Sample Term Paper Outline
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Course Instructor: W. Dale Stevens

**Title:** The Functional Specificity and Connectivity of the Visual Word Form Area

**Type of Paper:** Research Proposal

**Topic:**
The Visual Word Form Area (VWFA): Is it a general visual processing region, or specialized for word recognition/reading?

**Background:**
The VWFA is a region in the left occipitotemporal sulcus that is thought to become specialized for word recognition over the course of development (Dehaene and Cohen, 2011).

**Evidence for word/reading specialization:**

- Neuropsychology evidence: lesions to this region can result in "pure alexia", which is characterized by letter-by-letter reading, rather than whole word recognition (Reference)
- Neuroimaging evidence:
    - VWFA shows preferential activation for words, relative to other visual stimuli (Reference).
    - Activation of the VWFA is correlated with reading skill. For example, ex-illiterate individuals (people who were formerly illiterate but who have learned to read as adults) show an emergence and increase in VWFA activation as reading skills are acquired and improve (Reference).
- Neuronal recycling hypothesis: The acquisition of reading skill co-opts the involvement of a brain region that is otherwise involved in detailed visual processing, particularly of intersecting lines etc., making it particularly useful for reading.
    - Evidence for this is includes the fact that brain activation for other competing skills decreases in this region, and/or becomes right-lateralized, as reading skill develops. For example, face processing is bilateral in children, but becomes right-lateralized across development. Further right-lateralization of face processing is correlated with reading skill. (Dehaene and Cohen, 2011; Behrmann and Plaut, 2013).

**Evidence against word/reading specialization:**
In a series of papers, Vogel and colleagues (Vogel et al., 2014) argue that the VWFA is not specialized for reading, but rather, is a general visual processing region that is important for many tasks in addition to reading.

- Neuroimaging evidence:
    - Activation of VWFA is not specific to recognized words, but is similar for non-word characters (e.g., Amharic for English speakers), and other high-spatial frequency stimuli (Vogel, Petersen, et al., 2012).
    - The VWFA does not show preferential resting-state functional connectivity (RSFC) with reading/language regions, but rather, shows strong connectivity with the dorsal attention network. This functional connectivity increases with age and reading skill, but functional connectivity with reading-related regions does not. (Vogel, Miezin, et al., 2012)
    - Network analysis of RSFC among brain regions defined in a meta-analysis of reading studies did not show any reading specialized networks, but rather, broader networks involved across many tasks/skills (Vogel et al., 2013).

**Rationale for Study:**

There is a vigourous ongoing debate as to the functional specificity and connectivity of the VWFA:

- While Vogel and colleagues (Vogel, Petersen, et al., 2012) did not find word-specific activation in the VWFA, another study did (Glezer and Riesenhuber, 2009). Further, a second study by Glezer and Riesenhuber (2013) demonstrated that individually localizing the VWFA in each participant is required in order to detect word-specificity in the VWFA – i.e., group-defined VWFA regions do not accurately identify the VWFA in individual participants, and thus, word-specificity would not be observed.
- How else could one go about testing the word-specificity of representations in the VWFA? Could multi-voxel pattern analysis (MVPA) provide a better, more sensitive way of assessing this?
- Is it possible that Vogel et al. did not observe preferential RSFC of the VWFA with language/reading regions because they did not accurately define the VWFA as a seed region in their RSFC analyses by using an individual functional localizer?

**Hypotheses:**

The VWFA is a region specialized for word recognition by virtue of its preferential functional connectivity with other language regions.

- The VWFA will show word-specific activation; therefore, it should:
    1. Differentiate words from other categories of visual stimuli (e.g., Pictures and Pseudowords).
    2. Differentiate individual words from one another.
- The VWFA is a region of interface between the visual and language systems specialized for word recognition – therefore, it will:
    1. Show strong RSFC with visual attention regions.
    2. Also show preferential RSFC with regions of the language system, relative to other control regions in the ventral occipitotemporal cortex (VOTC).
- If the neuronal recycling hypothesis is true, then face-specific activation in the VWFA should be negatively correlated with reading skill.

**Methods:**

- An fMRI study with at least 30 healthy young adults (right handed) will be conducted.
- An fMRI functional localizer will be used to identify the VWFA, FFA, other language/reading-related areas, and other category-related regions in the VOTC.
- An MVPA analysis will be used to assess the word-specificity of activation in the VWFA by comparing the pattern of activation for words with other categories of stimuli.
- The strength of word-specificity in the VWFA, as measured using MVPA analyses, will be correlated with the participants' reading skill, as assessed using an independent task that will test reading skill of the participants.
- The individually localized VWFA regions will be used as seed regions in RSFC analyses in each individual participant to compare the strength of connectivity of the VWFA with other reading/language regions, relative to that of the group-defined VWFA (as done by Vogel, Petersen, et al., 2012) and other category-preferring regions.

References:

Behrmann, M., & Plaut, D. C. (2013). Distributed circuits, not circumscribed centers, mediate visual recognition. *Trends Cogn Sci, 17*(5), 210-219.

Dehaene, S., & Cohen, L. (2011). The unique role of the visual word form area in reading. *Trends Cogn Sci, 15*(6), 254-262.

Glezer, L. S., Jiang, X., & Riesenhuber, M. (2009). Evidence for highly selective neuronal tuning to whole words in the "visual word form area". *Neuron, 62*(2), 199-204.

Vogel, A. C., Petersen, S. E., & Schlaggar, B. L. (2014). The VWFA: it's not just for words anymore. *Front Hum Neurosci, 8*, 88.

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