A dynamic neural model of the interaction between social and lexical influences on speech production: the case of retroflex sibilants in Taiwan Mandarin.

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Speakers of Taiwan Mandarin navigate two types of stigmas associated with retroflex sibilants. Extreme retroflexion, which facilitates contrast with alveolar sibilants, is stigmatized as a marker of mainland China. Absence of retroflexion leads to merger with alveolar sibilants, an historically stigmatized pattern. Speakers who merge sibilants in some situations have been shown to de-merge when interacting with a non-merged experimenter (Lee-Kim & Chou 2022), a result we interpret as an effect of social expectation priming (e.g., Wade 2022). Our aim in this study is to model the cognitive mechanism underlying the interaction between contrast maintenance and social context.

Our approach builds on Stern & Shaw (2022/2023), who use a Dynamic Neural Field (DNF) (e.g., Schöner & Spencer 2016) to model contrastive hyperarticulation as a consequence of neural inhibition—a minimal pair competitor inhibits a portion of the DNF, effectively repelling speech planning away from the competitor. We incorporate social context by modeling expectation priming as an excitatory input to a DNF (see also Yi et al. 2023), driving neural activation towards social expectations.

We ran 500 simulations of retroflex productions for each of the three interactive conditions reported in Lee-Kim & Chou (2022) (see Table 1) as well as in corresponding non-interactive (no expectation priming) situations. We assume the relevant dimension of variation for retroflex sibilants is the length of the vocal tract cavity in front of the source of turbulence, i.e., front cavity length. We derived measures of front cavity length from the maximum amplitude frequency of retroflex fricative spectra in Lee-Kim & Chou's data. These measurements define Gaussian-shaped inputs to the DNF centered on 25 mm for the retroflex target; 13 mm for the alveolar competitor; and 40 mm (extreme retroflexion) for the social priming input. In each simulation, neural activation evolves over time under the influence of these inputs until an activation peak forms.

Figure 1 shows field evolution for retroflexes without minimal pair competitors (Fig. 1a), with minimal pair competitors (Fig. 1b), and with minimal pair competitors salient in the interactive context (Fig. 1c). Figure 2 shows box plots aggregating across 500 simulations of each condition. With no interlocut0r (Fig. 2: left), there is a small difference between conditions, consistent with past work on contrastive hyperarticulation (Baese-Berk & Goldrick, 2009; Wedel et al. 2018). In the interactive condition, neural activation peaks at a significantly more retroflexed location due to social priming, but only in the salient competitor condition. The interaction arises because strong inhibition of the alveolar (in the salient competitor condition) suppresses activation of the speaker's typical retroflex, allowing the field to evolve towards the social expectation input. This pattern of results matches the trends reported Lee-Kim & Chou (2022), who found significantly more retroflexed sounds only when there was a contextually salient minimal pair competitor.

With increasing attention to the cognitive mechanisms through which sociolinguistic variation is processed (e.g., Chevrot, Drager, Foulkes 2018), DNF models show promise for integrating linguistic and social influences on variation using cognitively plausible mental representations of both. **(493 words)**

Table 1: Example experimental stimuli, adapted from Lee-Kim & Chou (2022). The leftmost column identifies the experimental condition. In the no competitor condition, the target has no minimal pair in the lexicon. In the competitor condition, the minimal pair exists, but is not presented to the speaker. In the salient competitor condition, both the target and the minimal pair competitor are presented.

Condition	Target	Filler (presented alongside target)
No competitor	/ʂan^{214} tuə^{214}/ ‘dodge’	/tɕy^{55} kəŋ^{55}/ (*/ʂan^{214} tuə^{214}/) ‘bow’
Competitor	/ʂan^{55} tɕiaʊ^{214}/ ‘hillside’	/piŋ^{55} xə^{35}/ ‘iceberg’
Salient competitor	/ʂan^{55} tɕiaʊ^{214}/ ‘hillside’	/san^{55} tɕiaʊ^{214}/ ‘triangular’

Figure 1: Single trial simulations from each condition. Input locations are at 25 mm for the retroflex target, 40 mm for social expectation, and 13 mm (inhibitory) for the alveolar. (a) shows no alveolar inhibition; (b) shows weak inhibition and (c) shows strong inhibition.

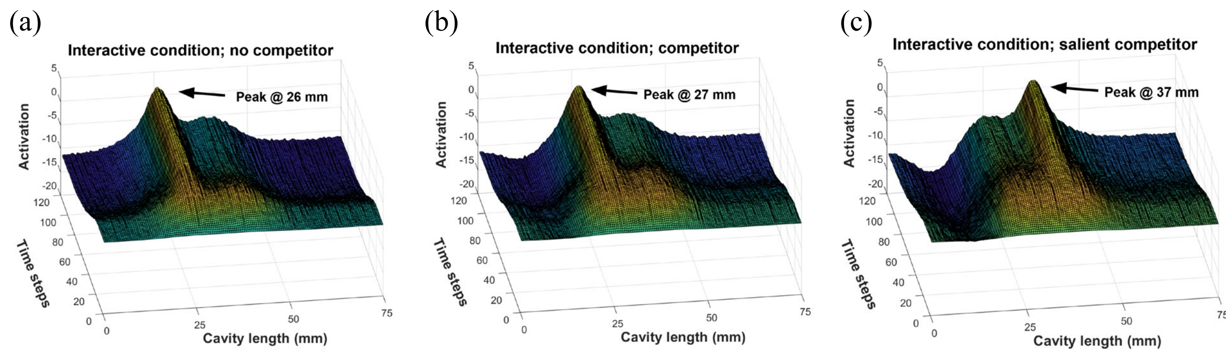
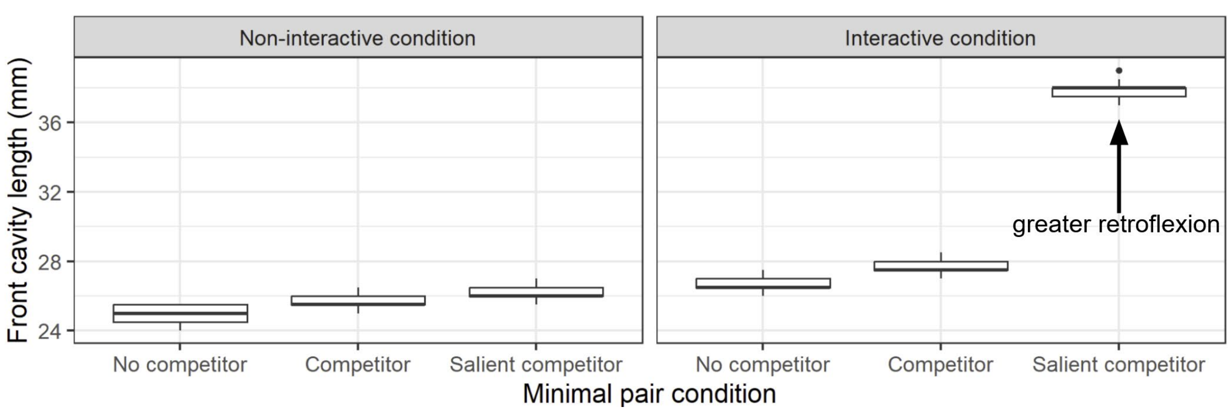


Figure 2: Each box shows 500 simulated DNF evolutions of retroflex production planning. Left panel shows the non-interactive condition (no expectation priming); right panel shows the interactive condition, corresponding to the single trial simulations in Figure 1. Longer front cavity lengths (y-axis) indicate greater retroflexion.



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