Order of nominal conjuncts in visual scene description depends on language

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Abstract

Previous work has found that experience with the directionality of a writing system (e.g., left-to-right in English, right-to-left in Hebrew) can affect constituent ordering during spoken language production. Specifically, this work found that speakers of languages with left-to-right writing systems exhibit the same directionality bias in the sequential mentioning of objects when describing pictures with multiple objects. This tendency has been considered a general neuropsychological property (e.g., due to the order in which we scan visual scenes based on experience with particular writing systems). We present evidence *in*consistent with this view. Two picture description experiments examined a highly bilingual population of speakers of Spanish and Yucatec Maya in Mexico. These speakers are literate in Spanish (left-to-right), but less so or non-literate in Yucatec (also left-to-right). When speaking Spanish (Experiment 1), participants exhibited a significant left-to-right bias, consistent with the neuropsychological hypothesis. However, when speaking Yucatec (Experiment 2), no such bias was observed. This suggests that the effects of writing systems on speech production are specific to the language associated with the writing system and thus not a general neuropsychological property. In addition, we discuss the potential influence of language-specific frames of reference, and their interaction with literacy, on directional cognitive biases.

Keywords: crosslinguistic sentence production; nominal order; left-to-right bias; literacy; Spanish; Yucatec Maya

Introduction

The many languages of the world vary extensively and in many different ways. One salient feature in which languages show variation is the direction in which they are written. Though most Western, Indo-European languages, such as English and Spanish, are written from left to right, other languages, such as Hebrew and Arabic, are written from right to left. Other languages, such as Japanese are written from top to bottom. The knowledge of a writing system entails the use of cognitive abilities that focus on a particular orientation, e.g. left-to-right, right-to-left, top-to-bottom.

A left-to-right bias in the processing of visual stimuli has long been observed with various methods. Adults process events from left- to right and prefer pictures of events with a left-to-right directionality (Christman & Pinger, 1997). Even the processing of semantic relations has been shown to be subject to the left-to-right bias. When asked to draw or choose a picture to match a transitive sentence, participants tended to draw or choose agents on the left and to respond faster to pictures that displayed agents on the left (Chatterjee, Southwood, & Basilico, 1999). This left-to-right bias widely demonstrated in the processing of visual stimuli and semantic relations has been argued to reflect a universal functional neuropsychological property of humans (Chatterjee, 2001; Barrett, Kim, Crucian, & Heilman, 2002).

The question that arises from a crosslinguistic and a crosscultural perspective is what influence does the directionality of the language that a person speaks have on the left-to-right bias. Adults who learn a right-to-left writing system do not show the left-to-right bias (Chokron & DeAgostini, 2000; Nachson, Argaman, & Luria, 1999; Spalek & Hammad, 2005; Tversky, Kugelmass, & Winter, 1991). In fact, additional cultural factors have been shown to influence the left-to-right bias. Maass and Russo (2003) investigated a range of populations who were monolingual, bilingual and living in their respective countries or living abroad on their biases for the comprehension of spatial relations. They found that the weakest left-to-right tendencies were among speakers of Arabic (a right-to-left orthography) living in their countries responding in Arabic. The left-to-right bias was comparatively stronger in speakers of Arabic living in Italy but responding in Arabic and strongest in speakers of Arabic living in Italy but responding in Italian (a left-to-right orthography). These studies suggest that not only does the directionality of one's language influence the ordering of linguistic elements in sentence production, but also the particular language being spoken (in the case of bilingual speakers) and even country of residence have a significant effect on the left-to-right bias, or lack thereof. Dobel, Diesendruck, and Bölte (2007) examined the left-to-right bias in adults and children who speak German (a left-to-right orthography) and Hebrew (a right-to-left orthography). They found the left-to-right bias to appear

among German-speaking adults and a reversed right-to-left bias among Hebrew-speaking adults. They found that neither bias showed up among the German or the Hebrew-speaking children, presumably because children have less exposure to the writing system. This suggests that level of experience with a writing system also influences the ordering of linguistic elements in sentence production.

We investigate how experience with the writing system of a particular language influences the ordering of linguistic constituents in sentence production. We ask whether experience with a left-to-right oriented orthography in one language will lead to a left-to-right bias in sentence production in a second language. To answer this question, we present the results of two field-based psycholinguistic experiments with speakers of Spanish and Yucatec Maya that were carried out in Mexico. Spanish and Yucatec Maya both have a left-to-right oriented and Roman-based writing system, but speakers of Yucatec Maya in Mexico are not taught to read and write in this language unless they pursue special instruction at the college level. Reading, writing and other subjects taught in school are Spanish-based.

The question that our participants can uniquely answer is whether experience with writing directionality in one language can influence the ordering of linguistic elements in visual scene description in a second language in which the speaker does not have the same experience with reading and writing. In particular, we examine the ordering of nominal conjuncts in the description of two objects in the visual scene. We predict our Spanish-speaking participants to show a left-to-right bias in the production of sentences that describe two objects in the visual scene. If our Yucatec-speaking participants do not show a left-to-right bias in the description of two objects in the visual scene, then we conclude that the experience one has with reading and writing in a particular language affects linguistic processing in that language but not in other languages this person may speak. If our Yucatec-speaking participants also show a left-to-right bias, there are a number of proposals that would be consistent with those results.

Our studies are relevant to the question of the origin of left-to-right bias. Is there is universal left-to-right processing bias that affects the processing of visual stimuli as well as linguistic cognition as suggested by Chatterjee (2001) and Barrett et al. (2002)? Or, is the left-to-right bias more aptly attributable to particular linguistic and cultural features as suggested by Dobel et al. (2007) and Maass and Russo (2003)? If speakers of Yucatec Maya do not show a left-to-right bias, despite being bilingual speakers of Spanish, a language in which they have experience reading and writing in the left-to-right orientation, then the evidence points in favor of the cultural proposal. If, however, Yucatec-speaking participants show a left-to-right bias, then the evidence is in favor of an alternative hypothesis, such as the neuropsychological proposal.

Our studies are also highly relevant to the growing subdiscipline of cross-linguistic sentence production (Jaeger & Norcliffe, 2009). Since one of the objectives of psycholin-

guistic research is to understand the mechanisms that drive real-time incremental sentence production, the mechanisms in question are assumed to be universal properties of human language production (e.g. Bock, Eberhard, Cutting, Meyer, and Schriefers (2001); Bock et al. (2006), cf. MacWhinney and Bates (1989)). We assume that the same architecture, mechanisms and interfaces are responsible for the linguistic behaviors of speakers of the more than 6,000 different languages currently spoken in the world. This assumption may not be warranted. Though in some area of sentence production research, crosslinguistic variation has revealed general shared tendencies, other areas of inquiry have revealed substantial crosslinguistic differences (see Jaeger and Norcliffe (2009) for an overview). Despite this very observation, crosslinguistic investigations of sentence production have been rare and limited in scope. Jaeger and Norcliffe (2009) suggest that at most 0.6% of the world's languages form the basis of the predominant models of sentence production. This limited empirical base is made up almost entirely of Western, Indo-European languages. Most of these languages share the feature of a long-established literary tradition and also having a left-to-right oriented writing system. Since many of the language users across the globe are not highly literate, the question of the effect of experience with a writing system on the ordering of constituents in sentence production is extremely relevant. This question is especially relevant to sentence production since one of the major goals of sentence production research is to explain what happens in the stages between conceptualization and linearization of sentence constituents. Our studies will shed light on the potential bias introduced by experience with writing systems and to what extent this bias is universal or language-specific. We also discuss the potential influence that language-specific frames of reference and their interaction with literacy may have on directional cognitive biases in language production.

Experiment 1: Spanish

Methods and Materials

Experiment 1 is a combined sentence repeat and picture description task. While under time pressure, participants were asked to repeat a sentence but replace the subject of the sentence (explained as who or what is doing the action) with what they saw in the picture. If the participant saw the picture in Figure 1a, depicting one chicken and one pig, and she heard the sentence in Spanish *El animal está comiendo* 'The animal is eating,' she was to respond in Spanish *La gallina y el cerdo están comiendo* 'The chicken and the pig are eating.'

The picture stimuli consisted of 16 pairs of human-human or animal-animal characters (e.g. a chicken and a pig, as in Figure 1, or a boy and a girl). The characters were chosen to be common nouns in Spanish and Yucatec Maya. The audio stimulus sentences in Experiment 1 were recorded from the AT&T Labs Natural Voices text-to-speech project using a synthetic male Latin American Spanish voice (called Alberto). The subject of the stimulus sentence was either

The person or *The animal* (depending on whether the corresponding picture item depicted humans or animals). And, the verbs in the stimulus sentences involved common intransitive verbs such as eating, jumping, running, or yelling.

We manipulated the number of characters and the side of the screen on which they appeared, one versus three, on the left or right. This led to four number conditions: 1) one left, one right, 2) three left, one right, 3) one left, three right, and 4) three left, three right (see Figure 1). The characters were matched for size and counterbalanced for which direction they faced (left or right), and the stimuli were arranged into four lists in a Latin Square design. We used 32 fillers in which the participant was to replace the object of a transitive sentence with the object or objects shown in the picture. For example, a participant would see a picture of three mangoes and hear in Spanish *The person is buying food*. The participant was to respond 'The person is buying mangoes.'

Participants Twenty Spanish-speaking participants at La Universidad de Oriente in Valladolid, Yucatan, Mexico (12 females and 8 males) between the ages of 18 and 26 (mean age 20.95, standard deviation 1.89) took part in Experiment 1 and were compensated 25 Mexican pesos (about 2 U.S. dollars) for their participation, which lasted no longer than 30 minutes. Four participants were highly monolingual Spanish speakers, and the remaining 16 were bilingual in Yucatec.

Procedure and stimuli After giving informed consent, participants took a seat at a table behind a MacBook Pro 15-inch laptop and put on a Creativ noise-canceling headset with a unidirectional microphone. The experiment was delivered by the Ex(periment) Builder software designed at the University of Rochester (Longhurst, 2006). Participants were given 15 seconds to utter a response, and a time bar at the bottom of the screen indicated the time remaining for that particular trial. If the time expired, the experiment automatically proceeded to the next trial. If the participant uttered his or her response with time remaining, the participant could press the spacebar to proceed immediately to the next trial. Participants carried out two practice trials and were prompted to ask any questions they had before starting the experimental trials.

Coding and Analysis The responses were transcribed and coded by the first author. We included responses that had at least two nominal constituents and a verb (e.g. 'The cook and the bride are jumping'). We also included utterances in which the nominal constituents were split into two phrases (e.g. 'The cook is jumping, and the bride is jumping').

We excluded from the analyses responses in which the participant simply repeated the stimulus sentence and did not replace the subject with the picture description. We excluded responses that had only one nominal (e.g. 'The cook is jumping'), responses that did not name the specific character depicted (e.g. 'A person and another other person are jumping'), and cases of no response. We also excluded one response that
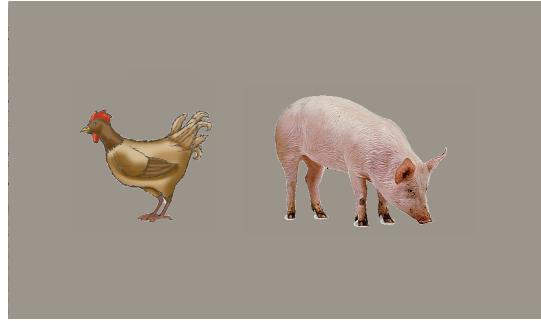
(a) One Left – One Right
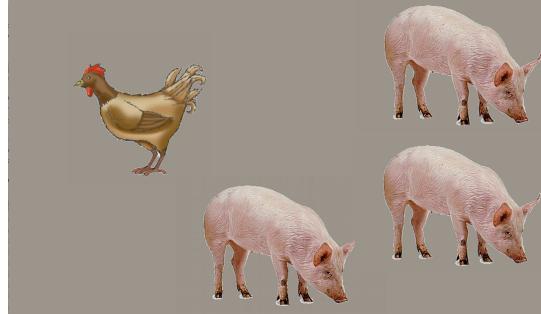
(b) One Left – Three Right
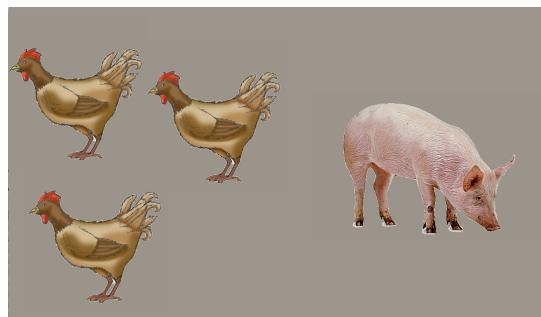
(c) Three Left – One Right
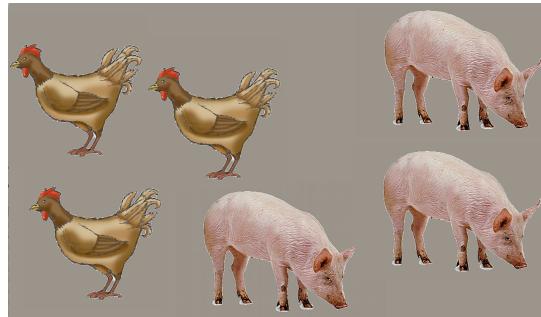

(d) Three Left – Three Right

Figure 1: Example stimuli (Experiments 1 and 2)

used pronouns rather than full nouns. These exclusions (one nominal, not specific, no response, pronoun use) are all categorized as incomplete in Table 1. We excluded responses in which the participant interpreted the picture transitively rather than repeating the intransitive verb (e.g. 'The cook will marry the bride'). The exclusion types and rates are shown in

Table 1 for Experiments 1 and 2.

Table 1: Exclusions for Experiments 1 and 2

Exclusion	Exp 1	(Spanish)	Exp 2	(Yucatec)
Repeated	73	23.0%	88	26%
Incomplete	11	3.5%	30	9%
Transitive	2	0.5%	23	7%
Unclear	–	–	11	3%
Total	87	27%	152	45%

A chi-squared test revealed a significantly higher than chance use sentences that named the two characters in the visual scene from left to right in Experiment 1 with participants speaking in Spanish (χ^2 (1) = 80.6, p < .001). The Spanish speakers in Experiment 1 used left-to-right descriptions at a rate of 79%, and right-to-left descriptions at a rate of 21%. In the Coding and Analysis section of Experiment 2, we report a mixed-effects logit regression analysis to compare the effects of language on left-to-right ordering in visual scene descriptions across Experiments 1 and 2.

Experiment 2: Yucatec Maya

We used the same methods, materials, procedure, coding, and analysis as in Experiment 1. The auditory stimuli were recorded by a 21-year old male native speaker of Yucatec Maya. Participants were instructed to give their responses in Yucatec Maya. Twenty-one participants from the same population, La Universidad de Oriente in Valladolid, Yucatan, Mexico, (10 female, 11 male, between the ages of 18 to 26, mean age 20.81, standard deviation 1.92) took part in Experiment 2. Eight of the participants had also participated in Experiment 1 in Spanish (allowing within-participants, across-language comparison; see below). For these eight participants in both Experiment 1 and 2, their participation in the second experiment was separated from their participation in the first by at least one day.

Coding and analyses

Exclusion rates for Experiment 2 are summarized in Table 1. A chi-squared test revealed that the rate of left-to-right descriptions in Experiment 2 with speakers of Yucatec Maya was not significantly higher than chance (χ^2 (1) = 0.2, p > .6). In Experiment 2, the Yucatec Maya speakers used left-to-right descriptions at an overall rate of 52% and right-to-left descriptions at a rate of 48%. Figure 2 shows the proportion of left-to-right descriptions in Experiment 1 in Spanish and Experiment 2 in Yucatec Maya. We then used mixed-effects logit regression analyses (Jaeger, 2008) to test the effects of language on the left-to-right bias in visual scene descriptions across Experiments 1 and 2. The analyses included the maximal random effect structure (by-subject and by-item intercepts and all by-item slopes). The model included language as a predictor of left-to-right ordering.

Language was a predictor of nominal ordering with significantly fewer left-to-right descriptions among Yucatec-speaking participants compared to Spanish-speaking participants (β = -1.32, z = -4.37, p < .001) (correlation of all fixed effects < 0.49). We do not include the number condition (one versus three on the left or right of the screen) as a predictor because the model would have been over-parameterized, given the sample size (see (Jaeger, 2011) and references therein). (In the model with language and number of objects on the left and right, language was a significant predictor of nominal ordering (β = -2.11, z = -2.84, p < .01), correlation of fixed effects < .78, all other effects n.s.).
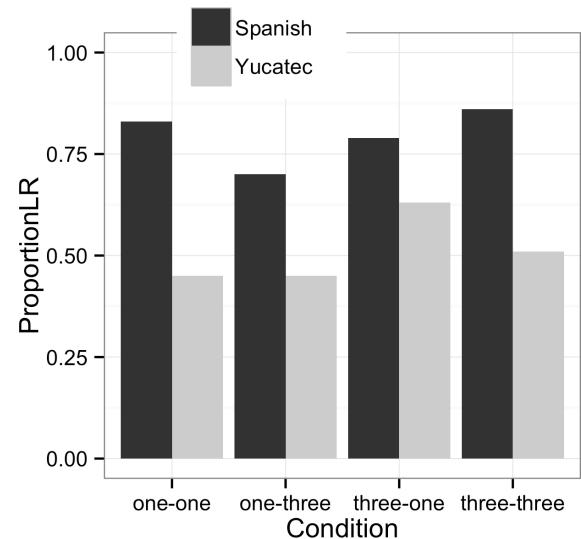

Figure 2: Proportion of left-to-right (LR) descriptions in Experiment 1 (Spanish) and Experiment 2 (Yucatec Maya)

Table 2: Rate of left-to-right (L-R) and right-to-left (R-L) descriptions among participant subgroups

Experiment	Participants	N	L-R	R-L
1 - Spanish	**Took Exp 1 & 2**	**8**	**70%**	**30%**
2 - Yucatec	**Took Exp 1 & 2**	**8**	**47%**	**53%**
1 - Spanish	Took Exp 1 only	12	84%	16%
2 - Yucatec	Took Exp 2 only	13	54%	46%
1 - Spanish	All participants	20	79%	21%
2 - Yucatec	All participants	21	52%	48%

Since eight participants took part in both Experiment 1 in Spanish and Experiment 2 in Yucatec, we can examine the behavior of these eight individual participants across the two languages. If the same individuals taking part in the same experimental task but speaking in two different languages still shows the same behavior as the findings for all participants, we have clearer evidence that the effect of left-to-right ordering of nominal conjuncts in picture description is indeed restricted to the language in which the participant is speak-

ing. The first two rows of Table 2 in bold show the proportion of left-to-right (L-R) versus right-to-left (R-L) descriptions for these eight participants who completed both Experiment 1 (Spanish) and Experiment 2 (Yucatec Maya) compared to participants who only completed one of the experiments.

A logit mixed-effects model for the data from the eight participants in both Experiment 1 and 2 included random by-subject and -item intercepts. In this model, language was a significant predictor of left-to-right ordering with participants speaking in Yucatec producing fewer left-to-right descriptions compared to speaking in Spanish (β = -1.02, z = -2.01, p < .05) (correlation of fixed effects < .62).

Discussion

We investigated the effect of directionality of writing system on the ordering of nominal constituents in visual scene description. In Experiment 1, with speakers of Spanish, we found that the use of left-to-right descriptions was significantly higher than chance. In Experiment 2, with speakers of Yucatec Maya, on the other hand, we found that the use of left-to-right (versus right-to-left) descriptions was chance. Language was a significant predictor of the ordering of nominal conjuncts across Experiments 1 and 2. Speakers of Spanish were significantly more likely than Yucatec speakers to use descriptions of two objects in the visual scene in left-to-right order.[1] Since we had eight bilingual participants who participated in both Experiment 1 in Spanish and Experiment 2 in Yucatec Maya, we were able to test an even stronger prediction: whether the same speaker would show different behavior depending on the language he or she was using. For these eight participants, language was still a significant predictor of the likelihood of left-to-right descriptions. The same individuals showed the left-to-right bias while speaking in Spanish but not while speaking in Yucatec. Based on these findings, we conclude that speakers of two languages who are literate in one language but not the other show the effect of orthographic directionality only in the language in which they are literate. Our findings support the experience-based crosscultural proposal of Dobel et al. (2007).

The experience with reading and writing among our participants is primarily based in Spanish. Participants who read and write in Yucatec (also a left-to-right oriented writing system), learn to do so at the college level. The most literate participants had only a few years of experience reading and writing in Yucatec. The limited experience with a writing system can be compared to the findings of Dobel et al. (2007) who found a left-to-right bias among German-speaking adults, a right-to-left bias among Hebrew-speaking adults, but no significant bias among German- or Hebrew-speaking children

(with less experience in reading and writing than adults).

It is possible that the eight participants in both Experiment 1 and 2 were influenced by factors related to taking the experiment more than once. For example, if these eight participants saw different experimental lists in which the left-right order of the objects on screen was the opposite, or if the participant first carried out the experiment in Spanish producing a left-to-right bias, this left-to-right bias could have persisted in their responses in the second experiment in Yucatec. In this case, three of the eight repeat participants took the experiment in Spanish first and in Yucatec second, and five of the participants took the experiment in Yucatec first and Spanish second. Three of the participants saw the same list in both experiments, while the other five saw different lists each time they carried out the experiment.

Writing system directionality is a conspicuous and enticing area of crosslinguistic variation when considering the differences observed in crosslinguistic studies of directional biases in linguistic processing. It is not the only explanation consistent with the data, however. Other language-specific influences are likely to be involved in the very complex cognitive task of sentence production based on visual scene processing. In fact, a difference between Spanish and Yucatec Maya in terms of frames of reference may be likely to influence order of elements in visual scene description.

Frames of reference in Yucatec Maya

A potential language-specific influence on the apparent absence of a left-to-right bias in Yucatec speakers involves spatial frames of reference. A consistent left-to-right bias in the processing of particular stimuli requires the projection of an extrinsic egocentric (or 'relative', Levinson (1996) reference frame derived from the observer's body onto the stimuli. Several independent studies have shown Yucatec speakers to be inconsistent users of such frames (Bohnemeyer & Stolz, 2006; Bohnemeyer, 2011; LeGuen, 2011). In linguistic representations of small-scale space, Yucatec speakers use all major frame types freely, including relative ones. However, unlike Euro-Americans and, for example, Mainland Japanese speakers (Kita, 2006; Mainwaring, Tversky, Ohgishi, & Schiano, 2003), they do not show a bias toward such frames. Meanwhile, in recall memory tasks, Yucatec speakers consistently prefer geocentric coding. The same holds for gestural representations, at least for those of mid-to-large-scale space (LeGuen, 2011).

If Yucatec speakers are indeed not consistent users of relative frames, this might impede them from showing a consistent left-to-right bias in tasks of the kind we conducted. However, a possible language-specific effect of this kind would itself likely be modulated by literacy. A large-scale study of six Mesoamerican languages including Yucatec, two non-Mesoamerican indigenous languages of the same region, and several varieties of Spanish (the local contact language) shows literacy (or frequency of reading and writing) to make a consistent contribution toward predicting reference frame type selection independently of first language and second lan-

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[1] Visual scene description in a second language may have higher cognitive demands and therefore influence the ordering of constituents in linguistic descriptions. Our bilingual participants report Yucatec Maya to be their maternal and preferred language, so the lack of left-to-right bias in Yucatec Maya is not likely to be due to a second language effect, however a more detailed analysis of language background can address this issue more directly.

guage use (Bohnemeyer et al., To appear), confirming earlier research (Danziger & Pederson, 1998). We did not formally assess the literacy of the participants in our study[2].

Thus, either or both of the following two factors may account for the effect we observed (left-to-right bias in Spanish, but not in Yucatec): (i) the presence or absence of a bias toward relative reference frames, along with the language in which the participant primarily uses such frames; and (ii) habituation to reading and writing in a particular script, along with the language in which the participant primarily reads and writes. Furthermore, these factors may also interact, due to the putative effect of literacy on frame use. Careful future research will have to attempt to discern between the impact of these factors.

Acknowledgments

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[2]For a direct comparison of languages with different frames of reference and literacy see (Bohnemeyer et al., To appear).