

**Syntactic Constraints and Production Preferences
for optional plural marking in Yucatec Maya**

Lindsay K. Butler^{a,*}, Jürgen Bohnemeyer^b, T. Florian Jaeger^{a,c}

^aBrain and Cognitive Sciences, University of Rochester

^bLinguistics, University at Buffalo (SUNY)

^cComputer Science, University of Rochester

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*Corresponding authors:
lbutler@bcs.rochester.edu

T. Florian Jaeger
University of Rochester
Brain and Cognitive Sciences
Box 270268
Rochester, NY 14620
fjaeger@bcs.rochester.edu

Abstract

We investigate the relationship between a near-universal semantic category and language-specific variation in its morphosyntactic representation and real-time processing. We examine this issue through the lens of optional plural marking on nouns and optional co-variant plural cross-reference marking on verbs in Yucatec Maya. In previous work, we have argued that Yucatec presents a previously unobserved case in the typology of plural marking. One particularly noteworthy property of Yucatec plural marking is that it is optional: both nominal plural marking and covarying plural marking on the verb are not required even when the noun is semantically plural. Two sentence production experiments with adult native speakers of Yucatec reveal what determines speakers' preferences to morphologically mark or not mark plurality. We find that speakers' production of optional plural marking in Yucatec is subject to effects similar to those that have been found to contribute to agreement *errors* in languages with obligatory plural marking, such as English. We discuss the implications of these results for linguistic and psycholinguistic theory and for the grammar of Yucatec and Mayan languages in general.

1 Introduction

One of the goals of linguistic theory is to examine the range of variation among languages in consideration of proposed universal tendencies. For some, this goal is limited to the grammatical structure of languages. Grammar, in turn, is seen as categorical – a structure is either grammatical or not. This view has nothing to say about alternations, cases in which a language provides multiple forms to encode synonymous or near-synonymous meanings. However, as others have pointed out, speakers' preference in alternations are not random – just like categorical properties of languages, speakers' preferences in alternations exhibit systematic patterns (Bresnan, 2006; Bresnan, Cueni, Nikitina, & Baayen, 2007).

For example, in English, ditransitive structures can be realized in two ways – either as preposition datives (*He gave a book to her*) or as double object structures (*He gave her a book*). While the exact same speaker might describe the same ditransitive event with either structure, the choice between the two structures is not random. Multiple factors, including, among others, the grammatical complexity and accessibility of the theme and recipient expressions, affect speakers' preferences for one or the other structure (Bock & Warren, 1985; Bresnan et al., 2007; for similar studies of other alternations, see also Arnold, Wasow, Losongco, & Ginstrom, 2000; Jaeger, 2010; Jaeger & Wasow, 2006; Lohse, Hawkins, & Wasow, 2004; Wasow, 1997).

Several of these factors have been found to affect speakers' preferences in alternations across languages (e.g., Branigan, Pickering, & Tanaka, 2008; Bresnan & Hay, 2007; Ferreira & Yoshita, 2003; Hawkins, 2007; for a recent overview, see Jaeger & Norcliffe, 2009), suggesting that such preferences stem from production mechanisms that are universal. This assumption is shared by much of modern psycholinguistics, which seeks to understand those mechanisms (for discussion, see Hawkins, 2007; Jaeger & Norcliffe, 2009). Furthermore, the same factors that have been found to affect gradient preferences in alternations seem to underlie categorical grammatical constraints in other languages (see, e.g., optional and differential case-marking, Aissen, 2003; Fry, 2003; Kurumada & Jaeger, submitted; Lee, 2006; or grammatical alignment systems, such as voice, Bock & Warren, 1985; Branigan et al., 2008; Bresnan, Dingare, & Manning, 2001). This has been taken to suggest that production preferences can become grammaticalized, thereby shaping languages over time (e.g., Bates & MacWhinney, 1982; Hawkins, 1994, 2004; MacDonald, in press; among many others).

In short, speakers' behavior in alternations seems to be non-deterministic, but systematic. Furthermore, this behavior seems to be systematically related to categorical grammatical constraints. While this points to an intriguing relation between production preferences and grammar (one that has, as a matter of fact, long been noted by functional linguists), its study has been held back by several challenges. While researchers in linguistics have studied a broad range of languages, the overwhelming majority of crosslinguistic data collection has been non-quantitative; relying heavily on acceptability judgments elicited from a handful –or

often just one—native speaker. Quantitative psycholinguistics studies, on the other, have been limited to a very small and typologically non-representative sample of languages (Jaeger & Norcliffe, 2009).¹

Here, we seek to contribute to the narrowing of this gap between linguistics and psycholinguistics by investigating a morphosyntactic alternation from both the linguistic and psycholinguistic perspective. We investigate plural marking in Yucatec Maya, an indigenous language spoken in the Yucatan Peninsula of Mexico.

While plural number is a near-universal cognitive and semantic category,² its morphosyntactic realization (henceforth *plural marking*) shows vast crosslinguistic variation. We first review evidence that Yucatec constitutes an important, previously undocumented, link in the typology of plural marking system (Butler, 2012).

In the remainder of the paper, we then focus on one particularly interesting property of the Yucatec plural marking system (shared with other languages) –plural marking in Yucatec seems to be optional: speakers of Yucatec can but do not have to morphologically mark plurality.³ Similarly, covariant plural marking between the verb and the nominals that express its semantic arguments seems to be optional as well. If confirmed, plural marking in Yucatec would constitute an example of an optional functional category (i.e., a functional category, in this case number, that is present in the language but only ever optionally realized). It would also make plural marking in Yucatec an alternation. Although optional functional categories are widely attested in the languages of the world, few studies to date have examined in detail the semantic and pragmatic conditions that govern the production of such categories. One exception is the phenomenon of ‘optional object marking’, in which the case marking of a direct object varies according to such conditions (cf. Fry, 2003; Kurumada & Jaeger, submitted; Lee, 2006; *inter alia*). In an attempt to understand what drives speakers’ preferences in such an alternation, we present two sentence production experiments with adult native speakers of Yucatec. As we discuss below, the data from these experiments inform linguistic accounts of plural marking in Yucatec (e.g., Lucy, 1992) as well as psycholinguistic accounts of agreement production (e.g., Bock & Miller, 1991). Relevant to linguistic theory, we investigate i) the extent to which plural marking on Yucatec nouns is sensitive to animacy (Lucy, 1992), ii) the extent to which different cues to plurality trade off with one another (motivated in part by the suggestion that plural markers and numeral classifiers may overlap in their semantic contributions; cf. Borer 2005 and references therein), and iii) where in the continuum between morphosyntactic agreement and anaphoricity (Nichols 1986; Van Valin 1977, 1985, in press; Jelinek 1984; Bresnan & Mchombo 1987; Austin & Bresnan 1996, *inter alia*).

Relevant to psycholinguistic accounts of agreement production, we provide evidence that speakers’ preference in the production of optional plural marking resembles effects found in the literature on agreement errors (Bock and Eberhard 1993; Bock and Miller, 1981; Hartsuiker, Schriefers, Bock & Kikstra 2003, Vigliocco, Butterworth & Semenza 1995), thereby providing a window into agreement processes that does not exclusively rely on error data. Finally, Yucatec is a head-marking polysynthetic language and hence typologically different from any language for which the production of plural marking and number agreement has previously been studied. To the extent that the processes underlying the production of optional plural marking in Yucatec resemble those observed in the production of obligatory plural marking in languages such as English, this further highlights the cross-linguistic systematicity of these processes (Bresnan et al., 2001, 2007; Bresnan and Hay, 2007; Wasow, 2002).

¹ For notable exceptions to this general trend, see, for example, MacWhinney and Bates (1978), Hawkins (1994, 2004, 2007), Bresnan et al. (2001, 2007), Branigan et al. (2009).

² Few languages do not mark plural at least optionally on either nouns or verbs, and such languages tend to express other number subcategories, such as duals. An example is the Tangkic language Kayardild of Queensland (Evans 1995; Dryer 2011). Kutenai, an isolate of Montana, Idaho, and British Columbia, does not express any number distinctions in the 3rd person, although it has separate plural forms for speech act participant pronouns (Matthew Dryer, p. c.).

³ Here we use the term ‘optional’ merely to indicate that plural marking in Yucatec is not obligatorily triggered by semantic plurality. We return to this point below.

2 The morphosyntax of plural marking in Yucatec Maya

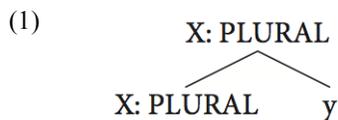
We first review the typology of plural marking proposed by Wiltschko (2008). This typology aims to predict where in nominal projections morphosyntactic plural marking can be realized. Then we introduce the basic properties of the Yucatec plural marking system (Bricker, 1981; Bohnemeyer, 2002) and outline an analysis of this system within Wiltschko’s typology (Butler, 2012).

2.1 The syntax of plural marking (Wiltschko 2008)

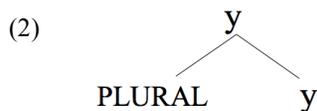
Wiltschko (2008) proposed a syntactic typology of plural marking according to which languages can vary by two parameters: 1) how the plural attaches (or ‘merges’ in Wiltschko’s/Minimalist terminology) – specifically, whether the plural marker is a head or an adjunct—and 2) where the plural attaches.

2.1.1 How the plural attaches

According to Wiltschko (2008), the first dimension along which languages vary is how the plural marker attaches: as a head or an adjunct. A plural morpheme that merges as the head of a phrase has the ability to change the label of the constituent to which it attaches, as illustrated in (1) (adapted from Wiltschko, 2008). This is the analysis Wiltschko proposes for languages with obligatory, inflectional plural marking, like English or Spanish.



A plural morpheme that attaches (or ‘adjoins’) as an adjunct, however, lacks this category-changing potential that a head shows. This is illustrated in (2) (adapted from Wiltschko, 2008), where the plural marker adjoins to a constituent of category *y* (for further discussion, see Hornstein and Nunes, 2008; Sato, 2010).



Wiltschko (2008) provides two diagnostics for a plural that attaches as an adjunct, that it is optional and that it does not trigger agreement. In English, plural marking is obligatory, as is number agreement. In Halkomelem (Salishan; Canada), however, plural marking is optional (Wiltschko, 2008). In (3a) and (3b), a noun phrase with the numeral ‘three’ does not require plural marking. Similarly, number agreement is optional, as illustrated in (4a) through (4d).

- (3) a. te lhíxw swíweles
 DET three boy
- b. te lhíxw swóweles
 DET three boy.PL
 ‘the three boys’ (Wiltschko 2008: 642)

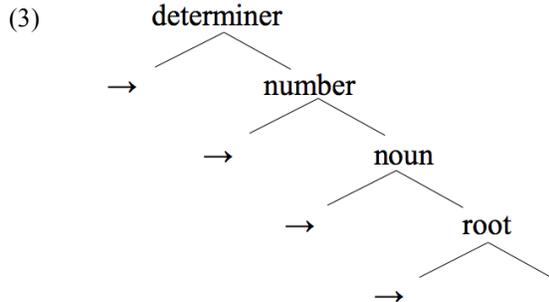
- (4) a. t’ílém ye s-í:wí:qe
 sing DET.PL man.PL
 ‘The men are singing’
- b. t’ílém te s-í:wí:qe
 sing DET man.PL
 ‘The men are singing’

- c. t'ílém ye swíyeqe
sing DET.PL man
'The men are singing'
- d. t'ílém te swíyeqe
sing DET man
'The man is singing' (Wiltschko 2008: 643)

Wiltschko concludes that plural marking and number agreement are not obligatory, and this is evidence that the plural marker in Halkomelem is an adjunct.

2.1.2 Where the plural attaches

The second dimension along which the syntax of plural marking can vary is where the plural attaches (Wiltschko 2008). Since the advent of the DP hypothesis (Abney 1987, also Brame 1982, Szabolczi 1983, 1987), which holds that the noun phrase is dominated by a determiner phrase (DP), a number of other functional projections have been proposed between the DP and the noun, or root of the nominal phrase. Wiltschko considers the determiner projection (or DP), the number projection (abbreviated NumP or #P), the categorizing nominal projection (nP) and the root as potential sites for a plural to merge along the spine of the DP (see the tree diagram in (5) below).



2.2 Plural marking in Yucatec Maya

Next, we introduce the basic properties of plural marking in Yucatec Maya and the basics of the person and number cross-reference marking paradigm in Yucatec Maya based on Bricker (1981), Lucy (1992) and Bohnemeyer (2002).

2.2.1 The plural morpheme in Yucatec Maya

In Yucatec Maya, the nominal plural marker is the morpheme *-o'ob*. The morpheme *-o'ob* is homophonous with the third person plural cross-reference marker (discussed in Section 2.2.2). The use of *-o'ob* is not required for the noun phrase to refer to a nonsingleton set of individuals, as in (6). If the plural morpheme is used on a noun phrase, then it must refer to a nonsingleton set, as in (7).

- (4) le x-ch'úupal-o'

DEF FEM-girl-D2
'the girl' / 'the girls'

- (5) le x-ch'úupal-o'ob-o'

DEF FEM-girl-D2-PL
'the girls' / NOT: 'the girl'

In the next section, we discuss the person and number cross-reference paradigm in Yucatec Maya. In Sections 2.2.3 and 2.2.4, we discuss further properties of the nominal plural marker that are relevant to the DP-adjoined plural hypothesis for Yucatec Maya (Butler, 2012).

2.2.2 Yucatec Maya person and number cross-reference paradigm

Yucatec is a head-marking language. The syntactic argument positions of verbs, nouns, prepositions, etc., are saturated by two paradigms of bound pronominal markers, customarily labeled ‘Set A’ and ‘Set B’ in Mayan studies. Yucatec exhibits split or ‘mixed’ morphological ergativity (Bohnemeyer 2004 and references therein). Set A markers (corresponding to the ergative set in Mayan languages without a split) express possessors, the actor argument of transitive verbs, and the single argument of intransitive verbs in the imperfective aspect and other aspect-mood categories. This paradigm involves a set of clitics that precede the lexical verb, but follow the initial aspect-mood marker. The plural Set A markers are discontinuous morphemes involving a suffix on the right edge of the verb. The suffixal component of the third person plural Set A marker is homophonous with the nominal plural and its use is optional.

Person	Singular	Plural
First	in	k...-o’on
Second	a(w)	a(w)...-e’ex
Third	u(y)	u(y)...(-o’ob)

Table 1 Set A cross-reference markers

The Set B markers are all suffixes. They express the undergoer argument of transitive verbs, the single argument of nonverbal predicates, and that of intransitive verbs in the perfective aspect and in subjunctive mood.

Person	Singular	Plural
First	-en	-o’on
Second	-ech	-e’ex
Third	-Ø/-ij	-o’ob

Table 2 Set B cross-reference markers

In transitive clauses, Set A marks the agent/actor argument, while Set B indicates the undergoer/theme/patient argument. In such sentences, the homophony between the plural Set B markers and the suffixal element of the discontinuous morpheme of the Set A marker causes ambiguity. This is illustrated in (8). Additionally, since the third person Set A marker can be used to mark possessors, its homophony with the nominal plural marker can cause the ambiguity illustrated in (9).

- (6) T-u bis-aj-o’ob
 PFV-A3 carry-CMP-A3.PL/B3.PL
 ‘S/he took them.’ / ‘They took it.’ / ‘They took them.’ (Lucy 1992: 53)

- (7) u péek-o’ob
 A3 dog-A3.PL/B3.PL/PL
 ‘his dogs’ / ‘their dog’ / ‘their dogs’ (Lucy 1992: 47)

In the remainder of the paper, we refer to the nominal plural suffix *-o’ob* as the plural morpheme and to the plural cross-reference markers as the (Set A or Set B) third person plural cross-reference markers.

2.3 DP-adjoined plural in Yucatec Maya (Butler, 2012)

Next, we briefly summarize evidence that the nominal plural marker in Yucatec is an adjunct (as in Halkomelem) that adjoins to the DP (unlike in Halkomelem). The first of these properties makes Yucatec a suitable test case for our current purpose –to study the factors that drive speakers’ preferences between producing or not producing a plural marker when it is optional. For further discussion, we refer to Butler (2012) and Butler (under review).

2.3.1 Adjunction of the plural in Yucatec

The first piece of support for the proposal that the plural morpheme *-o'ob* in Yucatec Maya is not a syntactic head but rather an adjunct is that its use is optional (cf. examples (6) and (7) above). The second piece of evidence is that it does not trigger obligatory number agreement. Wiltschko (2008) and Butler (under review) argue that the occurrence of covariant plural forms on heads and their dependent DPs does not imply that there is a syntactic agreement operation triggering the covariation. This may well be a general feature of purely head-marking languages such as Yucatec, although it does not need to be restricted to such languages. In head-marking (or ‘pronominal argument’) languages, arguments are ‘cross-referenced’ on their heads by bound 3rd-person pronouns. However, rather than to express agreement between the head and the DP, the cross-reference markers *are* the syntactic arguments, and the coindexed DPs are syntactically optional. The question of the nature of the syntactic relation between the cross-reference (or ‘pronominal argument’) markers and the coindexed optional DPs has always been a key concern of the research on head-marking (cf. Nichols 1986; Van Valin 1977, 1985, in press; Jelinek 1984; Bresnan & Mchombo 1987; Austin & Bresnan 1996; *inter alia*). One proposal suggests that the cross-reference markers may have a dualistic nature in some languages, saturating the argument positions of the head in case no coindexed DP is present, but serving to express agreement in the presence of a coindexed DP (Bresnan & Mchombo 1987). It is not immediately obvious that this analysis applies to Yucatec, at least not under a categorical interpretation. Consider (10):

- (8) Táan u k'aay(-o'ob) (le x-ch'úupal(-o'ob)-o')
- PROG A3 sing(-PL) DEF FEM-girl(-PL)-D2
- ‘(S)he/it/they/the girls are singing’

The DP *le xch'úupal(o'ob)* ‘the girl(s)’ is cross-referenced on the verb by the 3rd-person clitic pronoun *u* of the Set A paradigm, which is optionally augmented by the plural suffix *-o'ob* in case it refers to a nonsingleton set. If the DP is omitted, the sentence is understood to refer to a previously introduced discourse referent, which may be either singular or plural in the absence of the *-o'ob* suffix, but must be understood to be plural in its presence. If the DP is present, the referent of the Set A pronoun must satisfy the semantic predicate expressed by the nominal head (in (10), it must be one or more individuals describable as (a) ‘girl(s)’) and the uniqueness presupposition introduced by the definite article *le*. However, contrary to what a Bresnan-&-Mchombo-style analysis predicts if taken categorically, it is not the case that plural marking on the head of the DP obligatorily co-occurs with the plural suffix *-o'ob* on the verb. Nor is it the case that plural marking on the verb is required in case the sentence is understood to reference to multiple girls, as illustrated in (6)-(7) above. Thus, effectively, reference to a nonsingleton set can be marked on the verb, the cross-referenced DP, or both, but it does not need to be marked on either. The results of the two experiments described below confirm this. However, they also show a strong tendency for covarying nominal and verbal plural marking, and specifically for nominal plural marking to be more likely to co-occur with plural marking on the verb than vice versa. At least as a preference, this pattern is in line with Bresnan & Mchombo’s analysis.⁴

In sum, Yucatec exhibits both optional plural marking on nouns and optional plural cross-reference marking on the verb. It shares these properties with Halkomelem. As we show next, Yucatec differs from Halkomelem, however, in terms of *where* in the syntactic tree Yucatec plural marking attaches.

2.3.2 The plural in Yucatec is adjoined to the determiner (not the root, noun or number)

Whereas Halkomelem plural markers attach to the root of the categorizing noun projection and therefore can appear inside of compounds and derivational morphology (Wiltschko, 2008), the DP-adjunction analysis predicts that the plural marker combines higher in Yucatec and therefore does not show this distribution. This is not surprising, since inflectional processes across languages overwhelmingly apply outside (with reference to the root) of word formation processes. However, Halkomelem behaves different

⁴ In addition, there is no DP-internal agreement of any kind in Yucatec. That is to say, it is not the case that DP dependents agree with the nominal head in this language. The nominal plural suffix *-o'ob* does not spread to any dependents. There is a distributive plural suffix *-tak* on adjectives, which is again optional and which can, but does not need to, co-occur with the *-o'ob* suffix on the head.

from Yucatec in this respect, allowing plural marking inside of compounds and other word formation processes. As the following examples illustrate, this is not the case in Yucatec.

- (9) le pol-ch'oom-o'ob-o' *le pol-o'ob-ch'oom-o'
 DEF head-village-PL-D2 DEF head-PL-village-D2
 'governors'
- (10) x-muk-ub-o'ob *x-muk-o'ob-ub
 AG-bury-INSTR-PL AG-bury-PL-INSTR
 'shovels' (Bricker et al. 1998: 365)

Another piece of evidence in support of the DP-adjoined hypothesis for Yucatec Maya comes from the properties of plural marking with conjoined nouns. The syntax of coordination arguably involves a structure that is headed by a phrase of the same category as the conjuncts (Jackendoff 1977, Chomsky 1981, Gazdar et al. 1985, Sag et al. 1985). Thus two coordinated DPs are daughters of another higher DP. The DP-adjoined plural hypothesis predicts that a coordinated DP with plural morphology after the second noun is ambiguous as to whether it refers to the plurality of the second noun or to the coordination as a whole.

Butler (2012) tested this and other predictions in a translation experiment with Yucatec-Spanish bilinguals. In this experiment, participants heard Spanish sentences with conjoined nouns and an intransitive verb and translated them into Yucatec (for procedural details, see Butler (2012) and Experiment 1 below). Participants heard sentences in one of the four conditions shown in Table 3 (Latin-square design).

Condition	Noun 1 (N1)	Noun 2 (N2)	Verb
Singular-Singular (Sg-Sg)	<i>La muchacha y</i> The girl-SG and	<i>la mujer</i> the woman-SG	<i>están cocinando</i> are-PL cooking
Singular-Plural (Sg-Pl)	<i>La muchacha y</i> The girl-SG and	<i>las mujeres</i> the women-PL	<i>están cocinando</i> are-PL cooking
Plural-Singular (Pl-Sg)	<i>Las muchachas y</i> The girls-PL and	<i>la mujer</i> the woman-SG	<i>están cocinando</i> are-PL cooking
Plural-Plural (Pl-Pl)	<i>Las muchachas y</i> The girls-PL and	<i>las mujeres</i> the women-PL	<i>están cocinando</i> are-PL cooking

Table 3 The four conditions of the experiment reported in Butler (2012)

As predicted by the DP-adjoined plural hypothesis, speakers in the Pl-Sg condition produced plural marking on the first noun, second noun, or both. As a matter of fact, speakers were more likely to produce plural marking on the second noun than on the first noun. In a substantial number of cases in the Pl-Sg condition (about 15%) speakers even produced plural marking *only* on the second noun, despite the fact that only the first noun was semantically plural. This is shown in Figure 1, which summarizes the results of the translation experiment reported in Butler (2012). As also shown in Figure 1, plurality of only the second conjunct did not lead to the inverse pattern: plural marking was almost entirely restricted to the second noun. Finally, the results of Butler (2012) clearly confirm the optionality of plural marking in Yucatec Maya: even when both conjuncts were plural, speakers did not produce a plural marker on either noun in nearly 25% of all cases.

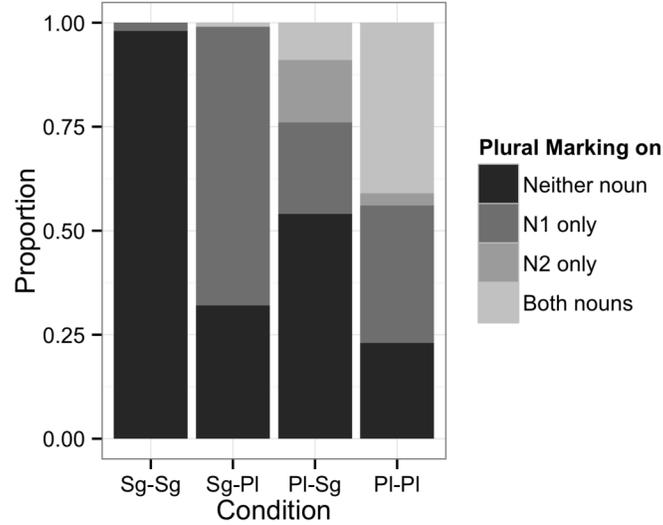


Figure 1 Plural marking on first and second noun by condition (based on Butler, 2012)

In summary, nominal plural marking in Yucatec differs from both English and Halkomelem, constituting a third type of system, predicted by Wiltschko’s typology: in Yucatec, the nominal plural marker is an adjunct to the DP. This is illustrated in Table 4, which summarizes five diagnostic properties of plural systems proposed by Wiltschko (2008; see also Butler, 2012 for further diagnostics).

Diagnostic	English	Halkomelem	Yucatec Maya
obligatory plural marking	yes	no	no
obligatory agreement	yes	no	no
plural inside compounds	no	yes	no
plural inside derivational morphology	no	yes	no
Acategorial	no	yes	no

Table 4 Properties of plural marking in English, Halkomelem and Yucatec Maya

3 Overview

The lack of obligatory plural marking makes Yucatec a suitable candidate to study the factors that influence speakers’ preferences in such systems. What determines whether a speaker does or does not produce nominal plural marking? What determines whether plural marking on the noun leads to covariant plural marking on the verb? And, what is the nature of the relation between plural marking on the noun and verb? In the remainder of this paper, we present two sentence production experiments that address these questions.

Given the highly parallel nature of the two experiments, we present their design and methodological details for both experiment and then discuss their results jointly. Both experiments elicited simple intransitive sentence (DP + verb), cross animacy and three number conditions. In Experiment 1, the three number conditions were singleton set (singular condition, e.g. *the boy*), set of two (‘two’ condition, e.g., *two boys*), set of unspecified cardinality (plural condition, e.g., *the boys*). Similarly, in Experiment 2, the number conditions were singleton set (one condition), set of two (‘two’ condition), and set of many (many condition, e.g., *seven chicken/the chickens/many/several chicken*).

The rationale behind the animacy manipulation was simply to test the claim the plural marking on Yucatec nouns is more likely for human nouns compared to animal nouns (Lucy, 1992).

The rationale behind the selection of the three number conditions was fourfold. First, the rate of plural marking in the plural/many conditions allows us to further assess whether plural marking is truly optional. Second, the presence of the singular/one condition provides a baseline, allowing us to assess whether speakers understand our task. Third, by comparing the rate of nominal plural marking in the ‘two’ and the

plural/many conditions, we can assess whether speakers' preference to produce plural marking is partly determined by trading off cues to plurality. Specifically, most speakers use Yucatec numerals only for sets of small cardinalities, so that numerals were more frequent in the 'two' condition, compared to the plural/many condition (we confirmed that this was indeed the case). This allows us to test whether the presence of a numeral, which constitutes a cue to plurality, caused speakers to be less likely to produce plural marking on the noun. Fourth, by investigating the covariation between nominal and verbal plural marking, we can begin to nature of this relation better. For example, is the relation one of strict co-occurrence, with plural marking always occurring on either both the noun and the verb or neither? If not, to what extent is the semantics of the noun determining plural marking on the verb even in the absence of plural marking on the noun? The answer to these questions will help to determine the status of the covariation between nominal and verbal plural marking in Yucatec.

Finally, we turn to our rationale for presenting two studies. One reason is simply that replication is particularly important when investigating production in lesser studied languages. Second, we each methodology comes with its own trade-offs. The two experiments we present employ different tasks (Experiment 1: translation; Experiment 2: picture description). The translation task provide a high degree of experimental control over the stimuli and is relatively natural for highly bilingual speakers, like those in our experiments, who may not be as experienced with psycholinguistic experiments and testing paradigms in general as are university students in more developed nations. There are, however, potential drawbacks of the translation method. Even for highly proficient bilinguals, translation experiments are more likely to require conscious effort, which might interfere with the automatic processes underlying sentence production in the absence of translation.

Furthermore, it is possible that cross-linguistic priming from the source language to the target language interferes with the effects of interest. Specifically, for the current question, it is worth noting that plural marking in Spanish (the source language for Experiment 1) is obligatory, so that its presences in the source stimuli might prime additional plural marking in the translations. We return to this point below.

4 Methods

Experiment 1 was a time translation task from Spanish to Yucatec. Participants heard intransitive sentences with subjects that were simple noun phrases in the singular or plural or contained the numeral 'two'. The participants translated these sentences under moderate time pressure. Experiment 2 was a picture description task. Participants were shown pictures and were told to describe them in one sentence under moderate time pressure.

4.1 Participants

Thirty bilingual Yucatec Maya-Spanish speakers between the ages of 18 and 42 participated in Experiment 1. Twenty-seven participants between the ages of 19 and 26 participated in Experiment 2. Both experiments were carried out at La Universidad del Oriente in Valladolid, Yucatan, Mexico. Participants were compensated 25 Mexican pesos (just over 2 U.S. dollars) for their participation, which lasted no longer than 30 minutes.

4.1.1 Materials

For Experiment 1, the Spanish stimuli were created with the synthesized male Latin American Spanish voice of Alberto from AT&T Labs Natural Voices® text-to-speech project. There were 30 item and 32 filler sentences. Of the thirty items, sixteen employed human referents and fourteen employed animal referents. Half of the fillers were transitive sentences in which the object varied in number or sentences. The other half of the fillers were sentences with predicate adjectives. The items and fillers were arranged in a Latin Squares design into three pseudo-randomized lists. Table 5 provides example items for each of the three conditions, listing both the Spanish stimulus and potential responses in Yucatec Maya.

Condition	Spanish stimulus	Potential Yucatec response
Singular	El muchacho está jugando DEF boy be.3SG play.GER “The boy is playing”	Le xibpal-o’ táan u bàaxal DEF male.child-D2 PROG A3 play “The boy is playing”
‘Two’	Dos muchachos están jugando two boy.PL be.3PL play.GER “Two boys are playing”	Ka’a-túul xibpal(o’ob) táan u bàaxal(-o’ob) two-CL.AN male.child(-PL) PROG A3 play(-PL) “Two boys are playing”
Plural	Los muchachos están jugando DEF.PL boy.PL be.3PL play.GER “The boys are playing”	Le xibpal(-o’ob)-o’ táan u bàaxal(-o’o’b) DEF male.child(-PL)-D2 PROG A3 play(-PL) “The boys are playing”

Table 5 The three conditions of Experiment 1 and potential responses

For Experiment 2, all of the stimulus pictures were clipart style, simple but clear drawings of people and animals in black and white or grayscale. There were 24 items and 48 fillers. Since, as mentioned above, some accounts hold that agent animacy affects plural marking in Yucatec, half of the items employed human referents and half employed animal referents. Table 7 gives example items of each type in all their conditions.

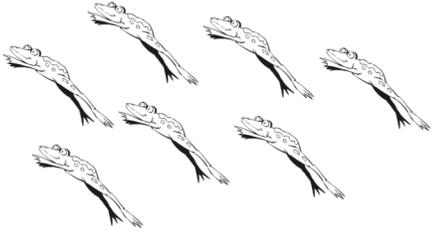
Condition	One	Two	Many (seven)
Human			
Animal			

Table 6 Example stimuli in the three conditions of Experiment 2

The fillers depicted transitive actions with one, two, three, or seven objects (e.g. a man eating two sandwiches). The items were counterbalanced for the direction in which the characters were facing (left, right, or forward). Three lists were arranged into a Latin Squares design and randomized with the fillers into three lists.

4.2 Procedure

For both experiments, participants were seated at a table in front of a laptop, wearing a Siemens headset with a unidirectional microphone. The experiment was delivered with the Experiment Builder software (Longhurst 2006). The participants were given oral instructions from the experimenter and written instructions on screen in Spanish and then completed four practice trials before the experimental trials began.

For Experiment 1, each trial consisted of stimulus presentation and the recording of the translation. During stimulus presentation, the screen displayed a cartoon picture of an ear. The Spanish stimulus sentence was presented auditorily. Participants heard the sentence at least once, but had the option of

listening to two further repetitions. They could advance to recording by pressing the spacebar anytime after the first instance of the sentence. During recording, the screen displayed a cartoon picture of a mouth.

For Experiment 2, each trial consisted of the presentation of a picture and the recording of the response. In both experiments trials were timed. A time bar appeared at the bottom of the screen and participants had 15 seconds to produce their spoken translation. Participants could press the spacebar to advance to the next trial at any moment.

4.3 Coding and exclusions

The same transcription, annotation, and exclusion criteria were used for both experiments. Responses were transcribed and coded by two native speakers of Yucatec Maya and by the first author. We coded for plural marking on the first noun, the second noun, and the verb.

Responses were excluded if they were uncodable and if they were incorrect translations. Responses were considered uncodable if they were partly or completely unintelligible, if there was no response, or if the response was a Spanish sentence (i.e., no translation took place). Responses were considered incorrect if they were missing a constituent or the numeral or if they included additional constituents that might influence the use of the plural. For example, if a response did not include a verb or a noun, it was excluded for constituency. If a response was translated as a transitive verb with an object or as a reflexive verb form, it was excluded because these additional constituents might affect the use of plural marking on the verb.

Responses with constituents that were borrowed from Spanish were *included* if they had Yucatec morphology (e.g. the Yucatec definite determiner, the distal deictic marker, the plural marker, or verbal morphology) because additional tests did not reveal a significant effect of Spanish borrowings on plural marking.

Experiment 1 yielded 900 critical responses. After exclusion of uncodable cases (76 cases, 8.4% of total) and incorrect translations (120 cases, 13.3%), 704 responses were left for the analyses reported below (78.2% of total). Experiment 2 yielded 648 critical responses, of which we excluded 54 (8%) because they were uncodable and 38 (6%) because they were incorrect or incomplete descriptions. This left 556 responses for the analyses reported below (86% of total).

5 Results and Discussion

Next, we present the results in separate sections, addressing the questions raised above in turn.

5.1 Is plural marking in Yucatec optional?

Both experiments clearly confirmed that Yucatec plural marking is optional both on nouns and verbs. This is illustrated in Figure 2, which shows the rate of nominal and verbal plural marking for Experiments 1 and 2, respectively. Neither nominal nor verbal plural marking was obligatorily present in the plural/many condition. The higher proportion of plural marking is found in Experiment 1 (a point to which we return below), but even in Experiment 1, plural marking is only observed in about 90% of all cases in the plural condition. This is unlikely to be due to errors, as the rate of both nominal and verbal plural marking in the singular/one condition is less than 2% in both experiments.

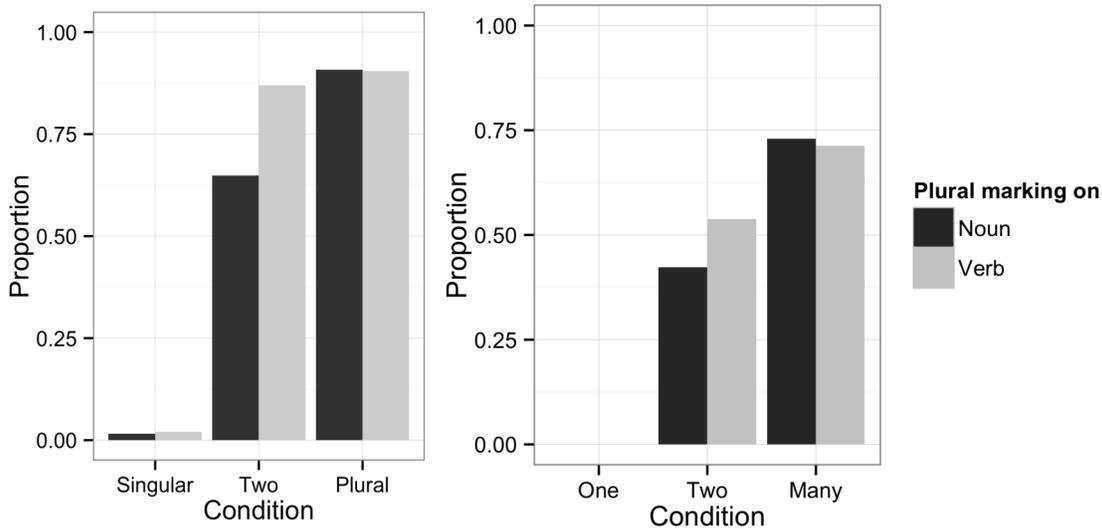


Figure 2 Proportion of plural marking on the noun and verb as a function of the experimental condition in Experiment 1 (top panel) and Experiment 2 (bottom panel)

This does not mean that plural marking was *random*. In both experiments, the rate of nominal plural marking depended on the experimental condition (Experiment 1: $\chi^2(2) = 411.1, p < .0001$; Experiment 2: $\chi^2(2) = 215.9, p < .0001$). The same held for verbal plural marking (Experiment 1: $\chi^2(2) = 498.1, p < .0001$; Experiment 2: $\chi^2(2) = 217.2, p < .0001$). Plural marking was clearly systematic in that it was more common in the plural/many condition, compared to the singular/one condition (nominal plural marking - Experiment 1: $\chi^2(1) = 388.0, p < .0001$; Experiment 2: $\chi^2(1) = 216.2, p < .0001$; verbal plural marking - Experiment 1: $\chi^2(1) = 380.8, p < .001$; Experiment 2: $\chi^2(1) = 208.6, p < .0001$).

Interestingly, the rate of nominal plural marking in the ‘two’ condition fell between those in the singular and the plural/many condition. Nominal plural marking was more frequent in the two condition, compared to the singular/one condition (Experiment 1: $\chi^2(1) = 212.6, p < .0001$; Experiment 2: $\chi^2(1) = 101.5, p < .0001$), but less frequent than in the plural condition (Experiment 1: $\chi^2(1) = 44.1, p < .0001$; Experiment 2: $\chi^2(1) = 33.5, p < .0001$). In terms of verbal plural marking, the ‘two’ conditions paired more closely with the plural/many condition: verbal plural marking was more frequent in the ‘two’ than in the singular/one condition (Experiment 1: $\chi^2(1) = 340.0, p < .0001$; Experiment 2: $\chi^2(1) = 139.7, p < .0001$); the comparison between the ‘two’ and the plural/many condition did, however, only reach significance for Experiment 2 (Experiment 1: $\chi^2(1) = 1.0, p > .3$; Experiment 2: $\chi^2(1) = 11.0, p < .0001$). We return to this point below. For now we note that both experiments found that both nominal and verbal plural marking are optional in Yucatec.

5.2 Is nominal plural marking in Yucatec sensitive to animacy?

Some accounts of Yucatec plural marking hold that animacy is a significant factor in the use of plural marking (Lucy 1992). According to this account, speakers are more likely to produce plural marking on human nouns compared to animal nouns. This prediction was not confirmed by either of our experiments.

To test whether our results might be driven by or at least depend on animacy, we compared the proportion of nominal plural marking across these two sets of items. We found no evidence for an effect of animacy on plural marking: the proportion of plural marking for human and animal agents differed neither on nouns nor on verbs (nominal plural marking - Experiment 1: $X^2(1) = 1.6, p > .2$; Experiment 2: $\chi^2(1) = .1, p > .9$; verbal plural marking - Experiment 1: $X^2(1) = 0.003, p > .9$; Experiment 2: $\chi^2(1) = .1, p > .9$). This lack of an effect was also observed if the analysis was restricted to only responses from the plural condition, where the effect would be expected to be strongest on (all $ps > .3$).

Thus, the current data do not provide evidence for Lucy’s claim. In defense of Lucy’s claim, it is possible that the contrast between human and animal referents is not sufficiently strong, but than an effect of animacy would be observed if human referents were compared to inanimate referents.

An alternative explanation for the correlations between animacy and plural marking that led to Lucy’s proposal is that they are due to indirect effects of animacy on constituent order. In Butler et al. (in prep), we examine constituent order variation in transitive clauses with a video description task. More animate agents

(humans > animals > inanimates) led to significantly more Agent-Verb-Patient orders, while more animate patient led to more Patient-Verb-Agent orders. So, animacy is a factor in word order variation.

In addition, in an experiment not reported here, we examined the use of plural marking on verb-initial versus verb-final clauses. We found that verb-initial clauses were significantly less likely to be marked with the plural cross-reference marker compared to clauses with agent-initial clauses. This suggests an intriguing link between animacy and plural marking in Yucatec: human agents are more likely to be clause-initial in Yucatec, thereby being more likely to receive plural marking. This would cause agent animacy to correlate with plural marking in Yucatec discourse, without a direct effect of animacy on plural marking. Put differently, this might be taken to suggest that the relationship between plural marking and animacy is mediated by constituent order.

5.3 Do cues to plurality trade off?

If nominal plural marking is not determined by animacy, are there other factors that affect speakers' preferences in the production of nominal plural marking? One possibility is that speakers are more likely to produce a plural marker on the noun, when the noun's plurality is not as easily contextually inferable. Indeed, a number of similar systems have been argued to exist in various languages. For example, speakers of language with optional case marking (e.g., Korean or Japanese) have been found to be less likely to produce case marking if the properties of the referents make the grammatical function assignment intended by the speaker more easily inferable (Kurumada et al., submitted; see also Fry, 2003; Lee, 2006;). Similarly, speakers of English are less likely to produce optional function words (e.g., complementizer or relativizer *that*) in lexical contexts in which the structures are more expected (e.g., Jaeger, 2010; Wasow et al., 2011).

Here we test whether a similar preference affects nominal plural marking in Yucatec. Several patterns in our data speak to this question. First, if plural marking is affected by speakers trading off cues to plurality, we would expect less nominal plural marking in the 'two' condition compared to the plural/many condition, because DPs in the 'two' condition contained two additional cues to plurality, the numeral *two* and a numeral classifier. This contrasts with the plural condition, in which only the plural marker, if present, encodes plurality. As mentioned above, this pattern was indeed observed: speakers produced nominal plural marking in the 'two' condition significantly less often than in the plural condition (Figure 2).

There is, however, an alternative explanation for this difference in nominal plural marking between the 'two' and plural/many condition. It might be that this difference is the consequence of conceptual factors. For example, it is possible that plural marking is sensitive to the perceived 'degree' of plurality (e.g., the set size of the referents) and that the plural condition was perceived to imply a larger degree of plurality than the 'two' condition.

One way to tease these two accounts apart is to compare whether descriptions of the *same* event differ in their rate of nominal plural marking depending on whether the description contains a numeral. In Experiment 2, speakers described pictures in the 'two' condition sometimes with a numeral (e.g., *two chickens*) and sometimes without (e.g., *chickens*). Contrary to what would be expected under the trade-off hypothesis, the presence of a classifier did not affect the rate of nominal plural marking in Experiment 2 ($p > .7$).

5.4 Do nominal and verbal plural marking covary in Yucatec?

As we mentioned above, the nature of the syntactic relation between the cross-reference markers and the coindexed argument DPs in head-marking languages has received considerable attention (e.g., Nichols 1986; Van Valin 1977, 1985, in press; Jelinek 1984; Bresnan & Mchombo 1987; Austin & Bresnan 1996). There is broad agreement that, for most if not all, head-marking languages this relation cannot be reduced to the same operation that causes agreement in languages like English. However, it has been suggested that cross-reference markers may have a dualistic nature in some languages, saturating the argument positions of the head in case no coindexed DP is present, but serving to express agreement in the presence of a coindexed DP (e.g., Bresnan & Mchombo 1987; Jaeger and Gerassimova, 2002).

Here we approach this question for Yucatec by investigating the factors that mediate the covariation between nominal and verbal plural marking in our experiments. First, we test whether plural-marking on

the noun and verb covaried at all. Figure 3 shows the proportion of four possible distributions of plural markers (plural marking only on the noun, only on the verb, on both, or neither) for Experiments 1 and 2, respectively.

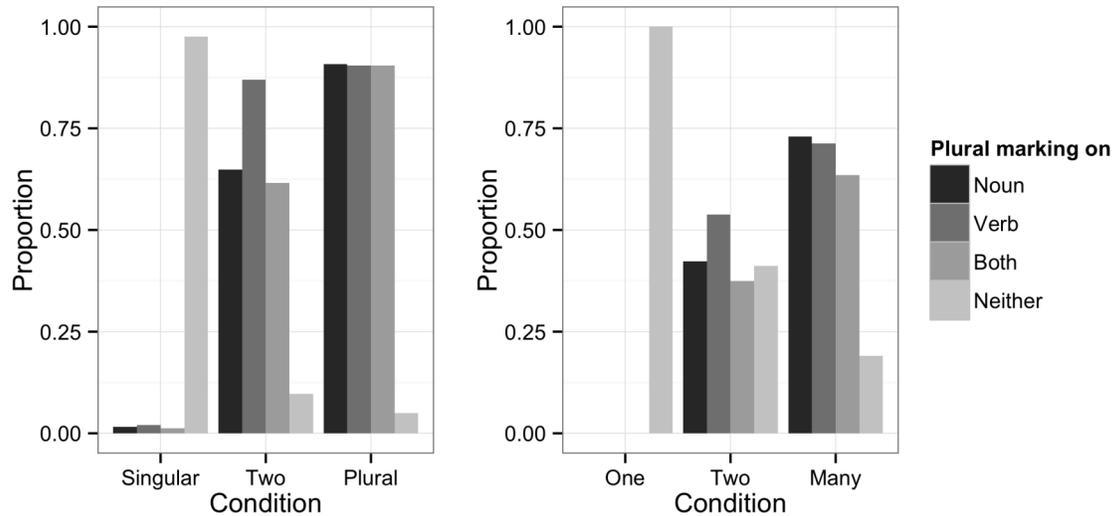


Figure 3 Distribution of covarying plural marking as a function of the condition in Experiment 1 (left panel) and Experiment 2 (right panel)

Overall, participants in both experiments preferred to mark plural on either both the noun and the verb or neither (Experiment 1: Spearman rank $R^2 = 0.58, p < .0001$; Experiment 2: $R^2 = .54, p < .0001$). This effect seems to be carried by nominal plural marking triggering verbal plural marking, rather than vice versa. In Experiment 1, 343 out of 362 cases with plural marking on the noun also contained plural marking on the verb (94.8%). The proportion of cases with plural marking on the verb that also contained plural marking on the noun was smaller (83.7%). The same asymmetry in the extent to which plural marking on the noun seems to ‘trigger’ verbal plural marking versus the opposite was also observed for Experiment 2 (though to a lesser extent, 87.4% vs. 80.4%). We return to this point below.

To test whether there are any morphosyntactic effects on the covariation of nominal and verbal plural marking, we compared the rate of plural marking on the verb depending on the presence of nominal plural marking. Since the singular/one condition unsurprisingly contains too few cases with nominal plural marking (cf. Figure 2), we restrict this comparison to the ‘two’ and the plural/many conditions. Turning first to the ‘two’ condition, in Experiment 1, the rate of verbal plural marking was significantly higher for cases with nominal plural marking (95.0%), compared to cases without nominal plural marking (72.4%, Fisher’s Exact $p < .001$).⁵ The same held in Experiment 2 (88.3% vs. 28.6%, Fisher’s Exact $p < .001$). A similar picture held in the plural/many condition of Experiment 1 (95.0% vs. 45.5%, Fisher’s Exact $p < .001$) and Experiment 2 (86.9% vs. 29.2%, Fisher’s Exact $p < .001$).

These data suggest that there are at least some morphosyntactic effects on the covariation of nominal and verbal plural marking in Yucatec. At the same time, there is evidence that the covariation between nominal and verbal plural marking cannot be exclusively due to morphosyntactic agreement. First, despite the high degree of covariation, plural marking *can* occur independently on the noun and the verb. Second, and perhaps more importantly, the pattern of plural marking in the ‘two’ condition points to the presence of additional effects. As mentioned above, nominal plural marking was associated with verbal plural marking more often than vice versa both in Experiment 1 and in Experiment 2. This asymmetry is carried predominantly by the ‘two’ condition. In the ‘two’ condition of Experiment 1, plural marking on the noun was associated with covarying plural marking on the verb in 133 out of 140 cases (95.0%). Plural marking on the verb occur with plural marking on the noun in only 70.7% of all cases. The same asymmetry is

⁵ Fisher Exact tests are used here since some of the expected cell counts were low, which can make the χ^2 -test unreliable. The results reported here do, however, also hold, if χ^2 -tests are used instead.

observed in Experiment 2 (though to a lesser extent, 88.3% vs. 69.4%). In comparison, the plural/many condition exhibits no such asymmetry. For example, for Experiment 1, cases with nominal plural marking occurred with verbal plural marking 95% of all times; cases with verbal plural marking occurred with nominal plural marking 95.4% of all times (for Experiment 2: 86.9% vs. 89%).

5.5 Is optional plural marking in Yucatec subject to cross-linguistic priming?

Finally, we turn to the extent to which the processes underlying the covariation between optional plural marking on nouns and verbs in Yucatec resemble those underlying the production of obligatory number agreement in languages like English.

The evidence discussed in the previous section already provides evidence for some parallels. We found that verbal plural marking is more likely in the presence of nominal plural marking, even when semantic plurality is held constant. This suggests that that optional plural marking in Yucatec is at least partly affected by morphosyntactic processes (these could be agreement operations or simply some type of morphosyntactic priming. For example, Haskell, Thornton and MacDonald (2010) found that participants produced more plural agreement errors in NP-PP productions when primed on collective noun phrases with prepositional phrase modifiers and plural agreement. The tendency to repeat recently processed linguistic structure (in this case, the agreement morphology) is not specific to agreement errors. Priming has been documented under various names for pronunciation (Giles, Coupland, and Coupland 1991, Kim et al. 2011, Pardo 2006), lexical processing (Branigan et al. 2011, Garrod and Anderson 1987), and syntactic production (Bock 1986, Pickering and Garrod 2004).

The data from Experiments 1 and 2 afford to test one further potential parallel between optional covariation in Yucatec plural marking and obligatory agreement in other languages. While both experiments showed the same qualitative pattern for the use of plural marking (see Figures 2 and 3 above), the effects were stronger in Experiment 2. This might be due to the absence of interfering effects caused by the translation task in Experiment 1. Most crucial for the current purpose, however, is the relative proportion of plural marking in Experiments 1 and 2. If the optional plural marking system in Yucatec is subject to the same effects that have been observed to cause agreement attraction in English and similar languages, we would expect crosslinguistic priming from Spanish to Yucatec to cause higher rates of plural marking in Experiment 1 compared to Experiment 2. This is indeed observed.

In the ‘two’ condition, speakers in Experiment 1 produced plural marking for 64.8% of nouns and 87.0% of the verbs, whereas speakers in Experiment 2 produced plural marking for 42.3% of nouns and 53.8% of the verbs. This difference was significant for both nominal plural marking ($\chi^2(1) = 19.3, p < .0001$) and verbal plural marking ($\chi^2(1) = 52.2, p < .0001$). Similarly, for the plural condition, speakers in Experiment 1 produced plural marking for 90.8% of nouns and 90.4% of the verbs, whereas speakers in Experiment 2 produced plural marking for 73.0% of nouns and 71.3% of the verbs (all $ps < .0001$). That is, plural marking was considerably more likely when speakers were translation stimuli that contained plural marking (Experiment 1) compared to when speakers described pictures (Experiment 2), suggesting that optional-plural marking in Yucatec is subject to crosslinguistic priming.

6 Concluding Remarks

The results of our experiments have consequences for accounts of Yucatec plural marking and for hypothesis about the universal structure of plural marking systems more generally. We review these consequences below. Following that, we briefly discuss two more general implications of our results –one of relevance to linguistic theory and one of relevance to psycholinguistic work on agreement production.

6.1 Morphosyntax of Yucatec and Mayan

The experiments presented here contribute to the surprisingly small body of research on number marking and agreement in Mayan languages (England, 2011). The pattern of plural marking observed in our experiments is best captured by the following assumptions (thereby providing support for them). First, in the presence of semantic plurality, nominal plural marking is optional (as predicted by the DP-adjoined hypothesis proposed in Butler (2012)). Second, plural marking on the verb is also optional (in the presence

of semantic plurality). Third, its covariation with nominal plural marking is not due to agreement, but rather due to either a) a mixture of anaphoric and agreement processes or b) a process that is neither typical agreement, nor insensitive to morphosyntactic effects.

Additionally, the results of our experiments speak to the claims the use of plural marking in Yucatec is determined by an animacy hierarchy (human>animal>inanimate, Lucy, 1992). We found no evidence for a direct effect of animacy on plural marking. Rather the correlations between animacy and plural marking observed by Lucy (1992) are likely to be indirect effects, mediated through effect of animacy on word order and effect of word on the rate of covariant plural marking.

6.2 The production of plural marking and agreement

Beyond Yucatec, our data speak to the typology of plural marking. Wiltschko's typology (Wiltschko, 2008) predicts that there are languages in which both nominal plural marking and covariant plural marking on the verb is optional. For Wiltschko, the optional nominal plural markers are adjuncts (i.e., they adjoin to the head). The account outlined by Wiltschko further predicts that such optional plural marking is possible at various syntactic projections, ranging (at least) from the root to the determiner phrase. Wiltschko (2008) presented evidence that plural marking in Halkomelem adjoins to the root. Butler (2012) proposes that plural marking in Yucatec *adjoins* to the DP, making it optional. This proposal is supported by both elicitation data (Butler, under review) and production experiments (our experiments and those reported in Butler, 2012). Examples of further types of plural marking systems—for example, quantifier-adjoined plurals and number phrase-adjoined plurals—are discussed in Butler (2012).

6.3 Optional functional categories

The existence of optional plural-marking is also of interest to linguistic theory beyond the typology of plural-marking. Specifically, our experiments constitute perhaps the first investigation not just of the production of optional plural marking in any language, but of the production of *any* optional functional category in any language. There has been surprisingly little sustained research on the phenomenon of optional functional categories to date. For example, although the notion of optional tense marking is frequently invoked in the literature on the tense-aspect-mood systems of pidgin and creole languages (cf., e.g., Singler ed. 1990), no in-depth case study has been presented to our knowledge. Optional functional categories have properties that seem puzzling and challenging to contemporary linguistic theory. The traditional view of functional categories that present-day linguistics has inherited is that of paradigms of markers out of which the selection of exactly one member is required by a morphosyntactic rule or construction. How this concept extends to optional categories is profoundly unclear. In this chapter, we have argued that optional functional categories have the production properties of syntactic alternations. It is our hope that this new view may contribute to the unraveling of the theoretical mysteries posed by optional functional categories. At the very least, it should suggest a new way of studying such categories.

6.4 A window into the processes underlying agreement production

Finally, optional plural marking in Yucatec Maya offers a lens into number marking and agreement processes without recourse to agreement errors. On the one hand, psycholinguistic research has gained much from studying the language production system at its limits, i.e., at points when it breaks down. Research on speech errors (e.g., phonological errors) and grammatical errors (incl. agreement errors) have informed theories of language production since the dawn of modern psycholinguistics (e.g., Bock & Miller, 1991; Dell, 1986; Dell & Reich, 1981). On the other hand, it has often been pointed out that studying a system at its limits is not *necessarily* reflective of its general dynamics (Levelt, Roelofs, & Meyer, 1999). The ability to study speakers' preferences in optional plural marking languages allows psycholinguists to address this concern.

Here, we have taken a modest step in this direction by establishing that Yucatec provides such an optional environment and that speakers' preferences in optional plural marking indeed seem to reflect similar processes as are observed in English agreement errors. Quantitative behavioral research on language production in lesser-studied languages comes with its own unique set of challenges, but, as we hope to have demonstrated, it also holds the promise to inform both linguistic and psycholinguistic theories.

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