

Influence of therapeutic Force Fields on Visuomotor Learning

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BACKGROUND: In rehabilitation, patients with motor impairments have to relearn motor control. Therapists manipulate arm movements of the patients by assisting, guiding or resisting these. Rehabilitation robots can manipulate the movements similarly, and simultaneously increase the training intensity for the patients and reduce the load on the therapist. In recent years, several manipulation algorithms have been implemented, like using assistive forces when deviating from the optimal trajectory, or forces which enlarge the errors to increase the awareness of the errors and accelerate adaptation. Although the effects of these manipulations on motor learning in healthy subjects are not yet fully understood, many of these manipulating forces are already in use in stroke rehabilitation.

GOAL: To increase the understanding of how dynamic force fields interact with human motor learning, we examined how different force field affected learning of a new visuomotor task.

METHODS: We used a admittance controlled robotic device to investigate adaptation to a 30° CCW visual distortion in several dynamic environments. Fifty subjects were divided equally into five groups, with each group subjected to different force fields. Subjects trained center-out reaching movements to five different targets. Group A ('Active') group, faced no additional forces. Group P ('Passive') were moved by the robot. Groups HG ('Hard Guidance') and SG ('Soft Guidance'), were guided during movements with, respectively, high and low, error-restraining stiffnesses. Group EE ('Error Enhanced') experienced a negative stiffness that augmented movement errors. All groups were tested through catch trials on adaptation and generalization effects, and finally washout effects.

RESULTS: Groups A, EE and SG did adapt to the kinematic distortion. No differences between group A and EE were found, whereas group SG adapted to a smaller amount. Preceding groups also showed generalization to alternative directions. Groups P and HG did not adapt to the novel kinematic field, evidenced by the absence of 'washout' effects. In active training, people adapted to novel kinematic fields and learned new visuomotor relations. Addition of forces during training did not accelerate visuomotor learning, but could slow or prevent it.

DISCUSSION: These results suggest that optimal visuomotor motor relearning after a stroke would be accomplished by rehabilitation programs consisting mainly of active participation of patients, in which (robotic) assistive support is minimized as soon as possible. For other rehabilitation targets such as increasing muscle tone, reach and pain relief, resistive or assistive force fields may be beneficial.