Asymmetric Learning in an Asymmetric Bimanual Task

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The Action Lab

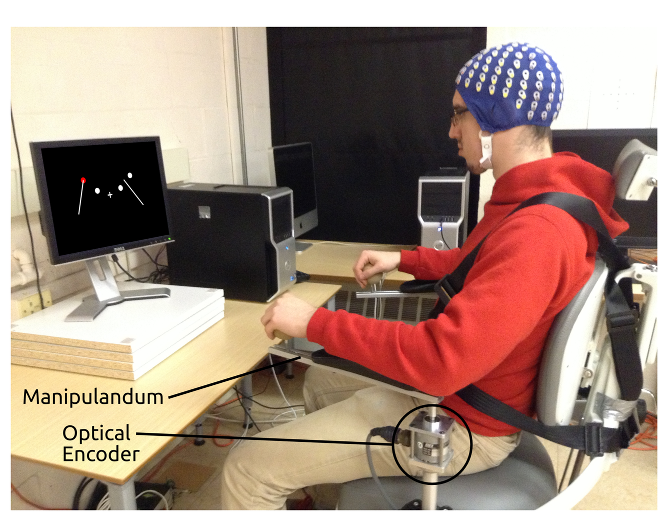
Introduction

Many everyday tasks such as eating with a knife and fork or opening a jar involve performing different actions with both hands simultaneously. While asymmetric bimanual actions abound in normal life, we frequently experience that dissociating the two hands is difficult, as seen anecdotally in rubbing the stomach and patting the head. The callosal connection between the two hemispheres of the brain enables communication between the hemispheres but also constrains and creates interference (e.g., Gerloff and Andres, 2002). Asymmetric bimanual tasks have received significantly less attention than unimanual or symmetric bimanual tasks in motor neuroscience because of the difficulty in measuring callosal communication and the lack of a theoretical framework (Obhi, 2004). The nature of cross-callosal interference and the extent to which it can be attenuated remains unknown. The present study examines interhemispheric communication in humans performing an asymmetric bimanual task to determine the type of interference and whether extensive practice can attenuate such interference.

Methods

Experimental Setup:

17 healthy, right-handed college students performed bimanual movements while seated with forarms on horizontal manipulanda. Elbow angle is recorded with an optical encoder. Subjects are shown arm position online on a monitor.



Instructions:

Left arm movement: On randomly timed cue, move left arm to other target dot as quickly as possible.

Right arm movement: Move arm smoothly and continuously between dots to metronome beat of .75 Hz (heard for 10 beats at beginning of each trial).

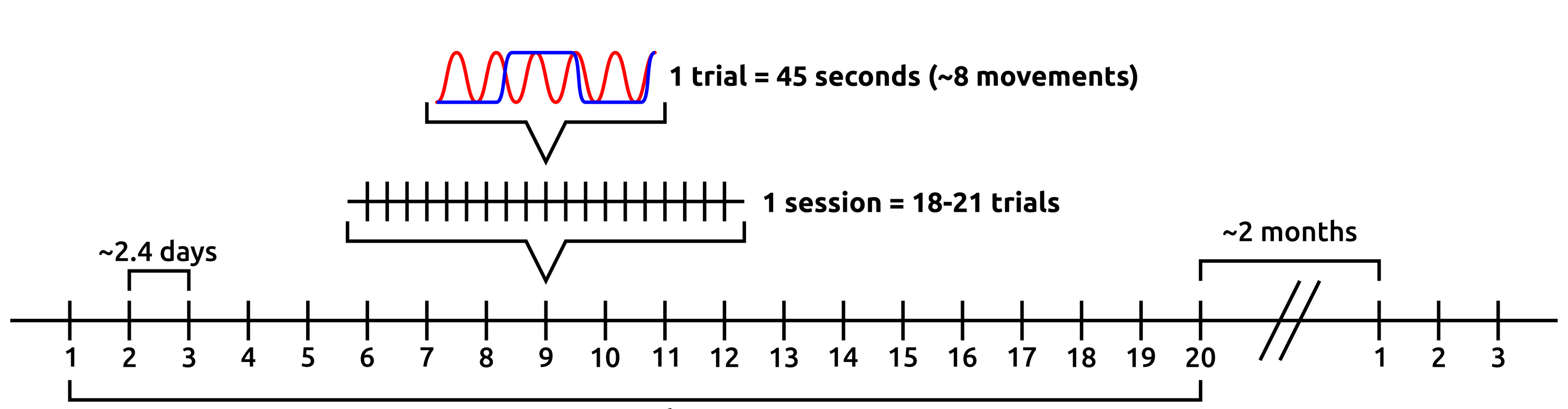
Protocol:

Visual feedback at end of each trial: Left arm peak velocity, right arm perturbation, and average right arm frequency.

Session 1: 4 practice trials with each hand separately (unimanual) and 16 bimanual trials.

Sessions 2-20: 16 bimanual trials, and 1 unimanual trial for each hand. All trials are 45 s long.

Retention Sessions 1-3: Same as sessions 2-20 after 2 month gap.

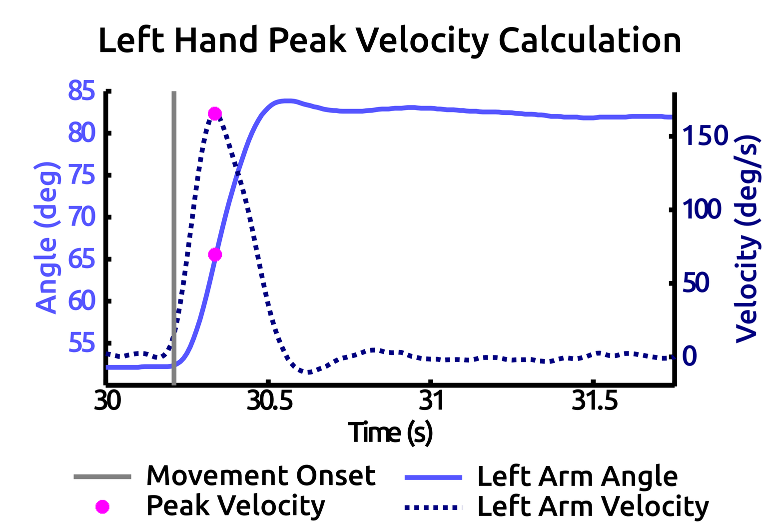


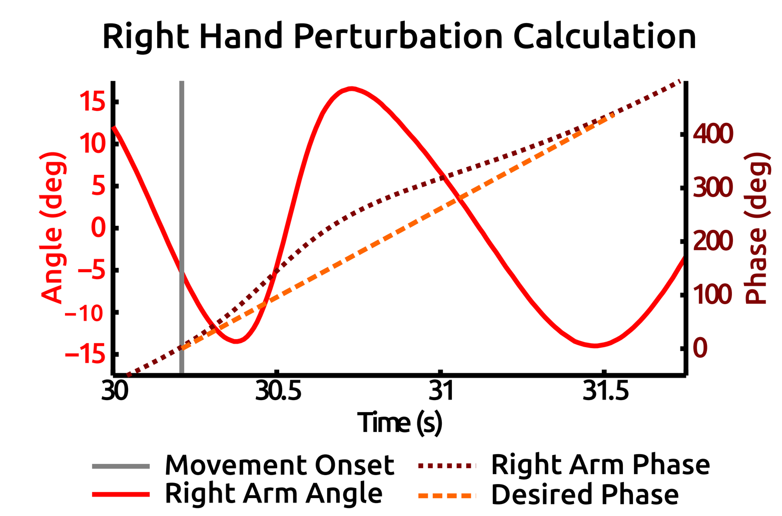
Data Analysis

Left Arm Peak Velocity:
Maximum of the first derivative of the left arm angle after movement onset

Right Arm Perturbation:
Root-mean-square difference between actual and desired right arm phase for 4/3 s (1 period) after left arm movement onset, determined from a Hilbert transform.

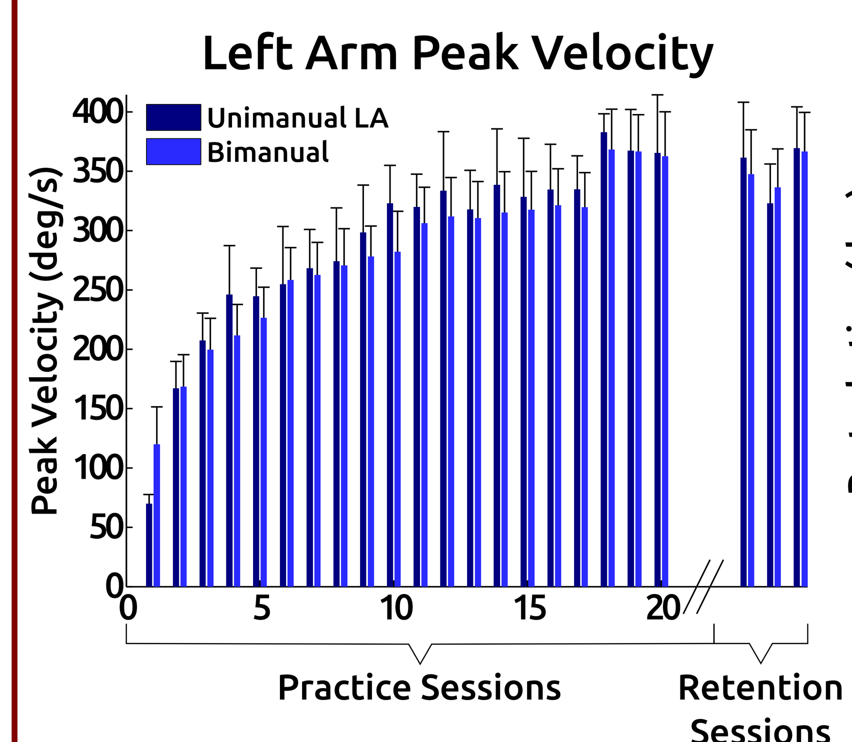
Right Arm Frequency:
First derivative of phase profile for entire 45 s trial

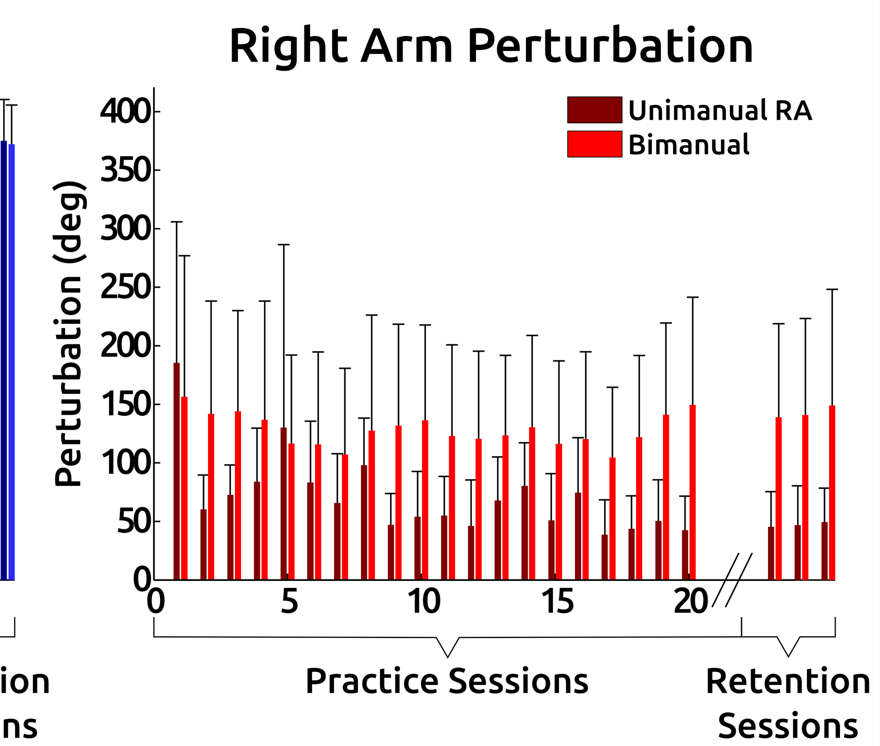




Results

Example Subject: Peak Velocity and Perturbation





Practice:

Left arm: Peak velocity increased with practice in both bimanual and unimanual conditions.

Right arm: Perturbation was not attenuated in bimanual tasks. A distinct difference exists between bimanual and unimanual performance. Bimanual perturbation did not increase with increasing velocity.

Retention:

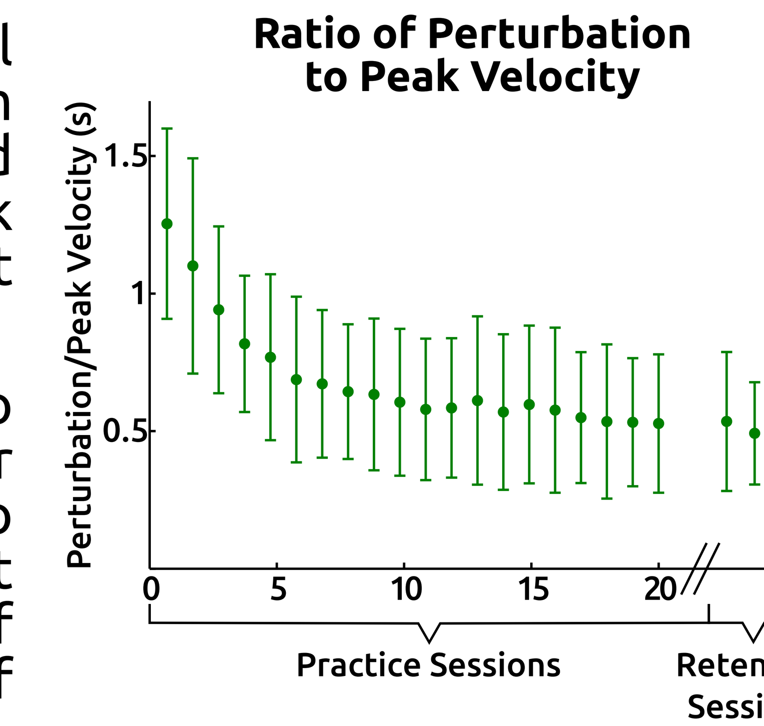
Left arm peak velocity and right arm perturbation levels were retained after a 2 month gap for individual subjects.

Results

Ratio of Perturbation to Peak Velocity:

In averaged data for all subjects (n = 17), right arm perturbation decreased relative to left arm peak velocity and plateaued at approximately Session 10.

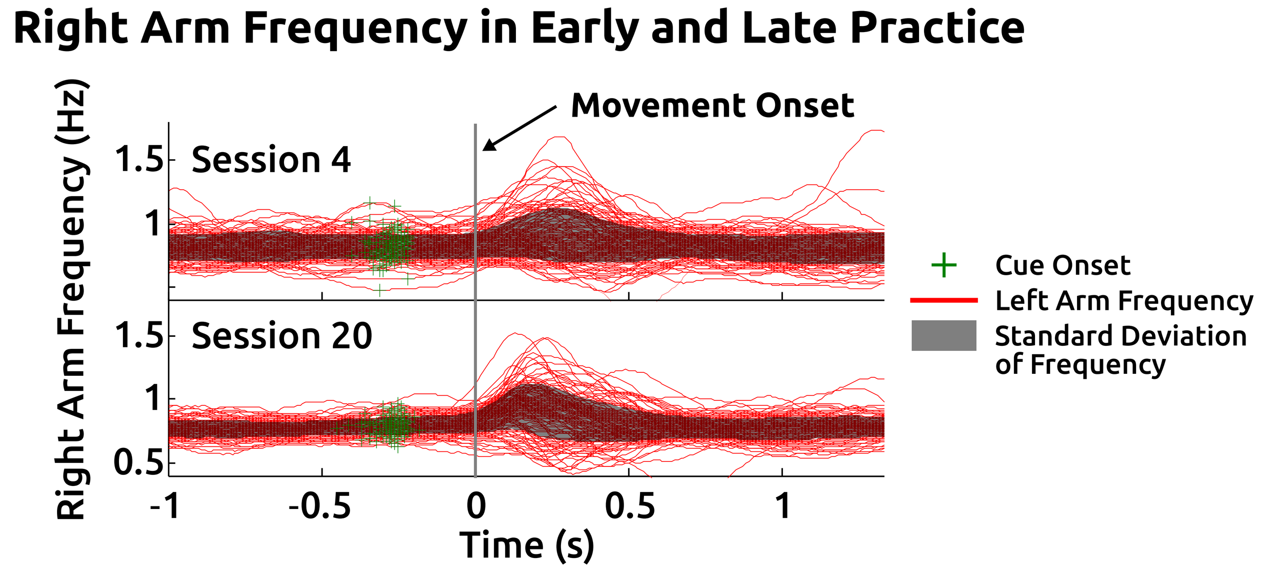
The ratio of perturbation to peak velocity was retained for all subject. There was no statistically significant difference between the end of practice and beginning of retention (p>0.7, paired t-test).



Right Arm Frequency:

The maximum right arm perturbation occurred after movement onset and concurrent with left arm movement. This excleded interference caused by movement preparation. The amplitude frequency from the perturbation did not decrease with practice.

Right Arm Frequency in Early and Late Practice



** Error bars for all figures are 1 standard deviation*

Discussion

Learning of the bimanual task was asymmetrical: improvement occurred in the discrete but not the rhythmic task. Interference from the left arm on the right arm cannot be attenuated. There was full retention of the task in both arms over a 2 month gap. These behavioral data cannot determine the origin of the asymmetry; it could result from differences between dominant and non-dominant arms, the different nature of rhythmic and discrete movement, or asymmetric interhemispheric communication. Further study will involve switching the tasks of each arm to test the role of dominance and repeating the experiment with EEG to determine neural correlates and interhemispheric interference.

Acknowledgements

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