Reading Words and Non-Words: A Joint fMRI and Eye-Tracking Study

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Past fMRI research has looked at brain activation caused by single word reading
- Fusiform gyrus (Visual Word Form Area)
- Superior Temporal Gyrus
- Middle Temporal Gyrus
  - (Cohen et al., 2002; Richlan et al., 2013)
Sentences and Words

- Most studies use isolated words because it is difficult to study sentences in the fMRI
- Sentences and single words have different patterns of activation (Cutting et al., 2006)
- Differences between word and sentence processing
Presentation Format

- Rapid Serial Visual Presentation (RSVP) used to present words one at a time
- Variability in stimulus duration can effect brain activation (Mechelli, Gorno-Tempini, & Price, 2003)
- Using fixation duration would be more reliable and would give an accurate representation of natural reading
Eye Tracking

- Monitoring and recording eye movements
  - Fixation durations
  - Number of fixations
  - Saccades
- Fixation duration dependent on word characteristics like word length and word frequency
Eye-Tracking + functional Magnetic Resonance Imaging

- Allow us to study brain activation during fixations and saccades
- Can use sentences instead of just words
- Reading task to study fixation durations while reading sentences of words and non-words
Hypotheses

- Eye tracking can be used with fMRI to study properties of words in sentences
  - There will be a correlation between fixation durations and brain activity
- Brain activation will be different for real words and non-readable words
- Brain activation will be different when presented in paragraph form and in rapid serial visual presentation (RSVP)
Methods

- Task: read words and non-words in sentence form
- 15 participants
- 2 functional runs per participant
  - 44 trials each, 88 trials total
- Eye-tracking
Stimuli

- 2 x 2 design
  - Word vs. non-word
  - Paragraph vs. RSVP

Two goldfish, named Maggy and Mythos, have become the smallest and hardest survivors of the devastating February earthquake in Christchurch, New Zealand. The fish spent four and a half months trapped in their tank in the city’s off-limits downtown without anyone to feed them or even any electricity to power their tank filter.
Stimuli

- RSVP

Two goldfish

6 s

200 ms

100 ms

200 ms

100 ms

100 ms

200 ms

100 ms

200 ms

100 ms
Eye-Tracking Data

- Average fixation durations:
  - Words: 230.19 ms
  - Non-words: 280.30 ms
Fixation Durations: Words

- Positive correlation in the occipito-temporal junction, intraparietal sulcus, and prefrontal cortex.
- Negative correlation in the left fusiform gyrus and occipital lobe.

[Images of brain scans with red and blue regions indicating increased and decreased activity]
Fixation Duration: Non-Words

- Positive correlation in the occipito-temporal junction
- Negative correlation in the occipital lobe.

= increased activity

= decreased activity
No correlation between fixation durations and brain activity in either word condition (words or non-words)
Paragraph: occipital lobe

RSVP: bilateral occipito-temporal junction
Paragraph: Words > Non-Words

- **Words**: greater activation for inferior frontal gyrus and left middle temporal gyrus
- **Non-Words**: left lateral prefrontal cortex
RSVP: Words > Non-Words

- Words: left superior temporal lobe
- Non-Words: medial frontal cortex and cingulate gyrus

= words

= non-words
Discussion

- Eye-tracking can be used to study brain activity and fixation durations
- Low and high level processing
  - Fusiform gyrus and occipital lobe
  - Prefrontal cortex and attention areas
- RSVP condition
  - Activates more attention areas
  - Not indicative of real fixation durations
Discussion

- Words activate areas associated with semantic and syntactic processing
- Non-words activate attention areas and higher level processing areas
Future Research

- Eye-tracking can be used to analyze brain activation
- Future research: use factors such as word frequency and word length
- Allow for deeper understanding of neural correlates of different aspects reading
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