

Visuomotor Adaptation in Aiming Movement: Effects of Order of Control and Dead Time on Error-Driven Switching Control

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BACKGROUND AND AIM. Motor adaptation is a form of learning in which the control of movements evolves through sensory-motor optimization during repeated task exposure or practice. To understand and exploit motor adaptation for rehabilitation use, the control strategy of humans exposed to a novel dynamic environment or altered sensory feedback during manual tracking in virtual reality was investigated. **METHODS.** Four young healthy male subjects, equipped with a head-mounted display, played a video game in which they aimed at and shot down incoming enemy planes randomly by operating a custom-made lever arm with their dominant hands. Each participant in principle was able to continuously control the sight device with three distinct dynamics: a zero-order system with dead time, a first-order system with dead time, and a second-order system. After 2-h training sessions for two successive days, the target, aim, and lever arm positions of each participant during manual tracking were recorded. The lever arm velocity was then analyzed in the phase-state space of the position, velocity, and acceleration errors between the target and aim. **RESULTS.** Systematic visuomotor adaptation was demonstrated using intervention parameters. The order of control and dead time oppositely affected the error-driven switching control after visuomotor adaptation in manual tracking: the switching line rotated counterclockwise as the order of control increased, whereas it rotated clockwise as the dead time increased. **CONCLUSIONS.** Our results show the adaptive and dynamic nature of a human operator. This finding can aid systematic and quantitative interventions in visuomotor training for motor improvement and enhancement.