

Learning compensation for different force fields and perturbation directions randomly applied during reaching

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Motor adaptation results from the acquisition of novel representations in the nervous system that allow improvement of control across a broad range of tasks. To date, there has been much emphasis on the acquisition of such patterns for predictable disturbances, and previous work highlighted that both prior (“feedforward”) and feedback control mechanisms express the same knowledge of dynamical interactions that arise during movement. Based on this observation we sought to investigate whether learning could be achieved based on feedback control only, such that the occurrence of unpredictable disturbances evoke gradually better online corrections. We instructed 18 healthy adults to perform reaching movements towards a visual target with a robotic handle (KINAMR, BKIN Technologies, Kingston). On a random subset of trials, we applied orthogonal (lateral force proportional to forward velocity), or curl field (lateral force proportional to hand speed) perturbations of clockwise and counter-clockwise directions randomly amongst unperturbed trials. We found a reduction in path length across force field trials for both perturbations and directions, indicative of better compensation for the applied disturbance. An analysis of average surface activity from the main muscles involved in lateral corrections indicated that there was no systematic increase in co-activation. We found that the measured force at the handle became gradually better correlated with the commanded force, re-calculated offline based on the velocity profile of each trial. Furthermore, for each force field, this correlation reached values significantly larger than when the measured force was correlated with the commanded force of randomly picked surrogate trials. Together these observations indicate that online corrections were not based on the control of limb impedance through co-contraction, or based on a one-fit-all default feedback response. Instead, they were tuned to the specific force profile experienced within each perturbation trials. These observations are consistent with the idea that the nervous system performs very fast, possibly online, adaptation to environmental dynamics with flexible online learning rates across encountered disturbances.