Modeling the time course of change following visuomotor adaptation in movement, proprioception and prediction

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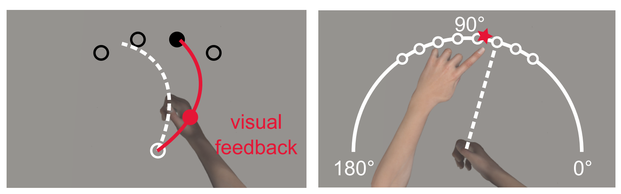
Hand Localization and Adaptation

People can quickly adapt to visuomotor rotations, which affects estimates of hand position, consisting of proprioception and predicted sensory consequences. We test how quickly these components of hand estimates change by measuring them on a trial-by-trial basis. We fit a two-rate model (Smith et al., 2006) to the reach data to see if the changes in hand estimates match the slow process, which has been linked to implicit learning (McDougle et al., 2015).

Experimental Procedure

All participants alternated between active reaches to the same targets and a different task and all used the same set-up shown below.



Multi-Rate Model

For reaches, we use a standard multi-rate model,where the motor output on trial t_1 is the sum of the output of a slow and fast proess:

$$X_{t1} = X_{s,t1} + X_{f,t1},$$

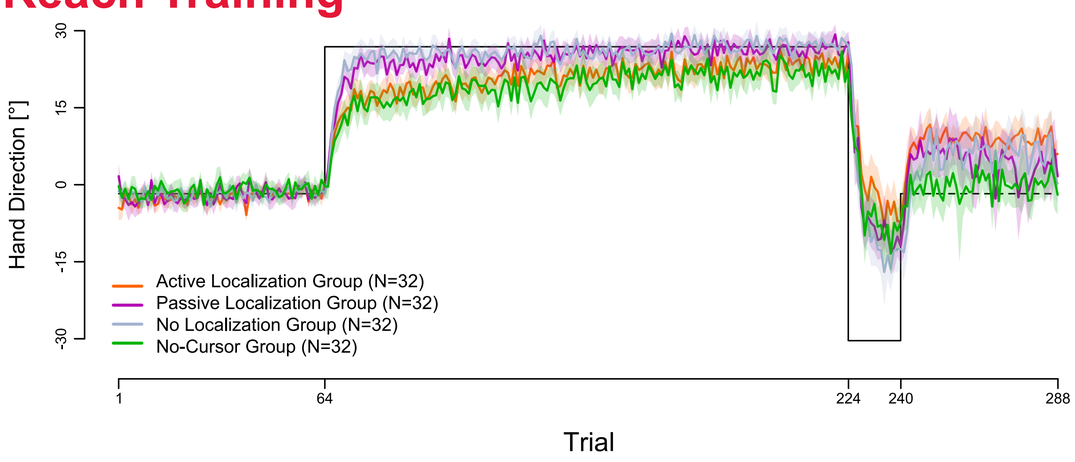
which are each determined by two parameters; a learning rate L and retention rate R:

$$X_{s,t1} = L_s \cdot e_{t0} + R_s \cdot X_{s,t0}$$

$$X_{f,t1} = L_f \cdot e_{t0} + R_f \cdot X_{f,t0}$$

Both Processes learn from the error on the previous trial (et_0) and retain part of their previous adaptation (X_{t0}). Constraints: $L_s < L_f$ and $R_s > R_f$.

Reach Training



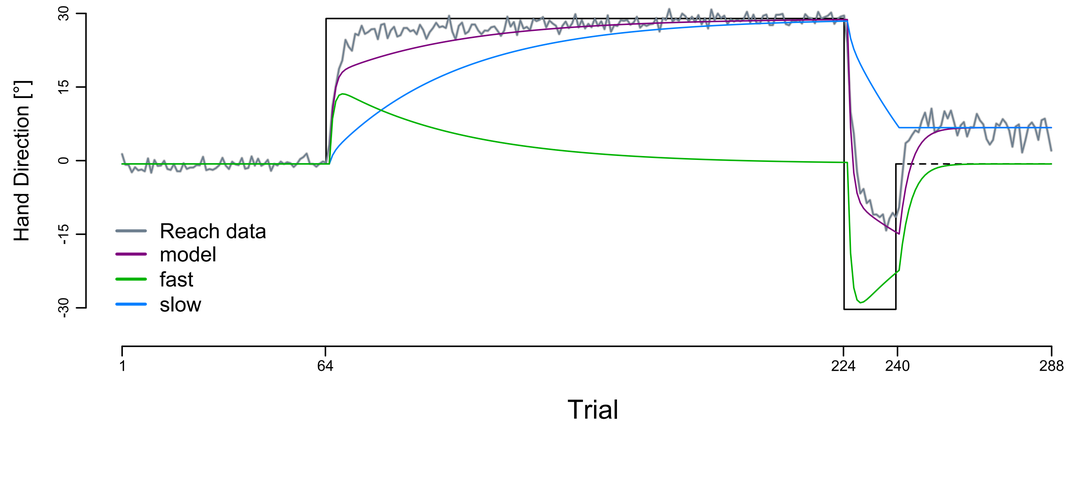
Reach Models

condition	Rs	Ls	Rf	Lf
Passive localization	1.000	0.054	0.750	0.217
Active localization	0.999	0.031	0.768	0.137
No-cursor	0.991	0.037	0.773	0.127
Pause	1.000	0.055	0.836	0.225

Multi-Rate Model for Active and No-Cursor Group

Reach Models

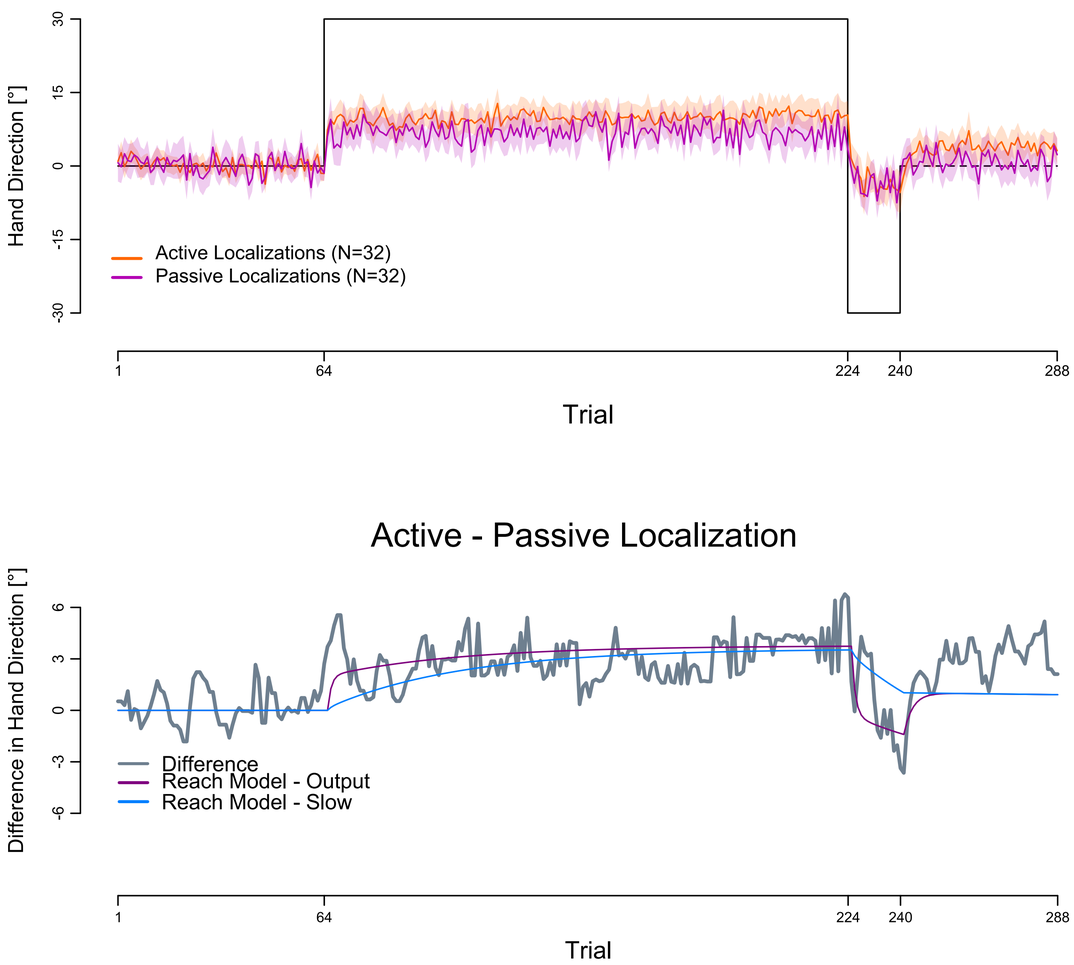
Multi-Rate Model for Passive and No Localization Group



Proprioceptive Recalibration

To measure the shift in hand estimates and their role in the model, 2 of 4 experiments measured proprioceptive estimates of hand location after every reach training trial.

Active vs. Passive Localizations



Active - Passive Localization

- **Implicit measures such as reach aftereffects and proprioceptive recalibration saturate quickly.**
- **None of these implicit measures match the fast or slow process.**

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