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Research Award Brief

Insights into Human Learning and Development from Visual Cortex Plasticity in Blindness (2014 – 2016)

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Research Question: How does growing up blind shape brain and behavior?

Interdisciplinary Approach: The current project bridges neuroscience, linguistics, and cognitive psychology to explore how blindness shapes the brain using Transcranial Magnetic Stimulation (TMS) and language comprehension assessments.

Potential Implications of Research: By studying the mechanisms of human brain plasticity, the research will lay the basic science groundwork for optimizing brain function. Results from the current project may also inform future brain stimulation techniques that guide neuroplasticity in cases of stroke and disease as well as inform decisions about sight restoration in blind individuals.

Human cognition depends on a collection of specialized neural circuits. Distinct brain areas support hearing sounds, moving our bodies, perception of the visual world, and communication through language. While it was once believed that brain areas have 'fixed' cognitive functions, emerging evidence reveals that the brain is 'plastic' and changes with experience. Blindness provides a key example of neuroplasticity. In visually deprived animals, the so-called 'visual' areas of the occipital lobe respond to sound and touch. In blind humans, 'visual' areas are active during auditory sentence comprehension, Braille reading, and word production. Together these findings suggest that the 'visual' cortex can acquire functions that are very different from vision. This plasticity offers a unique opportunity to study developmental specialization of the human brain. A key outstanding question concerns the behavioral consequences of neuroplasticity. How does occipital activation observed in imaging studies influence linguistic behavior? It remains possible that even though occipital areas are active during language tasks, such activity is merely epiphenomenal with respect to language processing.

The project examines neuroplasticity in the 'visual' cortex of blind individuals as a window into the effects of learning on neurocognitive development. In particular, this project will determine how 'visual' cortex plasticity contributes to linguistic behavior in individuals who are congenitally blind through three experiments:

- In Experiment 1, we will test whether blind individuals demonstrate superior sentence comprehension abilities compared to sighted individuals.
- In Experiment 2, we will examine whether blind individuals with greater 'visual' cortex activation during sentence processing show better language comprehension abilities than those with less activation.
- In Experiment 3, we will explore whether temporary inhibition of the 'visual' cortex (using Transcranial Magnetic Stimulation) disrupts language comprehension in blind individuals but not sighted individuals.

In this series of experiments we hope to show that developmental blindness enables 'visual' cortex to perform language processing. These studies of blindness provide insight into how nature and nurture drive cortical specialization during human brain development.