

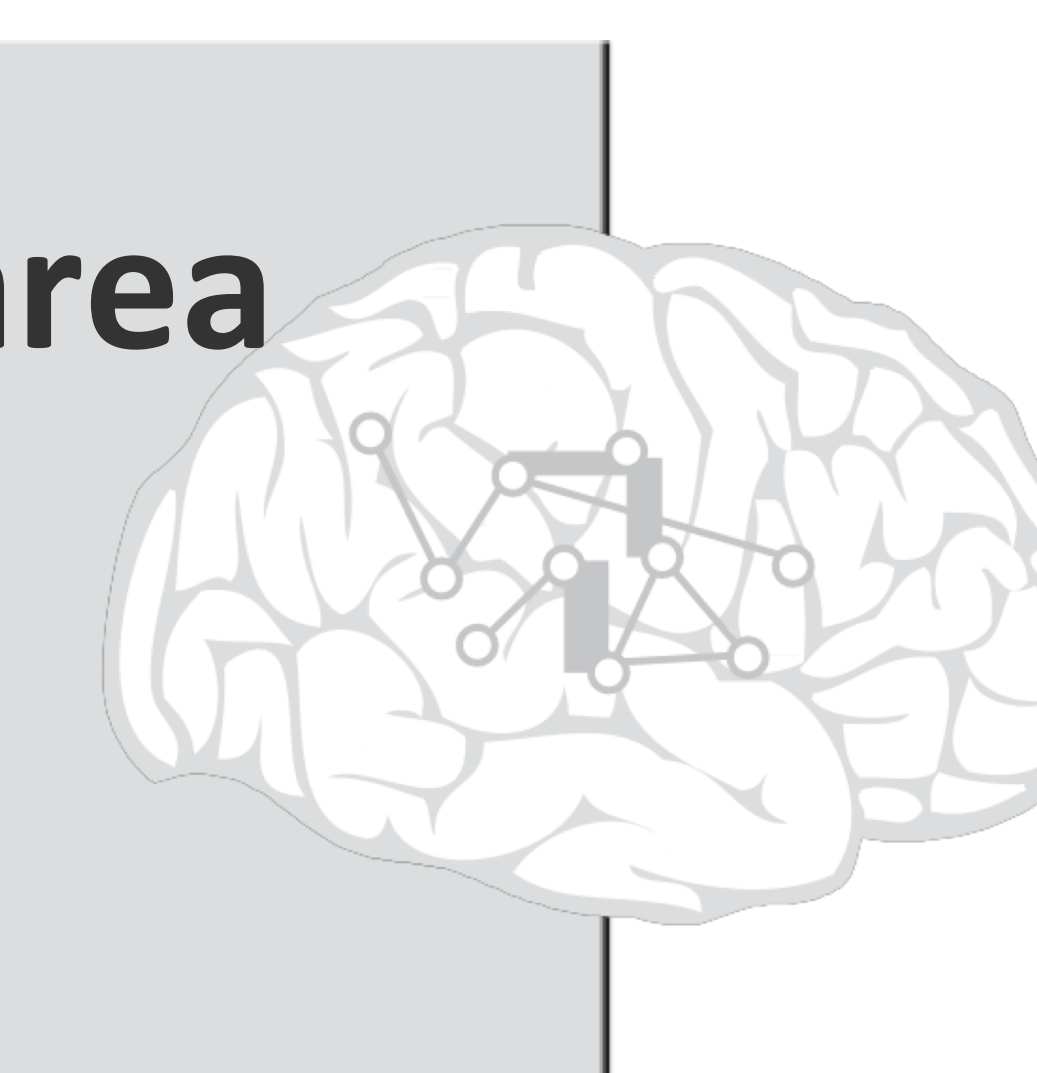
Effect of stimulus properties and task on electrophysiological dynamics in the human visual word form area

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Introduction

The **Visual Word Form Area (VWFA)** is a region within ventral occipitotemporal cortex that is named as such due to its selective responses to words/letters. The region has been implicated in the reading circuit¹, but the specific computations associated with and within the region continue to be debated.

Here, using the high spatio-temporal resolution of intracranial EEG, we aimed to understand not only the response amplitude, but also the temporal resolution of activations in the VWFA responding to a diverse set of stimuli parameters (see Methods).

Combining intracranial recordings and intracranial electrical perturbation, we explored the computational dynamics of the VWFA, its role in reading, and the interaction between this region and language regions.

Methods

Participants:

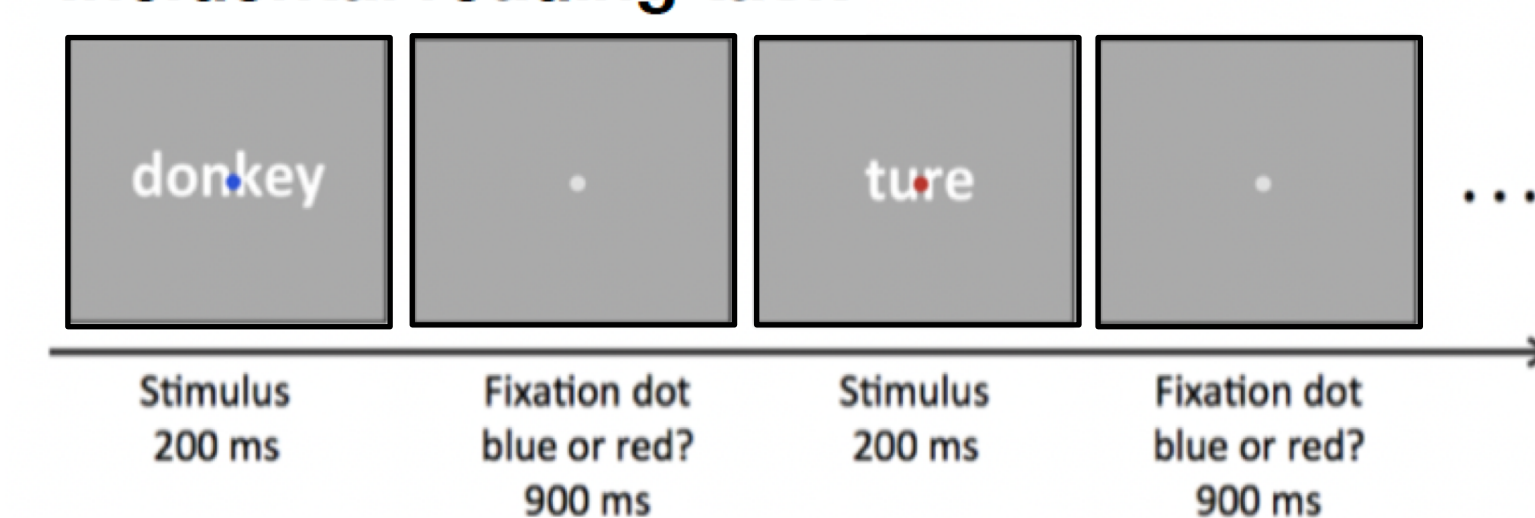
7 patients (4 males, all right handed) were implanted with ECoG electrodes for clinical purposes (6 left hemisphere; 1 right hemisphere). All subjects (7) performed an incidental reading task and 4 subjects completed a lexical decision task.

Stimuli:

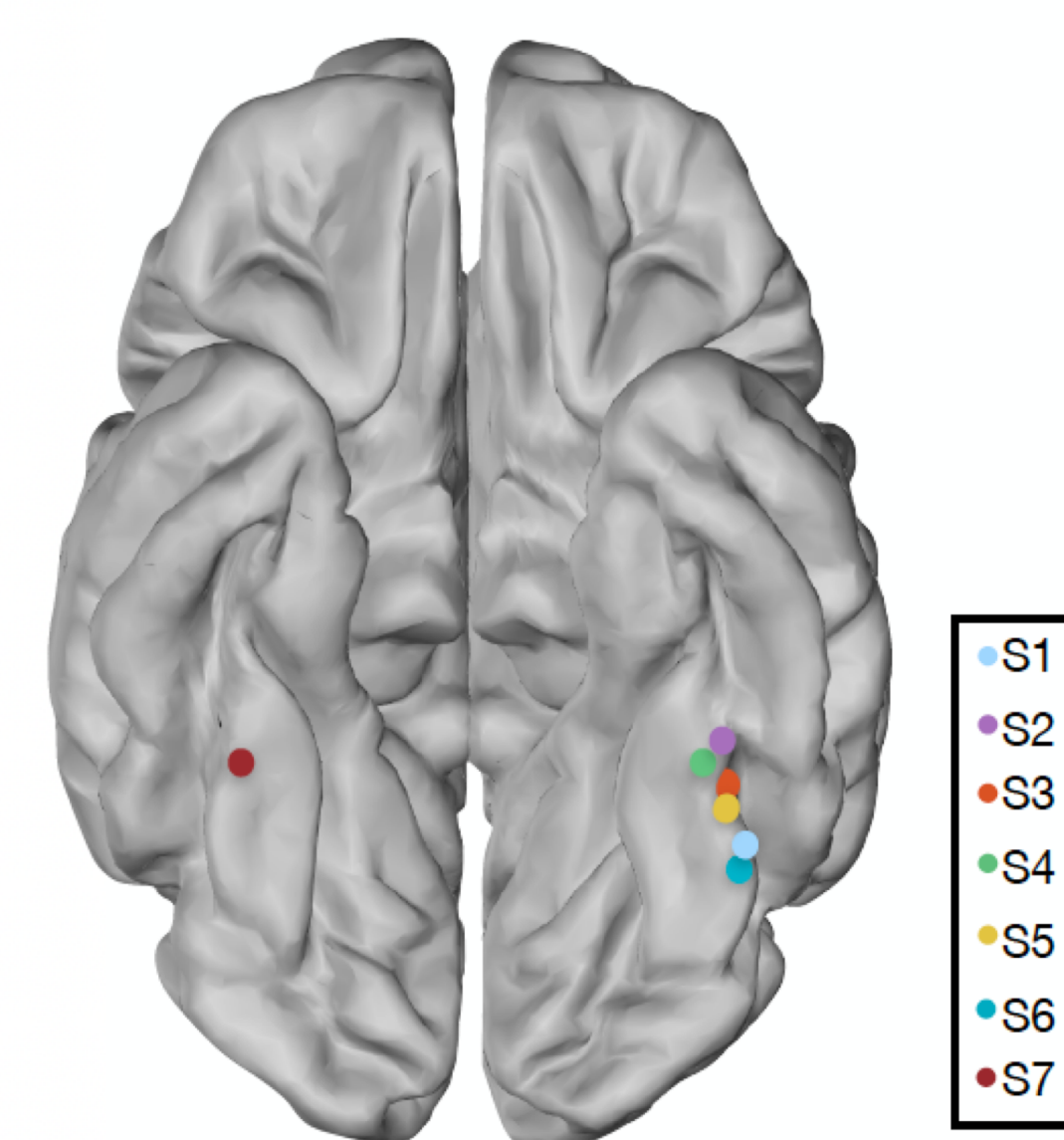
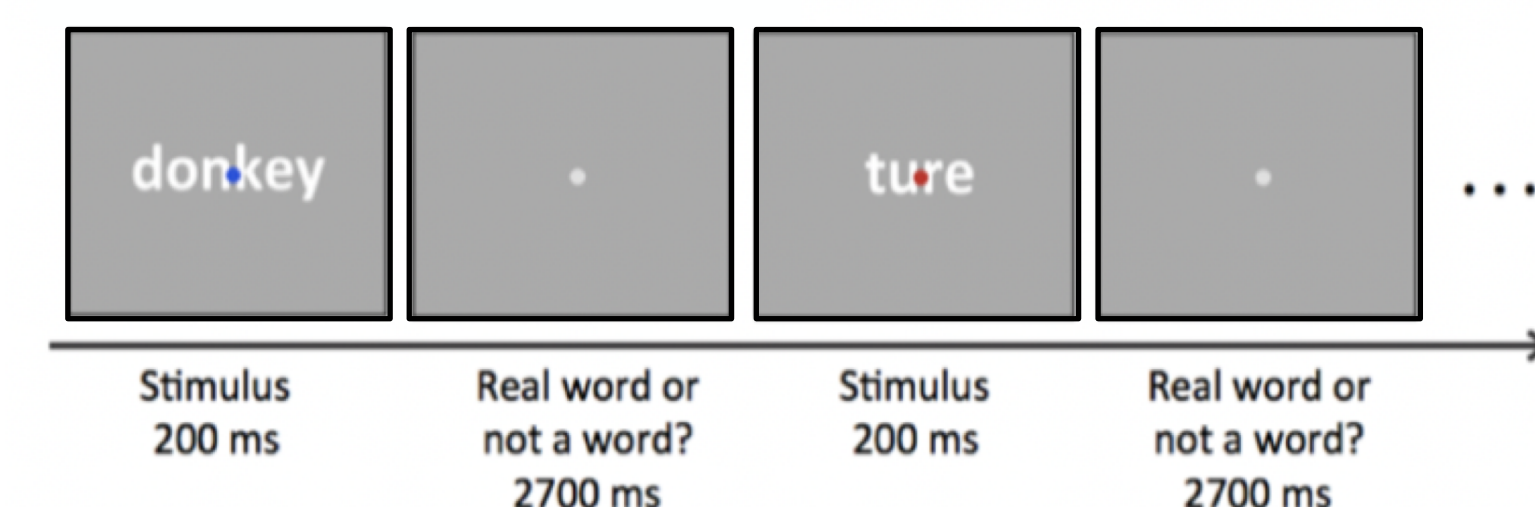
Visual word stimuli were manipulated with the introduction of noise and stimulus visual field position was varied. Stimuli could be categorized as follows:

- WORDS:** real words, pseudowords, consonant strings
- NOISE:** no noise, partial noise, full noise
- VISUAL FIELD POSITION:** ipsilateral, contralateral, central

Incidental reading task



Lexical decision task



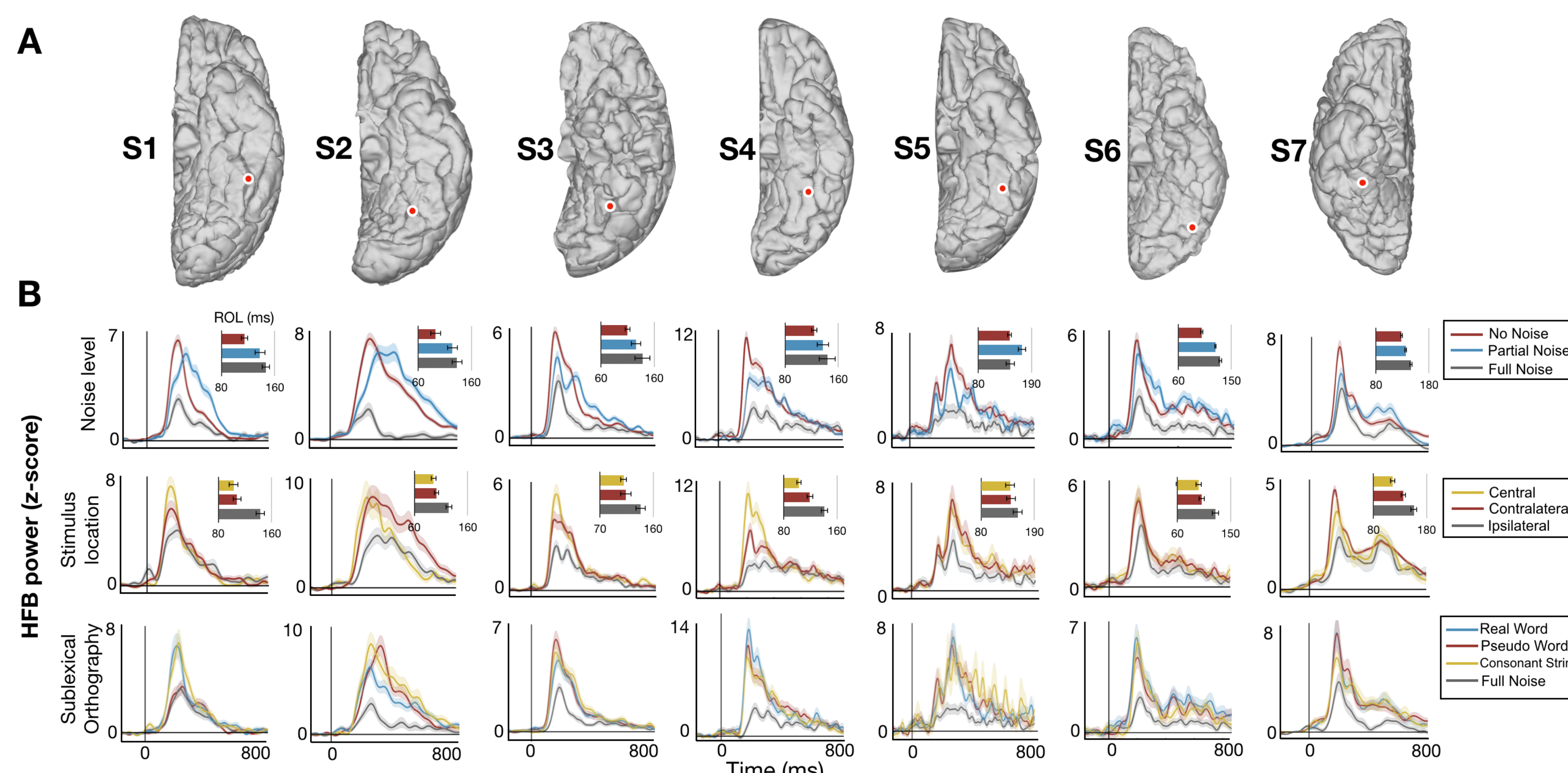
Data Processing and Analysis:

- We focused our analysis on the onset time and power of high frequency broadband (70-170 Hz)²
- VWFA site was defined by 3 criteria: 1. HFB response was significantly higher than baseline across all conditions. 2. The site showed **word selectivity** (HFB power for word-like stimuli > noise stimuli) 3. Anatomical location
- The same criteria was used to define Broca's / Wernicke's
- Response onset latency (ROL) analysis was done in each site of interest.

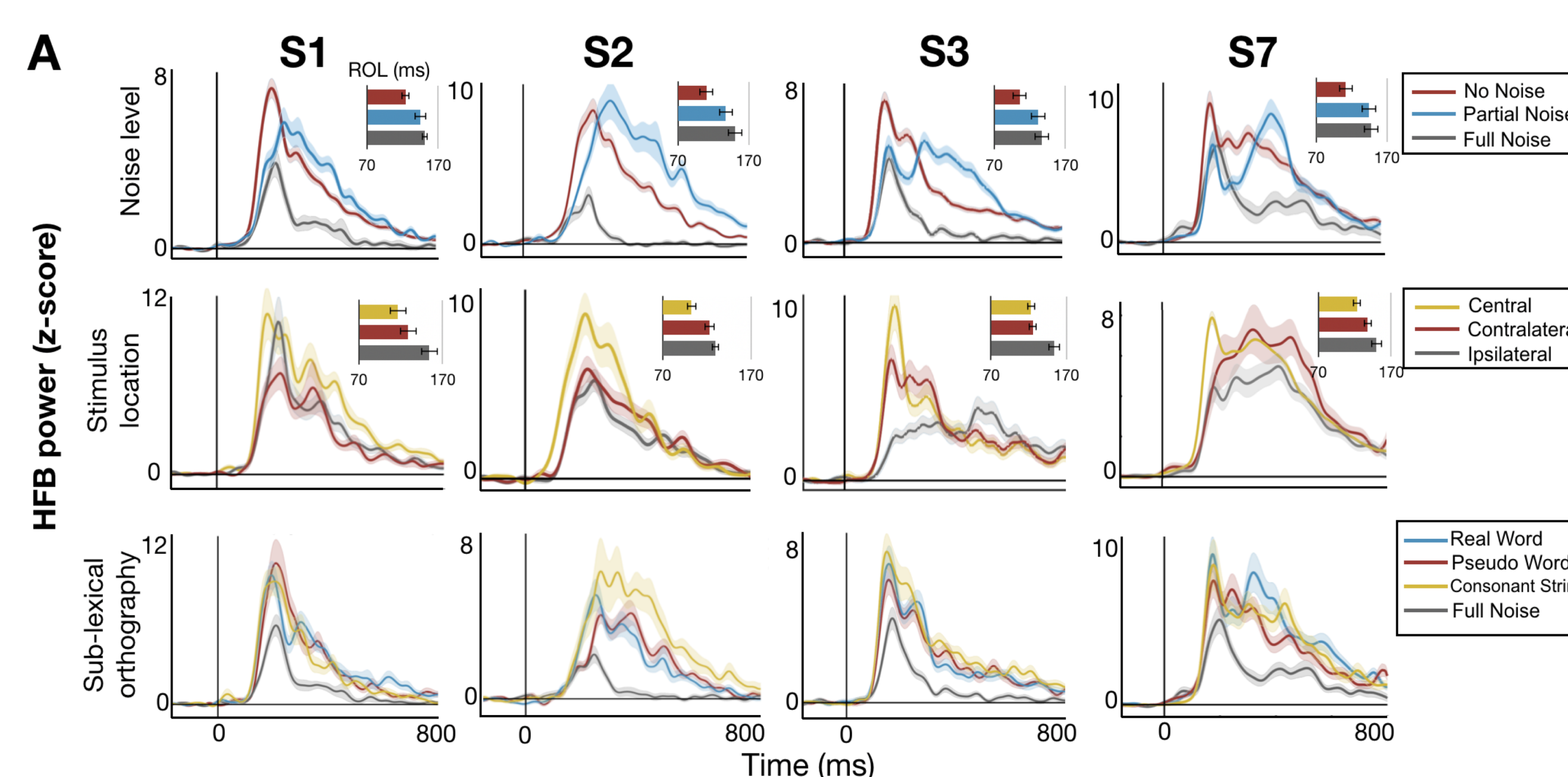
Results

*Task Specific Responses during Incidental Reading in VWFA

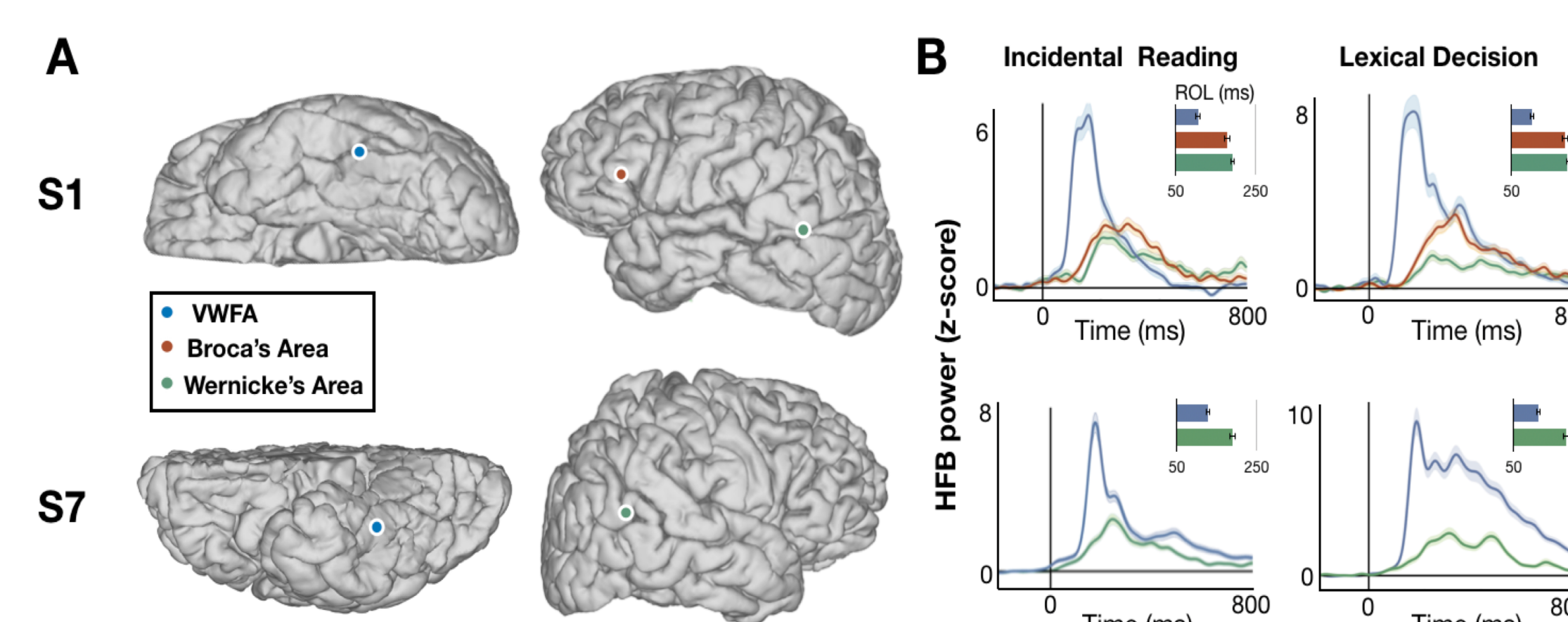
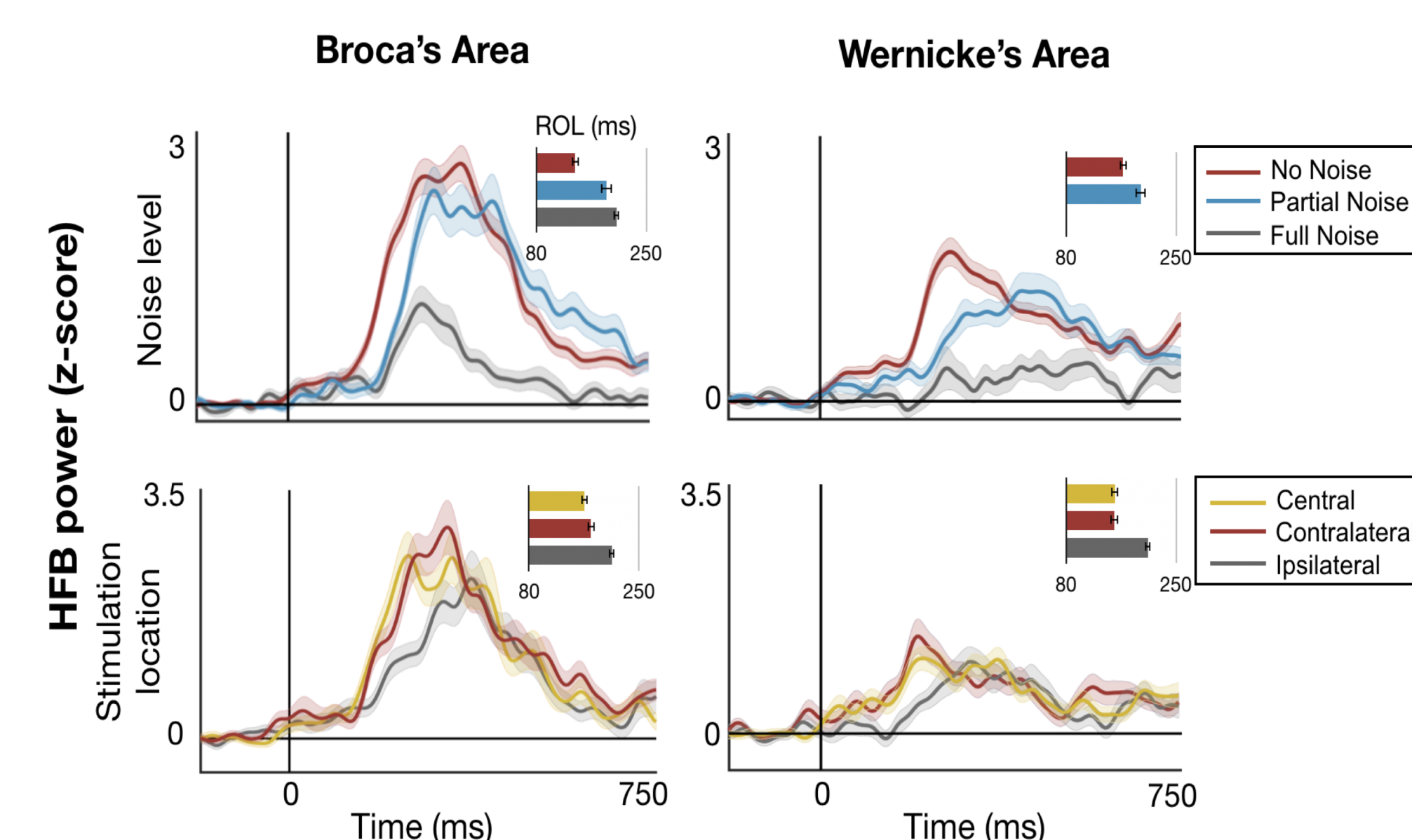
Z-scored HFB power is plotted around the stimulus onset across task conditions



*Task Specific Responses in the Lexical Decision task in VWFA



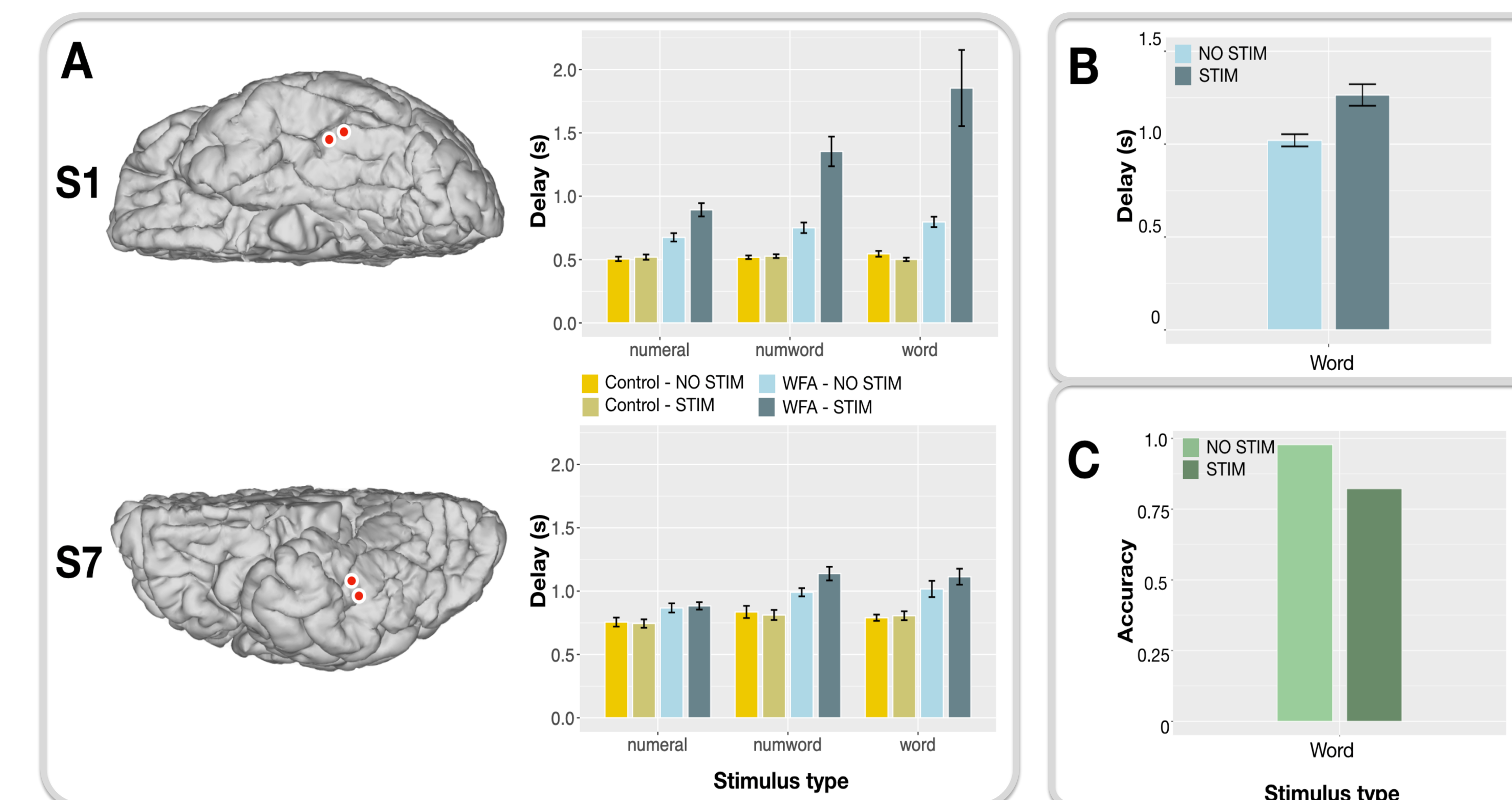
*Responses in the VWFA precede language areas



Results

*Intracranial Electrical Stimulation Perturbed Responses

Four subjects underwent stimulation in the VWFA and a non-selective site. Results in two sample subjects are presented below (A). These subjects were asked to read words, number words and numerals. Starting with stimulus onset, electrical charge was delivered at 3 mA and 100 Hz with a 200 μ s pulse width for 500 ms with stimulus onset. Group average differences in delay and accuracy are shown (B/C).



Conclusions

- In the reading circuitry, the VWFA operates between the early visual cortex and language regions.
- Real words, pseudowords and consonant strings elicited a similar magnitude and timing in HFB responses
- VWFA responses are delayed by 30 ms and have decreased amplitude when stimuli are suboptimal (bottom-up; with noise and when stimuli is in the ipsilateral field). Specifically, we report delayed left VWFA responses to words in the left visual field.
- Top down modulation increases response magnitude (there is higher activation in the VWFA in the lexical decision task than in the incidental reading task)
- Top down modulation also modulates the functional connection with language regions
- Our electrical stimulation results reveal that the VWFA operates as a bottleneck and is necessary for efficient reading.
- We also include data from the rVWFA of one subject (S7) that showed compatible results.
- This study constrains models of information flow between visual cortex and language regions during reading

References

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- Manning, J. R., Jacobs, J., Fried, I. & Kahana, M. J. Broadband shifts in local field potential power spectra are correlated with single-neuron spiking in humans. *J Neurosci* **29**, 13613-13620, doi:10.1523/JNEUROSCI.2041-09.2009 (2009).