

The role of working memory for syntactic formulation in language production
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This study investigates to what extent syntactic structure-building in language production involves working memory. We contrast an account in which syntactic formulation always involves keeping constituents in memory with an account in which it is possible for syntactic formulation to proceed with close to no working memory involvement, at least in some situations or for some structures (cf. Bock, 1982). Working memory involvement was shown for word order choice (Wasow, 1997; Bader, 2017) and subject-verb agreement errors (Hartsuiker & Barkhuysen, 2006). But this evidence is consistent with both accounts because both accounts assume working memory involvement for certain syntactic formulation situations - for example, when the eventual linear order does not map directly onto hierarchical constituent structure (i.e., in long-distance dependencies), or when several structural options need to be maintained active. A lack of working memory involvement in syntactic structure-building in production has been shown (Ivanova & Ferreira, 2019; Power, 1985) but admits alternative explanations.

We conducted a picture-naming experiment in Spanish that manipulates picture descriptions' syntactic complexity and concurrent verbal working memory load. We operationalized syntactic complexity as the number of nodes in a tree or the number of right brackets following the head noun (Ferreira, 1991), but without long-distance dependencies which could require working memory resources independently of syntactic complexity. The experiment thus involved producing noun phrases (Simple syntax condition: e.g., *el gato naranja* [Sp. the orange cat] or relative clauses (Complex syntax condition: e.g., *el gato que es naranja* [Sp. the cat that is orange]) on 24 trials each while simultaneously keeping in mind three digits (Load condition), or doing nothing (No load condition). The experiment was in Spanish because the standard Spanish noun-adjective word order allows manipulating syntactic complexity while keeping constant content word order (unlike English). Participants (N = 27/48) were Spanish-English bilinguals, under the assumption that working memory involvement in syntactic formulation would be easier to detect in bilinguals. This is because speaking in a non-dominant language is cognitively effortful (Abutalebi, 2008), managing conflict between the two languages may cause bilinguals to use their verbal working memory less efficiently (Luo et al., 2013), and even speaking one's dominant language requires cognitive resources to prevent interference from the non-target language (see Kroll et al., 2012). Objective language proficiency (also used to determine dominance) was assessed with the Multilingual Naming Test (Gollan et al., 2012).

We analyzed description initiation latencies, utterance durations and production errors on correct recall trials (77.3% of the data) with linear or logistic mixed-effects regression models. We assumed that a greater slowing and disruption of complex than simple descriptions by load (a statistical interaction between Complexity and Load) would be evidence for working memory involvement, while an equal slowing and disruption of complex and simple descriptions by load would be evidence against working memory involvement. Results (Figures 1-3) showed that descriptions were initiated more slowly (1532 ms.) under load than under no load (1401 ms.; $p = .002$), and (expectedly) complex descriptions, which contain more words, took longer to utter (1512 ms.) than simple descriptions (1145 ms.; $p < .001$). For production errors, there were no significant effects. Most importantly, the interaction between Complexity and Load was not significant for any of the three measures (all $ps > .2$). As predicted, bilinguals with lower Spanish proficiency initiated their descriptions more slowly (Spanish proficiency scores were a significant predictor in the latency analyses, $p = .002$), but there were no other effects or interactions of Spanish proficiency.

Taken together, these results show no evidence for working memory involvement in the current task, and thus suggest that it is possible for syntactic structure-building in production to proceed with little or no working memory involvement. Of note, this was the case even in a fairly challenging task with many instructions to keep in mind, and during cognitively effortful bilingual production.

Figure 1. Initiation latencies for Spanish noun phrases and relative clauses under load and no load.

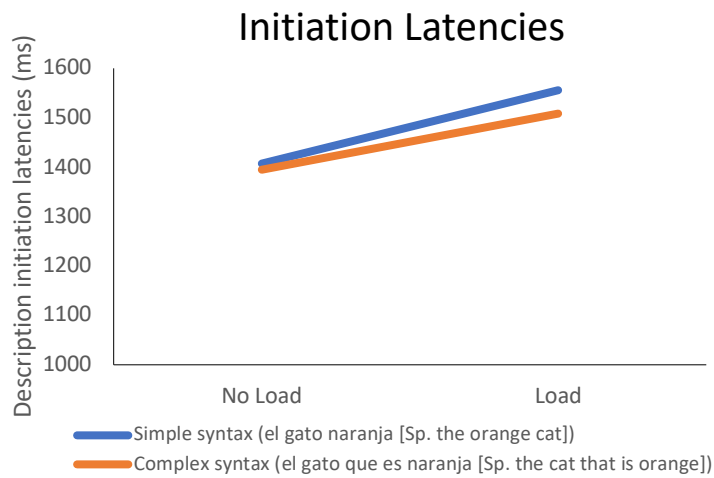


Figure 2. Utterance durations for Spanish noun phrases and relative clauses under load and no load.

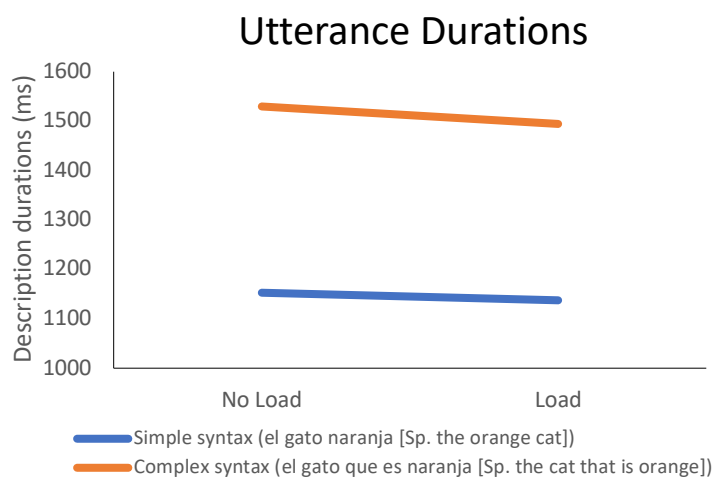


Figure 3. Production errors for Spanish noun phrases and relative clauses under load and no load.

