Diffusion-based magnetic resonance imaging (dMRI) methods have rapidly gained popularity for both diagnostic and research purposes since their advent in the early 1990s. Advances in hardware and analysis infrastructure have greatly accelerated the advent of ever more advanced models and applications of diffusion imaging. The sensitivity of diffusion imaging to small changes of the movement of water within the brain has made it the mainstay for imaging the restricted movement of water in white matter.

Learning and memory are essential parts of the human experience and key to our survival. To this end, research is actively ongoing to study these phenomena in the near fully matured brain and in the declining brain. Recent studies have shown cross-sectional diffusion MRI indications of neuroplastic response in a variety of tasks, including juggling, learning an instrument, and playing video games; however, none of these studies have provided both short-term and long-term changes, nor have they tested the ability of dMRI to discriminate between task-related changes. In this work, the ability of dMRI to detect both short-term and long-term brain changes in a cohort of young adults playing either *Guitar Hero* or *Need-for-Speed* was tested, as well as microstructural differences between the two video games.

In contrast to the evolving adult brain, it is important to understand the microstructure of the declining brain and its effects on cognitive ability. A key population to study is aging adults with Down syndrome (DS) brain which, due to trisomy of the 21st chromosome, experience early and elevated amounts of amyloid accumulation and increased Alzheimer's dementia (AD) prevalence. To provide a wholistic understanding of WM microstructure in adult DS, this work explores differences of microstructure between adults with DS with and without significant amyloid accumulation, as well as the relationship of WM microstructure to episodic memory performance.