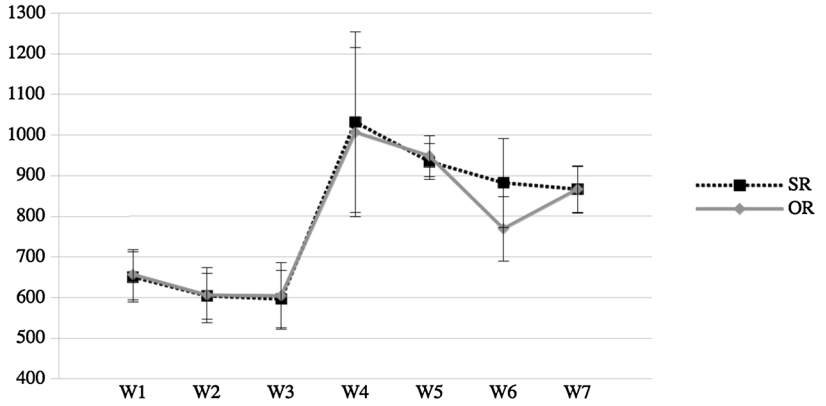


Fig. 3 Reading times (*ms*) for the transitive subject and object relatives in Basque (adapted from Carreiras et al. 2010)

These results may also reflect the parsers' inherent biases for initial resolution of morpho-lexical ambiguity. 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 parsers do not stall at ambiguities, but make an early commitment to a particular interpretation (Duffy et al. 1988; Frazier and Rayner 1987, 1990; Frazier et al. 1999; Fodor and Inoue 2000a; Bader and Häussler 2009, a.o.). The initial commitment is largely affected by prior experience, and it is reasonable to assume that "prior experience" incorporates both lexical biases (for particular noun/predicate combinations) and statistical preferences (for more frequent forms). There is evidence to suggest that the ergative singular is more common than the absolutive plural in Basque, and thus would receive support from prior experience: in 1496 utterances of adult speech examined in Austin (2007), there were 92 instances of the ergative singular and 46 instances of the absolutive plural.[8] If statistical prevalence of a given form in discourse affects initial commitments, readers may be more likely to commit to the ergative interpretation.

These factors all favor an initial commitment to an ergative singular interpretation for the word ending in *-ak*. That commitment, in turn, favors the interpretation of the gapped argument in the relative clause as an absolutive object. 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 and Bader and Häussler 2009 for a discussion of such costs and the processing models associated with them).[9]

icate: see Shapiro et al. (1987), Chen et al. (2005) for English, Jurka (2010) for German, Polinsky et al. (2013) for English and Russian.

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

[9]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

If our explanation is on the right track, then these results may be relevant for understanding ambiguity resolution and transitivity effects; however, they are not especially relevant to understanding the processing of ergative and absolutive gaps in relative clauses. The comparison in (6a, b) relies on differences at and after the disambiguation point for verbs that differ in both form and lemma meaning, which complicates the relationship between these data and the processing load for different relativization types.

3 Beyond dependent-marking

Up to now we have only 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, as well, ergative and absolutive are distinguished by case marking in addition to agreement: the ergative and the absolutive arguments have separate exponents.[10]

In order to evaluate the relationship between dependent-marking and head-marking, we need to contrast languages which mark ergativity with a separate case with those languages that show ergative alignment solely in agreement. Additionally, we need to consider languages which allow both subject and object extraction with a gap, i.e., languages which lack syntactic ergativity (at least in some structures). Several Mayan languages meet these requirements.

Mayan languages are important for the study of ergativity because they allow us to investigate whether the processing of agreement-marked ergativity is different from the processing of case-marked ergativity (or different again from the processing of ergativity marked by both case and agreement). This question goes beyond the specific theoretical and experimental issues of ergativity to bear more generally on our conception of case and agreement.

Let us assume for a moment that dependent-marking and head-marking are equally effective in licensing grammatical functions. If so, Mayan languages should show the same processing effects as Avar. As we show in Sect. 5, the argument that triggers ergative agreement has subject status, so it should enjoy the subject advantage (SPA). However, this same ergative marking also serves as a cue to project the absolutive, which should nullify the processing advantage for the ergative subject and cancel out the relative disadvantage of the absolutive as object. The overall prediction is that the processing cost of ergative and absolutive object gaps should be comparable because morphological cues (case cueing) and syntactic cues (the SPA) will cancel each other out.

or absolutive. Such a test would provide an independent measure of the comprehension bias that we have discussed.

[10]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.

We might also expect that the distinction between head- and dependent-marking will affect our results. Two known observations are relevant. First, potential targets for agreement relationships are selected based on their case (Moravcsik 1974, 1978; Bobaljik 2008; Preminger 2011); i.e., agreement depends on case, not vice versa. Next, unlike morphological case, agreement does not *directly* track grammatical function. Instead, it tracks phi-feature probes located in particular structural positions (see Preminger 2011 for an extensive discussion). This suggests that agreement may play less of a role than case in determining grammatical functions and, consequently, in processing preferences. Structure building based on agreement may be slower and more costly than structure building based on case.

Based on this reasoning, we can expect head-marking ergative languages to show less sensitivity to ergative alignment in processing as compared to dependent-marking ergative languages. In the absence of case cues in a relative clause, head-marking languages are likely to resort to the subject preference. In other words, phrase structure is expected to inform processing. Reliance on the SPA in the absence of other cues has been demonstrated in more familiar languages. For example, subject preference is observed in ambiguous relative clauses with feminine and neuter nouns in German, where the nominative and accusative cases are homophonous (Fanselow and Frisch 2006; Schwarz 2007). In Sect. 4, we will discuss ambiguous relative clauses in Russian, which also show heavy reliance on subject preference. In summary, since dependent-marking is a better cue than head-marking, we expect that ergative gap processing in Mayan should be easier than absolutive *object* gap processing. Our predictions are summarized below.

(7) PREDICTIONS CONCERNING THE PROCESSING OF RELATIVE CLAUSES IN MAYAN

a. ERG = ABS_{Obj}: Dependent-marking and head-marking (case and agreement) are equally diagnostic in predicting constituent structure; as a result, morphological cueing and SPA cancel each other out.

b. ERG > ABS_{Obj}: Dependent-marking (case) is superior to head-marking (agreement) in predicting constituent structure; in the absence of morphological cues, the parser relies on SPA alone.

Sections 5 and 6 pertain to our study of relative clauses in Ch'ol and Q'anjob'al. Before presenting our study, however, we discuss our methodology. We address concerns about gathering data from reading-based studies when there is little-to-no culture of literacy in the language of interest. We 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 Avar and Basque presented above, one is struck by the observation that reading times on individual words are quite high, roughly 700 to 1200 ms per word (see Figs. 2 and 3). This is almost twice the mean time-per-word for speakers of Korean, a language with comparable word-length (cf.

Kwon et al. 2010). There is also significant variance in the self-paced reading times, as can be seen in the large standard error of the mean spreads in Fig. 3. In choosing to pursue reading-based studies on a language, a researcher is forced to assume both the transferability of literacy skills from one language to another and the ability of statistical methods to compensate for speaker variability with regard to reading proficiency. However, Basque and Avar represent two languages whose speakers either do not use their writing systems on a regular basis or are more comfortable reading and writing in another language. With respect to Basque, researchers underscore that many 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 however Kirkwood 1990:Chap. 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: the number of copies printed in Avar is 24 thousand; in Russian, 31.5 thousand.[11]

The assumptions discussed above, that literacy skills transfer from one language to another and that our statistical methods are sufficient to account for speaker variability, lack significant empirical support for Basque and Avar. The problem is perhaps even greater with Mayan languages, for which the literacy rate is generally very low (Holbrock 2004; French 2010: Chap. 1). These considerations led us to look for an experimental paradigm that assesses processing load without requiring participants to read. Our solution is to rely on 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 (Weissenborn et al. 1990; Weist 1991, 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).

In order to ascertain whether the SPM paradigm is actually comparable to self-paced reading (SPR) in providing evidence on processing difficulty, we conducted a comparative study of SPR and 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, which arises exclusively with inanimate masculine DPs, and occurs as a result of scrambling. This ambiguity is comparable to the ambiguities we will be investigating in Mayan (see Sect. 6). For example, the sequence in (8a) has two parses: a subject relative (8b) and an object relative (8c).[12]

[11] Ас-Салам (As-Salam). (n.d.) in Википедия (Wikipedia); retrieved June 25, 2012, from http://ru.wikipedia.org/wiki/Ас-Салам.

[12] Self-paced reading studies of Russian include Levy et al. (2013) and Polinsky and Potsdam (2014). For an auditory study of the processing of Russian relativization, see Polinsky (2011).

[13] 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.

(8) 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[13]
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…'

In an SPR study, Russian subjects read sentences like the ones in (8) and then answered the question, 'Which object appears in front?' by clicking on one of two pictures (in the case of (8), either a box or a fish tank). They also read sentences 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 used 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 4 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 4 shows a significant subject preference under the ambiguous condition as measured by picture choice in both the SPR study ($p < 0.001$) and the auditory version ($p < 0.05$).

Figure 5 provides a side-by-side comparison of the 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 began when the last word of the item appeared on the screen; in the case of the auditory version of the study, response time began after the sound file played to completion. As in the previous case, there were three conditions: (i) unambiguous subject relative clauses, (ii) unambiguous object relative clauses, and (iii) ambiguous clauses that could be interpreted either as subject relatives or as object relatives.

The results look extremely similar to one another, indicating that the mode of presentation did not substantially affect the timing and accuracy of the choice task at stimulus offset. We take this to provide the necessary proof of principle that sentence-picture matching can be successfully used in lieu of self-paced reading to assess interpretation preferences in situations where self-paced reading is deemed inappro-

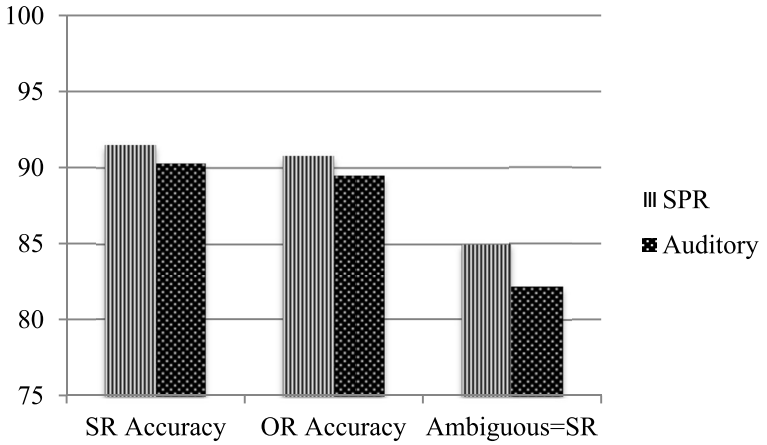


Fig. 4 Comprehension of Russian relative clauses: Accuracy on self-paced reading and auditory sentence-picture matching (percentage accurate)

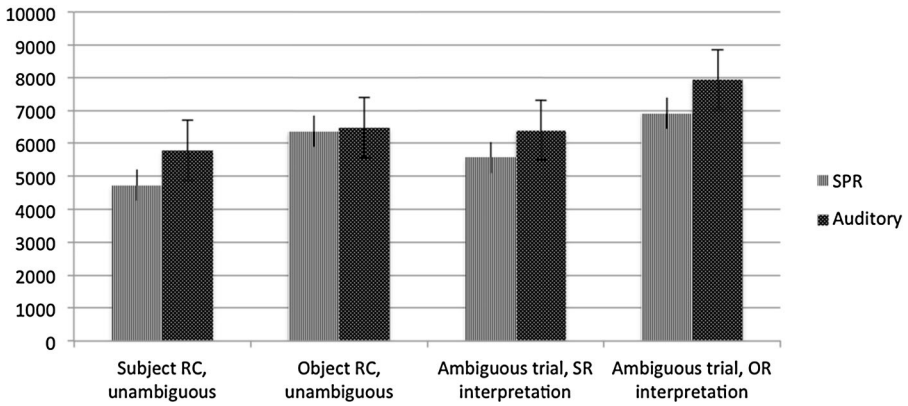


Fig. 5 Comprehension of Russian relative clauses: Response time (in *ms*) for picture choice upon self-paced reading or auditory sentence-picture matching

priate. We are now ready to address the Mayan languages we investigated using the sentence-picture matching paradigm.

5 Ch'ol and Q'anjob'al

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) (see Vázquez Álvarez 2011). Q'anjob'al belongs to the Q'anjob'alan branch of the Mayan family and is spoken primarily in Huehuetenango, Guatemala. The language data in this paper were produced for our study by Nicolás Arcos López (Ch'ol) and Pedro Mateo Pedro (Q'anjob'al).

Though numerous differences exist, 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.[14] In discourse-neutral constructions, overt nominals generally follow the predicate, but may also appear 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 shown in (9):

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

Eventive predicates typically require one of a series of aspectual particles, which appear preceding the stem. The verb stem consists of the root, optionally followed by voice or valence-changing morphology and in many cases by a "status suffix", which varies with transitivity and aspect. In all of the languages, the ergative marker, which cross-references transitive subjects, precedes the stem. 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". Absolutives are commonly referred to as "set B".

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

The ergative argument is structurally superior to the absolutive argument in transitive clauses in Mayan languages. Since the premise of this paper is that ergative languages uniquely allow us to investigate the separate roles of grammatical function and case in the processing of relative clauses, we will provide two arguments that the ergative is structurally superior to the absolutive in both Ch'ol and Q'anjob'al. These 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 akin to possessed nominals (recall that the

[14] We do not have corpus data on pro-drop for Chol or Q'anjob'al, but in a related language, Sacapultec, the ergative DP is pro-dropped 86.7 %, the absolutive subject, 47.3 %, and the absolutive object, 53.1 % (DuBois 1987:822).

[15] Stative or "non-verbal" predicates systematically lack aspect marking and show other differences, not discussed here (see Coon 2013 for discussion).

possessive markers and ergative markers are homophonous). The reflexive nominal has third person features, and this nominal is indexed by the third person absolutive marker on the verb ((10a) and (11a)), which is consistently null in Mayan. If the reflexive could appear in the ergative, we would predict the ungrammatical structures shown in (10b) and (11b). 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.

(10) CH'OL REFLEXIVES

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

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

(11) Q'ANJOB'AL REFLEXIVES

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

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

For Ch'ol, we also have a further diagnostic: obligatory control. In some nonfinite environments, it is the embedded ergative subject, rather than the absolutive object, that is obligatorily controlled. The sentence in (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 via the ergative prefix, coreference is obligatory in aspectless embedded environments (see Coon 2013 for discussion). Example (12b) shows that the construction instantiates obligatory control, and (12c) shows that it is impossible for the controllee to be the absolutive object.

(12) CH'OL OBLIGATORY CONTROL

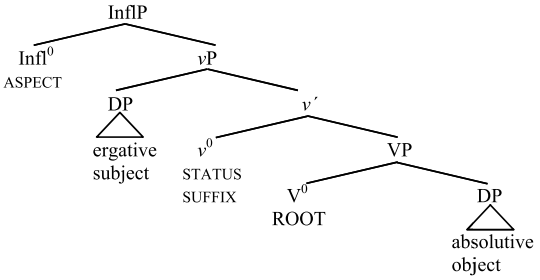
a. K-om [k-mek'-ety].
1.ERG-want 1.ERG-hug-2.ABS
'I want to hug you.'

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

c. *K-om [a-mek'-oñ].
1.ERG-want 2.ERG-hug-1.ABS
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:

(13) 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).

(14) a. 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 a subject relative and in (15b) for an object relative. Relative clauses in Ch'ol are marked with a second-position clitic, *-bä*, which attaches to the aspect marker in eventive verbal 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).

(15) a. 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.'

In the examples above, only one of the arguments in the clause is third person, and the sentences are unambiguous: in (15a), the second person argument triggers absolutive

marking, indicating that it is the object; in (15b), the second person argument triggers ergative marking, 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.

(16) a. 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
PRFV arrive-ITV DET woman PRFV-REL 3.ERG-cure-TV DET
wiñik __$_i$].
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 possible interpretations, but given an appropriately vague 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 (5) and (8) respectively). The possible ambiguity here provides an opportunity to determine whether speakers prefer to interpret relative clause gaps as ergative or absolutive, and whether one of these interpretations 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 known as Agent Focus—which we discuss below—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.

[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 classifier markers, such as *ix*, which is used for female humans. We gloss them all as "DET" for simplicity.

(17) a. TRANSITIVE CLAUSE—Q'ANJOB'AL
Max-ø y-uk' ix ix kapey.
PRFV-3.ABS 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 are freely relativized with a gap. This is illustrated in (18).

(18) a. 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.'

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. in press and references therein). AF constructions in Q'anjob'al differ from regular transitives in several important respects: (i) the transitive subject no longer triggers 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) with the transitive suffix *-a'* (18a)).

(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 in Q'anjob'al is not an antipassive, as it might first appear. In fact, Mayan languages including Q'anjob'al also contain antipassives, and the distinction between AF and antipassive has been amply

documented (Smith-Stark 1978; Craig 1979; Ayres 1983; Aissen 1992; Stiebels 2006; Tonhauser 2007). First, while there is no ergative agreement on the verb stem in (20), the absolutive still tracks the object, not the relativized subject (which triggers no agreement morphology). If this were a true antipassive, we would expect the absolutive marker to co-index the subject. 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, which are not present in (20).

5.2.2 Q'anjob'al progressive: ambiguity

In matrix clauses, the AF construction is limited to environments in which the transitive subject has been A-bar extracted. However, the suffix *-on* is also found in *all* non-finite embedded transitives in the language, regardless of whether or not a DP has undergone extraction (Pascual 2007). This is illustrated in the embedded transitives in (21). Notice that the progressive in (21b), 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-Toledo 2003; Mateo Pedro 2009 on Q'anjob'al; Coon 2013 on Ch'ol).[17] Note also that while the stem appears with the suffix *-on* and intransitive status suffixes, as in (20) above, here the ergative prefix is again present.[18]

(21) 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.'

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

Since the suffix *-on* is required on the predicate with all embedded transitives, it is precisely in these environments that extraction ambiguities arise in Q'anjob'al, as shown in (22).

(22) a. 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.'

[17] For a discussion of the cross-linguistic tendency to express the progressive aspect with biclausal constructions see Bybee et al. (1994), Laka (2006), and Coon (2013).

[18] In other work (e.g., Mateo Pedro 2009; Coon et al. in press), 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. 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

Ch'ol freely permits relativization of all core arguments. Though Ch'ol is morphologically ergative, A-bar extraction does not distinguish between ergative and absolutive DPs in this language. The fact that both types of DPs originate post-verbally, and that no case is marked on the nominals themselves, results in ambiguity in situations where agreement on the verb cannot be used to differentiate between the arguments (i.e., when both DPs are third person and one is extracted); 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 suffix *-on* associated with 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

As discussed in the preceding sections, ergative languages uniquely allow us to investigate the independent roles of grammatical function and argument marking in the processing of relative clauses. As we indicated above, the presence of an ergative morpheme serves as a cue for projecting the absolutive object, but not vice versa. If the SPA were a reflection of a hierarchy of argument marking, then we would expect to collect a greater number of accurate responses on object extractions in stimuli semantically biased for object interpretation than we found on subject extractions in stimuli semantically biased for subject interpretation. In other words, if a scene depicts a human/animate agent acting upon an inanimate object (e.g., a person drinking coffee, making tortillas, etc.), it should be easy to interpret the animate participant as the subject and the inanimate object as the theme. This expectation relies on the notion that the ergative in the relative clause would provide a cue for recovering the object. We would also expect fewer subject-compatible responses in ambiguous stimuli. This pattern would reflect the fact that absolutive gaps were being processed more successfully or accessed more easily than ergative gaps in ambiguity resolution.

If the SPA were instead controlled exclusively by phrase structure prominence, i.e., grammatical function, then we would expect a greater number of accurate responses on subject extractions in stimuli semantically biased for subject interpretation than were found on object extractions in stimuli semantically biased for object interpretation. We would also expect to find fewer object-compatible responses in ambiguous stimuli. This pattern would reflect the fact that subject gaps were being processed more successfully or accessed more easily than object gaps 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 (23a), gaps ambiguous between ergative subject and absolutive object (23b), ambiguous gaps semantically biased towards ergative subject (23c), and ambiguous gaps semantically biased towards absolutive object (23d). These gaps were situated in relative clauses on DPs in matrix clauses with minimal contentful material, either direct commands (e.g., "Show me…") or indirect commands (e.g., "Where is the…"). For each factor we manipulated, our stimuli contained both direct and indirect commands. Our stimuli contained 23 ambiguous transitives, 13 unaccusatives, 11 unergatives, 9 biased transitives (4 subject, 5 object), and 51 fillers. Each participant completed 109 trials, which took roughly 20 minutes.[19]

Recall that in Ch'ol, all transitive relative clauses are syntactically ambiguous. To create relative clauses with a bias towards subject or object interpretation, we systematically manipulated the animacy of the arguments with respect to one another. Thus, in (23) below, the object relative parse, 'Find the boy that the beans are picking' is a possible translation of (23c), and, 'Where is the coffee that is drinking the soldier' is a possible translation of (23d). But both of these interpretations are implausible for pragmatic reasons, so the manipulation of animacy leads to a semantic bias. Other factors we manipulated within relative clauses across stimuli included aspect (perfective and progressive), morphological form of the verb (root transitive vs. derived transitive; see Vázquez Álvarez 2011 and Coon 2013 for discussion of this distinction in Ch'ol), and type of intransitive verb (unergative vs. unaccusative).

(23) EXAMPLE STIMULI—CH'OL

a. INTRANSITIVE:
Baki añ jiñi chuch$_i$ [tsa'-bä tyijp'-i __$_i$ tyi i-ty'ej
where LOC DET squirrel PRFV-REL jump-ITV PRP 3.ERG-side
koneju]?
rabbit
'Where is the squirrel that jumped next to the rabbit?'

b. AMBIGUOUS TRANSITIVE, CONDITION (A):
Päsbeñ jiñi poli$_i$ [wol-bä i-käch (__$_i$) jiñi solraru (__$_i$)].
show DET policeman [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.'

[19]For stimuli and images, see Polinsky Lab Dataverse: http://dvn-4.hmdc.harvard.edu/dvn/dv/polinsky.

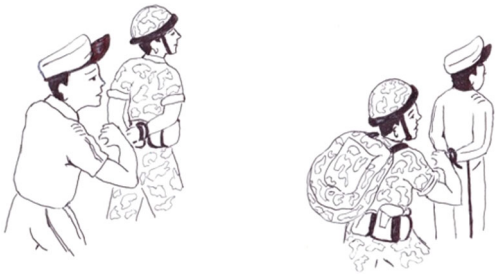


Fig. 6 Example screenshot from experiment. This screenshot corresponds to the stimulus item in (26b); *on the left*, a police officer is depicted tying up a soldier, *on the right*, a soldier is depicted tying up a police officer

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 policeman
'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, SUBJECT RELATIVE:
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 the beans.'
Implausible: 'Find the boy that the beans are picking.'

d. BIASED TRANSITIVE, OBJECT RELATIVE:
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 the region.

Our stimuli were constructed and normed in collaboration with a native Ch'ol speaker who recorded them at 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 ExBuilder (Longhurst 2006). Participants watched a short introductory video in Ch'ol (recorded by the same native speaker). They 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 such as (23a), there was a correct representation and an incorrect representation, i.e., one image in which a squirrel is shown jumping next to a grazing rabbit (correct) and one with a rabbit shown jumping next to a grazing squirrel (incorrect). For the biased stimuli, the options included only the plausible reading: for an example like (23d), participants would be given the choice between an image of a man drinking coffee and a man eating tortillas. For the ambiguous stimuli, the two possible parsing interpretations were represented. An example set of pictures is given in Fig. 6.

Table 1 Participant accuracy on unambiguous and semantically biased RCs (standard error in parentheses)

Gap type	Accuracy ($n = 47$)
Intransitive absolutive subject	72 (2)
Transitive ergative subject	96 (1)
Transitive absolutive object	86 (3)

Participants indicated their selection with a two-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 and the subject had the chance to ask questions before the experimental phase began.

63 native Ch'ol speakers completed the study. 16 participants were undergraduate students at *Universidad Intercultural de Tabasco* in Tabasco, Mexico. 41 participants were recruited and tested in Comunidad San Miguel, Chiapas, Mexico, and the remaining 6 in Tila, Chiapas, Mexico. For both Ch'ol and Q'anjob'al, we collected demographic data (language background, dialect, age, gender) in pre-experiment interviews. Seven participants were excluded before data analysis when it was determined that they had not understood the instructions. 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 intransitives against the error rate on semantically disambiguated object extractions. Each participant was then assigned the average of these scores. Two participants whose average d-prime scores were less than twice the standard deviation below the mean (2.1, s.d. = 0.87) were excluded from the analysis. Of the participants whose data were used, 28 were female and 19 were male. 36 participants reported being Ch'ol-Spanish bilinguals; the remaining 11 reported being monolingual speakers of Ch'ol. The age range was 15 to 54, with a mean of 29.

6.2 Ch'ol results

For semantically biased relative clauses, participants were both more accurate and faster with ergative subject relatives than with absolutive object relatives (see Sect. 6.2.1 below). In the case of ambiguous relatives, we found that participants were likely to resolve the ambiguity with an ergative subject interpretation; when they chose an absolutive object interpretation instead, they took longer to do so (Sect. 6.2.2). Degree of language experience produced an important effect: Ch'ol monolinguals and Ch'ol-Spanish bilinguals displayed similar response patterns, but the pattern of results, discussed below, was more pronounced in the case of the bilinguals (Sect. 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

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

Gap type		Mean RT (ms)
Intransitive absolutive subject		3574 (108)
Biased transitive	Ergative subject	2207 (140)
	Absolutive object	2890 (261)
Ambiguous transitive	Ergative subject	2914 (133)
	Absolutive object	3340 (269)

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.

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 containing absolutive object extractions (β: 0.06 ± 0.02, $p < 0.05$).[20] Participants were more accurate on extractions from transitive clauses than on extractions from intransitive clauses (β: 1.33 ± 0.17, $p < 0.001$).

Ambiguous relative clauses For gaps which were ambiguous between an ergative subject gap and an absolutive object gap, 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 assigned by the participants.[21] Response times were long (2–6 seconds; median RT: 3.1 seconds, IQR: 1.7–5.4 seconds), probably for two reasons: first, there was no deadline on the response, and second, many of our participants had little or no experience with computers. Table 2 reports the mean reaction times and standard error for each condition. For intransitive stimuli, only RTs from correct responses were used to determine the mean. For the biased stimuli, only the RTs for responses congruent with the direction of the bias were used in the calculations.

[20] Throughout this discussion, we report fixed effect coefficients, β, from mixed-effects regression, which include subjects and items as random effects. We used logistic regression in the case of choice data and linear regression in the case of response time data. Our data and analysis scripts are available in the supplementary materials at the Polinsky Lab Dataverse: http://dvn-4.hmdc.harvard.edu/dvn/dv/polinsky.

[21] 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 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 3 Accuracy on unambiguous and biased RCs according to language experience (standard error in parentheses)

Gap type		Accuracy by language experience	
		Monolingual ($n = 11$)	Bilingual ($n = 36$)
Intransitive absolutive subject		65 (4)	74 (2)
Biased transitive	Absolutive object	83 (6)	87 (3)
	Ergative subject	95 (3)	96 (1)

Table 4 Percentage of subject-compatible responses to unbiased ambiguous stimuli according to morphological form, aspect, and language experience (standard error in parentheses)

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)

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

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, $p < 0.05$).

Ambiguous relative clauses For the ambiguous stimuli without a semantic bias (Tables 4 and 5), bilingual participants ($n = 36$) gave more subject-interpretation responses than monolingual speakers did ($n = 11$) (β: 0.72 ± 0.25, $p < 0.005$). We found two additional main patterns in features that were not manipulated as controlled factors in our experiments—i.e., features that varied across items in our stimuli rather than across conditions within items. First, root (non-derived) transitives led to a higher percentage of subject-interpretation responses (β: 0.22 ± 0.07, $p < 0.001$). Second, progressive aspect led to more subject-interpretation responses (β: 0.30 ± 0.14, $p < 0.05$).

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.

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

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	**

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

a significant tendency to interpret relative clauses as subject-extractions (β: 0.36 ± 0.16, $p < 0.05$) and a significant effect of aspect (β: 0.60 ± 0.26, $p < 0.05$). 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 the number of participants in each of 5 categories: 0–20 % subject preference, 21–40 %, 41–60 %, 61–80 % and 81–100 %. Participants were split by language experience. Many participants in the bilingual group had near-total subject preference rates, while monolingual participants tended to show a subject preference, but not an extreme one. Note that no more than 2 individuals fell below 40 % in subject preference rates in either language experience group.

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, $t = -8.5$, $p < 0.001$).

6.3 Discussion of Ch'ol results

Participants were generally faster and more accurate with transitive stimuli than they were with intransitive stimuli. The difference between the transitives and intransitives in speed and accuracy 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—which included additional material in the form of a prepositional adjunct—was 4.0 seconds, but the mean duration for transitive stimuli was

only 2.8 seconds. We hypothesize that this difference in duration may account for the poorer performance found for intransitives, primarily because of our population's lack of experience in test taking. We return to this issue in Sect. 7.2.

When we consider transitives to the exclusion of intransitives, we find that participants were more accurate with subject-biased stimuli than with object-biased stimuli. This accuracy is matched by response rate: participants were 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 stimuli which contain root transitives (as opposed to derived transitives) and for stimuli whose verb is in the progressive aspect as opposed to the perfective aspect. This result is not important for our driving question, but it is worth mentioning that, overall, the particular root transitives used 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 more frequent lexical items.[22]

We conclude that, for speakers of Ch'ol, subject extractions are less complex than object extractions. Both 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 Sect. 7.2, 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 processing of the same four gap types investigated in Ch'ol: 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). In addition, we included syntactically unambiguous subject relatives (24e) and object relatives (24f). Syntactically unambiguous subject and object relatives are possible in Q'anjob'al but not in Ch'ol, because only the former is syntactically ergative (see Sect. 5.2). Note that in (24e), the predicate of the relative clause is in the agent focus (AF) form, which entails that the subject has been extracted. Conversely, in the non-AF transitive in (24f), the only argument that can be extracted is the absolutive object.

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

(24) 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.'

[22]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.

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 and normed by a native Q'anjob'al 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, and all stimuli are available at http://dvn-4.hmdc.harvard.edu/dvn/dv/polinsky.

This experiment was also run in ExBuilder (Longhurst 2006). Participants watched a short introductory video where instructions were given in Q'anjob'al. Our Q'anjob'al stimuli contained 10 ambiguous transitives, 13 unaccusatives, 11 unergatives, 26 unambiguous transitives (13 subject, 13 object), 12 biased transitives (8 subject, 4 object), and 61 fillers. Each participant completed 133 trials, which took roughly 30 minutes. For more information about our methodology, see Sect. 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 were removed from the study before

Table 7 Participant accuracy on unambiguous and semantically biased RCs (standard error in parentheses)

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)

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.[23] 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

Like the Ch'ol speakers, the Q'anjob'al participants were more accurate with subject gaps than with object gaps in unambiguous and biased relative clauses (Sect. 6.5.1). When relative clauses were ambiguous, participants preferred the subject interpretation (Sect. 6.5.2). Concerning the possible effect of language experience, we found that Q'anjob'al monolinguals and Q'anjob'al-Spanish bilinguals displayed similar response patterns, with the pattern of results sharper in the bilingual pool (Sect. 6.5.3)

6.5.1 Forced choice task

Unambiguous and biased relative clauses Table 7 reports the overall accuracy for unambiguous (24a, e, f) and semantically biased (24c, 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.

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, $p < 0.001$). This was not the case, however, for the biased stimuli, where object extractions received a higher proportion of correct responses than subject extractions. For the semantically biased relative clauses, the effect of bias was significant, and in the expected direction: subject bias led to more subject interpretations (β: 3.72 ± 0.25, $p < 0.001$). We can therefore look at the semantically biased and unambiguous transitives together, in which context, responses to subject

[23] 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 score 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.

Table 8 Mean RTs (ms) by gap type (standard error in parentheses)

Gap type		Mean RT (ms)
Intransitive absolutive subject		1472 (83)
Unambiguous 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)

extractions are indeed more often correct (β: 0.50 ± 0.12, $p < 0.001$). Finally, participants were less accurate on extractions from transitive clauses than they were on extractions from intransitive clauses (β: 0.52 ± 0.09, $p < 0.001$). Note that this is different from the Ch'ol results, where subjects were less accurate in the intransitives. We attributed the Ch'ol results to the difference in the duration of the intransitive vs. transitive stimuli. In Q'anjob'al, however, the stimuli were all of comparable length. We discuss both this result and the result favoring object extraction in more detail in Sect. 6.6.

Ambiguous relative clauses The percentage of subject interpretations of ambiguous stimuli with no semantic bias (24b) was 74 % (s.e.: 2 %). Participants thus showed a preference to interpret ambiguous transitive relative clause extractions as subject relative clauses.

6.5.2 Response times

We examined response times, with transitives split according to the interpretations assigned by the participants. 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 8 gives mean RTs by gap type.

Among ambiguous transitives, subject-compatible responses were shorter than object-compatible responses (β: -0.08 ± 0.04 log sec, $t = -1.9$, $p < 0.10$). 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 unambiguous and biased relative clauses according to fluency in Span-

Table 9 Accuracy on unambiguous and biased RCs according to language experience (standard error in parentheses)

Gap type		Language experience	
		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)

Table 10 Percentage of subject-compatible responses to unbiased ambiguous stimuli according to morphological form and language experience (standard error in parentheses)

Morphological form	Language experience	
	Monolingual ($n = 47$)	Bilingual ($n = 45$)
Nonderived	64 (3)	76 (3)
Derived	70 (3)	84 (2)

ish (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, $p < 0.001$). 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, $p < 0.001$). In other words, bilinguals were more likely to respond to biased stimuli in the direction of the bias.

Recall that participants were less accurate on extractions from transitive clauses than from intransitive 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, $p < 0.10$). We observe that transitive extractions were easier than intransitive extractions for Ch'ol participants. On the contrary, for Q'anjob'al participants, the transitive extractions are harder, but the effect of transitivity is dominated by the low accuracy on object extractions from unambiguous transitives. 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 than monolingual speakers (β: 0.73 ± 0.18, $p < 0.001$). Second, derived transitives led to more subject-interpretation responses than nonderived transitives (β: -0.42 ± 0.16, $p < 0.01$). 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 11 Fixed effects, logistic regression over subject-compatible responses

Coefficient	Estimate	Standard error	z-Value	$P(>\|z\|)$	
INTERCEPT	1.12	0.089	12.69	$<2e^{-16}$	***
MORPHOLOGICAL FORM (Root)	−0.42	0.158	−2.70	0.007	**
FLUENT IN SPANISH? (Yes)	0.73	0.178	4.09	$4.28e^{-05}$	***

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)

Response times In Table 12, reaction times are broken down by the morphological form of the predicate (root vs. derived), by presence/absence of ambiguity, and by language experience. There were no simple effects of language experience or morphological derivation on response times. As mentioned above, for the biased transitives, responses that were congruent with the direction of the bias tended to have shorter response times. 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, $t = -3.1$, $p < 0.005$).

6.6 Discussion of Q'anjob'al results

As was true for Ch'ol, the Q'anjob'al participants were generally more accurate on subject extraction than on object extraction in unambiguous transitive clauses. Additionally, in ambiguous stimuli with no semantic bias, participants consistently favored responses with the subject interpretation. This preference was most apparent for bilingual speakers. We also found 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 was the case for Ch'ol, however, we suspect that the difference in response type 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: does the frequency of different verb types play a role in online processing of Mayan languages? However, without information about lexical frequency, we must leave this question for future work.

Two other trends in the data deserve further discussion. First, in semantically biased relative clauses, participants were more accurate with object extractions (24d) than they were with subject extractions (24c). In contrast, participants show lower scores for syntactically unambiguous stimuli, and particularly low scores with unambiguous object extraction (24f).[24]

The semantically biased condition in Q'anjob'al was the only condition in either experiment where participants were more accurate with object relatives than with subject relatives, but it is also the only condition in the experiment where greater accuracy corresponded to a relatively longer response time. A possible explanation for the higher accuracy rate with biased object relatives is that speakers' performance on such clauses in Q'anjob'al reflects a speed-accuracy tradeoff: higher accuracy on absolutive objects corresponds to longer RTs, and lower accuracy on ergative subjects corresponds to shorter RTs. Although the RTs were not reliably different, the numerical trend suggests the possibility that speakers chose to respond more carefully on absolutive object extractions. It is an open question why Q'anjob'al speakers, but not Ch'ol speakers, might use this strategy, and we leave open the possibility that animacy may also play a role in confounding these data. The effects of animacy may be different across languages and individual structures, which would explain why the subject-object difference is observed only in semantically biased relative clauses in the progressive. We cannot rule out, however, the role of unknown structural factors, and would like to highlight this particular subtype of relative clauses for further research.

The other unexpected result of our study was the difficulty that participants had with unambiguous object extractions from sentences such as (24f), as reflected in both lower accuracy and longer RTs. Here, we would like to offer two considerations. The first consideration has to do with participants' expectations. Q'anjob'al has several strategies for relativizing themes (objects). While extractions from active voice constructions (like those in our stimuli, cf. (24f)) are licit object extractions, themes may also be extracted from passive constructions as in (25a, b). In Ch'ol, on the other hand, the expression of passive by-phrases is restricted based on the relative animacy of the agent and theme (Zavala 2007). Since Q'anjob'al speakers have a ready alternate strategy for extracting themes, the expectation that a theme is extracted from a given construction is lower, which leads to greater uncertainty in the data. In other words, speakers might prefer passive subject relatives (25b) to active object relatives (24d). There are no corpus data for Q'anjob'al to test this explanation, so we offer it as a tentative consideration.

(25) PASSIVE RELATIVE CLAUSES—Q'ANJOB'AL

a. cham doctor$_i$ [max iq–lay y-uj cham
DET doctor PRFV carry-PASS 3.ERG-REL_NOUN DET
mexhtol __$_i$]
teacher
'the doctor that was carried by the teacher'

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

b. te' kapey$_i$ [max uk'-lay y-uj ix ix __$_i$]
DET coffee PRFV drink-PASS 3.ERG-REL_NOUN DET woman
'the coffee that was drunk by the woman'

The second consideration has to do with the possibility that clauses such as (24f) are not unambiguous for all the speakers. It is possible that the requirement to use AF is less categorical in Q'anjob'al than has been reported, and that transitive forms are also sometimes used for extracting ergatives. Extraction of ergatives is possible in two types of contexts. Ergative can be extracted from clauses with reflexive objects and objects in which the possessor is co-referential with the subject. Ergative extraction is also possible when the ergative argument is 1st or 2nd person (Pascual 2007; Coon et al. in press). Stiebels (2006) reports a range of variation within the Mayan family regarding when AF is required, optional, and impossible. In Tzotzil, for example, extraction of the external argument can proceed either from a transitive clause or an AF clause, with the choice determined by the relative salience of the two arguments (Aissen 1999). When the arguments are balanced for animacy and definiteness, as in our Example (24f), extraction of the external agent is possible from both transitives and AF clauses. Participants' performance on stimuli such as (24f) offers experimental evidence suggesting that Q'anjob'al transitives might be undergoing a change towards a system more like that of Tzotzil. The availability of the passive construction for the relativization of the theme may only reinforce such a change.

Setting these two special cases aside, 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 than object extractions.

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

7.1 Subject preference

7.1.1 Subject preference in Mayan

In both Mayan languages, we found that participants were more accurate and responded more quickly to subject relative clauses than to object relative clauses in the absence of ambiguity. We also found that participants in both languages demonstrate a preference for subject interpretation in the resolution of unbiased ambiguous items, and that the response time to stimuli was lower for subject-compatible responses than for object-compatible responses. In other words, both languages show SPA effects unmitigated by any potential predictive properties due to the presence of the ergative marker on the verb. We saw no cueing by head-marking.

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 their respective roles in processing are different. Our predictions from Sect. 3 are repeated below:

(7) PREDICTIONS CONCERNING THE PROCESSING OF RELATIVE CLAUSES IN MAYAN

a. ERG = ABS_{Obj}: Dependent-marking and head-marking (case and agreement) are equally diagnostic in predicting constituent structure; as a result, morphological cueing and the SPA cancel each other out.

b. ERG > ABS_{Obj}: Dependent-marking (case) is superior to head-marking (agreement) in predicting constituent structure; in the absence of morphological cues, the parser relies on SPA alone.

Under (7a), dependent-marking and head-marking are expected to be equally diagnostic in predicting the structure that needs to be recovered. The presence of the ergative agreement marker on the predicate of the relative clause in Mayan languages should therefore serve as a cue for the parser to project the absolutive argument and the rest of the (transitive) clause. Extraction of the absolutive thus gets a boost from the ergative agreement cue, while extraction of the ergative gets the normal subject boost. The two "boosts" could cancel each other out, and we would end up with a scenario like Avar, where the extraction of either argument would require about the same processing effort.

The second scenario (7b) is based on rejecting the equal predictive power assumption. This scenario assumes 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, there is no dependent-marking. Word order is also uninformative; subject relative clauses have the same order as object relative clauses. (The verb precedes the single DP, whether subject or object.) The remaining option is to rely on grammatical function. This leads to the second scenario, in which ergative subject extraction is easier to process 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 pattern of resolution in ambiguous clauses and participants' accuracy and response time in unambiguous (or semantically disambiguated) clauses are relevant measures for both of these hypotheses.

Our results strongly support the second scenario. Extraction of the ergative subject was significantly faster and more accurate than extraction of the absolutive object, and ambiguous clauses were significantly more likely to be parsed as subject relative clauses. This has several immediate implications. First, this result confirms the conclusion from primary data that the ergative argument is structurally superior to the absolutive in transitive clauses (see Sect. 5). Second, this result shows that subject preference emerges as a default 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 do (see Sect. 4 for Russian and Schwarz 2007 for German).

7.1.2 Accounting for subject preference

While our results establish novel evidence for the SPA, we have not discussed the motivation for the presence of the SPA in language in the first place. Existing approaches to the SPA seek explanations in working memory, speaker expectations, and phrase structure.

The *working memory approach* reasons that the longer a dependency is unresolved, the more costly it is to the processor, where cost is usually cast either in terms of the difficulty of maintaining unintegrated dependents in short-term memory (Wanner and Maratsos 1978; Gibson 1998; Grodner and Gibson 2005) or of retrieving dependents at their point of thematic integration (Gordon et al. 2004; Lewis et al. 2006, a.o.). According to this approach, the presence of the SPA in an SVO language with head-initial relative clauses reflects the fact that the distance between the head of the relative clause and the dependency resolution position is shorter for subjects than for objects.

A theory based on *speaker expectations* uses structural probabilities to predict the relative difficulty of processing different structures (Mitchell et al. 1995; Jurafsky 1996; Hale 2001; MacDonald and Christiansen 2002; Levy 2008; Gennari and MacDonald 2008, a.o.). If most clauses in a language are SVO, then a language with head-initial relative clauses should display the SPA, because the constituent order in the subject relative clause is $S[_{RC}VO]$. For example, in English, transitive subject relative clauses are much more common than transitive object relative clauses (Roland et al. 2007), and this fact impacts the processor's partial incremental analysis.

Finally, the *phrase-structural approach* postulates that subjects are most accessible under parsing because of their prominence in the hierarchical structure of the clause. According to this perspective, the SPA should be universal, because subjects are universally structurally superior to objects, which makes them easier to extract (Keenan and Comrie 1977; O'Grady 1997, 2011; Hawkins 1999, 2004; Lin and Bever 2006).

The phrase-structural account diverges from the working memory and expectations-based accounts in its predictions with regard to the universality of the SPA. The phrase structure account predicts that the SPA should be active in all languages. The working memory and expectations-based accounts predict that some languages will instead privilege objects in the processing of relative clauses. It is worth noting that results from languages with head-final relative clauses are mixed. Research on the processing of relative clauses in Japanese, Korean, and possibly Mandarin supports the existence of the SPA (Miyamoto and Nakamura 2003; Kwon et al. 2006; Lin and Bever 2006, a.o.). In contrast, other results from Basque and Mandarin challenge the universality of the SPA (Carreiras et al. 2010; Hsiao and Gibson 2003; Gibson and Wu 2013; Lin and Garnsey 2011).

We are not in a position to choose between these various approaches on the basis of the present experiment. However, it is important to bear in mind that, while different psycholinguistic theories may assign distinct proximal causes to processing preferences, this does not mean that these theories must be mutually exclusive. In fact, it may turn out that these various approaches are each helpful for explaining different aspects of the SPA. For example, a frequency-based account of the SPA does not provide an explanation for the relative abundance of subject and object extractions, but one might appeal to working-memory difficulties to explain these preferences. We leave a definitive account of the motivation for the SPA for future research.

7.2 Head-marking and dependent-marking

While we are confident in our conclusion that the SPA is strong in the two Mayan languages we have investigated, we remain cautious in our conclusion concerning the processing instructions provided by head-marking. Our results suggest that head-marking (agreement) could be qualitatively different from dependent-marking (case) in terms of cueing effects. Perhaps the parser assigns lower weight to agreement cues than to case cues in Ch'ol and Q'anjob'al because computing grammatical functions based on agreement would net too little information for the processing cost involved. This heavier reliance on dependent-marking may be particularly expedient in third person configurations, where there tend to be many null exponents and quite a bit of homophony. This is true for Mayan languages—where third person absolutive is consistently null—as well as many other languages. For instance, in a study of the exponence 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. This conclusion matches the result presented by Fodor and Inoue (2000b), who discuss the competition between case and number agreement in German. They show that case features and number features have a different effect on sentence processing. According to Fodor and Inoue (2000b), case information is a "positive symptom," which requires the parser to build up all the structures involved, and to correct any incorrect structures. Conversely, a number mismatch is a "negative symptom"; it invalidates an incorrect structure without showing how to rebuild it.

An alternative explanation for the observed difference between head-marking and dependent-marking as processing also exists, which we cannot rule out in the absence of empirical data. It is possible that the discrepancy between Avar, which shows a strong tension between morphological cueing and the SPA, and the Mayan languages, which exhibit the SPA alone, may have to do with the relative order of the head noun and relative clause in each language.[25] Recall that Avar displays prenominal relatives, whereas the Mayan languages we have investigated have postnominal relatives. In a prenominal, predicate-final relative clause where the predicate appears relatively late, the parser may rely more on the morphological cues provided by the early arguments. In contrast, if the predicate of a postnominal relative clause appears early on (but following the head noun), the semantic information from the head noun and the predicate of the relative clause may be sufficient for parsing; less dependence on morphological cues would therefore be necessary.

Ideally, in order to rule out this alternative explanation, one would need to complete the paradigm by collecting data from two other types of ergative languages: languages with postnominal relatives that have case marking instead of (or in addition to) agreement, and languages with prenominal relative clauses and no case marking. These languages would also need to allow extraction of the ergative with a gap. The

[25] Basque also has postnominal relatives (see footnote 6), which reveal subject preference (Carreiras et al. 2010); however, postnominal RCs do not present an ambiguity of the type discussed in Sect. 2, so the comparison with prenominal RCs is more difficult.

Table 13 Dependent-/head-marking and word order in ergative languages without syntactic ergativity

Headedness	Dependent-marking (case)	Head-marking (agreement)	Both
Prenominal RC	Shipibo-Konibo (Valenzuela 2002)	Unattested	Avar, Basque (references above)
Postnominal RC	Niuean (Seiter 1980)	Mayan languages without AF[26]	Georgian (Hewitt 2005)

pool of languages which meet all these criteria simultaneously is unfortunately rather small, and is further restricted by an additional limitation: prenominal relatives are typically found in head-final languages, and such languages rarely lack case marking (Mallinson and Blake 1981:179, 332). Among ergative languages, only Abkhaz seems to fit that profile; it is verb-final, has head-marking, and lacks case marking. However, it is syntactically ergative; only the absolutive argument can extract leaving a gap at the extraction site. The ergative in Abkhaz requires resumption in the verb form (Hewitt 1979).

Table 13 lists ergative languages that do not display syntactic ergativity and differ in headedness and marking.

Of the languages shown in this table, Niuean is particularly relevant for comparison to the Mayan languages without AF; it is also verb-initial, it allows ergative and absolutive extraction with a gap equally, and it is exclusively dependent-marking. 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 had been extracted), which makes it uniquely relevant and also more comparable to the ergative languages we have already explored. Consider Examples (26a) and (26b):

(26) a. 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'

The processing of relative clauses in Niuean has 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 such a 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. We could then definitively claim that the differences between Avar and Mayan languages are due to differences

[26] See Sect. 5 for a discussion of Agent Focus (AF) in Mayan.

in the processing effects of agreement and 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 subordinate clause and relativized nominal would need to be re-evaluated for both ergative and accusative languages.

7.3 Language experience and psycholinguistic work in the field

With both Ch'ol and Q'anjob'al, we found that bilingual and monolingual speakers patterned in the same ways in terms of trends in the data and significant findings, but these effects were often stronger for bilingual speakers than for monolingual speakers. A possible explanation appeals to transfer effects. Both Ch'ol and Q'anjob'al bilinguals had Spanish as their second language; Spanish itself has strong subject preference (Betancort et al. 2009), and due to bilingualism, this preference could be transferred to Ch'ol and Q'anjob'al. However, at least two points argue against such an 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. If this suggestion is correct, the difference between the two groups is primarily the result of extralinguistic variation.

Until recently, experimental work has been confined to the university setting, with researchers testing undergraduates who are already comfortable with relevant aspects of the setting (familiarity with computers, experience with test-taking in general, etc.). Data from these sorts of participants may include some individual differences, but the sheer rate of experimental replication on familiar topics such as passives, past tense, or 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 change dramatically. For example, response rates on most measures were slower in our study than would be expected from populations in which a higher percentage of the population has access to formal education. The level of noise in our data is also greater than would be expected from speakers of English, Russian, or Japanese in the lab. Moreover, the significance of both these factors increases when we consider only monolingual speakers of Ch'ol or Q'anjob'al—i.e., precisely those speakers who are likely to be least familiar with a standard experimental setting. Similar concerns about the level of noise in the data have arisen 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 are taken 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 lack of noise contributes to the fact that the significant effects we found were stronger for bilingual

speakers. Bilingualism is correlated to the level of formal education (Spanish is the primary language used in schools in Mexico and Guatemala), and we believe that the difference between the two groups has primarily to do with exposure to formal education.[27]

Perhaps it seems improbable that speakers would require formal education in order 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. Nonetheless, 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 with test-taking skills, familiarity with technology, experience interpreting abstract images, etc. Such skills include the desire to cooperate with the experimenter (see Rosenthal and Rosnow 2009 for a detailed discussion). These skills are often assumed when preparing experiments, but they are likely to be underdeveloped in monolingual speakers of Mayan languages, since they are skills one develops in school.

Another result that supports our observation has to do with participants' performance on longer sentences. Recall that our results became less accurate as the sound stimuli became longer in duration. This was particularly apparent in Ch'ol intransitives, which were longer in duration than any other stimuli. The lower performance on Ch'ol intransitives was observed both in bilinguals and monolinguals, but it was greater for the monolinguals. We hypothesize that this discrepancy pertains to working memory capacity. There is independent evidence that educational experience correlates with working memory capacity (Gathercole et al. 2004). Longer stimuli can impose 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 among bilingual speakers.

Every testing situation is different and every population is different. When investigating minority languages, two competing factors are relevant: monolingual speakers lack the confound of interference from the dominant language; on the other hand, bilingual speakers, who presumably learned the dominant language in school, are likely to be more comfortable with the framework of the experiment (although this does not mean that they will test in exactly the same way as the traditional populations of experimental linguistic studies). The general expectation to be derived from results such as ours is that everyone should be prepared for a greater level of noise in this sort of study. As linguistics as a field becomes 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. We had more subjects in Q'anjobal, for instance, and although the data still had a fair amount of noise, the statistical effects were stronger.

[27] 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 Guatemala to observe noisy data.

8 Conclusions

We started this paper with a set of questions that relate ergativity to extraction phenomena from a processing perspective. We will now review our responses to those questions. First, the validity of 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 the 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.

Another reason to explore the processing of extraction in ergative languages has to do with possible differences between dependent-marking (case) and head-marking (agreement) in tracking grammatical functions. Are they equal in their ability to license grammatical functions, and if so, is this reflected in processing? Our results suggest that the cueing effect associated with ergative case marking is not replicated in agreement.

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 seem to help the parser project the absolutive. This leads us to conclude that dependent-marking is superior to head-marking in tracking grammatical functions; in the absence of case cues, structural preferences become more pronounced.

The fact that speakers of both ergative and accusative languages exhibit subject preference in relative clauses provides novel support for the independent status of the category of grammatical subject. Our results also demonstrate that subject preference is best observed in the absence of surface cues—Mayan languages are in this sense "clean" examples, on par with the ambiguous Russian relative clauses that we also discussed in this paper.

The third 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: 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. If the findings are on the right track, and they extend to other

domains of syntactic ergativity, for instance, wh-questions or topicalization, then it stands to reason that an explanation for syntactic ergativity should be sought not in processing, but instead in constraints on the grammatical design of ergative languages (for syntactic accounts of syntactic ergativity, see for example, Campana 1992; Aldridge 2004; Coon et al. in press; Manning 1996; Polinsky 2013).

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.

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