

# Vowel Production by Spanish-English Bilingual Children: An Instrumental Articulatory Study

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Studies of bilingual speech sound development have focused on the extent to which bilinguals' productions are language-specific or rather the two languages influence each other in development (Gildersleeve-Neumann & Goldstein, 2022). Most of these studies have used auditory techniques, which rely on phonetic transcription failing to capture fine phonetic differences. Other studies have used acoustic techniques, which focus on the acoustic output of speech sounds inferring the articulatory gestures that generated them. In contrast, instrumental articulatory methods, which examine the articulators that produce speech sounds, provide unique information on the articulatory actions performed by the speaker, proving particularly useful when the same acoustic result can be achieved by different articulatory gestures (Zhou et al., 2008).

This study examines Spanish-English bilingual children's articulatory gestures during the production of English and Spanish vowels using articulatory methods. We used ultrasound tongue imaging in order to estimate tongue surface contours during /i/ and /ɪ/ vowel production in five 4-to-6-year-old Spanish-English bilingual children as compared to three English monolingual peers. We also examined bilinguals' articulation of Spanish /i/ to assess whether the children differentiated it articulatorily from English /i/. While the number of participants is small, previous ultrasound studies have used comparable sample sizes due to the time-consuming nature of analyzing individual tongue shapes.

Ultrasound tongue imaging data was collected using the Articulate Assistant Advanced system (AAA; Articulate Instruments, 2025) while children participated in a picture identification task in which they named items that included high-frequency minimal pairs in English (32 words) and matched Spanish words (16 words). An ultrasound probe, stabilized with the Ultrafit Stabilization Headset, was placed beneath the child's jaw to record the midsagittal view of the tongue. We fitted tongue splines to the ultrasound images using DeepLabCut (Wrench & Balch-Tomes, 2022) and extracted the coordinates of the tongue splines at temporal midpoint. We then used Principal Component Analysis to reduce the complexity of the midsagittal tongue shape into a series of linear functions. We finally fitted two linear mixed effects models in which the dependent variable was normalized PC1, corresponding to variation in the height of the front of the tongue and advancement/retraction of the tongue root, to quantify differences in tongue shape.

The results showed that most participants produced somewhat separate /i/ and /ɪ/ lingual gestures, although the results did not reach significance at the group level. Children with the largest English vocabularies displayed the most contrastive /i/ and /ɪ/ lingual gestures, suggesting that vocabulary development may drive the development and refinement of articulatory gestures. The results also showed that most bilingual children adopted different tongue shapes when producing English /i/ and Spanish /i/, articulating Spanish /i/ with a significantly higher tongue front and more advanced tongue root compared to English /i/. We interpret these findings as preliminary evidence that, by 4-to-6 years of age, bilingual children who have reached a sufficient level of bilingual competence might have developed language-specific lingual gestures to contrast perceptually similar sounds by articulatory means.

## References

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