How long is long?

M100 response in Bangla tracks number of phonemes not graphemes of glyphs.

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References

[1] Pylkkänen et al., 2010 [2] Grainger et al., 2008
[3] Rastle el al., 2000 [4] Gwilliams el al., 2016
[5] Lewis et al., 2011 [6] Wray et al., 2022

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1 Introduction

- ▶ M170 typically taken as earliest stage of lexical processing [1,2,3]
- ▶ we show that M100 – typically thought as 'low-level' sensory processing – reflects earlier linguistic analysis, viz., mapping orthography to phonology

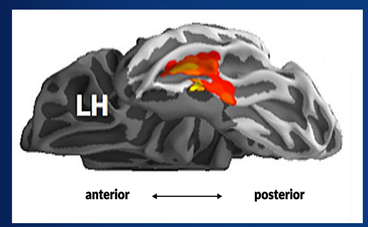

Fig 1a. Activity in the anterior left fusiform gyrus peaking around 170ms [4]

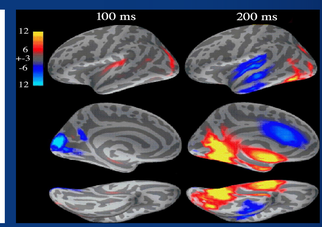

Fig 1b. grand averaged activity at 100 ms increments [5]

2 Questions

(1) Are M100/M170 responses universal?
(2) Does M100 reflect early stages of linguistic analysis, or only psychophysical responses to visual stimuli?

Bangla's script (abugida) has

a. each simple character corresponds to one consonant.
b. vowel ligatures are written on either side of the consonant, above, or below it.
c. some consonants have an unwritten "implicit" vowel.
d. some consonant clusters can be represented as a single complex character.

PROTEST	Word
P R O T E S T	Graphemes (7)
protest	Letters (7)
/prə'tɛst/	Phonemes (7)

প্রতিবাদ	Word
প্ র তি বা দ	Graphemes (4)
প্ ্ র ি ত ব া দ	Letters (7)
/p r ô t i b a d/	Phonemes (8)

distinct ways to quantify word length, e.g. প্র(prô)

i. 1 grapheme
ii. 2 glyphs: প্(p) and ্র(r)
iii. 3 phonemes: /p/,/r/,/ô/.

(3) Which measure of word length best correlates with the M100 response?
(4) Is a stem-to-whole word TP-effect observed in the M170 response?

3 Methodology

- ▶ MEG recordings, 22 Bangla speakers (18-62 years, X̄=28) lexical decision task.
- ▶ 152 morphologically complex grammatical words and 152 pseudowords.
- ▶ measures of length ◉ no. of graphemes, ◉ no. of glyphs (unicode derived, nchar() fn in R) and ◉ no. of phonemes
- ▶ TP was estimated as the log of lemma frequency to stem frequency.

4 Analysis

- ▶ 600ms epochs were extracted for each word.
- ▶ two-stage regression analysis : fit at each time-point and source point per subject for TP and word length.
- ▶ six regressions : TP + word length for 3 definitions of word length in two separate time windows.
- ▶ Spatio-temporal cluster-based permutation tests on the one-sample t-test values derived from the beta coefficient of the regressions in left fusiform gyrus in the M100 (100 - 130ms) and M170 (170 - 200ms) time window.

5 Preliminary Results and Findings

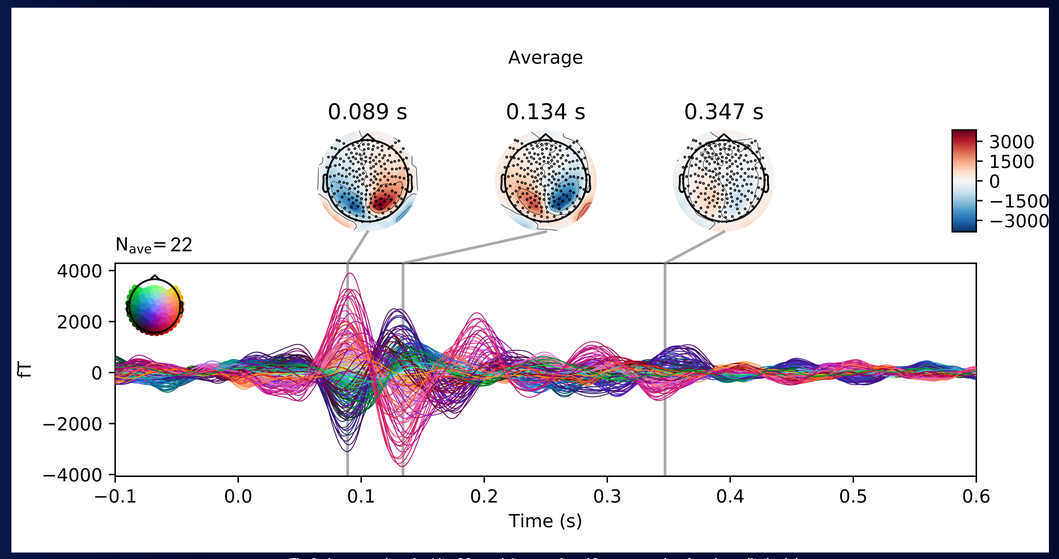

Fig 2. Average plots for N = 22 participants after 60ms correction for photodiode delay

Fig 3. Posterior Left Fusiform Gyrus cluster M100 (100-130ms) (p = 0.01)

Fig 4 Anterior Left Fusiform Gyrus cluster M170 (170-200ms) (p = 0.04)

After correction for multiple comparisons,

- ▶ only one word length cluster was significant (p = 0.01), corresponding to the number of phonemes in posterior left fusiform gyrus from 100ms-130ms.
- ▶ one TP cluster was significant and negatively correlated in anterior left fusiform gyrus from 170ms-200ms (p = 0.04).

6 Conclusions

- ▶ early visual responses to words suggest rapid analysis of abstract linguistic structure.
- ▶ **our results leverage the complexity of an abugida system to demonstrate that the M100 response is modulated by the number of phonemes in a writing system without a clear one-to-one phoneme-grapheme correspondence**
- ▶ the M170 reflects stem-to-word TP, consistent with results for other languages [6]