# Higher syntactic complexity requires more listening effort for Spanish-English bilinguals

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**Background** Dual task studies provide insight into *listening effort*, or how listeners allocate cognitive resources to overcome challenges when processing language; they approximate real-world listening contexts, as outside of the laboratory, listeners are rarely in contexts where linguistic input is the only thing drawing their attention and cognitive resources. Research shows that processing in a non-dominant language under dual-task conditions requires more effort as the linguistic signal becomes more difficult **[ex. 1,2]**. However, work on bilinguals has primarily manipulated linguistic signal difficulty by introducing noise, degraded quality of the signal, or masked speech; syntactic complexity has been manipulated in studies on monolinguals **[3]**.
**Aim** The present study tests whether an increase in *syntactic complexity* for bilingual listeners increases listening effort and thus the use of domain-general cognitive resources. We test three groups of Spanish-English bilinguals in a dual-task paradigm. If comprehending and encoding more syntactically complex structures requires more listening effort, we expect to see decreased performance on a concurrent non-linguistic task. We predict this effect to be least pronounced for Spanish-dominant speakers and most pronounced for L2 learners.
**Participants** Participants were Spanish-dominant recent immigrants to the US (SPs; n=52), English-dominant heritage speakers (HSs; n=34), and English-dominant second-language learners of Spanish from the same university-level Spanish class (L2s; n=21). Participants completed a language dominance questionnaire, a cognitive control task (Flanker), and a receptive vocabulary test using the verbs and nouns from the main linguistic task.
**Methods: Single-task** Participants completed a series of experimental blocks alternating randomly between (a) a non-linguistic motion-object tracking task (60 trials; difficulty manipulated through tracking 1, 2, or 3 bubbles) **[Figure 1] [3]**; and (b) a linguistic picture-matching task in which participants heard an auditory phrase and selected the corresponding image (120 trials) **[Figure 2]**. Difficulty in the linguistic task was manipulated by relative clauses of increasing complexity: reduced relative (RR), subject relative (SR), and object relative (OR) **[Ex. 1]**. Relative clauses have consistently been shown to have a clear ordering of processing difficulty, including in monolingual and bilingual Spanish **[4]**.
**Results: Single-task** Difficulty was a forward-difference-coded categorical variable. A mixed effects logistic regression model predicting accuracy on the non-linguistic task found an expected main effect of difficulty (1>2, $\beta$=0.93, SE=0.09; t=10.5, $p<0.001$; 2>3, $\beta$=0.56, SE=0.07, t=7.87, $p<0.001$) and no main effect of group. A model predicting accuracy on the linguistic task found an expected main effect of difficulty (RR>SR, $\beta$=0.47, SE=0.16, t=2.90, $p=0.004$; SR>OR, $\beta$=4.18, SE=0.38, t=10.98, $p<0.001$) and a main effect of group ($\beta$=1.07, SE=0.13, t=7.95, $p<0.001$): the SPs were overall more accurate than the other two groups.
**Methods: Dual-task** In each trial, participants were presented with the non-linguistic and the linguistic stimuli simultaneously but only prompted with which they needed to respond to at the end of the trial; this way, information from both tasks was processed and encoded in memory prior to response. Trials (120) fully crossed all levels of the linguistic and non-linguistic tasks.
**Results: Dual-task [Figure 3]** A mixed effects logistic regression model predicting accuracy on non-linguistic task identified a main effect of non-linguistic task difficulty (1>2 & 2>3) consistent with single-task results, as well as a main effect of group indicating that overall SPs were most accurate ($\beta$=0.20, SE=0.10, t=1.99, $p=0.047$) and L2s were least accurate ($\beta$=-0.26, SE=0.12, t=-2.16, $p=0.03$) on the non-linguistic task under dual-task conditions. Crucially, the model found a main effect of linguistic-task difficulty (SR>OR, $\beta$=0.26, SE=0.09, t=3.011, $p=0.003$).
**Implications** Results indicate that accuracy on the non-linguistic task was affected by the linguistic task demands. This suggests that an increase in syntactic complexity also increases listening effort, requiring more domain-general cognitive resources. Main effects of group suggest different types of bilinguals were impacted differently by the concurrent need to process Spanish-language speech, but did not differ in the effect of its increased syntactic complexity.

**Figure 1** Illustration of non-linguistic task trial (single-task) tracking two bubbles; participants indicate whether the red bubble at the end is one of the ones that flashed red at the beginning.

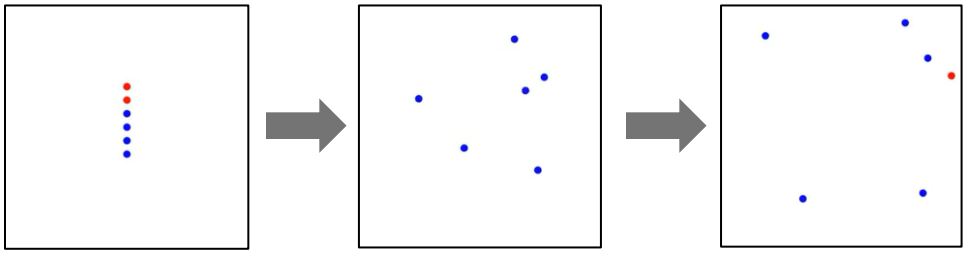
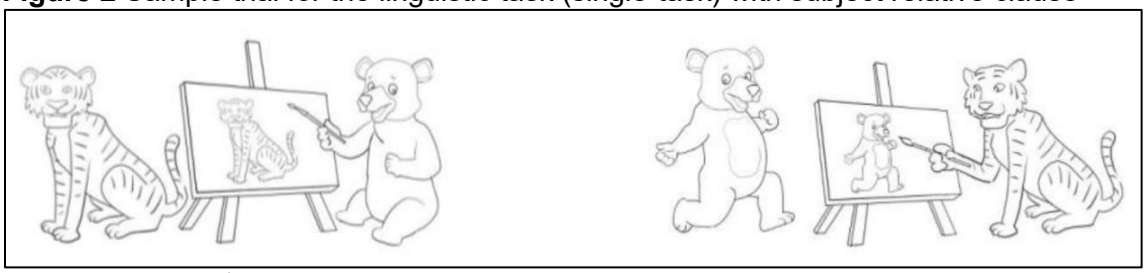


**Figure 2** Sample trial for the linguistic task (single-task) with subject relative clause

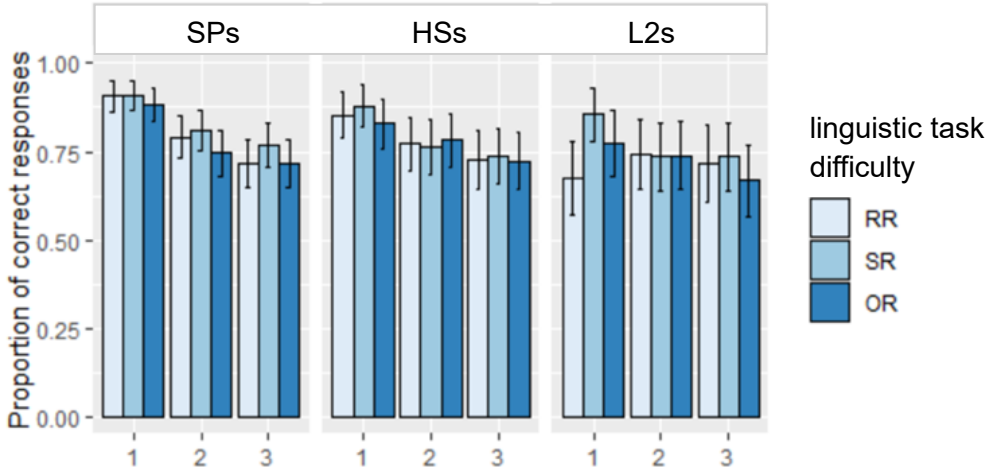


el oso que pinta al tigre (the bear who is painting the tiger)

**Ex. 1** linguistic task difficulty

RR: el oso pintando al tigre (the bear painting the tiger)
SR: el oso que pinta al tigre (the bear who is painting the tiger)
OR: el tigre al que pinta el oso (the tiger who the bear is painting)

**Figure 3** Dual task: accuracy on non-linguistic task




**References [1]** Declerck, M., & Kormos, J. (2012). The effect of dual task demands and proficiency on second language speech production. *Bilingualism: Language & Cognition*, *15*(4), 782–796. **[2]** Francis, A. L., Tigchelaar, L. J., Zhang, R., & Zekveld, A. A. (2018). Effects of second language proficiency and linguistic uncertainty on recognition of speech in native and nonnative competing speech. *Journal of Speech, Language, and Hearing Research*, *61*(7), 1815–1830. **[3]** Heyselaar, E., & Segaert, K. (2019). Memory encoding of syntactic information involves domain-general attentional resources: Evidence from dual-task studies. *Quarterly Journal of Experimental Psychology*, *72*(6), 1285–1296. **[4]** Dąbrowska, E., Pascual, E., & Macías Gómez-Estern, B. 2022. Literacy improves the comprehension of object relatives. *Cognition* (224). 104958.