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

Jonathan Geary
jonathangeary@email.arizona.edu
University of Arizona

THE UNIVERSITY OF ARIZONA

1. Introduction

Does spoken word recognition tolerate changes to the order of parts of the acoustic signal (e.g. phonemes)?

In speech (unlike writing), the signal unfolds across time. Consequently, the order of phonemes *should* matter.

I In the **cohort model** (Marslen-Wilson and Welsh 1978 et seq.), order in the acoustic signal constrains lexical activation: (1) listeners activate an initial cohort of candidates based on the first segment of the acoustic signal, and then (2) reduce the candidate set as subsequent phonemes are processed.

Changes to the order of phonemes will (1) activate a different initial cohort and/or (2) deactivate different candidates.

II **Metathesis** (i.e. change to the order of speech segments; e.g. *metathesis* > *methatesis*) is a rare process across the world's languages. Metatheses involving (1) early or (2) non-adjacent sounds are especially rare, perhaps because they more severely disrupt lexical access (Hume 2001; Mielke and Hume 2001).

Using the **visual world paradigm**, Toscano et al. (2013) found that listeners fixate more on **phonemic anadromes** of the target (e.g. *gum*, target: *mug*) than on onset-overlap (e.g. *mud*) and unrelated distractors (e.g. *fish*). **Listeners consider lexical candidates consisting of a given set of phonemes, regardless of their actual order.**

Present Study: We adapt **transposed-letter priming** for use with auditory lexical decision to further explore the contribution of phoneme order to auditory lexical access.

Readers are faster to recognize words following a prime formed by transposing two target letters (e.g. *anwser*, priming *ANSWER*) (Forster et al. 1987). Greater distance between the transposed letters reduces the priming effect (Perea et al. 2008).

Are comparable distance effects observed in spoken word recognition? The visual world paradigm cannot test this, nor the effects of early versus late transpositions (cf. Hume 2001), because of the requirement that distractors be real words.

We test for **transposed-phoneme (TP) priming** (e.g. [bɪksət] priming *biscuit* [bɪskət]) using **auditory masked priming**, which does not require that primes be real words.

2. Methods

Thirty monolingual English speakers (all undergraduates at UA) completed an auditory lexical decision task.

Target items included 72 real English words and 72 non-words. All targets and primes had a CVCCVC structure.

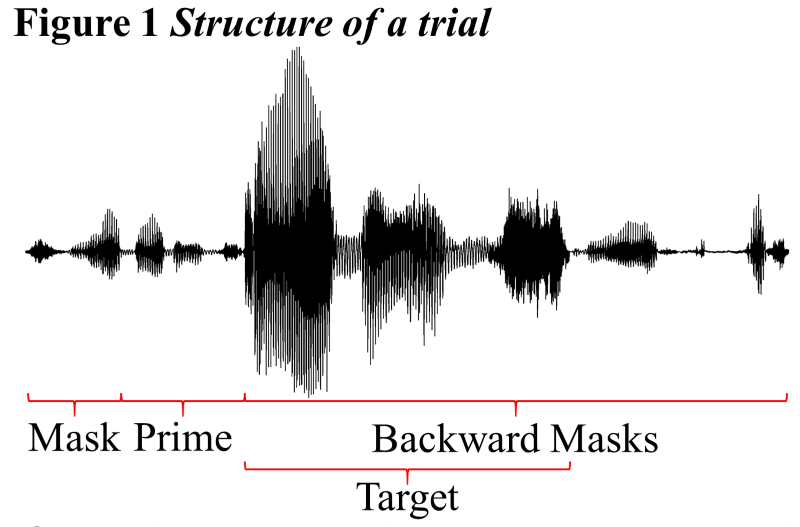
Real-word targets occurred in six priming conditions:

- **Repetition** e.g. *biscuit* [bɪskət], priming *biscuit* [bɪskət]
- **Initial transposition (TP-13)** e.g. *sibcuit* [sɪbkət]
- **Final transposition (TP-46)** e.g. *bistuic* [bɪstək]
- **Inner transposition (TP-34)** e.g. *bicsuit* [bɪksət]
- **Outer transposition (TP-16)** e.g. *tiscuib* [tɪskəb]
- **Unrelated** e.g. *ranjom* [rændʒəm]

All **non-repetition** primes comprised phonotactically-legal non-words. The **TP** primes were formed by transposing two of the target word's consonant phonemes.

Items were presented using the auditory masked priming paradigm (Kouider and Dupoux 2005; Schluter 2013) in DMDX (Forster and Forster 2003). Primes were masked by being:

Figure 1 ***Structure of a trial***



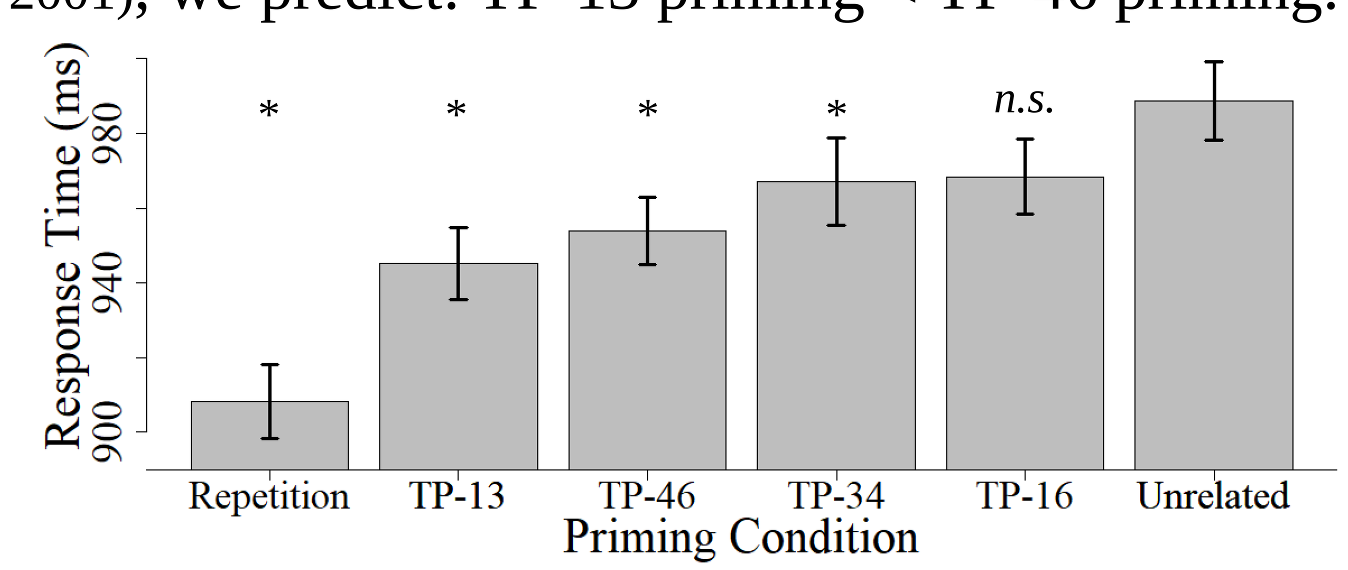
(1) compressed to 240 ms;
(2) amplitude-attenuated;
(3) embedded in a series of "masks" (Figure 1).

We recorded and analyzed RT from target onset.

If spoken word recognition tolerates some reordering of phonemes, we should find some TP priming. Moreover:

I If TP priming is sensitive to distance/adjacency, we predict: TP-16 priming < TP-13, TP-46 < TP-34.

II If TP priming is sensitive to segment position (cf. Hume 2001), we predict: TP-13 priming < TP-46 priming.



An asterisk "*" indicates that the difference in RT relative to the Unrelated condition is significant ($p < 0.05$). The difference between any of the TP conditions is not significant.

3. Results

RTs to real-word targets were analyzed in R using a linear mixed effects regression analysis (lme4; Bates et al. 2015).

lmer(−1000/RT ~ prime + duration + log(CD) + (1|Subjects) + (1|Targets))

RTs were significantly faster in the **Repetition** ($t(1,781) = -8.70$, $p < 0.001$; $M = 908$ ms), **TP-13** ($t(1,781) = -4.22$, $p < 0.001$; $M = 945$ ms), **TP-46** ($t(1,781) = -2.76$, $p < 0.01$; $M = 954$ ms), and **TP-34** conditions ($t(1,781) = -3.10$, $p < 0.05$; $M = 967$ ms) than in the Unrelated condition ($M = 989$ ms).

Priming in **TP-16** condition was not significant ($M = 968$ ms).

4. Discussion

Facilitatory TP priming further supports that **auditory word recognition tolerates some variance in the order of phonemes in the acoustic signal** (cf. Toscano et al. 2013).

The lack of TP-16 priming may reflect a distance constraint, as is found with transposed-letter priming (Perea et al. 2008).

These results are inconsistent with (1) the cohort model and (2) processing-based explanations for patterns of metathesis (Hume 2001; Mielke and Hume 2001), since both early and non-adjacent transpositions permit TP priming effects.

Future: Does TP priming reflect partial, contiguous overlap?

We will test this with CVCVC words, comparing priming by TP primes (e.g. *vasage* [væsɪdʒ], priming *savage* [sævɪdʒ]) versus form-overlap primes (e.g. *gavage* [gævɪdʒ]) which exhibit greater contiguous overlap with the target.

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