Cognitive Ergonomics of Eye-Hand dyscoordination in chronic stroke

John Ross Rizzo[1], Todd E. Hudson[2], Mahya Beheshti[3], Acran Salmen Navarro[4]

[123]NYU Langone Health, USA

[4] NYU Population Health Science Scholars Program, USA

Statement of the Problem: Eye-hand coordination relies on the ability to visually determine details in the environment and direct goal-oriented hand movements. During task-specific movements, multimodal sensory predictions and feedback are essential to visuomotor integration and motor control. It is widely agreed that ocular motor and manual motor impairment can be caused by cerebral pathologies such as neuro degeneration and stroke. We have previously reported stroke participants had significant eye-hand dyscoordination in visually guided reaching, i.e., temporal decoupling between primary saccade and reach onsets, greater endpoint errors in both effector systems (poorer spatial performance), and an increased frequency of saccades during the temporal decoupling as compared to healthy participants. Movement repetition increases feelings of tiredness and mental fatigue, which have been shown to negatively influence performance. Accurate eye-hand coordination is important in every aspect of life but particularly important for work-related tasks, especially those requiring precision and human factors interaction with the workplace. When performing tasks that require visually guided upper extremity repetitive motion, use of hand tools, manual material handling and constant pinch / grip, ergonomic interventions are critical to adapt workplaces to the users, avoid human errors, reduce risk factors and implement safe return-to-work programs after neuro-rehabilitation. Here we sought to investigate spatiotemporal measures of eye-hand coordination during a repeated visually guided point-to-point reaching task to investigate performance decrements over the evolution of a trial block.

Methodology & Theoretical Orientation: To assess eye-hand coordination, we tested eye and hand movement performance over repeated eye-hand movement in a saccade-to-reach paradigm in chronic stroke participants. We hypothesized that participants would show impaired saccadic and manual motor control after repetitive motion as a result of cognitive fatigue. A cross-sectional study was performed on ten stroke participants (aged 46-75) with middle cerebral artery stroke and mild-moderate motor impairment (Fugl-Meyer Score 43-65). The physical configuration of the table surface and monitor allowed participants to simultaneously view the screen and make point-to-point reaches on a table top with a motion sensor attached to the index finger. Custom Matlab scripts were used to display visual stimuli and perform real-time integration of data acquired from the Eye link II eye tracker and Polhemus limb tracker.

Findings: Aside from our typical findings of dyscoordination in the experimental block, standard deviation for fixation duration changed nearly linearly from about 200ms to 400ms over the course of the experiment. Eye movement frequency was elevated consistently during the experiment, at about 6-10 eye movements per reach.

Conclusion & Significance: Cognitive ergonomics is driven by the capability of the human mind to interact with the workplace and to leverage products and tools to facilitate efficiency. Perception, memory and mental processing are all mental functions that work synergistically with eye movement in nearly all occupational settings. When normal eye behaviour is disrupted for any reason, the risk of human error increases and may lead to accidents, ultimately decreasing work productivity. Here we show fixational variance nearly doubles over the course of a short block of trials, demonstrating increasingly non-uniform fixations, as might be expected with increasing cognitive fatigue. Future studies that further characterize eye-hand coupling and the evolution of metrics over time objectively in unconstrained and naturalistic tasks within the workplace with ecological validity may produce high-yield results for occupational health, neuro rehabilitation and neuroscience.

Biography

John-Ross (JR) Rizzo, M.D., M.S.C.I., is a physician-scientist at NYU Langone Medical Center's Rusk Rehabilitation, where he serves as vice chair of Innovation and Equity for Physical Medicine and Rehabilitation with cross-appointments in the Department of Neurology and the Departments of Biomedical & Mechanical and Aerospace Engineering at NYU-Tandon. He is also the Associate Director of Healthcare for the renowned NYU Wireless Laboratory in the Department of Electrical and Computer Engineering at NYU-Tandon. He leads the Visuomotor Integration Laboratory (VMIL), where his team focuses on eye-hand coordination, as it relates to acquired brain injury, and the REACTIV Laboratory (Rehabilitation Engineering Alliance and Center Transforming Low Vision), where his team focuses on advanced wearable's for the sensory deprived and benefits from his own personal experiences with vision loss.