

## Does bilingual experience influence statistical language learning?

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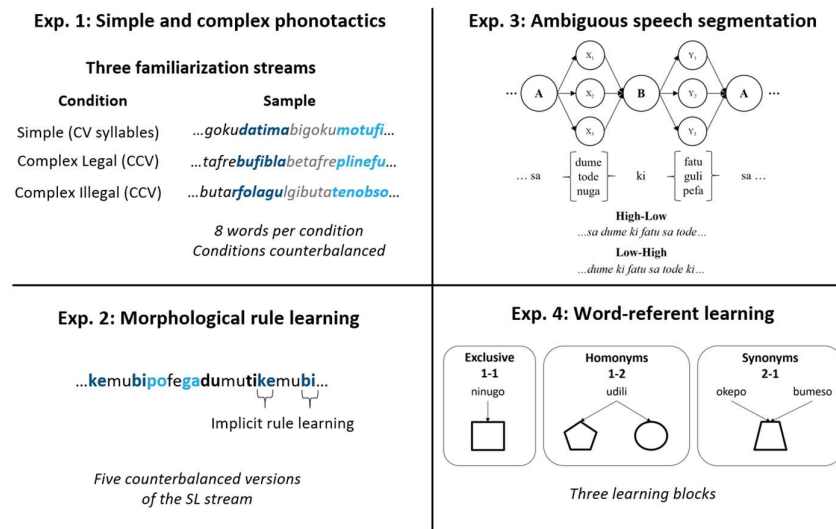
The field of language acquisition has taken a particular interest in *statistical language learning* (SL) as one of the primary mechanisms through which humans implicitly learn languages<sup>1</sup>. Prior linguistic experiences, particularly bilingual experience, may influence performance in SL tasks<sup>2-4</sup>. However, the extent to which bilingual experience influences SL is still largely unexplored. Here, we compared Spanish monolingual and two (Spanish-Basque and Spanish-English) bilingual groups across four well-established SL tasks. Each task targeted a different aspect of language as a proxy—i.e., sub-lexical, morphological, word order, and lexical-semantic levels. We hypothesized that both bilinguals would outperform monolinguals in all tasks due to their experience with potentially conflicting statistics in two languages. The three groups were matched on their age, education level, and non-verbal IQ. Moreover, the bilingual groups had comparable exposure, age of acquisition, and proficiency in their L1 and L2. There were 40 participants per group per experiment.

In **Exp. 1**, we manipulated sub-lexical phonotactic patterns to vary the difficulty of the SL task and presented participants with three auditory SL streams containing words with simple (consonant-vowel; CV) and two types of complex (CCV; legal/illegal) syllables. In **Exp. 2**, we included non-adjacent dependencies as a proxy for morphological rule learning in an SL task and tested participants' ability to generalize knowledge from an auditory speech stream. **Exp. 3** involved an ambiguous SL speech stream that could be parsed based on participants' known language's word order to disentangle overall bilingual experience effects from specific properties of known languages. Finally, in **Exp. 4**, we tested auditory word learning using a more challenging audio-visual cross-situational SL task that entailed learning exclusive (one-to-one) and multiple (homonym/synonym) word-referent mappings across three learning blocks. All experiments involved a familiarization phase followed by 2AFC test phases. See **Figure 1** for an example of stimuli and experimental conditions.

We analyzed participants' accuracy in the four experiments using generalized linear mixed modeling (GLMM) with a binomial distribution and logit link for participants' accuracy scores. All GLMM analyses included planned contrasts to compare both bilingual groups against each other against the monolingual group<sup>5</sup>. The GLMM results showed no differences between the three groups in Exp. 1 and 2. Notably, in Exp. 3, there was an advantage for the Spanish-Basque speakers—due to Basque being a postpositional subject-object-verb (SOV; see Page 3) language—but no overall bilingual experience effects. Lastly, Exp. 4 revealed that bilinguals outperformed monolinguals in learning the exclusive mappings but not the multiple mappings. Participant's average accuracy by group for all experiments is depicted in **Figure 2**.

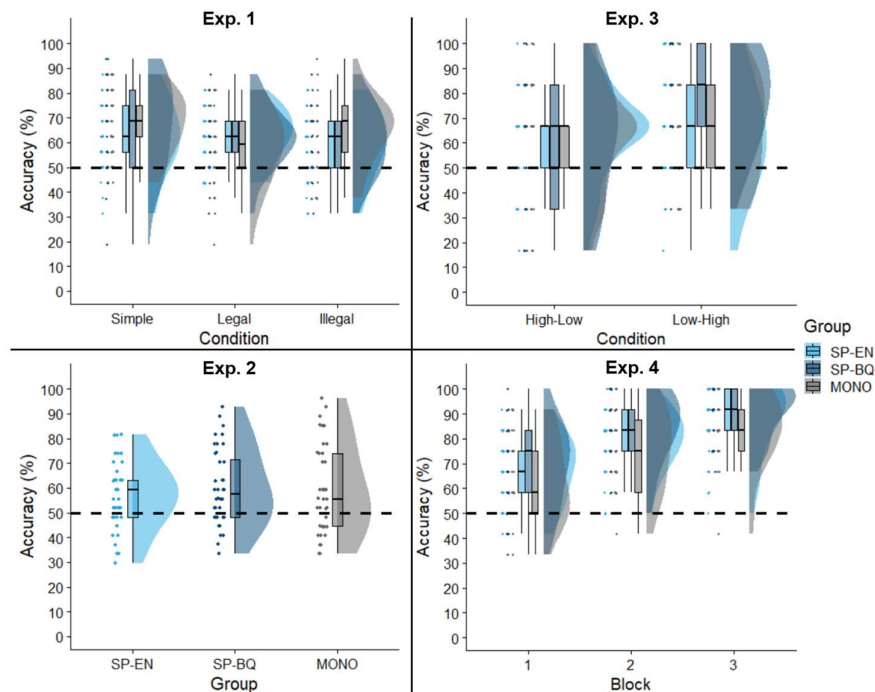
This study examined whether bilinguals outperformed monolinguals across four SL experiments targeting distinct aspects of language as a proxy. The inclusion of two bilingual groups and different manipulations allowed us to disentangle the effects of bilingual status from those stemming from task difficulty or specific language properties. Critically, we did not find any overall advantage from bilinguals in experiments one to three. Instead, Exp. 3 suggested that knowledge of Basque influenced SL performance in Spanish-Basque speakers. Exp. 4 indicated that bilingual participants performed better than their monolingual peers when learning exclusive (but not multiple) word-referent mappings. Together, these results suggest that (1) specific properties of the known languages (i.e., word order) can influence performance in SL tasks and that (2) bilingual status might influence SL performance primarily at the lexical-semantic level<sup>6</sup>. Future studies could focus on the process of learning rather than the outcome as measured by 2AFC tests.

**Figure 1**  
Sample materials for all experiments



*Note.* **Exp. 1** involved segmenting words with simple and complex (legal/illegal) syllables from three counterbalanced SL streams. **Exp. 2** entailed generalizing non-adjacent frame syllables from the SL stream. **Exp. 3** tested segmentation of words from an ambiguous speech stream that could be parsed based on the frequency of constituent elements into *High-Low* and *Low-High* patterns. **Exp. 4** tested word-referent learning using *exclusive* and multiple (homonym/synonym) mappings.

**Figure 2**  
Results from all experiments



*Note.* Raincloud plots of accuracy scores by group in each experiment. Dots reflect individual observations. Exp. 4 only depicts the exclusive condition. SP-EN = Spanish-English bilinguals; SP-BQ = Spanish-Basque bilinguals; MONO = Spanish monolinguals.

References

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### **Information about the Basque language**

Two bilingual groups were included in this study to isolate the effects of bilingual experience rather than specific language combinations. Spanish-English and Spanish-Basque bilinguals were compared to each other and against a Spanish monolingual group. While prior studies have emphasized the characteristics that differentiate Spanish and English, it is essential to briefly comment on the commonalities and differences between the Spanish and Basque languages. Spanish and Basque do not share any common root, but Basque possesses many Spanish loan words due to their geographic proximity within Spain. Some language-specific bigrams differentiate Basque from Spanish (e.g., "tx", "tz"). However, the two languages are phonologically similar. The Basque language also possesses a predominantly subject-object-verb (SOV) word order, which involves a postpositional and agglutinative morphology—i.e., morphemes and determiners are appended to the end of word roots (e.g., *eskolan* – *school the in*). These properties differentiate Basque from Spanish, English, and many other Indo-European languages. In Exp. 2, since we were targeting whether specific properties of the languages (i.e., word order) influenced performance in the SL task, we contrasted the Spanish-Basque (SOV) speakers against the other groups.