Pre-attentive processing of duration contrasts

Sandra Kotzor, Adam Roberts, Allison Wetterlin & Aditi Lahiri

Language and Brain Laboratory, University of Oxford

Introduction

Many languages use consonantal duration to distinguish meaning. Most commonly, this contrast between long (geminate) and short (singleton) consonants is seen word medially like in the following example from Bengali:

[kana] 'blind' vs. ***[kan:a]*** 'tears'.

The primary acoustic cue for this contrast is the duration of the consonant as the geminate-singleton contrast in Bengali is independent of other cues which can contribute to the identification of consonant duration (e.g. pitch in Japanese).

Previous work has shown listeners to be extremely sensitive to any change in duration and the MMN shows language-specific effects during the early stages of speech processing (e.g., Näätänen et al., 1997; Pulvermüller & Shtyrov, 2006).

Previous investigations of the Bengali geminate-singleton contrast have found a processing asymmetry where a nonword with a long consonant duration is accepted in place of the real word (**[ken:a]* for *[kena]*) but not vice versa (**[g^{h}ena]* for *[g^{h}en:a]*). This asymmetry is attributed to a difference in specificity in phonological representations and should be evident in MMN responses if those representations are accessed during early processing (cf. Phillips et al., 2000).

Research Question

Is the detection of the geminate-singleton contrast in pre-attentive processing based purely on acoustic properties or are long-term phonological representations involved in this process?

Experimental Design

	Experiment 1 (*real word singleton*)		Experiment 2 (*real word geminate*)	
	Standard	Deviant	Standard	Deviant
A	[kena]	*[ken:a]	[g^{h}en:a]	*[g^{h}ena]
B	*[ken:a]	[kena]	*[g^{h}ena]	[g^{h}en:a]

- standard-deviant reverse paradigm with two disyllabic Bengali word-nonword pairs which differ only in medial consonant duration (600 trials per experiment)
- four tokens of each stimulus recorded and digitally modified to control for whole word duration, vowel duration and medial consonant duration
- MMN analysis time-locked to the beginning of the medial consonant ([n])
- 28 Bengali native speaker listeners

Hypotheses and Predictions

Acoustic duration

- Previous research has shown that both short and long duration deviants elicit MMN responses.
- Amplitude and latency differences between shorter and longer deviants are also expected with longer stimuli resulting in earlier and higher MMNs.

➔ On a purely acoustic basis, [kena] and *[g^{h}ena] should pattern together while geminates *[ken:a] and [g^{h}en:a] should both show similar MMNs which may be higher and peak earlier than those of the singletons.

Lexical effect

- MMNs have also been shown to be sensitive to differences in long-term memory traces (i.e. lexical representations) and can reveal information about phonological representations (Näätänen et al., 1997 & Näätänen et al., 2007 for a review; Eulitz & Lahiri, 2004).

➔ Real words, which allow access to long-term memory traces, should result in higher, earlier MMN responses while those stimuli which cannot activate a lexical representation are expected to be later and lower.

Results

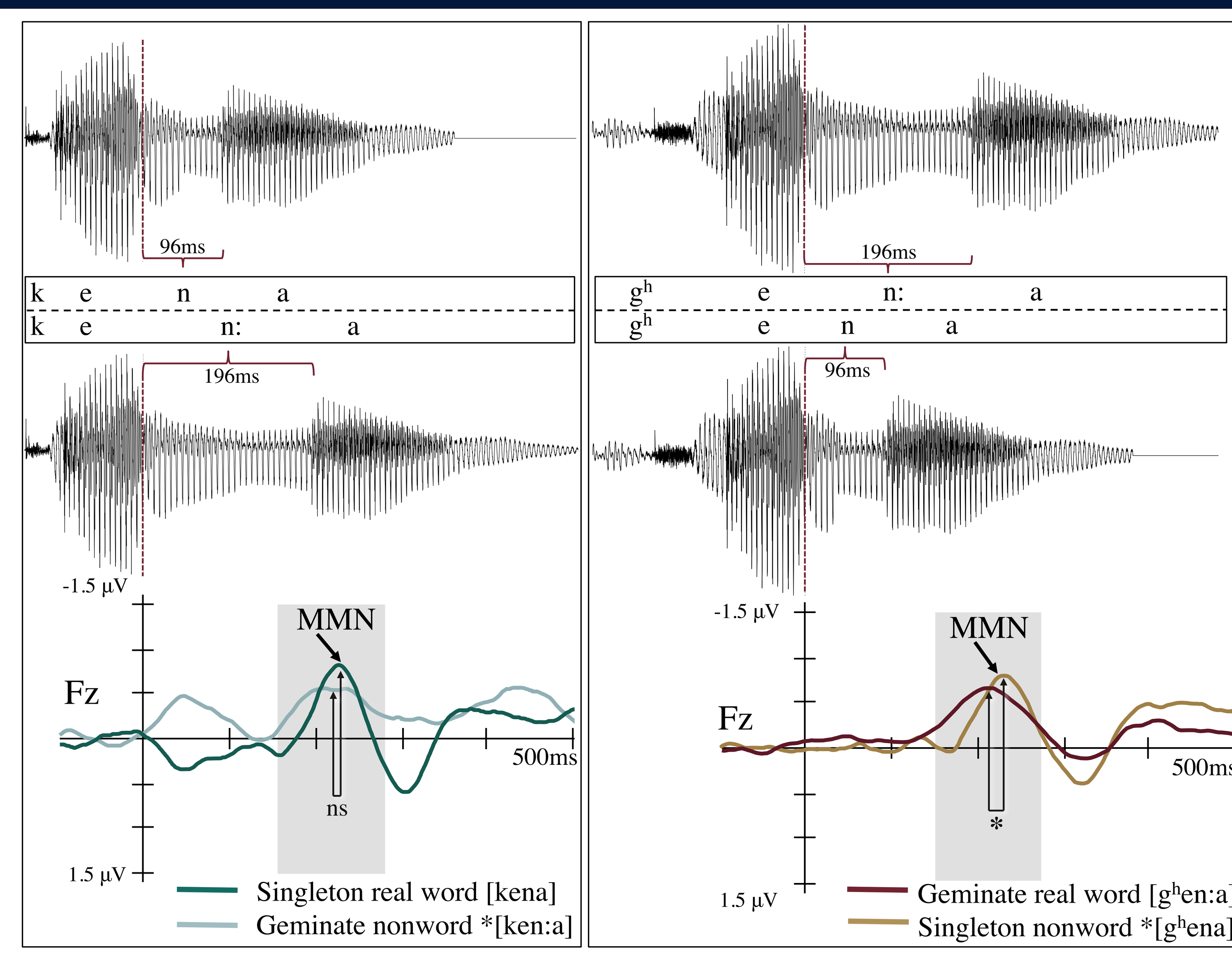

Figure 1 *Acoustic waveforms for both stimulus pairs ([kena]/*[ken:a] & [g^{h}en:a]/*[g^{h}ena]) aligned with MMN waveforms illustrating the latency difference between [g^{h}en:a] and *[g^{h}ena]*

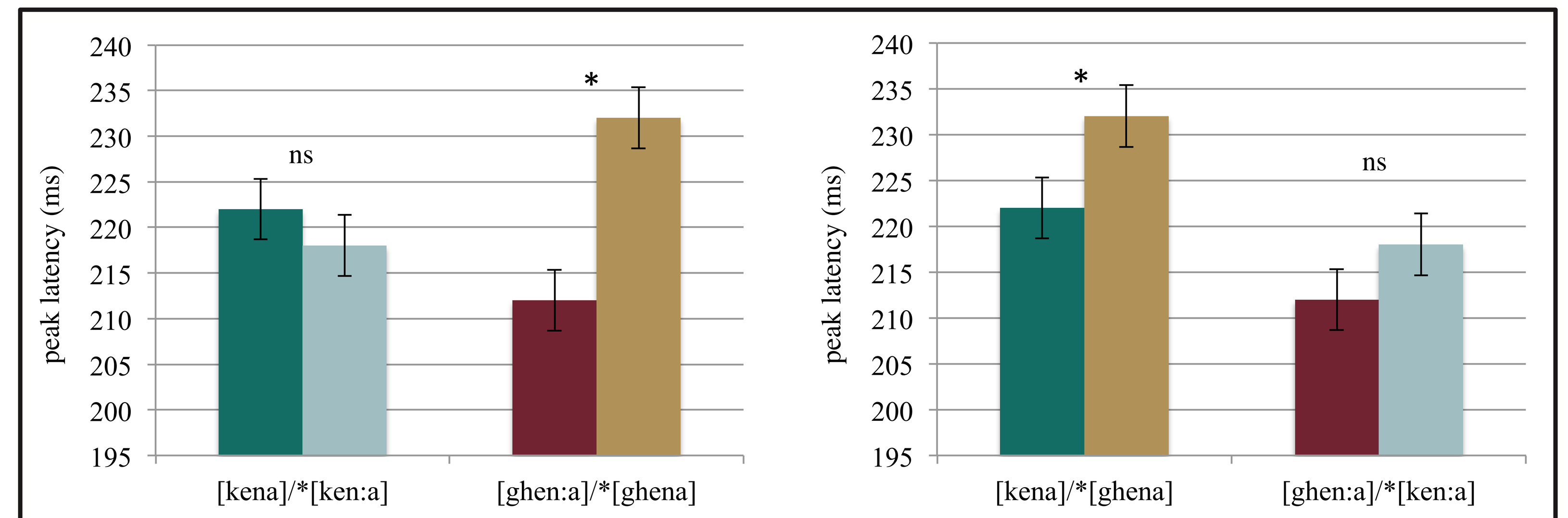

Figure 2 *Peak latency comparisons measured at anterior electrodes (Afz, Fz, FCz, and Cz) in word-nonword comparison (2a) and geminate-singleton comparison (2b)*

- all deviants elicited an MMN response
- no amplitude difference between geminate-singleton or word-nonword deviants
- latency difference significant between [g^{h}en:a] and *[g^{h}ena] but not between [kena] and *[ken:a]
- significant latency difference between [kena] and *[g^{h}ena]

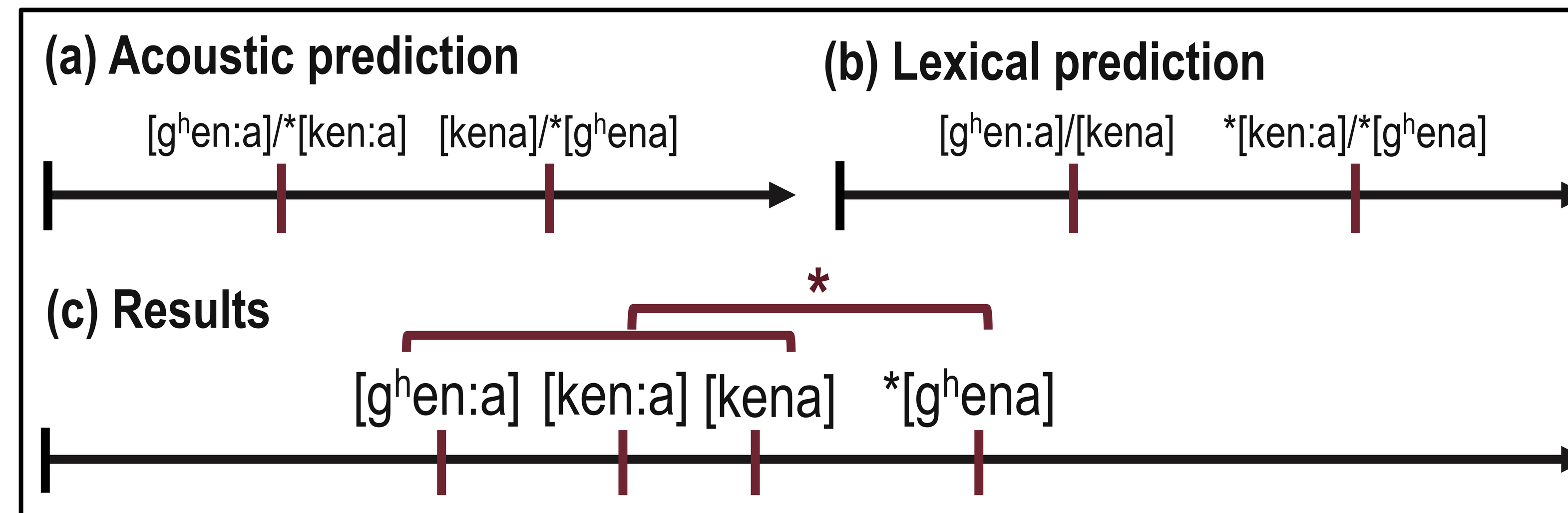

Figure 3 *Peak latency predictions for acoustic (a) and lexical (b) hypotheses in comparison with experimental latency results (c)*

Discussion

- The lack of amplitude differences is attributed to the identical degree of deviance between stimuli in addition to identical featural information.
- Latency differences show an interaction of both acoustic and lexical effects.
- In line with previous research, *[ken:a] does not differ significantly from the corresponding real word [kena] while this is not the case for [g^{h}en:a]/*[g^{h}ena].

While both geminate (nonword and word) stimuli peak earlier than their singleton counterparts, *[ken:a] is not significantly faster than the corresponding singleton real word [kena]. It thus seems likely that the MMN is also indicating a lexical effect driven by the ability to access a long term memory trace for some of the stimuli but not others.

Contact

http://brainlab.clp.ox.ac.uk/

sandra.kotzor@ling-phil.ox.ac.uk

Selected References

Eulitz, C., & Lahiri, A. (2004). Neurobiological evidence for abstract phonological representations in the mental lexicon during speech recognition. *Journal of Cognitive Neuroscience, 16(4),* 577–583.; **Hankamer,** J., Lahiri, A., & Koreman, J. (1989). Perception of consonant length: voiceless stops in Turkish and Bengali. *Journal of Phonology, 17,* 283–298.; **Kirmse** et al. (2008). Modulation of the mismatch negativity (MMN) to vowel duration changes in native speakers of Finnish and German as a result of language experience. *International Journal of Psychophysiology, 67,* 131–143.; **Näätänen** et al. (1997). Language-specific phoneme representations revealed by electric and magnetic brain responses. *Nature, 385*, 432–434.**; Näätänen**, R., Paavilainen, P., Rinne, T. & Alho, K. (2007). The mismatch negativity (MMN) in basic research of central auditory processing: A review. *Clinical Neurophysiology, 118*, 2544–2590.; **Phillips** et al. (2000). Auditory cortex accesses phonological categories: an MEG mismatch study. *Journal of Cognitive Neuroscience, 12(6),* 1038–1055.; **Pulvermüller**, F. & Shtyrov, Y. (2006). Language outside the focus of attention: The mismatch negativity as a tool for studying higher cognitive processes. *Progress in Neurobiology, 79*, 49–71.; **Roberts**, A. C., Kotzor, S., Wetterlin, A. & Lahiri, A. (2014). Asymmetric processing of durational differences - electrophysiological investigations in Bengali. *Neuropsychologia 58*, 88–98.; **Ylinen,** S., Huotilainen, M., & Näätänen, R. (2005). Phoneme quality and quantity are processed independently in the human brain. *NeuroReport, 16*, 1857–1860.

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