Force adaptation of speeded reaches in the absence of a force perturbation

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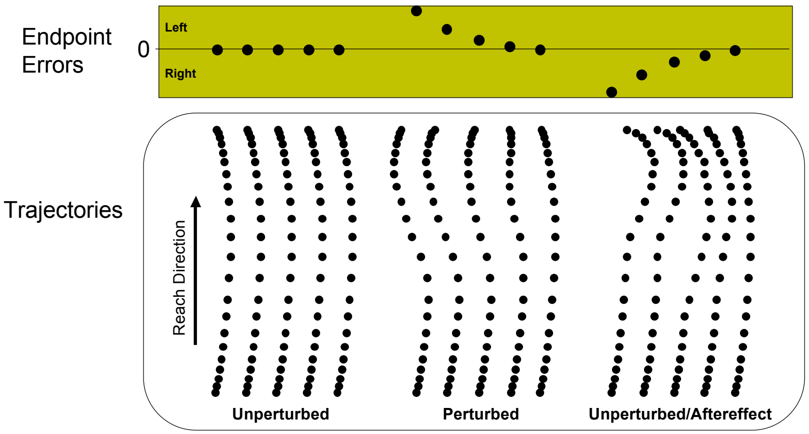
1. Background

Motor adaptation is commonly studied by applying force perturbations to a reaching arm.

When such perturbations are predictably applied, trajectories and endpoints show compensation for the perturbation over repeated reaches that results in a negative aftereffect when the perturbation is eventually removed. For example:



The observed negative aftereffect suggests that compensation results from the CNS computing and adding a set of time-varying torques to the arm, equal to the negative of the perturbation, when programming the reach.

2. Questions

If a nonforce perturbation is predictably applied to the arm during reaching movements using the Manual Following Response[1] (MFR), in which motion of a large-field visual stimulus perturbs a reach in the direction of stimulus motion, will trajectories and endpoints show compensation over repeated reaches?

If compensation is observed, what changes describe the computation of reach trajectories and/or endpoints of the compensated reaches?

Three possibilities:

1) Compensation will occur just as if a force perturbation had been applied (additional forces will be applied to null the 'effective applied force').

2) Subject will only recompute aim points to compensate, so that trajectories remain distorted until the visual motion (and hence the MFR) is eliminated.

3) Compensation will consist of reducing the gain of the sensory-motor feedback loop responsible for the MFR.

[1] Saijo, Murakami, Nishida & Gomi, *J NeuroSci, 25*, 4941-51, 2005

3. Prediction

We focus here on the possibility that the CNS uses an energy-conservative strategy for compensating the perturbation[2,3,4].

An energy-conservative strategy predicts possibility #3, in which no negative aftereffect would be observed following adaptation.

[2] Alexander, *Biol Cybern, 76*, 97-105, 1997; [3] Todorov & Jordan, *Nat Neurosci, 5*, 1225-35, 2002; [4] Todorov, *Nat Neurosci, 7*, 907-915, 2004

4. Task

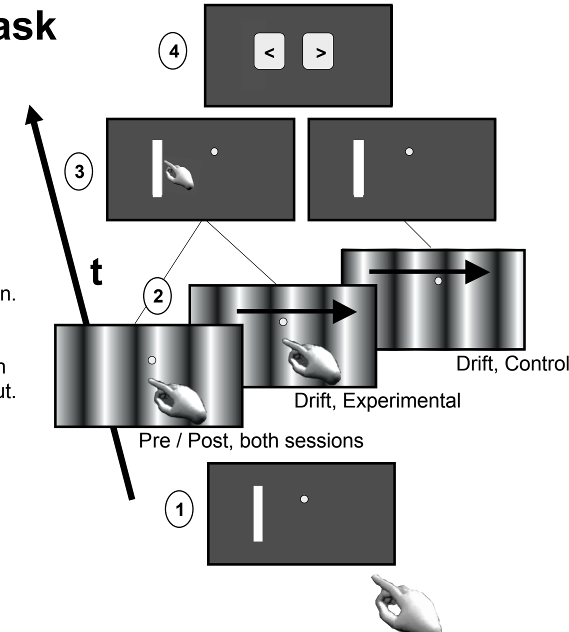
Two sessions:
- ● - Main Experiment
- ■ - Visual Control Experiment

Each session consists of:
Pre / Drift / Post trials.

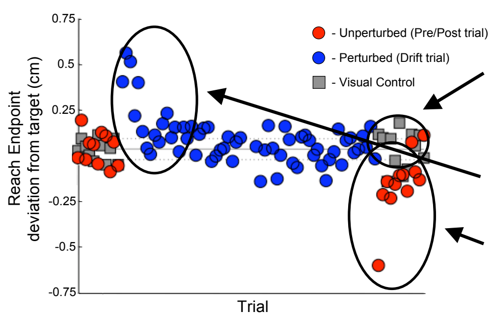
Pre & Post Trials (both sessions):
(1) Target is shown; as reach begins, sine grating shown.
(2) Grating continues to be shown throughout reach.
(3) Screen touched; target and feedback shown.
(4) Subject indicates whether '<' or '>' flashed in fixation circle, to verify that fixation was maintained throughout.

Drift Trials, Main Session:
Same as Pre & Post, except:
(2) Partway through the reach, grating drift begins.

Drift Trials, Visual Control:
Same as in Main Experiment Drift trials, except that no reach is made.



5. Results & Conclusion



- Because control reaches made after viewing (but not reaching toward) drifting gratings show no aftereffect, the aftereffect seen in experimental reaches is not due to a visual motion aftereffect.
- Force compensation to nonforce perturbation? YES (Possibility 1 or 2)
- Compensation as gain change? NO (Possibility 3)

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