# That's not my hand: Attributing errors to external sources dampens predictive but not proprioceptive changes in hand position estimates

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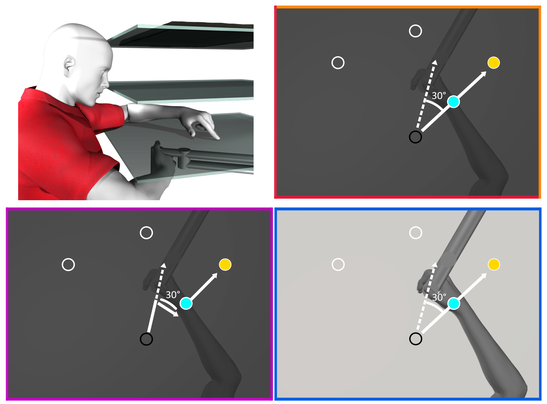
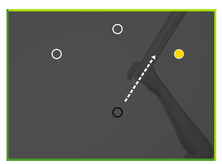
## Source attribution and motor adaptation

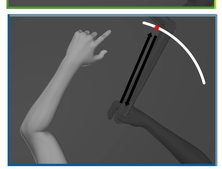
People account for the source of motor errors during adaptation within dynamic conditions. When visual feedback of the hand is altered, adaptation involves updating hand position estimates based on both proprioception and efferent-based predicted sensory consequences. If the source of the error experienced is clearly external in nature, rather than being internally-driven, then updates in hand position estimates should be reduced. To test this, we trained participants to reach with a 30° rotated hand-cursor, and we manipulated the extent of external error attribution.



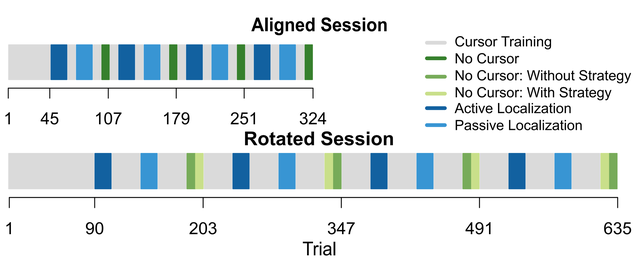

Non-Instructed group (n=20): control, received neither instructions nor different visual stimuli
Instructed group (n=21): received a counter-strategy for the rotation
Cursor Jump group (n=20): saw the rotated cursor mid-reach on every trial
Hand View group (n=29): saw their actual hand along with the rotated cursor on every trial



No Cursor reaches
- With Strategy
- Without Strategy

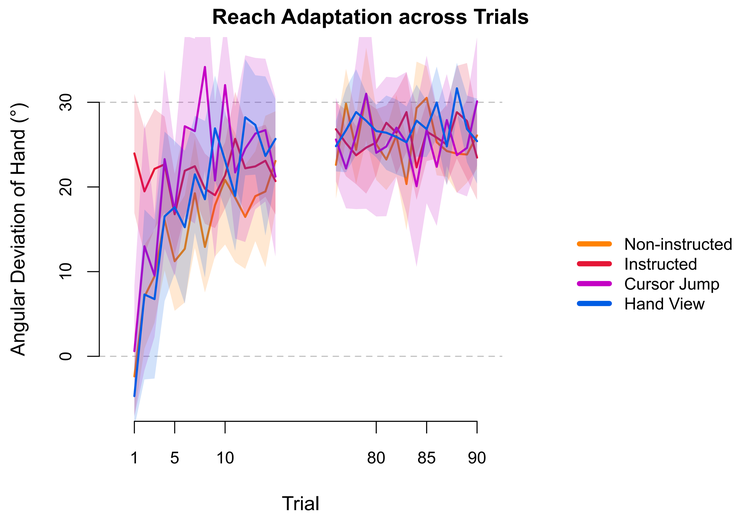


Hand localization
- Active Localization: Participant-generated movement, allowing hand localization with both proprioception and predictions.
- Passive Localization: Robot-generated movement, allowing hand localization with only proprioception.

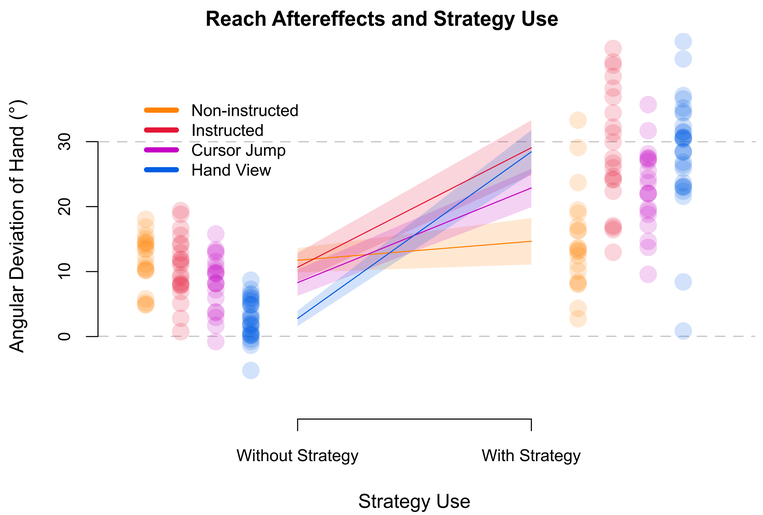



## Despite attributing errors externally, reach aftereffects persist

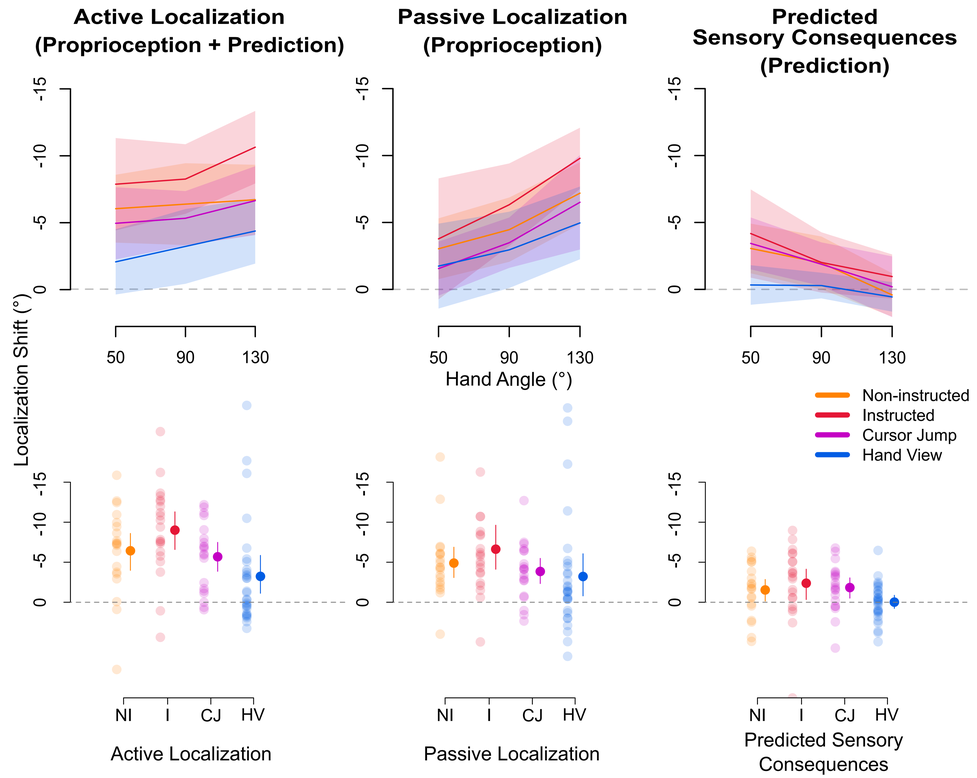
During adaptation training, only the Instructed group was able to immediately counter for the rotation. Nevertheless, all groups learned to compensate for the perturbation by the end of training.



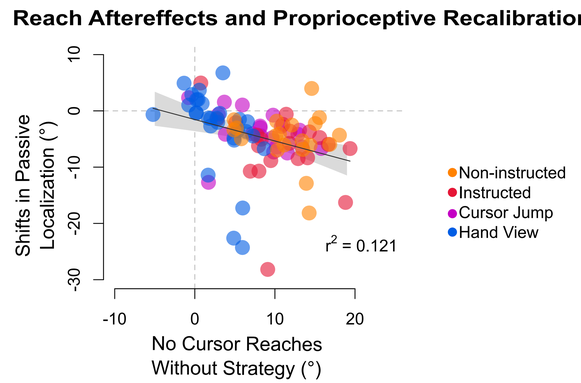

When asked to either use or not use any strategy they could have developed during adaptation training, only the Non-Instructed group could not do so at will, suggesting unawareness of the nature of the perturbation. Importantly, reach aftereffects were present across all groups, but was reduced for only the Hand View group.




## External error attribution affects changes in predictions, but not proprioception




Hand estimates based on predictions were reduced for the Hand View group, but changes in proprioception persisted for all groups. Moreover, we found that reach aftereffects correlated with proprioceptive recalibration, suggesting that proprioception could be contributing to implicit motor changes.




**Although the nature of the perturbation was clearly external for the Hand View group, both implicit aftereffects and updates in proprioceptive estimates persisted. It seems that these two implicit processes are insuppressible.**

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