Research Question: How does working memory training improve cognitive ability?

Interdisciplinary Approach: This fellowship project combines cognitive and clinical psychology with electrophysiological methods to determine how working memory training is effective in improving general cognitive ability, and how deficits in attention influence training outcomes.

Potential Implications of Research: The results of this research will help us understand how working memory training improves general cognitive ability. The results will also inform theories of learning and memory and provide new directions for improving training programs for specific populations with working memory deficits, such as individuals with ADHD.

Imagine looking at a map or hearing a list of directions and having to keep that information in mind while you navigate somewhere new. This ability to “hold” information in mind is known as working memory (WM). WM plays an important role in our ability to learn and function in society. However, WM is very limited and we can only hold 3-4 items in WM at once. If you are given 10 directions to remember, chances are you’re going to get lost because you can’t keep all 10 items in mind. Importantly, this “WM capacity” predicts a broad array of cognitive abilities such as intelligence and educational achievement and is known to be smaller in individuals with attention deficits.

Despite WM’s limitations, we can improve our WM through practice. Moreover, recent work has begun to show that WM training may be effective in improving learning and memory across the lifespan for both healthy individuals and those affected by neurological disorders. Yet it is still unclear how such training improves cognitive abilities. It may be the case that WM training improves the ability to control attention, which in turn, improves performance. On the other hand, WM training may improve the ability to figure out and hold relationships in mind, which in turn, improves cognitive performance. In the current project, we will explore how two types of WM training may lead to different outcomes. Half of our participants will train on a dual n-back task, which requires the relationships between memory items to be remembered (Figure 1A). The other half of our participants will train on a span task, which requires control of attention between memory items (Figure 1B). Drawing on previous work, we predict that those trained to find and remember relations among objects (i.e., dual n-back training) will show gains in fluid intelligence and relational WM, while those who were trained to control attention (i.e., symmetry span training) will show gains in item-specific WM. Using electroencephalography we will also explore how these two types of training cause different brain activation patterns, and whether one pattern better predicts training success. We will also explore how individual differences in a variety of characteristics influence training outcome. Specifically, individuals with ADHD are known to have WM deficits, which make them a target group for WM training. We will test how ADHD symptoms influence training responsiveness. By understanding how WM training works and how its effectiveness changes as a function of ADHD symptom severity, we can optimize training programs in the future for this population and others.

Figure 1. Two WM training tasks used in the current project. (A) Dual n-back: an example “2-back” trial where observers must decide if a letter and the location of a square are the same as the one they saw 2 before. (B) Symmetry Span: Observers must remember the location and order of red squares while deciding if an image is symmetrical in between each red square presentation. Both training tasks are adaptive, meaning the difficulty adjusts based on an individuals’ performance.