Motor learning by observing the movements of a computer-animated, human-like actor and a non-limb observational video

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Background

Motor learning

- Learning a new motor skill involves mapping an internal model of the forces required for the movement in the brain [5].
- Internal models represent features of the body and the external environment [5].
- Motor learning can occur through physical practice or through observation, the latter of which explicitly engages the visual system in viewing stimuli to facilitate learning [2].
- Regions of the dorsolateral and ventromedial prefrontal cortices have also been shown to be active when an individual is processing motor skills through observation [2].
- The dynamical characteristics of the stimuli used to facilitate observational motor learning can implicitly provide information such as joint torques or muscle forces that dictate "how" a movement is performed [1].

Forcefield learning paradigms

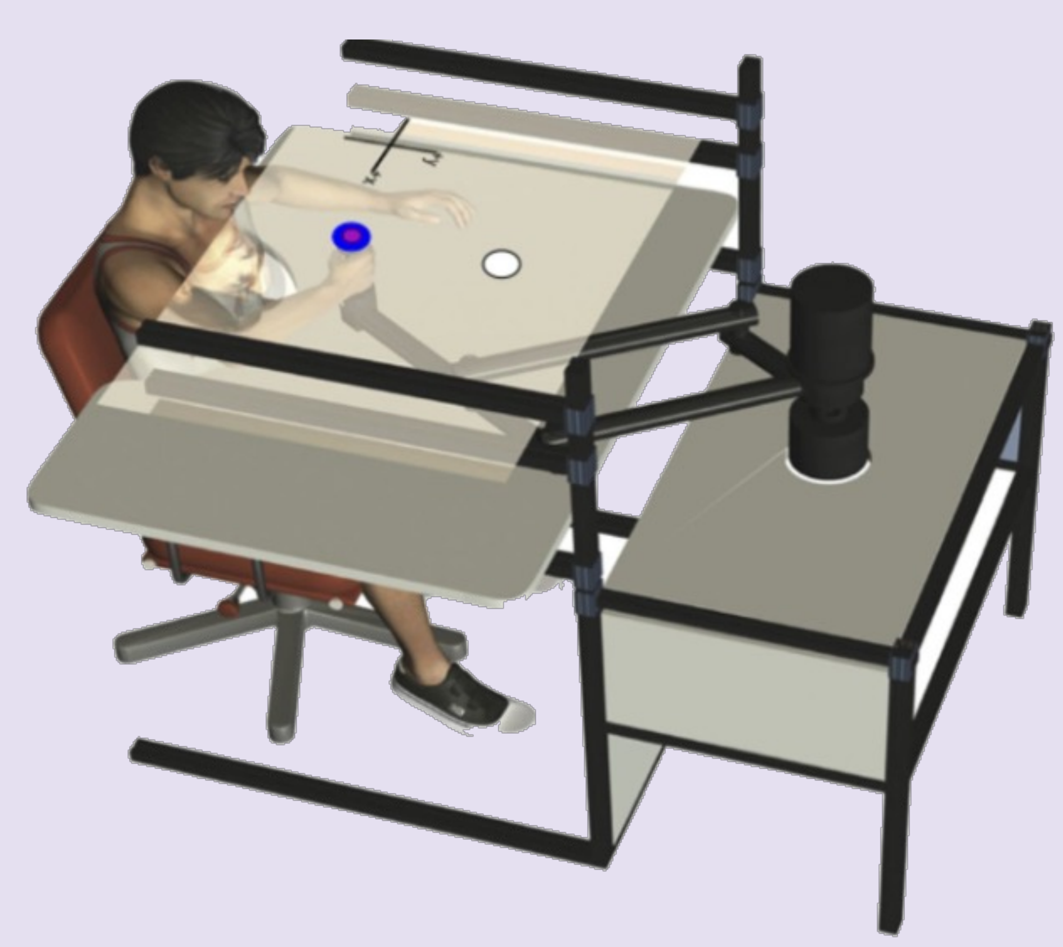


Figure 1. Schematic showing the robotic manipulandum used to study observational motor learning. A robot-generated forcefield can perturb participants' arm reaches in a clockwise or counter-clockwise direction. It has been shown that participants who observed a video another person learning to reach in a forcefield environment performed better than subjects who did not observe the video [2]. Further, participants can adapt their lateral force output to compensate for a forcefield that they have not experienced themselves [4]. Schematic adapted from McGregor and Gribble (2015).

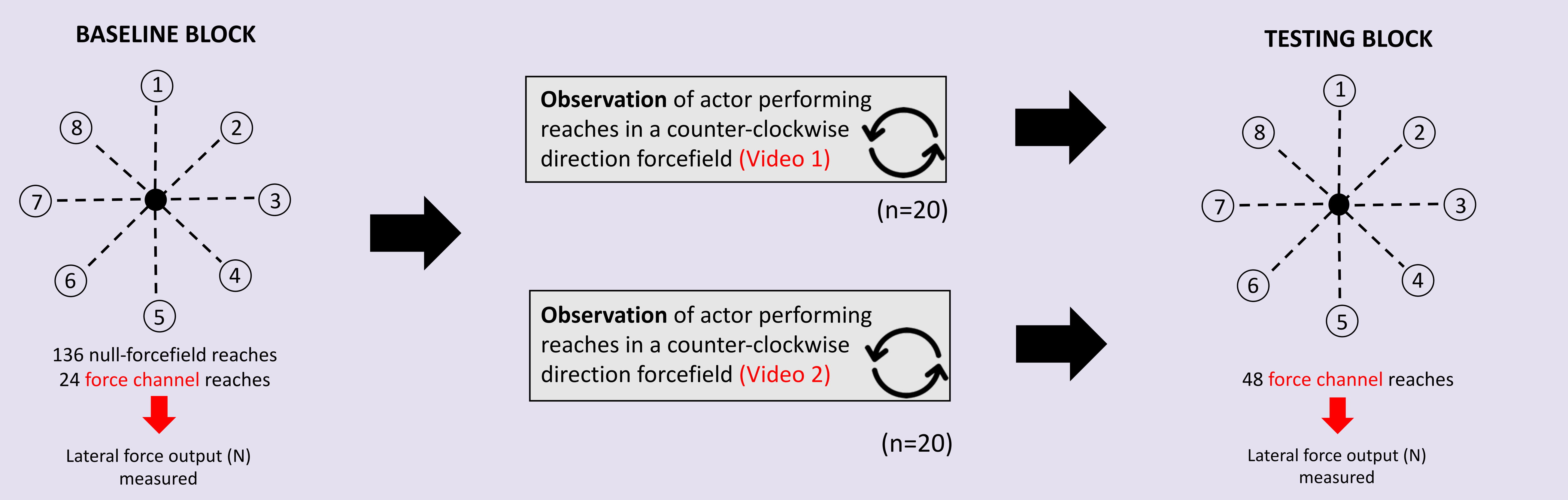
Rationale

- It is known that the visual system is involved in transforming visual stimuli into neural representations of motor movements [5].
- Are there certain components of the human tutor's movement patterns that can prime the visual system to learn a motor task?
- It is unknown what specific aspects of visual stimuli can drive motor learning. For instance, would depicting an computer-animated representation of a human will be sufficient to elicit learning.

Hypothesis

1) Observing a computer-generated video of an animated, human-like tutor learning to reach in a forcefield would elicit motor learning
2) Observing a video of a tutor learning to reach in a forcefield without structural features (i.e. arm or torso) would elicit motor learning.

Methods



**Video 1:* depicts a bird's eye view of a computer animated actor's right arm and hand grasping a manipulandum **Video 2:* depicts only the handle cursor

Results

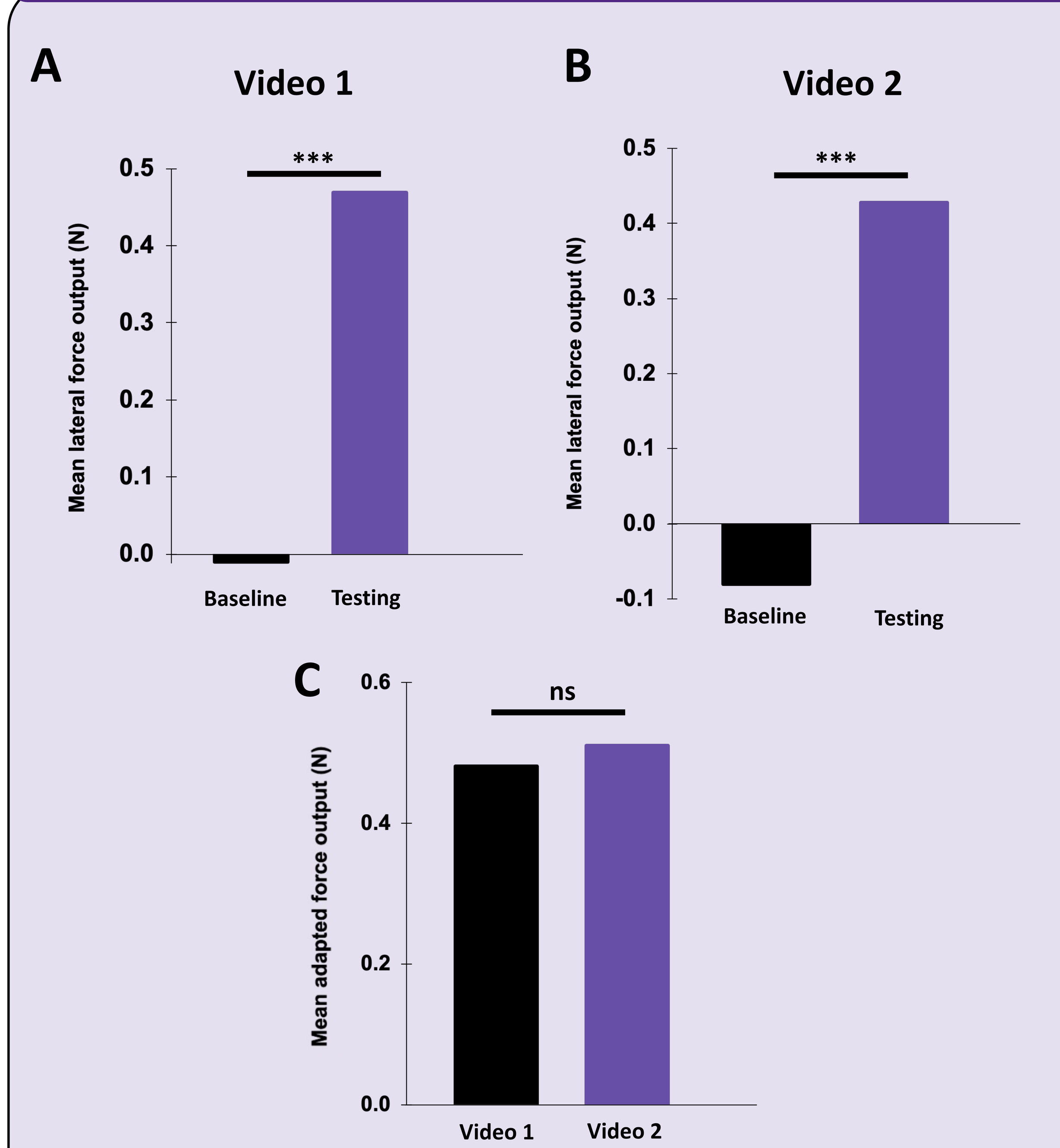


Figure 2. Force output measurements for the observational video groups. (A) The mean lateral force output for the Video 1 observation group showed a significantly increased mean (±SE) lateral force output in the testing block when compared to baseline (***P<0.001). **(B)** The Video 2 observation group showed a significantly increased mean (±SE) lateral force output in the testing block when compared to baseline (***P<0.001). **(C)** The mean change (±SE) in lateral force output for the Video 1 and Video 2 group were not significantly different from each other. (P=0.1373).

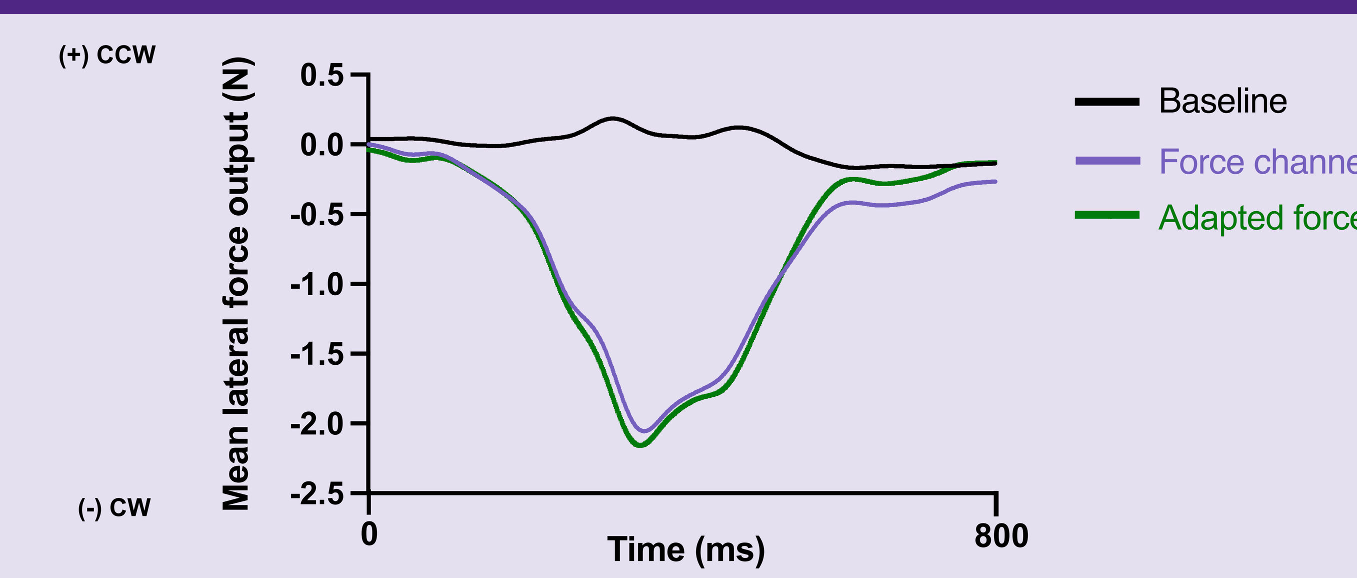


Figure 3. Mean lateral force time series plot for the counter-clockwise observation video. The data was generated from a pilot study of a human participant who performed arm reaches, using the robotic manipulandum, in the presence of a counter-clockwise perturbing forcefield. Data is a visual representation of the compensatory force changes to a counter-clockwise perturbing forcefield by the pilot study participant.

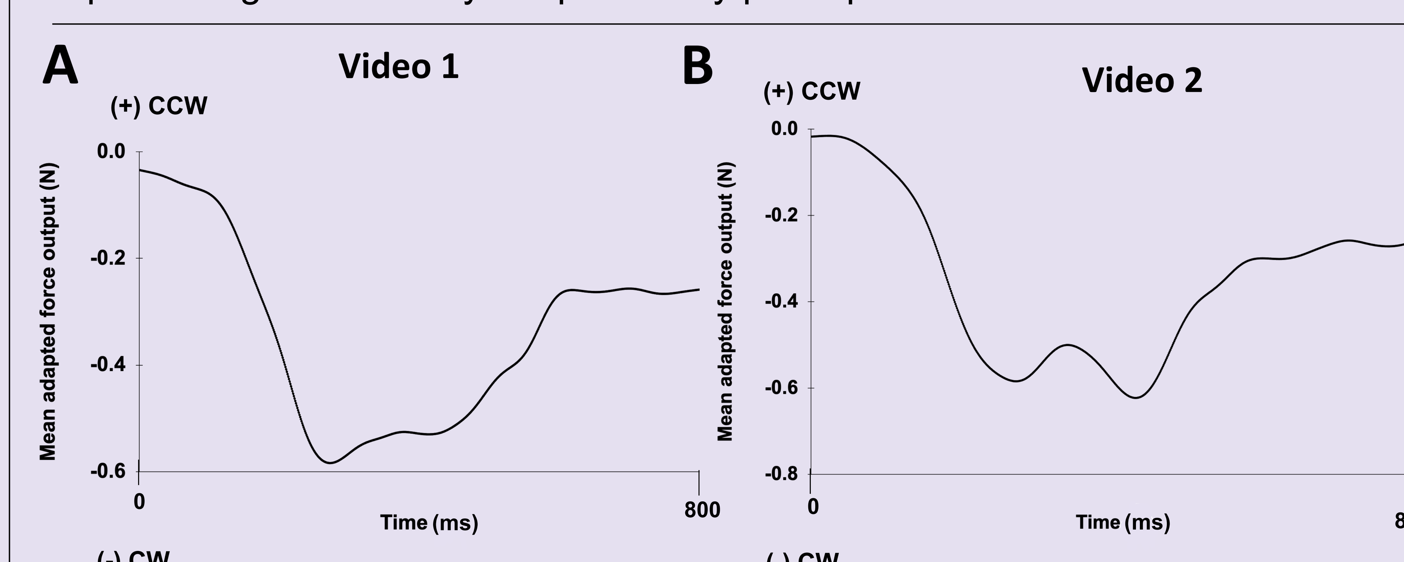


Figure 4. Mean adapted force time series plots for the observational video groups. Data shown are the time series of the adapted force output averaged over the first eight testing block force channel trials for the counter-clockwise (CCW) forcefield video observation groups. The adapted force output was calculated as the difference between the force channel trials in the testing block and the baseline block.

Discussion & Conclusion

- Observing both Video 1 and Video 2 of a tutor learning to reach in the counter-clockwise direction forcefield resulted in significant adaptive force changes compared to baseline; suggesting motor learning.
- Participants who observed Video 1 or Video 2 showed a similar compensatory force profile as pilot study participant who physically experienced the forcefield.
- Results suggest that a modified representation of a human is sufficient to elicit motor learning. Motor learning might depend more on the movements being observed rather than the physical qualities of the tutor
- Findings could inform novel neurorehabilitation approaches.

References

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