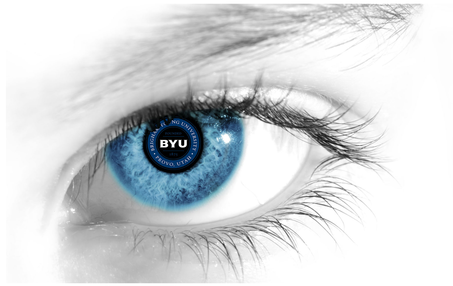
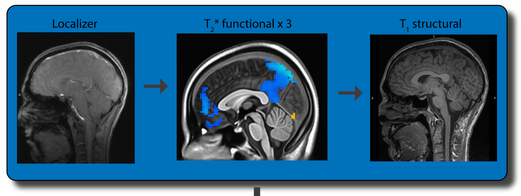


Individual Variation in the Cortical Response to Word Predictability in Naturalistic Reading

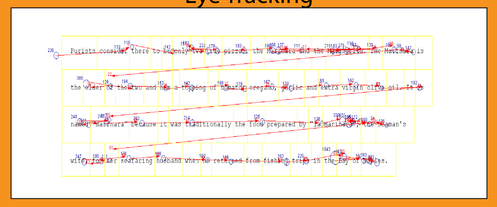
Benjamin T. Carter, Steven G. Luke

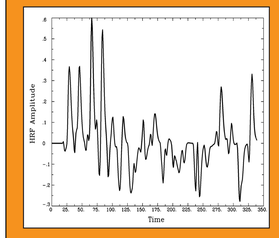
Methods

- Participants: 41 participants (14 female), right-handed with normal vision and no history of neurological or learning disorders.
- Apparatus: MRI safe BOLDScreen from Cambridge Research Systems was used for stimuli presentation. Eye movements were recorded with a SR Research Eyelink 1000 plus long-range MRI eye-tracker with sampling at 1000 Hz.



Eye Tracking

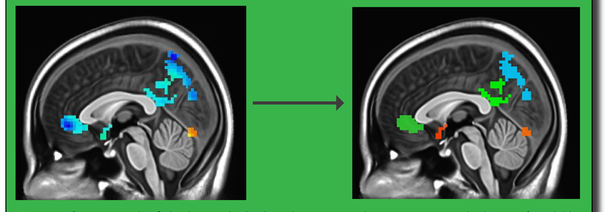




54 previously standardized paragraphs (18 during each run) were presented serially. Participants were instructed to read the text at their normal reading pace.

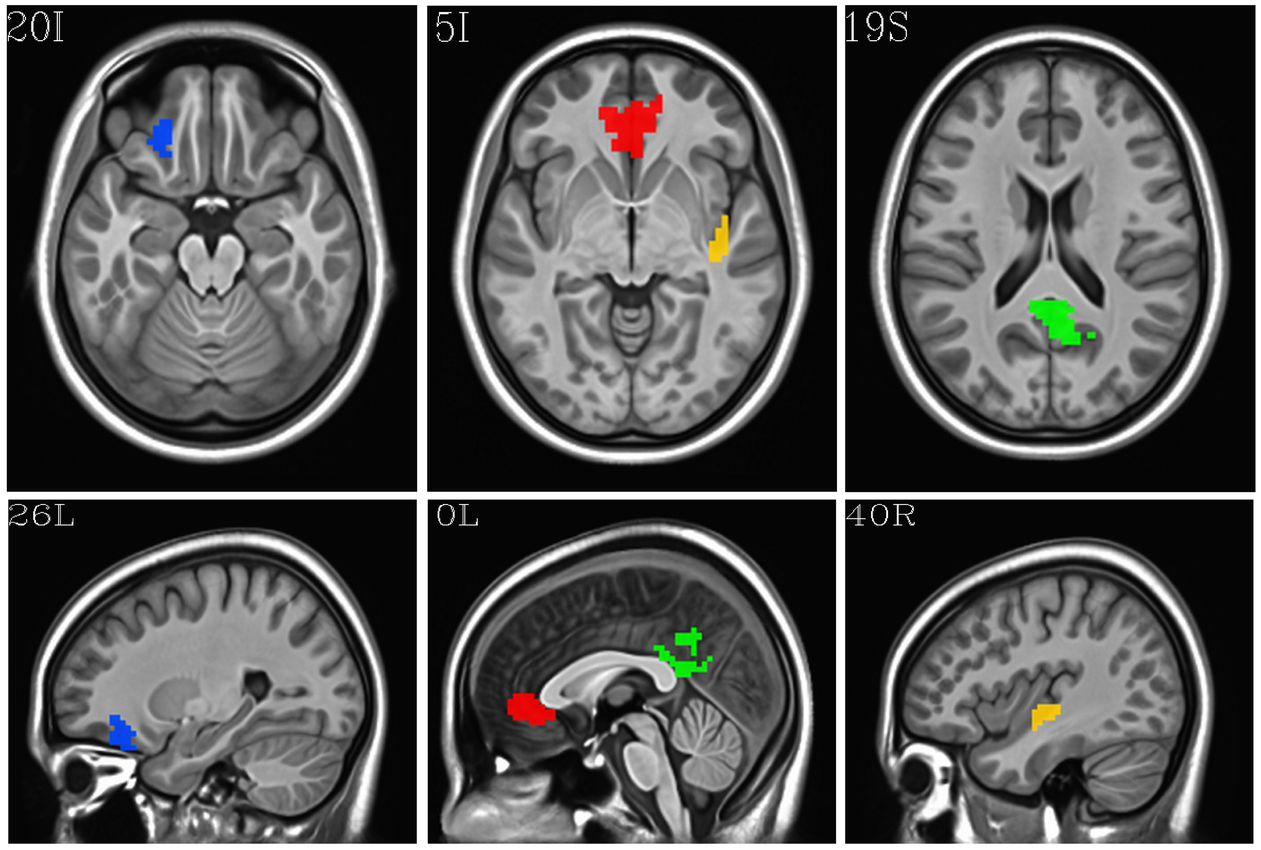
Eye movements were measured while participants read. Fixations times and durations were measured and extracted. Individual slopes were extracted for participant response to lexical predictability.

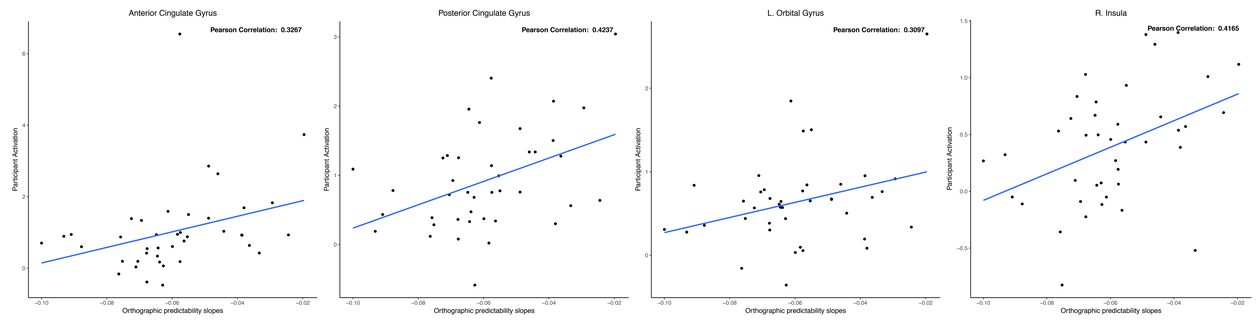
Fixation onset, first fixation duration and log-transformed lexical predictabilty were then used to create an amplitude and duration modulated hemodynamic response function.



15 regions of interest were identified at the group-level and a mask was constructed to compute participant level statistics for each ROI.

Regions Associated with Lexical Prediction Slopes





Background

- When engaged in receptive language tasks (e.g. listening to speech, reading), the brain facilitates comprehension by making predictions about the future.
- How predictions are made in a natural reading environment is poorly understood.
- Reading skill covaries with prediction skill.
- Understanding which regions are associated with prediction skill is key to understanding how we make predictions when reading and serve as markers for future study.
- Gaze duration (the time spent viewing a word) can be used as an inferential measure of prediction skill, with longer durations implying increased difficulty.
- Gaze duration is associated with lexical predictability, a measure of how easy it is to predict a word based on previous text.
- Brain regions with whose activity varies with lexical prediction may serve as regions of interest in studies of reading skill.

What does this mean?

Increased sensitivity to lexical predictability (i.e. increased slopes or greater fixations on difficult versus easily predicted words) is associated with increased activation within these regions. Therefore, functional changes within these regions should be associated with reader experience and skill level relative to the text.

Anterior cingulate gyrus (aCG) has previously been shown to be negatively associated with measures of reading comprehension (Welcome & Joanisse, 2012). A positive association with predictability slope is surprising and somewhat opposes this previous observation. Van de Meerendonk et al., (2011) observed increased activity in the aCG in response to spelling errors. The aCG may be engaged in error monitoring when an individual is less reliant on prediction.

Posterior cingulate gyrus (pCG) has been previously shown to become more active with increased word frequency and imageability (Graves, et al., 2009) and has an active role in semantic processing. pCG activity may reflect an increased reliance on semantic information by skilled readers, allowing for them to focus more on the meaning of the text rather than simply decoding it.

The association of the left orbital gyrus (lOG) is interesting. The orbitofrontal cortex is directly connected to the inferior occipital lob via the inferior longitudinal fasciculus and is usually implicated in visual-reward type functions. This region has also been shown to be active in error detection when there is a mismatch between expected and actual input (Rolls, 2015). Similarly, the right insula (rI) enages in error monitoring during lexical decision tasks (Wang, et al. 2015). This may indicate that as bottom-up processes become more efficient, individuals are able to monitor incoming stimuli for errors relative to expectations, with the lOG focused in visual errors and the rI focused more on lexical errors.

These results corroborate and extend previous findings to a more ecological reading environment. Future investigations should focus on determining how these regions change both functionally and structurally in response to various factors such as skill, development, and text difficulty.

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