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 can assist in making movements by guiding movements. However this is labor intensive, especially when training with high intensities is required. The use of rehabilitation robots can overcome this problem. These robots can also be developed and programmed to provide a large range of other forces to facilitate recovery as just passive guiding. In the past years, different algorithms to provide guiding forces have been implemented, like assistive forces when the subjects deviate from the optimal trajectory, but also forces which enlarge the errors to make the subject more aware of their errors and accelerate adaptation. All these guiding forces have been tested in stroke patients while it is still unknown which of these forces would result in the accelerating or improving motor learning in healthy subjects

Goal

To gain a better 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

In this experiment we used a Haptic MASTER robotic device to investigate adaptation to a 30° CCW visual distortion in altered dynamic environments. Fifty subjects were equally divided into five groups, with each group subjected to different force fields. Subjects trained 'centre-out' reaching movements to five different targets. Group *A*, the *'Active'* group, faced no additional forces. The *'Passive'* group *P* were moved by the robot. Groups *HG* and *SG*, the *'Hard Guidance'* and *'Soft Guidance'* group respectively, were guided during movements with large and small error restraining forces. Subjects of the *'Error Enhanced'* group *EE* experienced forces that augmented movement errors. All groups were tested through catch trials on adaptation and generalization effects. Besides that, subjects were tested on '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. Instead, guiding forces did even inhibit learning of the visuomotor task.

Discussion

These results suggest that optimal motor relearning after a CVA would be accomplished by rehabilitation programs consisting mainly of active participation of patients in their training 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 can be beneficial.

Keywords: visuomotor learning, force fields, error augmentation, assistive control, robotic rehabilitation, CVA.