Reaching for a Good Aiming Strategy in People with Cerebellar Degeneration

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Summary of Results

- Cerebellar ataxia (CA) patients are only mildly impaired at developing a cognitive aiming strategy when reaching to a single target.
- Reaching to more than one target location leads to a substantial impairment for CA patients.
- Patients show a deficit in adaptation from sensory prediction errors independent of task performance.

Error Clamp Task Design

Participants reached to four targets spaced in 90° increments. On visual error clamp trials, the feedback cursor was locked to a fixed heading angle that was offset from the target by 45°. This breaks the contingency between angular deviation of the hand and cursor feedback, while maintaining a temporal correlation.

Error Clamp Results

Mean hand angle over the last 10 episodes (40 trials) of the error clamp block for both groups and individuals. Patients were impaired relative to controls.

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Background

A classic observation in the field of motor control is that persons with cerebellar ataxia exhibit deficits not only in the coordination of movements, but also in sensorimotor adaptation tasks. The specific cause of this deficit has, however, remained elusive. Much recent work has attempted to break sensorimotor adaptation into various components, such as implicit and explicit processes, action-selection and error-based learning, or temporally stable and labile motor memories. Distinctions such as these may yield new insights if applied to the motor learning deficit in cerebellar ataxia.

Here we examined learning in two task contexts where we could dissociate action-selection from implicit adaptation to sensory prediction errors. The first task employed arbitrary color cues that allow the flexible use of aiming strategies to boost task performance. By switching the cue on and off, we can reveal the relative contribution of both processes. The second task induces task-irrelevant sensory prediction errors to assay implicit learning in relative isolation.

Cue-Evoked Savings

The difference between that first and second rotation block trials shows where cue-evoked savings can exist in aiming. Surprisingly, this change in behavior can only be attributed to the presence of the cue, as no evidence was found of sensorimotor adaptation, suggesting that the behavior is not under the control of the cerebellar cortex.

Cue-Evoked Savings

The aftereffect size is similar in 1- and 4-target conditions. CA group shows less benefit from the cue. The after-effect for the second rotation was lower for all groups in both the single- and four-target conditions. This suggests that the after-effect is driven by explicit adaptation and not implicit learning, however, this could also come about if the locus of implicit learning is the aiming location. If participants only implicitly learn aiming strategy and explicit learning, generalization would show a reduced after-effect at the goal location.

Aftereffects

Aftereffects size is similar in 1- and 4-target conditions. CA group shows less benefit from the cue. The after-effect size is similar in 1- and 4-target conditions. CA group shows less benefit from the cue.