Testing the role of phoneme order in lexical access using transposed-phoneme priming

Introduction: Some influential models of spoken word recognition, such as the cohort model (Marslen-Wilson and Welsh 1978; Marslen-Wilson 1987), ascribe considerable importance to the sequential order of elements in the acoustic signal for lexical access. Recent work using the visual world paradigm, however, challenges this assumption: Toscano et al. (2013) found that listeners fixate more on distractors that comprise phonemic anadromes of the target (e.g. target *sub*, distractor *bus*) than on distractors which share the target's onset and nucleus (e.g. *sun*) and unrelated distractors (e.g. *well*), suggesting that listeners consider lexical candidates that consist of a set of phonemes, regardless of order. To further explore the effects of different re-orderings of the acoustic signal, we adapt the visual transposed-letter priming paradigm for auditory lexical decision. In visual lexical decision, readers judge words faster when primed by nonce letter strings formed by transposing two of the target's letters (e.g. *nakpin* primes *NAPKIN*; Lee and Taft 2009). We test for "transposed-phoneme" (TP) priming: that is, whether listeners judge words faster when primed by nonce auditory strings formed by transposing two of the target's phonemes.

Methods: Thirty native monolingual English speakers judged the lexicality of 72 auditorily-presented CVCCVC English words and 72 CVCCVC non-words. Stimuli were presented in DMDX (Forster and Forster 2003) using the auditory masked priming paradigm (Kouider and Dupoux 2005; Schluter 2013). Real-word targets occurred in six priming conditions: repetition (e.g. prime/target *biscuit* [bɪskət]), initial-consonant transposition (TP-12; e.g. prime [**s**ɪ**b**kət]), final-consonant transposition (TP-34; e.g. prime [bɪs**t**ə**k**]), inner-consonant transposition (TP-23; e.g. prime [bɪ**ks**ət]), outer-consonant transposition (TP-14; e.g. prime [**t**ɪskə**b**]), and control (e.g. prime [rænʤəm]). Phonotactically legal non-words comprised all of the non-repetition primes.

Results: We conducted a linear mixed-effects regression analysis to analyze RTs to real-word targets using the lme4 package (Bates et al. 2015) in R (R Core Team 2017) and using the lmerTest package (Kuznetsova et al. 2016) to simulate Satterthwaite approximations for degrees of freedom to assess significance. The model included negative reciprocal RT (-1000/RT) from target onset as the dependent variable; priming condition (reference level: the control condition), target frequency using SUBTLEX-US log contextual diversity values (Brysbaert and New 2009), and target duration as fixed effects; and subjects and targets as random effects. We found that participants responded significantly faster in the repetition ($t(1{,}781) = -8.70$, $p < 0.001$; $M = 908$ ms), TP-12 ($t(1{,}781) = -4.22$, $p < 0.001$; $M = 945$ ms), TP-34 ($t(1{,}781) = -2.76$, $p < 0.01$; $M = 954$ ms), and TP-23 conditions ($t(1{,}781) = -3.10$, $p < 0.005$; $M = 967$ ms) than in the control condition ($M = 989$ ms). In contrast, the effect of priming in the TP-14 condition was not significant ($t(1{,}781) = -1.92$, n.s.; $M = 968$ ms), suggesting that the length of the transposition constrains TP priming.

Discussion: We obtained significant facilitatory priming by nonce acoustic strings formed by transposing the segments of the target word, reinforcing that words may be activated by strings which contain the same phonemes regardless of their order (cf. Toscano et al. 2013). Our results challenge assumptions that a strict ordering of phonemes is essential to lexical access, such that changes to this ordering disrupt processing: as in vision, spoken word recognition is robust to (some) transpositions. Moreover, they validate the use of auditory masked priming for further investigating the effects of different transpositions on word recognition (e.g. short- versus long-distance transpositions). Further, the facilitatory priming in the TP-12 condition challenges claims that metatheses which involve segments at the beginning of a word are rare cross-linguistically because such metatheses disrupt lexical access (Hume 2001; Mielke and Hume 2001).

Previous studies using auditory masked priming have not found priming by strings which simply overlap in form with the target, but such studies have used real words as form overlap primes (e.g. Davis et al. 2010; Kouider and Dupoux 2005; Schluter 2013). In an ongoing second experiment, we investigate the contribution of form overlap to the observed TP priming effect by comparing priming by nonce strings formed by phoneme-transposition versus ones formed by replacing one of the target's phonemes (e.g. [**s**ɪ**b**kət] versus [**n**ɪskət] priming *biscuit* [bɪskət]).

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