Augmenting Joint Speed Feedback to Improve Myoelectric Prosthesis Adaptation

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Summary

We rely on bi-directional communication between our brains and limbs for coordinated movement.
Lack of proprioception in robotic prostheses fragments this communication and drastically impacts coordinated control.
Often, artificial sensory feedback can improve control, <u>but only with sight of the limb obscured</u>

The aim of this study was to provide sensory feedback that yields a benefit in the presence of vision
This necessitates providing sensory information that is not accurately provided by vision: speed

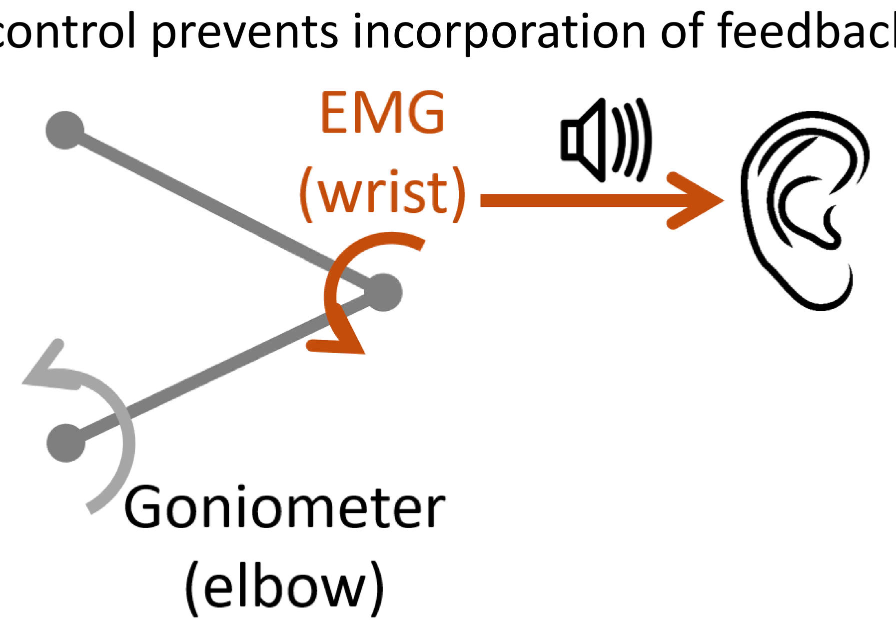
I ran reaching experiments requiring ballistic simultaneous control of biological and robotic joints to investigate how limb speed information affects reaching performance and adaptation to self-generated and perturbation-generated reaching errors
My work suggests that <u>coordination of ballistic hybrid movements is possible</u>, but found <u>no evidence for differences in adaptation behavior with feedback</u> to self-generated or perturbation-generated errors

This suggests joint speed feedback may improve robotic prosthesis control even in the presence of vision, but differences in behavior are not well described using traditional motor learning frameworks

Center-Out Reaching Setup

Control

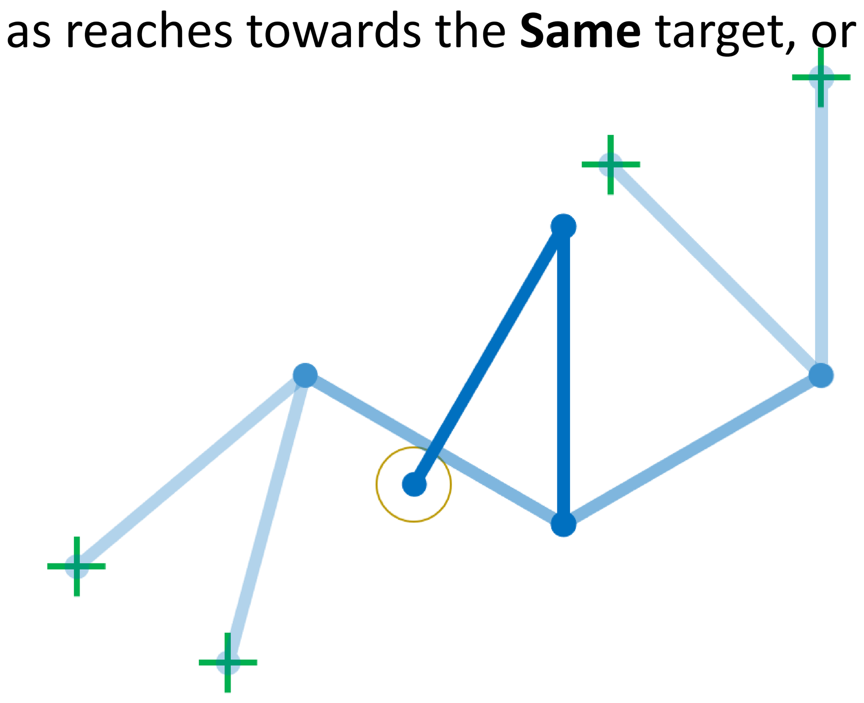
Hybrid virtual ballistic center-out reaching task requiring biological (elbow) and robotic (wrist) control prevents incorporation of feedback during reach



During **Feedback** conditions, frequency-modulated audio tones proportional to wrist speed were provided

Task

Subjects made ballistic reaches towards 4 different targets (below). Target order organized as reaches towards the **Same** target, or **Different** targets

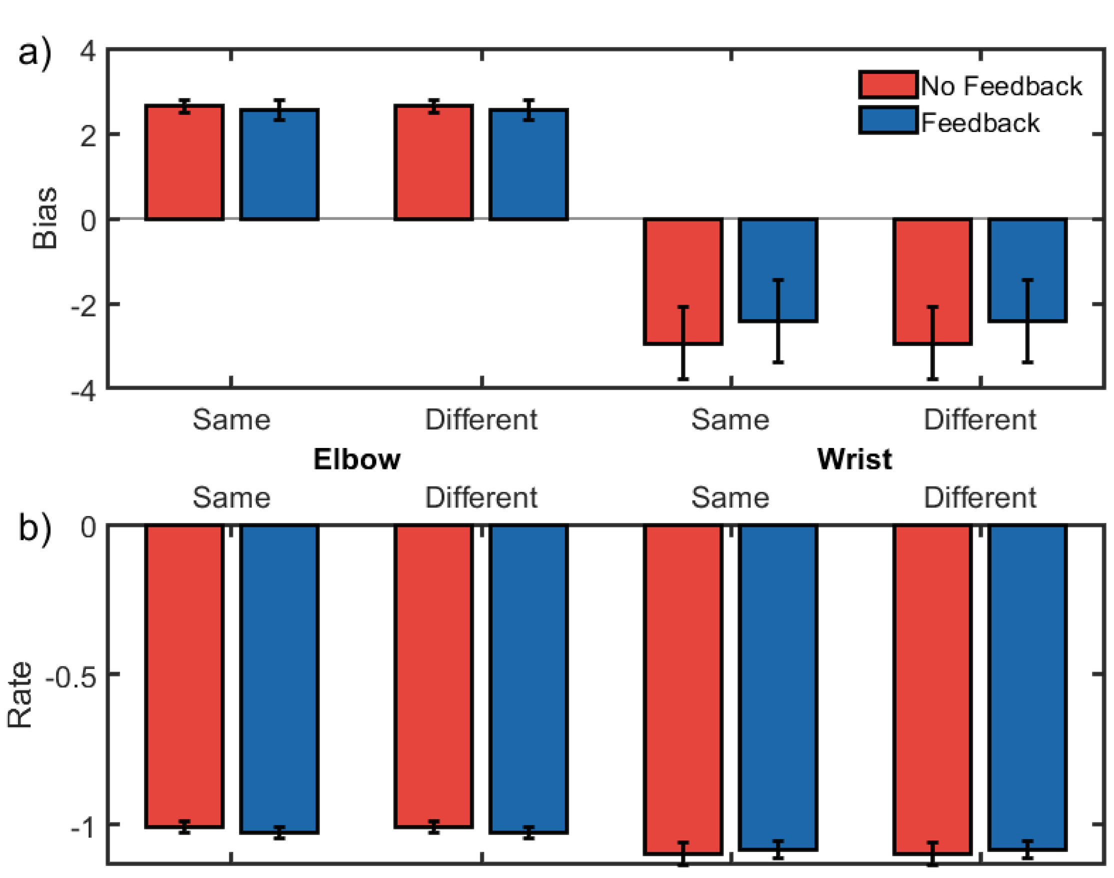


During the Perturbation block, wrist EMG gains were doubled, drastically impacting control of the limb

Trial-by-Trial Adaptation

No co-variation between biological and robotic control suggests coordination of hybrid movements even during ballistic movements, during which feedback of movements cannot be incorporated into the motor plan

Greater clustering while reaching towards the same targets confirms improved performance during task-specific, over generalized, repetition



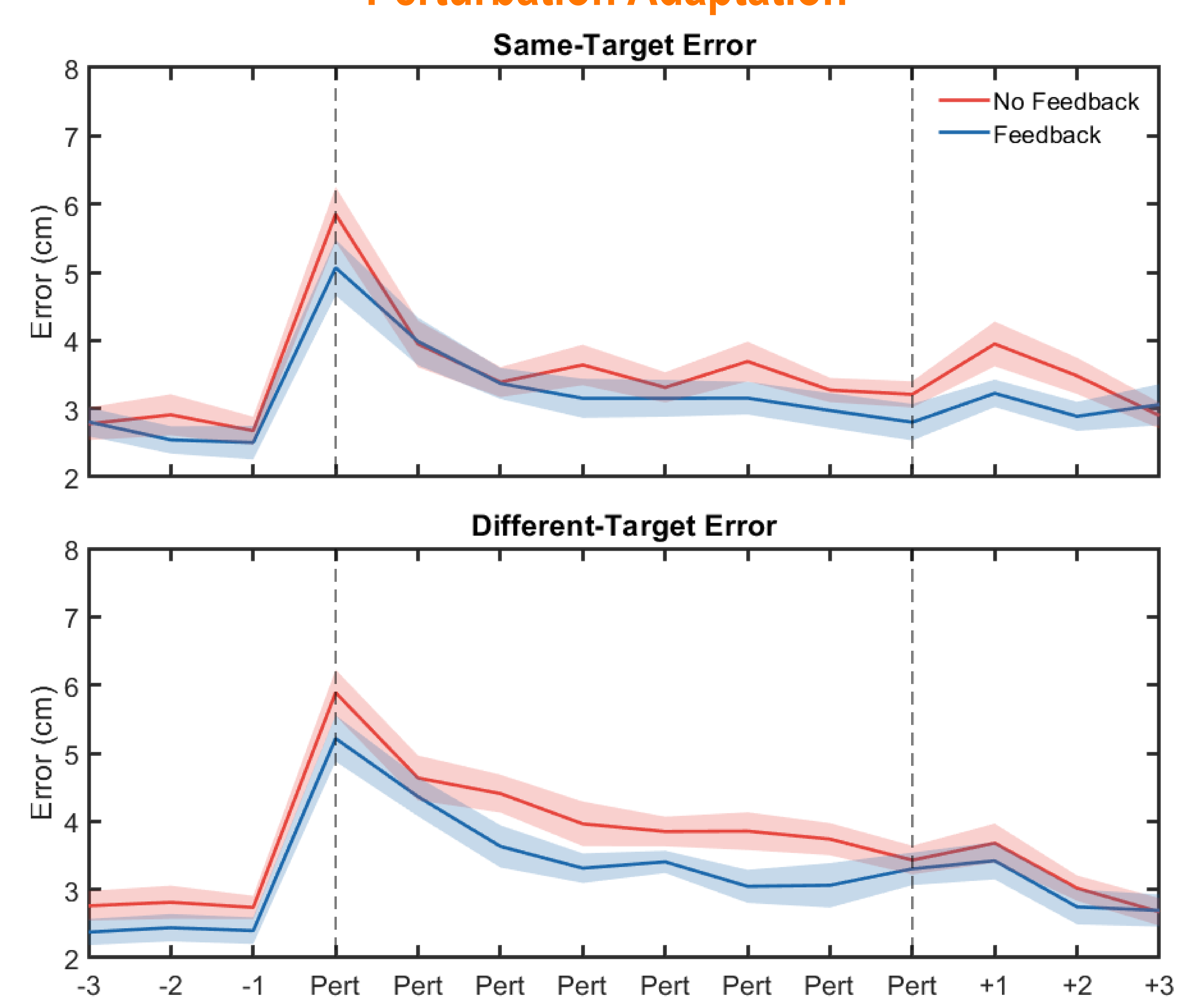
Trial-by-trial adaptation rate fit according to:

$$\Delta_{Error}(t+1) = a * Error(t) + \Delta_0$$

where a is the adaptation rate and $\frac{-\Delta_0}{a}$ is the bias

Results suggest lower adaptation rate for both biological and robotic control during generalized reaches

Perturbation Adaptation



Perturbation data were fit to an exponential decay model with the form:

$$y = \alpha e^{-\lambda x} + \epsilon_\infty$$

where ϵ_∞ is the steady-state error, α is the gain, and λ is the adaptation rate

Broadly, results suggest lower steady-state error with artificial sensory feedback available, but provide no evidence for differences in adaptation rate

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