

Awareness of implicit adaptation during reaching

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Overview

Background: One method for isolating implicit adaptation is to use 'error clamped' visual feedback^[1,2,3]. Participants reach towards a target while receiving false, clamped visual feedback missing the target at a constant offset. They are told to ignore the feedback, thus eliminating any strategic corrections.

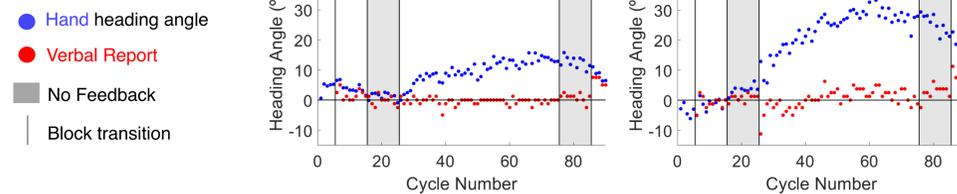


Aim: Here, we test a central assumption of this method, that participants understand the dissociation between their hand and the cursor. We also assess whether participants are aware of their ongoing adaptation.

Conclusion: Participants understand the instructions and are largely unaware of their adaptation in the error clamp paradigm.

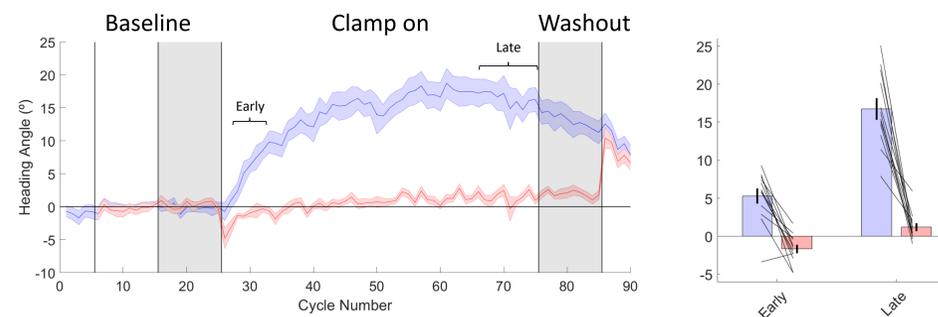
Experiment 1: 15° Error clamp

Individual results



Two example participants adapting to the error clamp (blue) and reporting their felt heading angle (red).

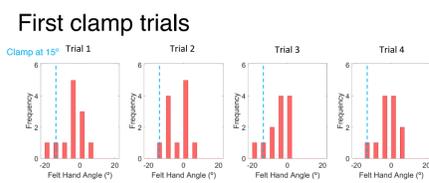
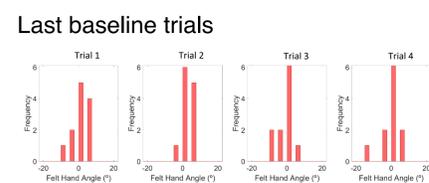
Group results



In the early clamp cycles (cycles 3-7), participants were biased to report feeling as though their heading angle was closer to the clamped feedback (mean -1.7° , $p = 0.012$).

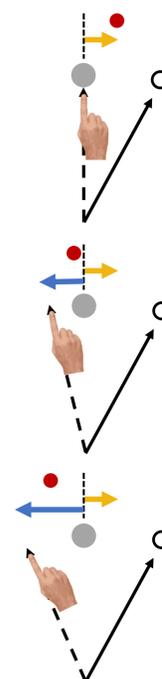
By the end of the clamp block (last 10 cycles), participants felt their heading angle was biased towards their true heading angle (mean 2.26° , $p = 0.045$).

Trial by trial distribution of hand reports



Participant's initial hand report bias towards the clamp is not due to mistaking the cursor with their hand

Possible Interpretation



Hand report data may reflect operation of two processes:
1. Attraction towards clamp (visual signal)
2. Attraction towards hand position (proprioceptive signal)

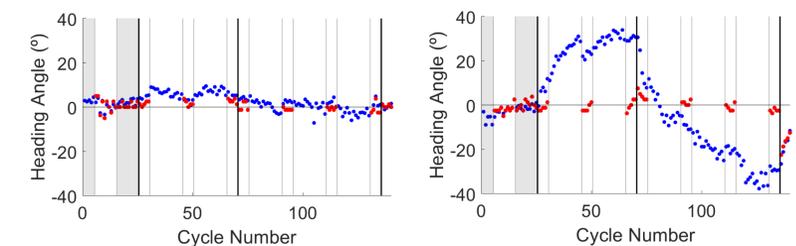
Visual attractor is always at maximal value but with a lower saturation. The hand report data reflects greater influence from this signal, since hand location is near target.

Motor adaptation occurs more slowly and has a larger saturation. The hand report data reflects greater influence from the proprioceptive signals, since hand location is far from target.

Experiment 2: 45° Error clamp with reversal

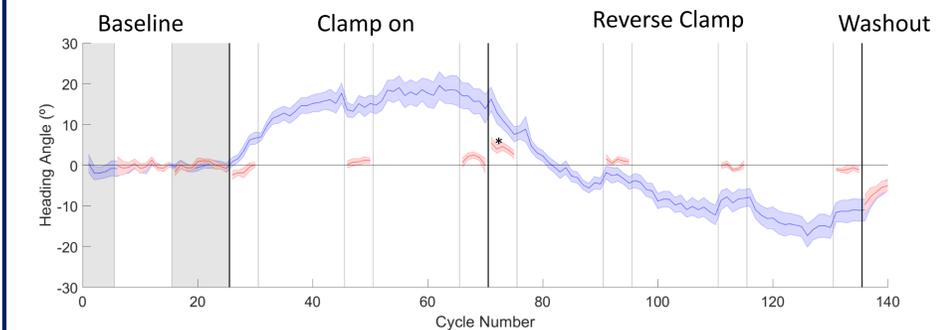
Reverse direction of clamp to provide stronger assay of shifts in perceived hand position.

Individual results

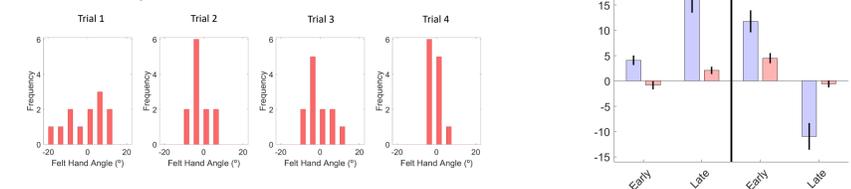


Two example participants showing small (left) and large (right) amounts of adaptation

Group results



First clamp trials

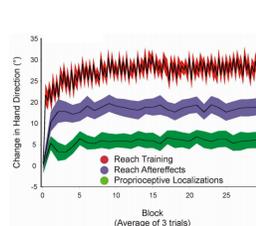


Results are qualitatively similar to Experiment 1. *Notably, at the point of the error clamp reversal, participants felt heading angle is increased from 2.1° to 4.5° ($p = 0.029$), towards the direction of the new error clamp. This is despite the actual heading angle decreasing from 16.5° to 11.8° ($p = 0.001$).

Discussion

Participants show only small shift in perceived hand position, indicating negligible awareness of clamp-induced adaptation. Likely reflects strong prior to expect hand at aimed location.

However, systematic biases are present which we hypothesize reflect two processes (see 'Possible Interpretation'). This is consistent with previous work from Ruttle et al showing proprioceptive recalibration in response to perturbed visual feedback can occur quickly and with a lower saturation than motor adaptation.



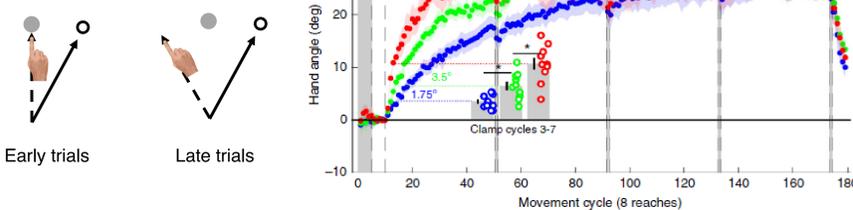
Ruttle et al 2018

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References: [1] Morehead et al 2017; [2] Kim et al 2018; [3] Parvin et al 2018; [4] Ruttle et al 2016.

Methods

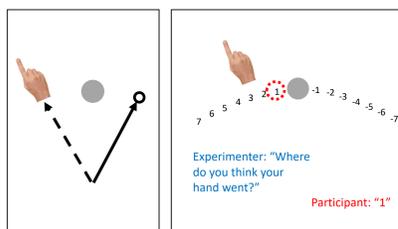
Error Clamp Paradigm



From Kim et al 2018

Left: Participants reach towards target while receiving clamped feedback. Over time, reaching heading angle shifts away from the clamp, indicative of adaptation. Right: Adaptation converges on common asymptote, independent of error size^[2].

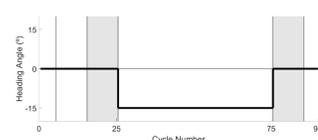
Verbal report of estimated heading angle



Participants instructed to shoot past target and maintain final position. After 1s, ring of numbers is presented and participants report number corresponding to felt hand position when passing target.

Experimental Design

4 targets (45° , 135° , 225° , 315°).
Shooting movements with online feedback.
Clamp directions counterbalanced CW/CCW.



Experiment 1: -15° clamp

Experiment 2: -45° & 45° clamp

- Reverse direction of clamp to provide stronger assay of shifts in perceived hand position.
- Intermittent probe of hand position for efficiency.

