The Effect of Sibilant Merger on Phoneme Categorization in Taiwan Mandarin

The Ganong lexical effect has been widely replicated (Ganong, 1980) in speech perception. This effect has been further investigated to examine factors such as word frequency (Connine et al., 1993; Politzer-Ahles et al., 2020) and markedness (Yang et al., 2022). In a recent study by Soo & Babel (2023), tonal continua with tonal categories at two ends undergoing merger in Cantonese were tested using the same methodology. Their findings revealed a greater acceptance of variation when one end of the continuum was a tonal gap, while categoricity was maintained when both ends were words. This demonstrates a lexical competition effect in relation to tonal merger. Building upon these previous research, the current study focuses on the interplay between the lexicality effect and the dynamic nature of sound change in the context of phoneme merger. Specifically, we investigate how native listeners categorize the alveolar-retroflex sibilants in Taiwan Mandarin (TM).

It has been well-documented that in TM, the alveolar sibilants /s ts ts^h/ and retroflex sibilants /ʂ tʂ $tʂ^h$/ are undergoing a process of merger. This merger primarily involves the *de-retroflexion* of the retroflex category (Kubler, 1985; Ing, 1984). The sibilant merger has been reported to span a broad spectrum, ranging from complete merger and clear contrast (Lee-Kim & Chou, 2022), resulting in an ambiguous phoneme boundary. This study aims to address several questions: 1) To what extent is the identification of alveolar-retroflex sibilants in TM affected by the lexical effect? 2) Is the merger also subject to lexical competition? 3) Does the high exposure to alveolar sibilants resulting from de-retroflexion affect sibilant identification? By examining these factors, the study aims to provide insights into the intricate relationship between lexicality, frequency, and phoneme categorization in TM.

A two-alternative forced-choice identification experiment was conducted using stimuli sampled from various alveolar-retroflex sibilant continua, with words on both ends or either end (i.e., word-word, gap-word, word-gap). To date, 10 Taiwan Mandarin speakers (5 female, 5 males; aged 20-28, *M* = 22.9) have been recruited for the experiment. The experiment involved 18 minimal pairs of disyllabic words (alveolar COG mean= 9955.76 Hz ; retroflex COG mean= 5473.51 Hz), with 6 targeted Mandarin sibilants (/s/ <s> – /ʂ/ <sh>, /ts/ <z> – /tʂ/ <zh>, /ts^h/ <c> – /$tʂ^h$/ <ch>) in the word-initial position (e.g., word-word: *zānghuà* ‘profanity’ vs. *zhānghuà* ‘Changhua city’; gap-word: **sénjīng vs. shénjīng* ‘nerve’; word-gap: *cǎihóng* ‘rainbow’ vs. *chǎihóng). Participants responded to alveolar or retroflex sibilants by pressing a corresponding key on the keyboard. The experiment involved 126 resynthesized stimuli (3 continua × 3 pairs × 7 steps × 2 items) using Tandem-Straight (Kawahara et al., 2008), which were randomly presented to the participants using E-Prime (Schneider et al., 2012).

A mixed-effect logistic regression model was fit using the *lme4* package in R with alveolar/retroflex responses as the dependent variable (‘retroflex’ coded as 1), and continua (‘word-word’ as baseline), step (centred) and their interaction as determiners. We also incorporated the random intercepts and slopes for participants. The findings (Figure 1) emphasize a significant expansion of the endpoint category that made words (green dotted and blue dashed lines in Figure 1), demonstrating a strong lexical effect. Significant continua effects were observed for both the word-gap (β = -1.68, p = .038) and gap-word (β = 2.99, p < .001) continua, with

reference to the word-word continuum. This effect is particularly notable as it extends to the end points of the continua. Furthermore, an early shift (i.e., stronger lexicality effect) towards retroflex responses at the alveolar gap ends (i.e., gap-word continua) was observed. We attribute this to the deretroflexion process: the gaps with alveolar sibilants are likely to be perceived as "de-retroflexed" variants of retroflex and treated as retroflex words. Conversely, in continua with words at both ends, the frequency effect becomes more pronounced, resulting in a preference for the high-frequent alveolar ends. These findings indicate a strong dependency on the lexicality status in the case of phoneme merger, underpinning the influence of top-down linguistic knowledge on listeners' perception during the dynamic merging process. The frequency effect, on the other hand, becomes more prominent in the absence of a lexical effect, leading to a bias towards the high-frequent end.

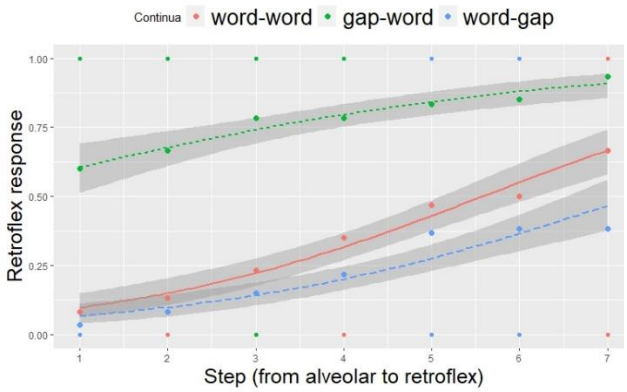

Figure 1: The aggregated and estimated proportion of retroflex sibilants responses as a function of Step and Continua.

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