

## Dynamic L1 and L2 transfer in L3 vowel acquisition

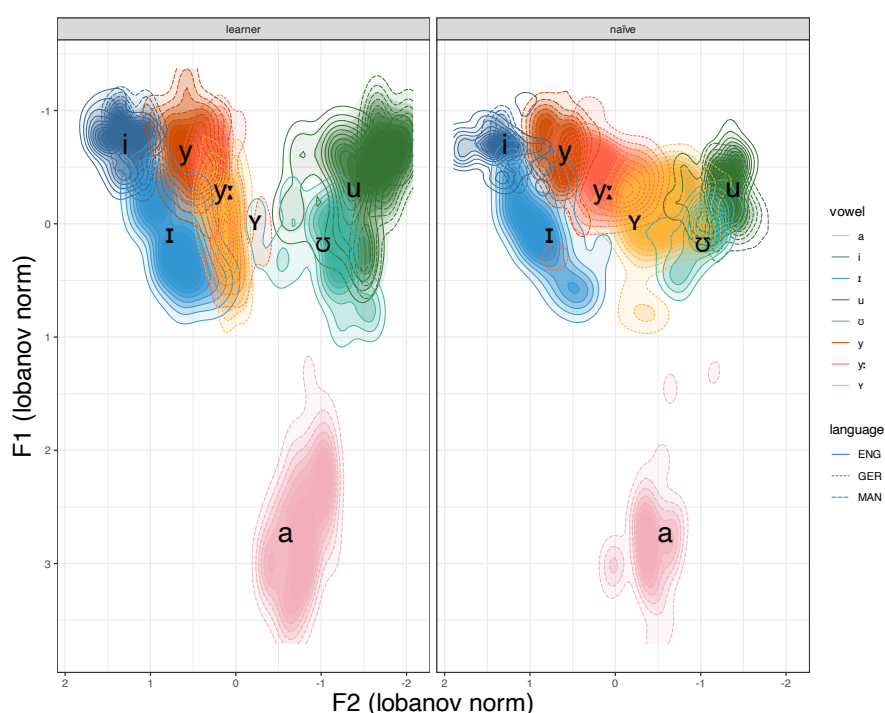
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This study investigates L1 and L2 transfer in the acquisition of L3 vowels. L3 phonological studies have shown that learners can utilize both their L1 and L2 knowledge in acquiring L3 sounds<sup>1-4</sup>. This finding aligns with the property-by-property transfer assumption proposed by some L3 morphosyntactic learning models, such as the Linguistic Proximity Model (LPM)<sup>5,6</sup> and the Scalpel Model<sup>7</sup>. Meanwhile, it also supports an extension of existing L2 speech learning models, including the Perceptual Assimilation Model (PAM)<sup>8,9</sup>, the Speech Learning Model (SLM)<sup>10,11</sup> and the Second Language Linguistic Perception Model (L2LP)<sup>12-14</sup>, all of which posit that non-native sounds will be mapped to existing phonological categories. While most studies have considered such assimilation at a phonemic or allophonic level, evidence from perception experiment suggests that L3 learners can also utilize subphonemic features from previous languages in discrimination L3 phonemes<sup>1</sup>. This raises a key question: do L3 learners parse and combine features from L1 and L2 phonemes when producing L3 sounds, or do they transfer the articulatory configuration of existing categories in a holistic manner?

To investigate this question, we examined the perception and production of German vowels by L1 Mandarin-L2 English speakers. We focus specifically on the novel vowel /y/, which shares a front-round configuration with Mandarin vowel /y/ but exhibits a lax feature similar to English /ɪ, ʊ/. Thirteen native Mandarin speakers (7 naïve listeners, 6 German learners) with an advanced level of L2 English were recruited. The experiment consisted of categorization, discrimination and production task of all German vowels, along with elicitation tasks of all L1 Mandarin and L2 English vowels. Synchronized ultrasonic tongue images, lip videos and speech audio were recorded in AAA<sup>15</sup>. Audios were segmented using MFA<sup>16</sup>, from which acoustic measurements were obtained using FastTrack<sup>17</sup>. Tongue splines and lip gestures were tracked using DeepLabCut<sup>18,19</sup>.

Categorization results show that naïve listeners have mostly categorized /y/ as Mandarin /u/ (71.4%), followed by English /ʊ/ (17.9%), whereas learners primarily mapped /y/ to Mandarin /y/ (41.7%), and secondarily to English /ʊ/. The discrimination results revealed that naïve listeners were able to utilize the tense-lax contrast in L2 to distinguish /y-y/ (accuracy:  $M = 0.964$ ,  $SD = 0.060$ ), but less capable of transferring the front-back distinction from L1 to discriminate /y-ʊ/ ( $M_{acc} = 0.68$ ,  $SD = 0.122$ ). For the latter, learners have demonstrated significant improvement ( $M_{acc} = 0.875$ ,  $SD = 0.194$ ). In the imitation task of /y/, naïve listeners showed great inter- and intra-individual variations in terms of tongue position and lip gesture, despite exhibiting relatively consistency in mimicking the short duration. The most frequent realizations for /y/ observed in naïve listeners were close to English /ʊ/. The other variants were mostly realized with a central tongue position accompanied by varying degrees of lip rounding, auditorily similar to schwa or the fronted allophone of English /u/. The insensitivity to the front-round tongue position was also found in the L1 vowel /y/, where target-like perception and production were mostly found in the consonantal context /l\_/\_ that is compatible with L1 phonotactics. Learners, however, mostly demonstrated front-round tongue position similar to /y/ but varied in temporal realization, resulting in less distinction between /y/ and /y/.

This study comprises perception, acoustic and articulatory data to illustrate the dynamic L1/L2 transfer in L3 vowel acquisition. Initially, L1 Mandarin-L2 English speakers were able to transfer L2 categories as well as lax feature to the non-native vowel /y/, whereas the transfer from L1 was hindered by contextual constraints despite of existing phonetic similarity. German learners improved L1 feature utilization but showed less stability with L2 features. The findings suggest that both phonemic and subphonemic properties in L1/L2 are available in L3 vowel learning, with their relative usage evolving as experience accumulates.



**Figure 1 Vowel Space (Naïve Listeners vs. Learners)**

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