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Limb Stabilization in Older Adults and Chronic Stroke Survivors: A Pilot Study

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SECTION I.

Introduction

Many activities of daily living require individuals to both manipulate and stabilize objects simultaneously at different points within their workspace. The quality of life of many individuals is impacted negatively when the ability to move and stabilize hand-held objects is impaired due to age-related declines in executive function and/or somatosensory acuity, as well as due to acute neuromotor injury such as stroke. Consider, for example, the act of driving a car down a bumpy road. In order to maintain a proper heading, the steering wheel must be continually stabilized against unexpected perturbations caused by imperfections in the roads surface. Visual feedback allows the driver to confirm that they are appropriately stabilizing against the perturbations. In some instances, the driver's vision may be impaired due to a glare, or an object obstructing their view. How then, is the driver able to confirm that they are maintaining the proper heading?

SECTION II.

Methods

Three populations of subjects participated in the study, 12 Control subjects (age between 19 and 48 years of age), one Aging subject (65 years of age), and one Stroke survivor (57 years of age, two years post ischemic stroke). Each subject grasped the handle of a one degree of freedom MRI compatible wrist manipulandum that was fastened to the inside of the scanner bore. During the stabilization periods, two types of extension torques were applied about the wrist, constant (CT, $\text{mean}=1.2$ Nm) and stochastic (RT, $\text{mean}=1.2\pm1.1$ Nm). Subjects were unable to see their limb and were instructed to stabilize against the perturbations by maintaining 20° flexion. Three varying types of visual feedback fidelity were displayed to the subject, no visual feedback (NV), true visual feedback (TV), and random visual feedback (RV). In order to compare kinematic results, RMS error was calculated for each trial and normalized to the Constant-Torque-No-Vision (CTNV) trial for each population. BOLD activation maps were computed for each visual condition and perturbation type.

SECTION III.

Results

A substantial amount of variance was observed in the normalized RMS error for the TV condition in each population. A 2-Way ANOVA and multiple comparison test revealed that all subject groups exhibited a significant increase in stability (lower RMS error) when higher fidelity feedback was provided. BOLD activation maps comparing TV and NV were computed to determine how visual feedback fidelity effected the neural mechanisms contributing to limb stability. When comparing Aging and Control populations, similar regions-of-interest (ROIs) were observed. Enhanced activity was found in the left postcentral gyrus (BA 3), middle frontal gyrus, thalamus (medial dorsal nucleus), and right middle temporal gyrus (BA 37). Unlike the Control and Aging activation maps, ROIs exhibited in the Control and Stroke populations were mostly not overlapping. The Stroke subject showed no activity in the somatosensory cortex nor thalamus. In contrast, the subject exhibited elevated activity in the left middle occipital gyrus.

It appears that the visual feedback did not stimulate regions of the brain that have been associated with wrist postural control [1], suggesting that the Stroke subject employed a different strategy to accomplish the stabilization task.

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