A Computational Model of Sensory Motor Training Following Neurologic Injury

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The nervous system can be assisted in reprogramming itself to control movement following injury with intensive rehabilitation therapy. It is currently unclear what the optimal reprogramming techniques are, but expert movement therapists have developed intuition. For example, therapists speak of "assisting only when needed" and "eliciting normative sensory input to enhance motor output". In this talk I will present a computational model of sensory motor training that is based on biologically plausible assumptions and predicts outcomes consistent with therapists' intuition. The model's basic assumptions are: 1) The CNS probabilistically interprets sensory information in real time in order to generate motor output. 2) Sensory-motor pathways become more reliable with repetitive activation in a sort of Hebbian Learning. 3) Normal sensory input sometimes elicits abnormal motor output following neurologic injury due to disrupted neural organization. These assumptions are captured in an adaptive Markov model of sensory motor control. The model predicts that abnormal sensory motor pathways will be reinforced if neural disorganization is severe. However, if an external trainer (i.e. a rehabilitation therapist or robotic therapy device) recognizes the abnormal motor output and mechanically intervenes to correct it, normal sensory motor pathways are reinforced, producing an improvement in sensory motor performance that persists when training is stopped. The model predicts the best movement recovery when the trainer intervenes to correct errant movements on an "as-needed" basis, compared to no assistance or continual assistance. However, as-needed assistance is only effective for moderate levels of sensory-motor impairment, does not enhance recovery when sensory information plays a reduced role in determining motor output, and depends on the trainer's skill relative to the patient's impairment. These predictions provide a computational rationale for the incorporation of mechanical assistance on an as-needed basis during neurorehabilitation therapy.