IS THE MISSING-VP ILLUSION DUE TO MEMORY OVERLOAD? EVIDENCE FROM SPANISH

Claudia Pañeda (University of Oviedo) & Sol Lago (Goethe University Frankfurt)
panedaclaudia@uniovi.es

It is notoriously hard to understand double center-embedded structures like "*The carpenter* [*who the electrician* [*who the plumber called*$_{VP1}$] *hit*$_{VP2}$] *supervised*$_{VP3}$ *the apprentice"*. In English and French, when the second verb phrase (VP2) is missing, the resulting ungrammatical sentence seems equally or even more acceptable and easier to comprehend than the grammatical version with all three verb phrases [1,2,3]. This "missing-VP illusion" can be explained under the assumption that double-embeddings lead to a memory overload that causes the forgetting of the VP2 prediction [1]. However, the missing-VP illusion varies crosslinguistically: German and Dutch comprehenders are more immune to the illusion and correctly prefer grammatical to ungrammatical sentences [4,5,6; cf. 7]. The *language statistics account* proposes that double embeddings are more acceptable in these languages because they are verb-final and thus consecutive VPs occur more frequently [5]. Given this key explanatory role of word-order differences for the missing-VP illusion, we assessed its existence in Spanish, a language with canonical SVO sentences like English, but more flexible word order [8,9]. To evaluate the role of memory overload, we measured participants' memory capacity: If memory overload causes the illusion, then speakers with higher memory capacity should be more immune to the missing-VP illusion.

METHOD. 80 Spanish speakers performed a reading speeded acceptability judgment task (SOA: 400ms, 2000ms response deadline) with 24 items in a 2×2 design. We crossed the number of embedded clauses (*one/two*, **Table 1**) and the grammaticality of the sentence (*grammatical/ungrammatical*). Ungrammatical sentences were created by removing VP2 (e.g. "*hit*"). Single-embedded clauses served to diagnose participants' detection of ungrammaticality when no memory overload was expected. Working memory capacity was measured with an operation span task [10]. Acceptability and response times to correctly-answered trials were analyzed with maximal Bayesian mixed-effects models.

RESULTS. With single embeddings, participants rejected ungrammatical sentences more often than grammatical sentences, consistent with a canonical grammaticality effect (posterior mean -6.14 log-odds, 95% credible interval [-7.34, -5.15] log-odds). However, with double embeddings the pattern was reversed, such that ungrammatical sentences were accepted more often than grammatical sentences (4.27 [3.29, 5.36] log-odds), resulting in a grammaticality×clause number interaction (10.31 [8.90, 11.89] log-odds). This interaction supports a missing VP illusion in Spanish. A grammaticality×clause number interaction was also attested in response times (-0.31 [-0.57, -0.05] log ms). With regard to the role of working memory, there was no indication that it modulated the missing-VP illusion, as the three-way interaction working memory×grammaticality×clause number had a wide distribution that included both positive and negative estimates (*acceptability*: 6.05 [-1.74, 13.60] log-odds; *response times*: 0.33 [-0.95, 1.60] log ms). As shown in **Figure 1**, there was no indication that ungrammatical double embeddings were more likely to be rejected by participants with higher working memory scores.

DISCUSSION. Our results show that the missing-VP illusion occurs in Spanish, even though it has a more flexible word order than English. Furthermore, a higher working memory capacity did not protect Spanish speakers from the illusion, suggesting that increased memory capacity by itself does not help comprehenders better remember verb predictions. Instead, our results are more compatible with language statistics accounts such as [3,5]. The illusion may be fully explained by language statistics: i.e., it may be caused by the infrequency of three consecutive verb patterns. Alternatively, while within-language working memory differences did not modulate the effect, the illusion may still result from a memory overload if statistical patterns influence the strength of predictions across languages. Thus, speakers of languages that allow verb-final clauses may make stronger verb predictions, which are less prone to decay or interference during processing.

TABLE 1. Sample item set. Each participant saw 24 experimental and 80 filler trials.

1-CLAUSE grammatical	*El carpintero* [*al que el electricista golpeó*] *supervisó al aprendiz.* *The carpenter who the electrician hit supervised the apprentice.*
1-CLAUSE ungrammatical	**El carpintero* [*al que el electricista* Ø] *supervisó al aprendiz.* *The carpenter who the electrician Ø supervised the apprentice.*
2-CLAUSE grammatical	*El carpintero* [*al que el electricista* [*al que el fontanero llamó*] *golpeó*] *supervisó al aprendiz.* *The carpenter who the electrician who the plumber called hit supervised the apprentice.*
2-CLAUSE ungrammatical	**El carpintero* [*al que el electricista* [*al que el fontanero llamó*] Ø] *supervisó al aprendiz.* *The carpenter who the electrician who the plumber called Ø supervised the apprentice.*

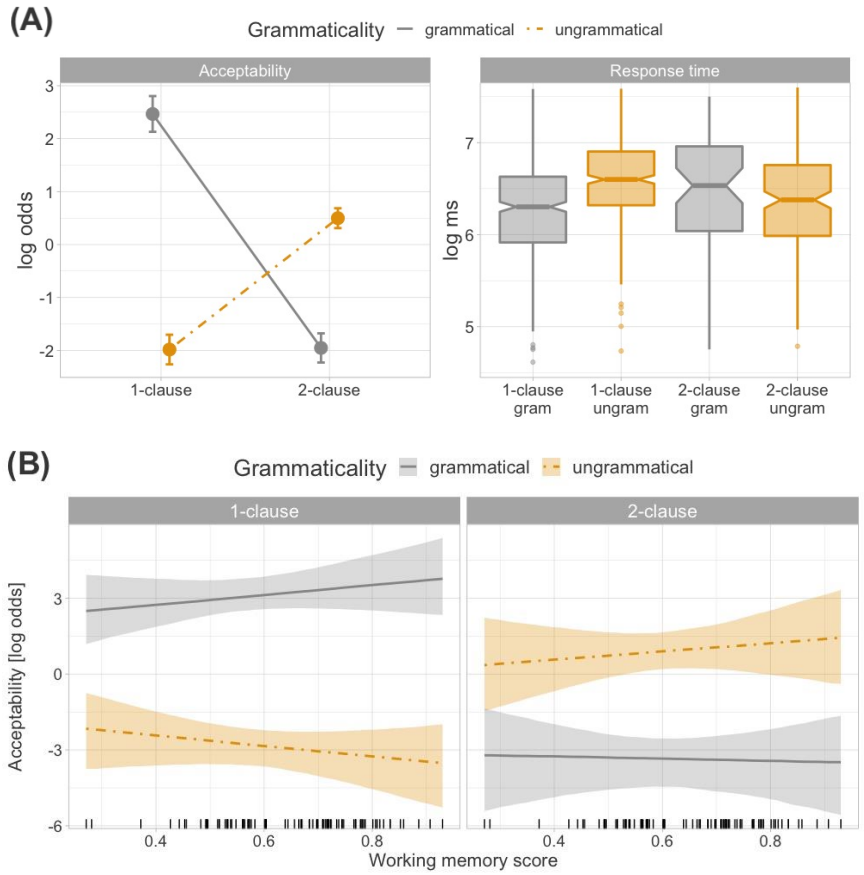

FIGURE 1. (A) Acceptability and response times by condition. **(B)** Conditional effects of *grammaticality* and *clause number* as a function of participants' centered working memory scores. The x-axis shows working memory scores on a 0–1 scale, with vertical black bars representing the number of participants at each point of the scale. By participants' working memory capacity did not seem to modulate either the acceptability of double embeddings or the acceptability of single embeddings.

REFERENCES **[1]** Gibson & Thomas (1999) *Lang Cognitive Proc* **[2]** Christiansen & MacDonald (2009) *Lang Learn* **[3]** Gimenes et al. (2009) *Lang Cognitive Proc* **[4]** Vasishth et al. (2010) *Lang Cognitive Proc* **[5]** Frank et al. (2016) *Cognitive Sci* **[6]** Frank & Ernst (2019) *Psychol Res* **[7]** Häussler & Bader (2015) *Front Psychol* **[8]** Valverde et al. (2005) *Proc. TLT4* **[9]** Ordóñez (2000) *The clausal structure of Spanish*, NY: Garland **[10]** von der Malsburg (2015) https://github.com/tmalsburg/py-span-task