Target size modulates motor adaptation from sensory prediction errors

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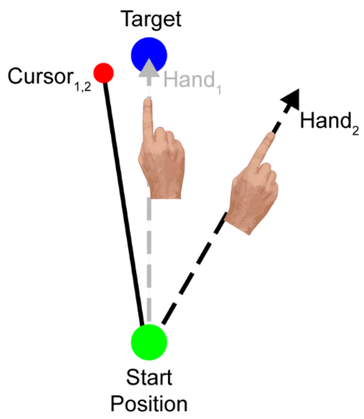
Background

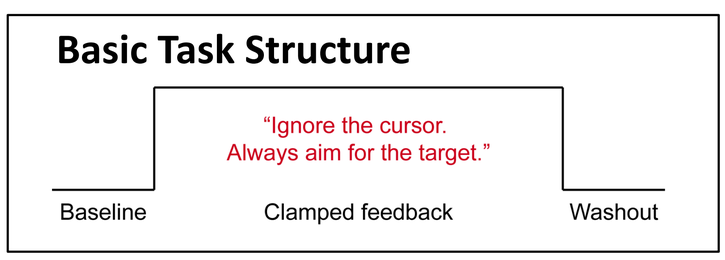
- Our recent work has described constraints on adaptation using clamped visual feedback, a procedure intended to isolate learning from sensory prediction error by making task performance error irrelevant (Morehead et al. 2017; Kim et al. *SfN* 2016)
- For several of the smaller clamped errors we previously tested, the cursor partially overlapped the target, potentially weakening the visual perception of an error and/or providing an unintended reward signal which could attenuate adaptation (Reichenthal et al. 2016)
- Here, we test this hypothesis by systematically varying the target and clamp sizes, thus manipulating the strength of the sensory prediction error and associated task performance error

Clamped Visual Feedback

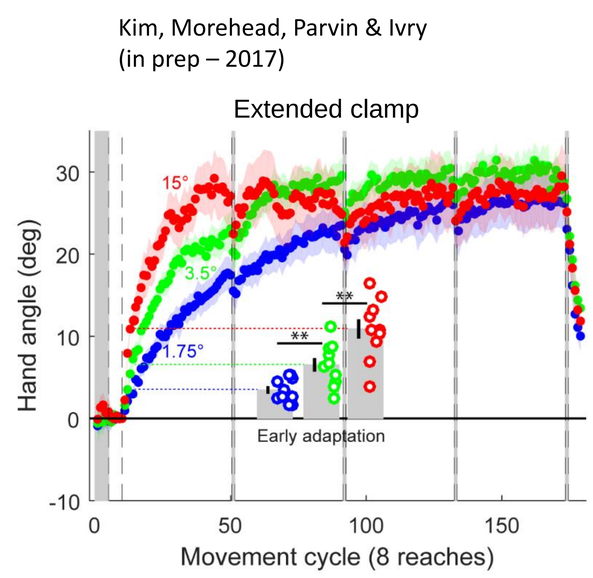


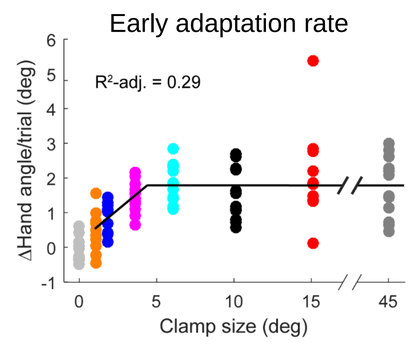
- **Shooting movements**
- **4 or 8 target sets**
- **Cursor trajectory is invariant (spatially uncorrelated) with respect to the hand position**
- **Participants fully informed of the clamped feedback**
- **Kinematic data are sampled from a digitizing tablet (Intuos4 XL) at 225 Hz with a monitor refresh rate of 144 Hz**

Basic Task Structure

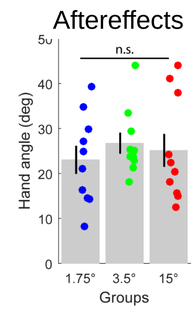


Different clamped errors elicit different adaptation rates, but learning functions converge near a common asymptote



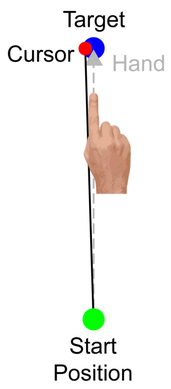


Early adaptation rates scale for small error sizes before quickly saturating for larger errors



Similar final aftereffects in response to 1.75°, 3.5°, and 15° clamps were achieved by the end of 160 movement cycles (1280 reaches)

Lower asymptote when cursor is fully enclosed by target

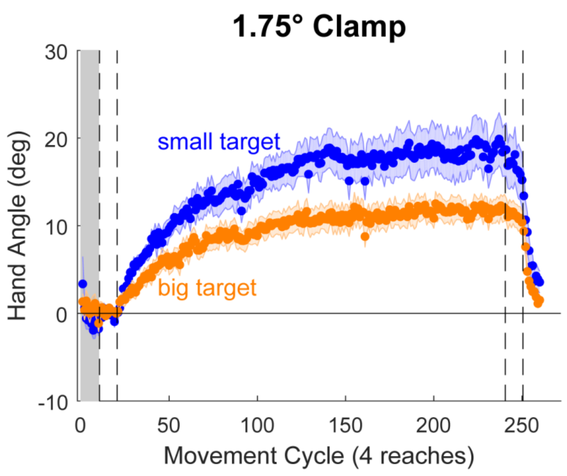


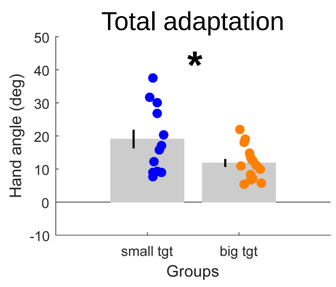
Between subjects design:

Group 1 – small target
Group 2 – big target

Group 1 + Group 2 train with 1.75° clamp

clamped error$_1$ = clamped error$_2$ = 1.75°





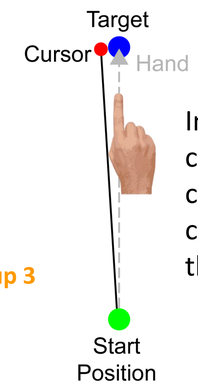
The big target group reached a significantly lower asymptote (p=.02)

Partial overlap of cursor and target does not modulate adaptation

Between subjects design:

Group 1 – small target
Group 2 – medium target
Group 3 – big target

Group 1 + Group 2 + Group 3 train with 3.5° clamp

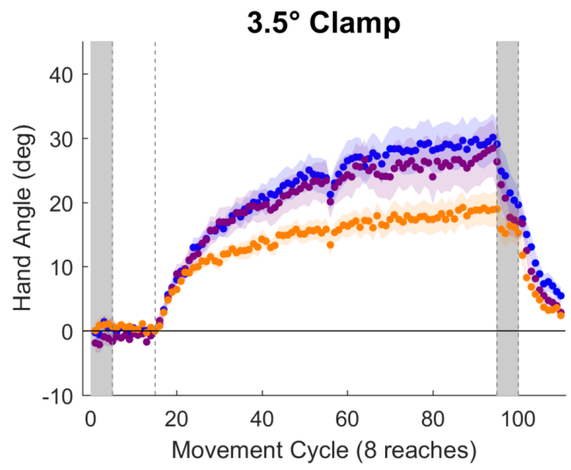


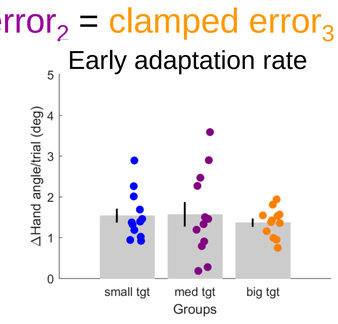
In the small target condition, the clamped cursor feedback is completely outside of the target

In the medium target condition, the clamped cursor feedback is straddling the target

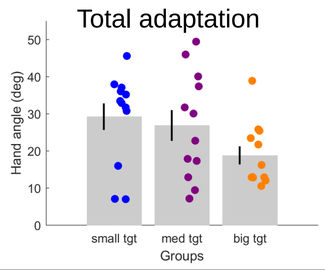
In the big target condition, the clamped cursor feedback is fully embedded within the target

clamped error$_1$ = clamped error$_2$ = clamped error$_3$ = 3.5°



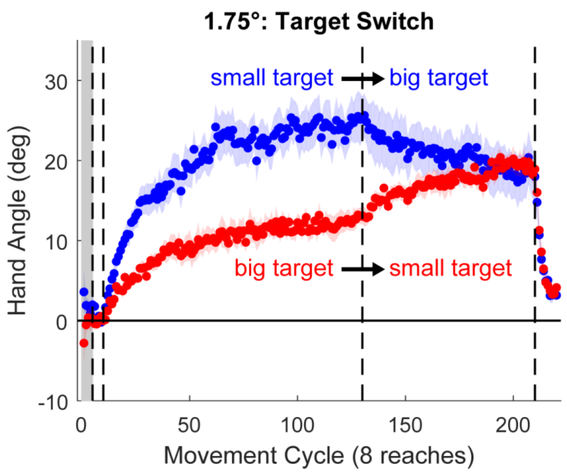


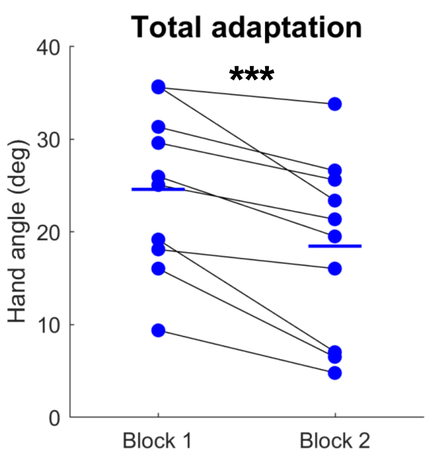
No differences in early adaptation rates were observed across groups

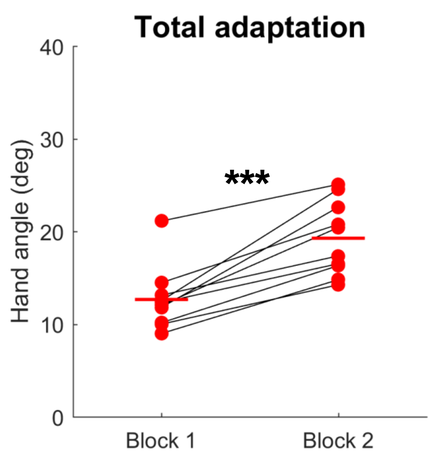


Accumulated learning was significantly different between the big and small target groups (p=.01)

Specific directional effects by switching target size within same session







Changing target size within the perturbation block has a strong effect on the magnitude of adaptation

Conclusions

- **Manipulating target size alone in a clamp paradigm produces robust changes in adaptation**
- **Effect was observed even when the cursor trajectory was clearly off center (i.e., 3.5° clamp), suggesting differences in error detection were not solely responsible**
- **Ongoing experiments are aimed at identifying whether a non-contingent task performance signal could modulate or act in parallel with the adaptation system in order to produce behavioral changes**