The Effect of Visual Uncertainty on Implicit Motor Adaptation

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Introduction

- Motor adaptation involves both implicit and explicit processes [1].
- Implicit motor adaptation is driven by sensory prediction error, difference between predicted and actual feedback.
- Noisy error information attenuates motor adaptation. This has been modeled as resulting in a weaker error signal [2, 3].
- We re-examined the effect of visual uncertainty on implicit motor adaptation using a modified visuomotor rotation task [4].
- Prior work with this task has led to a revised model of adaptation, one that emphasizes constraints associated with motor updating the sensorimotor map rather than the size/strength of the error signal [5].

The Error Clamp Paradigm

- Cursor/cloud path is invariant, deviating by an invariant angle from the target (3.5° or 30°).
- Participants are fully informed of manipulation and asked to ignore the visual feedback.
- Adaptation is observed as a change in hand angle opposite of the direction of the feedback.
- Participants are unaware of change in hand direction.

Modeling Adaptation

Motor Correction Model (MCM)

- Noisy adds variance to the perceived error location.
- Small errors are sometimes perceived with the opposite sign, with the net effect being attenuated adaptation.

Kalman Filter (KF)

- Noise weakens the error signal.

Relevance Estimation Model (REM)

- Noise weakens the error signal.
- Large errors are less likely attributed to the motor system.
- Noise adds ambiguity to the estimation, increases likelihood of large errors attributed to the motor system.

Exp. 2: Implicit Adaptation with visual uncertainty is better explained by MCM

Adaptation was again attenuated for small but not large errors.
- Implicit adaptation can be better explained by MCM compared to REM.

MCM can explain previous studies’ results

Exp. 1: Visual Uncertainty attenuates adaptation to small but not large errors

- Early Adaptation Rate was attenuated with the cloud feedback for 3.5° clamp but not for the 30° clamp.
- Implicit adaptation can be better explained by the Motor Correction Model compared to the Kalman Filter model.

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References: