Implicit components of learning and the two-rate model

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Two-Rate Model for Motor Learning

We test if a two-rate model (Smith et al., 2006) explains effects of feedback during training and if implicit changes, reach aftereffects or proprioceptive changes, match the slow process (McDougle et al., 2015). The two-rate model sets the motor output on trial t as the sum of a slow and fast process:

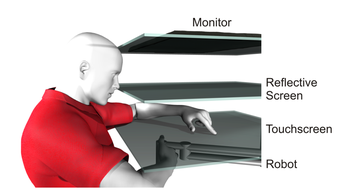
$$X_t = S_t + F_t$$

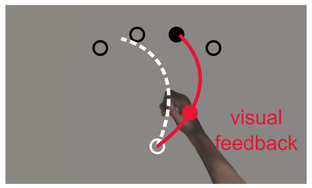
which are each determined by a learning rate L and retention rate R:

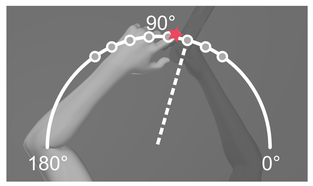
$$S_{t+1} = \mathrm{Ls} \cdot e_t + \mathrm{Rs} \cdot S_t$$

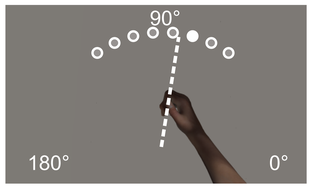
$$F_{t+1} = \mathrm{Lf} \cdot e_t + \mathrm{Rf} \cdot F_t$$

Both processes learn from errors on previous trials (e_t) and retain some previous adaptation (F_t, S_t). Constraints: Ls < Lf and Rs > Rf. The model explains a rebound after a brief reversal of the rotation.









Experimental Procedure

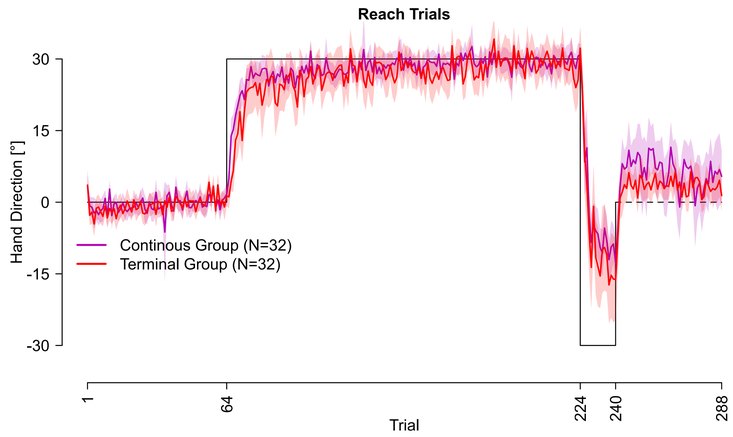
All groups experienced a visuomotor rotation following the two-rate model paradigm. Five different experimental groups were collected which varied on the type of training and the alternating test trial.

Continous	Active training with continous feedback and hand localizations.
Terminal	Active training with terminal feedback and hand localizations.
Exposure	Exposure training with continous feedback and hand localizations.
No-Cursor	Active training with continous feedback and no-cursor trials.
No-Cursor Instruct	Active training with continous feedback and instructed no-cursor trials.

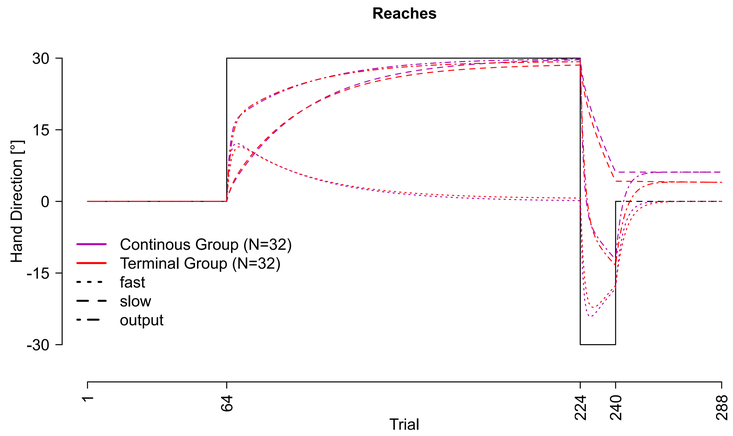
Model Parameters & Quality Of Fit

Condition	Rs	Ls	Rf	Lf	1 Rate Likelihood
Continous N= 32	1.000	0.055	0.728	0.240	0.021
Terminal N= 32	0.999	0.057	0.780	0.182	0.035
No-Cursor N= 32	0.994	0.025	0.778	0.115	0.132
No-Cursor Instruct N=16	0.994	0.028	0.670	0.170	0.147

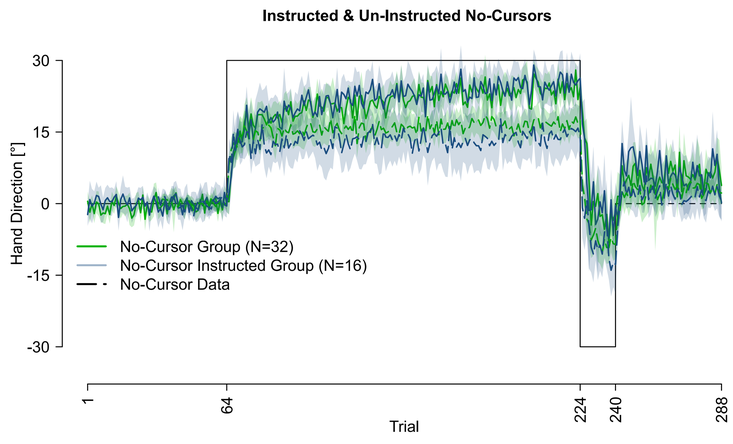
Terminal Feedback Produces A Smaller Rebound



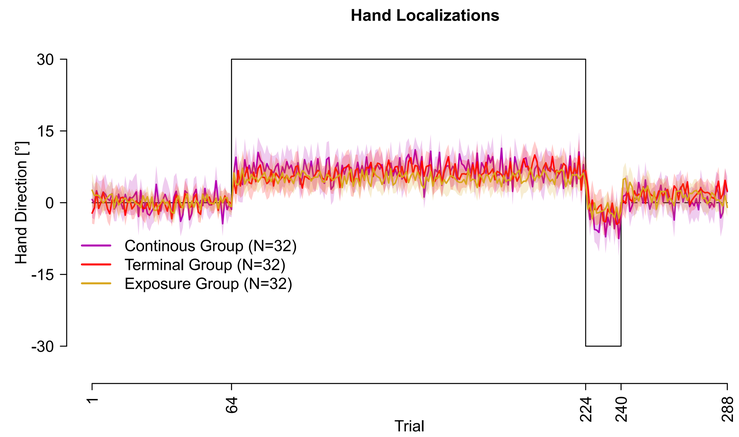
Model Predictions Similar Across Feedback Conditions



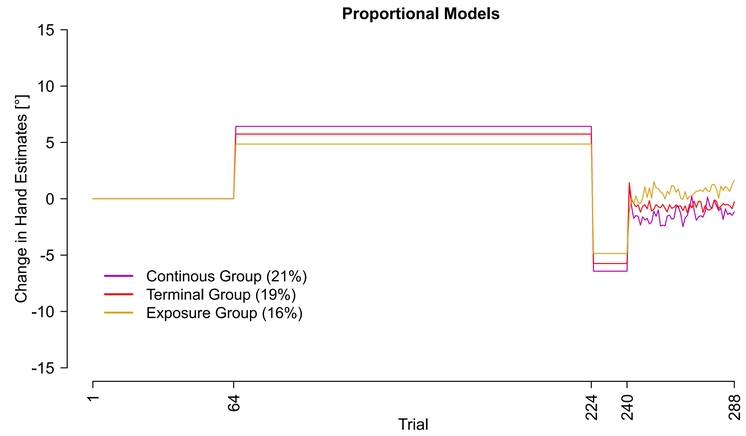
Instructions Do Not Affect Reach Aftereffects



Hand Estimates Are Similar Across Training Paradigms



Proportional Model Best Captures Changes in Localization



Two-Rate Model Captures Terminal Feedback Adaptation

Neither Reach Aftereffects Nor Changes In Hand Estimates Match The Slow Process

Hand Localization Shifts Are A Proportion Of The Visuo-Proprioceptive Discrepancy

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