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The carrot and the stick seem to enhance motor learning in patients with stroke

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Reinforcement enhances the rate of motor learning in patients with stroke

Each year five million people are left permanently disabled by stroke.[1] Identifying novel approaches to address their impairments is an important challenge. In their JNNP paper, Quattrocchi *et al* show that both reward-based and punishment-based feedbacks enhance the rate of motor learning following stroke[2]. Patients who trained with this additional feedback learnt to adapt their movements to counteract a robot-induced force field faster than those who received neutral feedback. Patients who had learnt under the reward or punishment conditions were also faster to adapt their movements when exposed to a similar perturbation on a subsequent day. These results suggest that reinforcement can have lasting beneficial effects on the rate of motor learning after stroke.

Rehabilitation is an arduous process. Developing approaches to enhance the efficiency of rehabilitation should result in direct benefits to patients, in turn leading to reduced demands on caregivers and hospital services. Notably, recent evidence from animal models suggest that training during the window of spontaneous biological recovery that occurs shortly after stroke may have a synergistic effect,[3] considerably enhancing neurological recovery when compared with the limited benefits of training in the chronic phase.[4 5] Unfortunately, this sensitive period is transitory in nature, providing only a limited window of opportunity to change neurological restoration.[6] Nonetheless, even if this effect does not translate to humans, the rehabilitation process also involves learning to deal with impairments, whether by performing tasks using different motor solutions or by compensating for specific deficits. Maximising the efficiency of rehabilitation interventions is therefore of crucial importance.

Although the Quattrocchi *et al* study presents intriguing and exciting results, it is important to note that motor adaptation paradigms have short-lived effects on real world tasks.[7] Thus, the task used in the current study likely has limited relevance to stroke recovery. However, the present results illustrate the principle that reinforcement can lead to faster learning after stroke, and as such this effect warrants further investigation with more clinically relevant tasks (eg, the acquisition of motor skills). Furthermore, in contrast to previous work with healthy individuals, the present study showed minimal differences between reward and punishment. This might suggest that the additional feedback provided by the reward and punishment could be the critical ingredient to the observed effects (particularly as they are mainly driven by incomplete adaptation in the neutral feedback group).

The prospect of augmenting feedback to enhance the rehabilitation process (and the potential for this to interact with interventions such as pharmacological agents[8] and/or non-invasive brain stimulation[9]) provides important avenues for future research. Interventions to enhance stroke rehabilitation are of increasing importance; the world population is becoming older, and age is the single most important risk factor in stroke.[10] Beyond prevention and rescue interventions, there is a critical need to develop approaches that will optimise rehabilitation. Determining whether operant feedback can be leveraged to enhance learning in clinically relevant tasks will be an important future endeavour to follow-up the results by Quattrocchi *et al*.

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