Automatic morpheme identification in reading development: MEG evidence from Fast Periodic Visual Stimulation

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Introduction

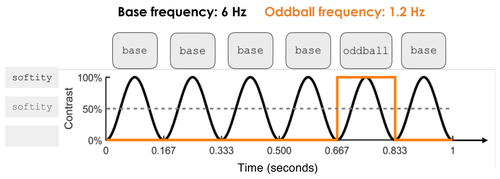
- Morphemes: smallest linguistic units that carry meaning. A complex word such as *artist* has a stem, ***art-***, and a suffix, ***-ist***.
- Reading development benefits from the morphological structure of words, especially from the presence of stems [1]. Behavioral evidence: morphological structure is accessed when processing complex words [2].
- EEG evidence for selective word [3] representations in the brain.

AIM: to investigate **selective neural responses to morphemes** embedded in pseudowords, in reading development.

Method

Participants: 28 skilled adult readers and 17 developing readers (5th-6th graders) monitored a central fixation cross and responded to color change.

Paradigm: Fast Periodic Visual Stimulation (FPVS) with an oddball paradigm [3] and MEG recording (160-channel Yokogawa system).



Stimuli

Adult readers: pseudoword combinations of 12 stems (e.g., *soft*),12 suffixes (e.g., *ity*), 12 non-stems (e.g., *trum*) and 12 non-suffixes (e.g., *ust*). Four experimental conditions (Design section, left-hand side). 5 trials per condition.

Developing readers: pseudoword combinations of 6 stems (e.g., *soft*), 6 suffixes (e.g., *ity*), 6 non-stems (e.g., *trum*) and 6 non-suffixes (e.g., *ust*). Two experimental conditions (Design section, right-hand side). 6 trials per condition.

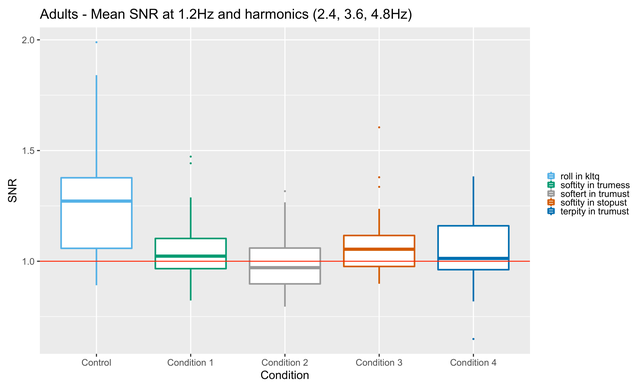
Design

	Skilled adult readers	Developing readers
Stem detection	**Condition 1:** ***stem+suffix*** in *non-stem+suffix* *trumess joskive molpory firnure* ***softity*** *berfise* **Condition 2:** ***stem+non-suffix*** in *non-stem+non-suffix* *trumust joskune molpute firnint* ***softert*** *berfere*	**Condition 1:** ***stem+suffix*** in *non-stem+suffix* *trumess joskive molpory firnure* ***softity*** *berfise*
Suffix detection	**Condition 3:** ***stem+suffix*** in *stem+non-suffix* *stopust helpune parkute lastint* ***softity*** *townere* **Condition 4:** ***non-stem+suffix*** in *non-stem + non-suffix* *trumust joskune molpute firnint* ***terpity*** *berfere*	**Condition 3:** ***stem+suffix*** in *stem+non-suffix* *stopust helpune parkute lastint* ***softity*** *townere*
	Control condition: ***words*** in *non-words* *kltq rdsc fgnl pdrk* ***roll*** *tmkj*	**Control condition:** ***words*** in *non-words* *kltq rdsc fgnl pdrk* ***roll*** *tmkj*

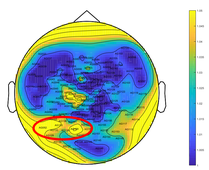
Predictions: MEG response at oddball frequency and its harmonics upon successful detection of morphemes. Discrimination response indexes detection of stems (conditions 1 and 2) and suffixes (conditions 3 and 4).

Results

Skilled adult readers



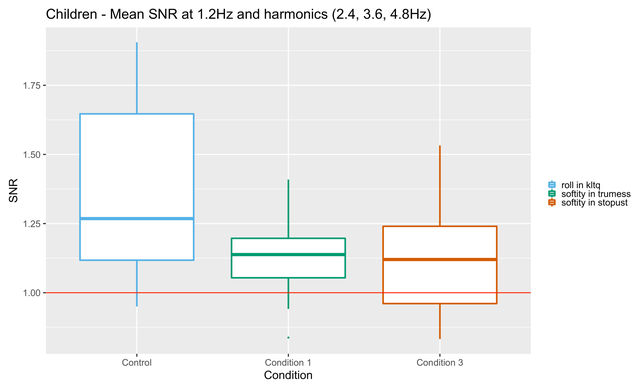
Sensor-level ROI: based on signal-to-noise ratio (SNR) on grand averaged response across conditions to first oddball frequency harmonic (2.4Hz, the most prominent).



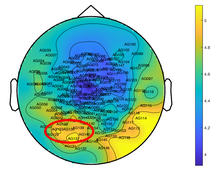
Statistical analysis: one tailed t-test performed on mean SNR at oddball frequency (1.2 Hz) and its first three harmonics (2.4, 3.6, 4.8 Hz) in left occipital sensor-level ROI.

Control condition: mean SNR = 1.29, t(27) = 5.22, p < .001
Condition 1: mean SNR = 1.06, t(27) = 1.93, p = .03
Condition 2: mean SNR = 0.99, t(27) = -0.06, p = .52
Condition 3: mean SNR = 1.08, t(27) = 2.68, p = .006
Condition 4: mean SNR = 1.03, t(27) = 0.93, p = .18

Developing readers



Sensor-level ROI: based on signal-to-noise ratio (SNR) on grand averaged response across conditions to oddball frequency + first three harmonics.



Statistical analysis: one tailed t-test performed on mean SNR at oddball frequency (1.2 Hz) and its first three harmonics (2.4, 3.6, 4.8 Hz) in left occipital sensor-level ROI.

Control condition: mean SNR = 1.37, t(16) = 4.91, p < .001
Condition 1: mean SNR = 1.13, t(16) = 3.75, p <. 001
Condition 3: mean SNR = 1.15, t(16) = 2.62, p = .009

Discussion

- **Stems** and **suffixes** were **discriminated** from non-stems and non-suffixes only when presented in **fully decomposable pseudowords** (conditions 1 and 3).
- **Sensor-level** analysis reveals a successful discrimination response at the oddball frequency (1.2Hz) and its harmonics (2.4, 2.6, 4.8Hz) in **left occipito-temporal regions**, both in developing and skilled adult readers.
- These results provide evidence for **automatic morpheme identification**, even at relatively **early stages of reading development**, and are in line with all major accounts of morphological decomposition [1,4,5]. Critically, these findings also suggest that morpheme identification can be modulated by the **context** in which the morphemes appear.

Next steps: Additional analyses to provide more refined spatial and source-level information, in order to help shed light on the neural underpinnings of morpheme identification in visual word processing.

References

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