

The combined effect of aging and L1 interference: Cross-situational learning of non-native tones in older adults

Yin-To Chui¹, Quentin Zhen Qin¹

¹*The Hong Kong University of Science and Technology*

Cross-situational word learning (CSWL) allows learners to acquire vocabulary under referential ambiguity [1], yet this mechanism is constrained by the ability to encode phonological detail. Previous research shows learners exhibit significantly lower accuracy on Minimal Pair (MP) trials (where target and distractor words differ by a single segment) compared to distinct Non-Minimal Pair (Non-MP) trials [2]. This challenge is magnified in L2 acquisition where the L1 acts as a perceptual filter [3], and CSWL performance further drops when target sounds in MP trials are perceptually assimilated into a single L1 category [4]. A recent study on suprasegmental contrasts reported similar findings, where Cantonese speakers performed worse on Tone-MP trials than Non-MP trials when the target language was Mandarin [5]. They struggled specifically for the high-level (T1) - falling (T4) target-distractor pair, which is likely assimilated onto a single Cantonese high-level category. However, it remains unknown how this L1 interference interacts with healthy aging. While CSWL remains functional in older adulthood for phonologically distinct words [6, 7], learners generally exhibit flatter trajectories. This study investigates whether aging exacerbates the known L1-based difficulty of L2 tonal contrasts – potentially stalling learning entirely compared to distinct words – and whether the specific T1-T4 confusion persists in older adulthood.

Fifty-five cognitively healthy older L1-Cantonese speakers (Mean age = 64.7; <1 year formal Mandarin training) participated. We employed a CSWL paradigm adapted from [5], with nine novel word-object mappings (**Figure 1**), doubling the training trials to accommodate older learners' processing needs. Stimuli were disyllabic pseudowords (e.g., /pati/), where the first syllable (i.e., the target) was produced with three Mandarin tones (high-level T1, rising T2, falling T4). Mappings created two conditions: Tone-MP (e.g., /pa1ti1/ vs. /pa4ti1/), and Non-MP (e.g., /pa1ti1/ vs. /ji1ko1/). Participants completed a training phase (8 blocks) identifying referents in a 2-alternative-forced choice (2AFC) task, followed by a test phase (1 block) in a 3AFC task (**Figure 2**). On Tone-MP trials, the distractor(s) were the referent(s) for the other tonal variations of the base syllable, forcing identification solely based on tonal cues.

A GLMM on training accuracy revealed a significant Block $\times$ Trial Type interaction ($\beta = 0.19$, $SE = 0.03$, $p < .001$). While Non-MP learning was robust ($p < .001$), the Tone-MP trajectory was constrained (**Figure 3**). Specifically, Tone-MP accuracy began at chance ($p = .578$) and only reached above-chance levels by Block 8 ($p = .003$), indicating that learning occurred but required extensive exposure. Test phase accuracy was significantly lower for Tone-MP than Non-MP trials ($\beta = -0.76$, $SE = 0.08$, $p < .001$). Crucially, error analysis revealed a specific asymmetry (**Figure 4**): accuracy for T1 targets was significantly lower than for T2 or T4 ($p < .001$). T1 targets also elicited significantly more T4 errors than T2 errors ($p < .001$), mirroring the confusion pattern of younger adults [5] and confirming perceptual assimilation.

While general CSWL abilities are preserved in aging [1, 2] – evidenced by robust Non-MP learning – our data highlights the high efficiency cost imposed by L1 phonology. The specific T1-T4 confusion indicates a persistent perceptual ambiguity, which likely constrained the accumulation of statistical evidence during training. Unlike younger learners who show a steeper improvement [5], older adults remained near chance for most of the training, only achieving successful learning after extensive exposure (Block 8). This suggests that while L2 tonal contrasts remain learnable in late adulthood, the combined load of aging and perceptual assimilation resulted in a significant hurdle to resolve referential ambiguity. Future work will directly compare tonal versus segmental CSWL to confirm if L2 tones pose a unique bottleneck compared to segments.

		Tone-MP		
Non-MP		T1-T1	T2-T1	T4-T1
	/leifa/			
	/jiko/			
	/pati/			

Fig. 1. The 9 pseudowords and their corresponding referents used for the current study.

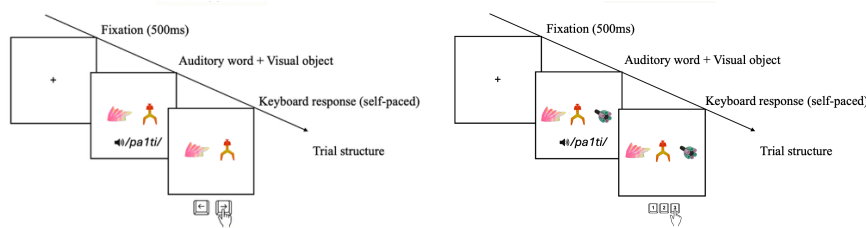


Fig. 2. (Left) Schematic representation of a trial in CSWL training (576 trials over 8 blocks). Target and Distractor occur at a 8 :1 contingency. (Right) Schematic representation of a trial in CSWL test (54 trials over 1 block). No inter-trial interval for either task as the tasks are self-paced. The item order of presentation is randomized for participants.

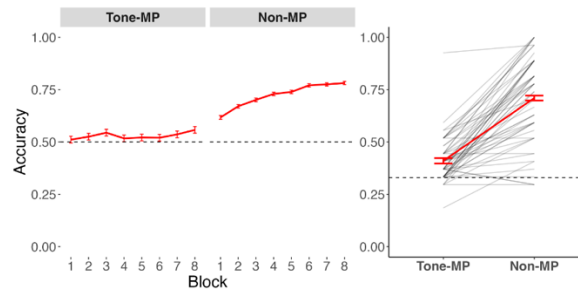


Fig. 3. Performance in (Left) CSWL training, and (Right) CSWL test across trial types.

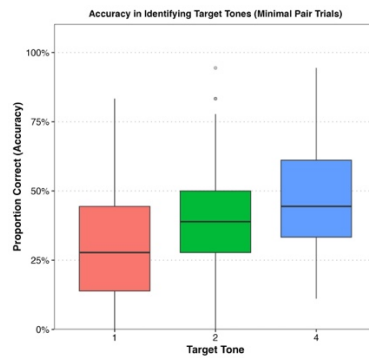


Fig. 4. Accuracy in identifying target tones. Boxplots: median, IQR, whiskers (1.5×IQR). Dots: outliers.

References

- [1] Yu, C., & Smith, L. B. (2007). Rapid word learning under uncertainty via cross-situational statistics. *Psychological science*, 18(5), 414-420.
- [2] Escudero, P., Mulak, K. E., & Vlach, H. A. (2016). Cross-situational learning of minimal word pairs. *Cognitive Science*, 40(2), 455-465.
- [3] Escudero, P., Smit, E. A., & Mulak, K. E. (2022). Explaining L2 lexical learning in multiple scenarios: cross-situational word learning in L1 Mandarin L2 English speakers. *Brain Sciences*, 12(12), 1618.
- [4] Tuninetti, A., Mulak, K. E., & Escudero, P. (2020). Cross-situational word learning in two foreign languages: effects of native language and perceptual difficulty. *Frontiers in Communication*, 5, 602471.
- [5] Chui, Y. & Qin, Z. (2026). The role of L1 tonal experience in cross-situational learning of non-native tone contrasts. In *Proceedings of the 13th International Conference on Speech Prosody (Speech Prosody 2026)*, Philadelphia, United States.
- [6] Ge, Y., Correia, S., Lee, Y. W., Jin, Z., Rothman, J., & Rebuschat, P. (2025). Statistical learning of foreign language words in younger and older adults. *Bilingualism: Language and Cognition*, 28(3), 716-727.
- [7] Bulgarelli, F., Weiss, D. J., & Dennis, N. A. (2021). Cross-situational statistical learning in younger and older adults. *Aging, Neuropsychology, and Cognition*, 28(3), 346-366.