Which learner has the best profile to learn L2 lexical tones?
A study of linguistic and non-linguistic learner-specific factors.

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Lexical tone is a notoriously difficult aspect of L2 speech to acquire, but some learners appear to learn tones more easily than others do. Previous research has shown that both linguistic factors (such as L1 experience with tone) and non-linguistic factors (such as pitch sensitivity and musical experience) of individual learners can determine how easily tones are acquired [1]. However, most previous studies have only separately examined either linguistic or non-linguistic influences on L2 tone acquisition, with a few exceptions, such as [2], [3]. Moreover, the vast majority of work on L2 tone acquisition tends to investigate perceptual performance, but in order to truly understand the learning process and attainment, we argue that acquisition should be examined simultaneously in other domain modes, such as spoken production and word-learning. Therefore, this study investigated the simultaneous effects of linguistic and non-linguistic factors in L2 tone acquisition in multiple domain modes, in order to propose a cohesive theoretical account of L2 tone acquisition that goes beyond models based on purely perceptual performance [4], [5].

Two groups of adult native speakers of English (a non-tone language, n=20) and Mandarin Chinese (a tone language, n=20) participated in two-day experiment. The English participants had no knowledge of a tone language. Musical experience, measured by years of formal instruction per instrument (cf. [6]), and working memory, measured by a backwards digit span task, were balanced across both participant groups.

Participants were first tested on non-lexical pitch sensitivity through a tone identification task of vowels carrying either a rising, a falling, a mid-level, or a low-level tone. They were then trained by means of a listen-and-repeat session to learn a set of 16 pseudolanguage words with a four-way segmental (/jar/, /jur/, /lɔn/, /nɔn/) and a four-way tonal contrast (rising, falling, mid-level, low-level). After training, they were tested on their productive word recall in a picture-naming task, and subsequently on their passive word recall with picture-matching. Normalized f_0 data were obtained to determine tone production accuracy. The training and the two word recall tests were repeated on day 2.

At the end of training, average passive word recall for all participants was 77.41%, but with a large variance in both groups (**Figure 1**). 'Tone-Only Errors' (e.g. misidentifying /jár/ as /jàr/) strongly predicted the amount of total recall errors made ($p < 0.0001$, $R^2 = .833$), showing that learning the tones was the hardest aspect of learning the words. A mixed regression showed that passive word recall was most reliably predicted by non-lexical pitch sensitivity, musical experience and working memory, but crucially, not by L1 tone experience (**Figure 2**). Yet, L1 tone experience did affect performance for specific tones: Mandarin speakers predominantly confused mid-level tones with low-level tones (a contrast that does not exist in Mandarin tone phonology), whereas English speakers confused all tones across the board (**Figure 3**). This particular finding shows categorical perception effects from L1 phonology, in line with speech-learning models like the Perceptual Assimilation Model [7], and highlights how L1 tone experience can actually impede the learning of specific tones for tone language speakers. The results from the productive word recall were largely symmetrical with those of the passive word recall, both in terms of the individual speaker factors contributing to word recall success, as well as in terms of the error patterns.

We propose an 'L1-Modulated Domain-General Account' as a new theoretical account for the learning of tone in a second language: this account posits that the acquisition of tone in general is facilitated by non-linguistic factors such as non-lexical pitch sensitivity and working memory, but that the acquisition of certain tones may be constrained due to mismatches between L1 and L2 tone phonology.

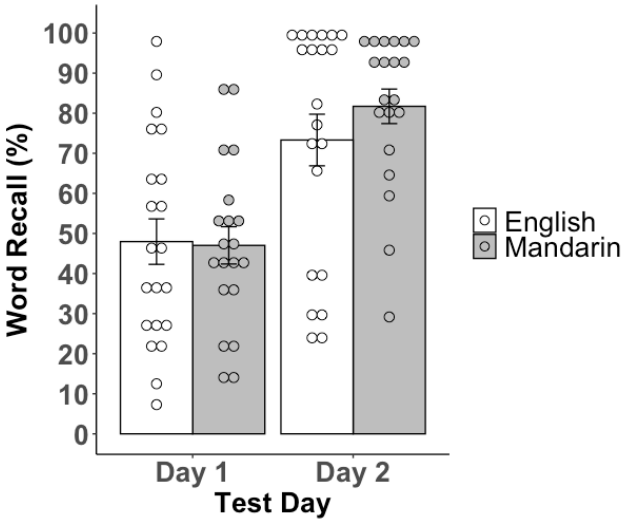

Figure 1: *Passive Word Recall Accuracy per Group*

Model Summary	[$F(4,36) = 15.394$, $p < 0.0001$, $R_2 = 0.631$]		
Coefficients	*Coefficient*	*t-statistic*	*p-value*
Non-Lexical Tone Identification	.502	4.266	< **0.001**
Working Memory	.369	3.268	< **0.01**
Musical Experience	.271	2.390	< **0.05**
L1 Tone Experience	-.033	-.299	> 0.05

Figure 2*: Mixed Regression Predicting Passive Word Recall for all Participants on Day 2*

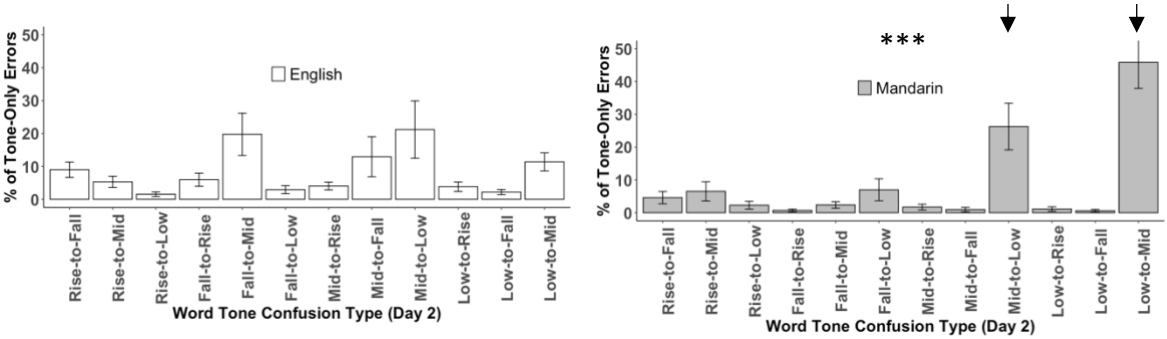

Figure 3: *Mandarin speakers predominantly confused level tones with one another. (72.12% of all Tone-Only Errors)*

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