

## Subtle, but significant: the centralization of Spanish unstressed vowels

**Context & problem:** Stress is a contrastive property of Spanish, distinguishing words such as *hablo* /'a.blo/ 'I speak' and *habló* /a.'blo/ 'he/she spoke'. Previous work has shown that stressed vowels (in words produced in isolation) are typically realized with higher f0, longer duration, and greater intensity than unstressed syllables in the same word (e.g., [1], [2]). However, we know less about how the spectral properties of Spanish vowels might differ by stress and whether any such difference would contribute to cuing stress in Spanish. Some sources state that Spanish unstressed vowels do not centralize (e.g., [3], [4]) while others suggest that they centralize slightly, but not to the extent that they do in English (e.g., [5], [6], [7]). The purpose of this study is to provide a careful look at the acoustic realization of stressed vs. unstressed vowels in Spanish, including vowel formants alongside f0, duration, and intensity.

**Research Questions:** *RQ 1:* Are unstressed vowels more centralized in the acoustic space compared to stressed vowels? *RQ 2:* If so, does this centralization contribute to distinguishing stressed and unstressed vowels in production in addition to f0, duration, and intensity?

**Methodology:** 48 native speakers of Mexican Spanish participated in a production task in which they read aloud 20 pairs of disyllabic Spanish words with the target vowel in the first syllable. The word pairs differed by position of stress (first vs. second syllable) and were controlled for segmental context surrounding the first vowel (e.g., *casa* /'ka.sa/ 'house' vs. *casar* /ka.'sa/ 'to marry'). Participants read the list of words aloud in random order three times. Target vowels were analyzed for duration, mean f0, mean intensity, and F1 and F2 at the midpoint of the vowel using a Praat script. Euclidean distance from the mean F1 and mean F2 (across all speakers and tokens) was calculated for each vowel as a measure of distance from the centre of the acoustic space.

**Findings:** *RQ 1:* Graphical analysis suggests that all 5 vowels are somewhat centralized when unstressed as compared to when stressed (see Fig. 1 and 2 on the next page). A mixed effects model with Euclidean distance as the response variable and stress and vowel, plus an interaction between the two, as fixed effects finds that Euclidean distance from the centre of the vowel space is statistically significantly smaller when the vowel is unstressed ( $\beta = -23.936$ ,  $p < 0.001$ ). A posthoc test confirms that this holds for all vowels except /e/, where the difference was not significant. This indicates that most Spanish unstressed vowels are statistically significantly more central than their stressed counterparts. *RQ 2:* However, when Euclidean distance is included as a fixed effect with F0, duration, and intensity in a logistic mixed effects model predicting the stress of a vowel, it is found to be non-significant ( $\beta = -0.24$ ,  $p > 0.05$ ), while f0, duration, and intensity are (f0:  $\beta = -3.02$ ,  $p < 0.001$ ; duration:  $\beta = -2.92$ ,  $p < 0.001$ ; intensity:  $\beta = -0.91$ ,  $p < 0.001$ ). This suggests that while unstressed vowels are more central than stressed, these formant differences are likely not as strong as cues to stress than f0, duration, and intensity.

**Significance and contribution:** This study provides acoustic evidence that Mexican Spanish vowels centralize to a statistically significant, yet subtle, degree when unstressed, supporting previous work for other dialects. The results also suggest that this centralization may not be as strong a contributor to the perception of stress as f0, duration, and intensity. This study sets the stage for future work determining the relative cue weighting of centralization versus these three main cues of stress in perception.

## Figures

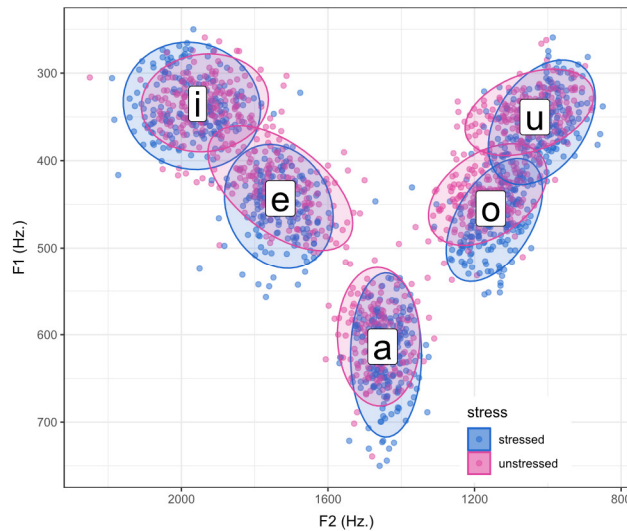


Figure 1. F1 and F2 of Spanish stressed and unstressed vowels.

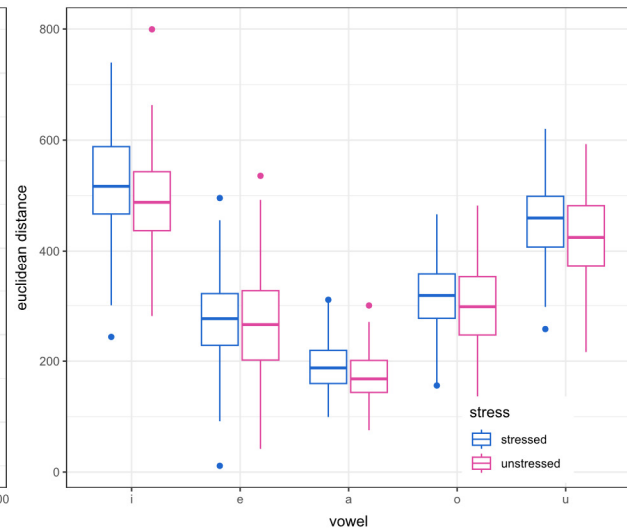


Figure 2. Euclidean distance from centre of acoustic space of Spanish stressed and unstressed vowels

## References

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