

Predicting L3 Cue Weighting with L2LP and SHAP: The Case of L1 Spanish–L2 English Learners

Jooyoung Lee¹, Kakeru Yazawa², James Whang³, Paola Escudero¹
¹Western Sydney University, ²University of Tsukuba, ³Seoul National University

Background and purpose: This study presents a computational simulation of first (L1), second (L2), and third (L3) language acquisition within the Second Language Linguistic Perception (L2LP) framework [1, 2, 3]. Although existing L2 models typically assume that all subsequently learned languages follow similar developmental patterns (e.g., assimilation to L1), growing evidence points to L2-to-L3 influences [4]. Here, we extend L2LP’s *Full Copying/Full Access* hypotheses to a multilingual context to provide *a priori* predictions about how L2 learning experience affects L3 perception. Specifically, we simulate how L1 Spanish listeners of varying L2 English proficiencies reweight relevant acoustic cues as a function of L2 training, which in turn affects the perception of L3 Dutch vowel contrasts that are absent both in L1 and L2.

Methods: The simulation utilized three corpora: DIMEx100 (Mexican Spanish; /i, e, a, o, u/), TIMIT (American English; /i, ɪ, ε, æ, ʌ, α, ɔ, ʊ, u/), and a Dutch vowel corpus [5] (/i, ɪ, y, ʏ, ε, a, α, ɔ, u/). A multi-layer perceptron network was trained to distinguish L1 Spanish vowels using F1, F2, F3, and duration, normalized using Nearey [6, 7]. Following L1 training, the model was trained on L2 English vowels. Five categories were “copied” from L1 (Fig. 1, blue), and four (/ɪ, æ, α, ʊ/) were added as new categories (Fig. 1, orange). L2 proficiency was simulated by varying the number of training repetitions or epochs: 1 epoch for a “novice” learner and 32 epochs for an “advanced” learner (training = 29,254 tokens, testing = 10,825 tokens per epoch). Finally, naïve L3 Dutch perception was simulated by mapping Dutch inputs onto the model’s L2 English categories. We applied SHapley Additive exPlanations (SHAP) to estimate acoustic cue contributions to vowel classification, which were then transformed to cue weights by dividing each SHAP value by their sum.

Results: The Dutch /a:/-/α/ contrast is presented as a representative example. Fig. 1 shows categorization patterns for L3 Dutch vowels as a function of L2 English proficiency. Both novice and advanced learners distinguish the contrast, but with different categorization patterns. The novice learner categorized Dutch /a:/ and /α/ as English /ʌ/ and /ɔ/, both L1-copied categories corresponding to Spanish /a/ and /o/, respectively. The advanced learner, by contrast, perceived Dutch /a:/ as English /æ/ (i.e., a new category) and Dutch /α/ as English /ʌ/. We explored the mechanisms underlying these differences by analyzing cue weighting shifts from novice to advanced models. Fig. 2 shows that, while spectral cues (F1 and F2) are primary cues for L2 English perception in both learners, the advanced learner relies more heavily on durational cues, except for English /α/. As illustrated in Fig. 3, this reweighting supports acquisition of English /æ/, leading long Dutch /a:/ tokens to be mapped onto this category. Similarly, the perception of Dutch /α/ as English /ʌ/ can be explained by increased durational cue weight for /ʌ/, which favors shorter vowel durations.

Discussion: Our findings suggest that as L1 Spanish learners become more proficient in L2 English, they gain access to L3 Dutch vowel distinctions, albeit indirectly, via reweighting of durational cues. The model predicts that newly established L2 vowel categories can shift a NEW L3 scenario to a SIMILAR scenario, allowing listeners to prioritize certain acoustic cues in ways unlikely if only L1 grammar were active during L3 perception. By extending the L2LP framework to L3 modeling, this study offers precise and testable predictions of cue (re)weighting effects before empirical behavioral data are collected. During presentation, we will validate simulation results across a broader range of Dutch vowel contrasts by comparing them with human listener data.

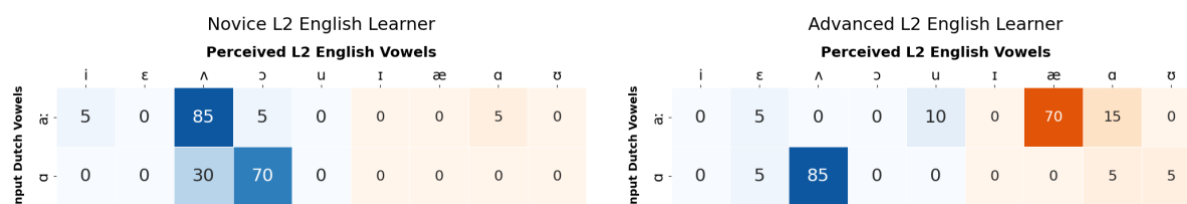


Fig. 1. L3 Dutch vowel categorization by novice and advanced L2 English models

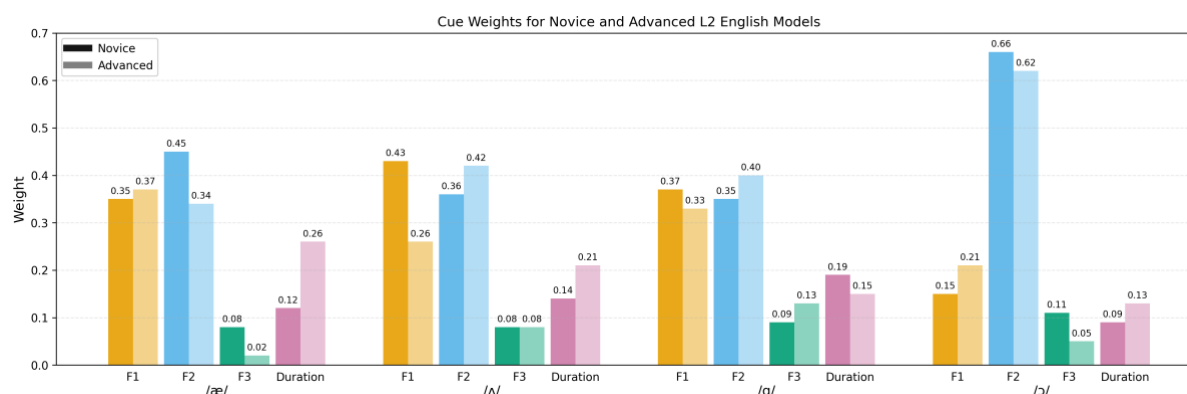


Fig. 2. SHAP cue weights for L2 English low vowels

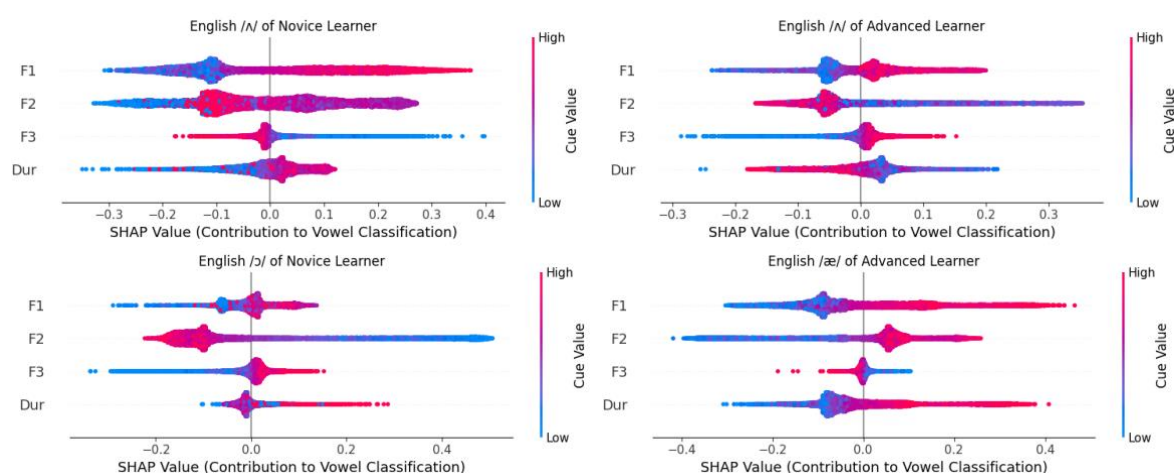


Fig. 3. SHAP plots of L2 English low vowels by novice and advanced models

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