Asymmetric Learning in an Asymmetric Bimanual Task

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Action Lab

Background

Research on bimanual coordination has largely focused on rhythmic movements, in 1:1 or n:m frequency relation. Many everyday tasks are non-rhythmic and asymmetric, such as stirring soup while reaching for the salt shaker or driving while changing gears in a car.

Performing two different movements with the right and left arms is difficult as one has to overcome an inherent tendency toward symmetric movements.[1,2]

Given these bilateral symmetry constraints, we asked to what degree asymmetric movements can be learned and bilateral symmetry overcome.

We composed an asymmetric task discrete and rhythmic movements that assured activation overlap and therefore interference:[3]
Contralateral primary motor areas in rhythmic movement.
Bi-lateral cortical activation in parietal and also motor cortex in discrete movement.

We tested practice of this bimanual task over a long period (10-20 days) to test the plasticity of interhemispheric coupling.

Methods

Participants: 21 healthy, right-handed adults.

Data: Angular displacement of both arms.

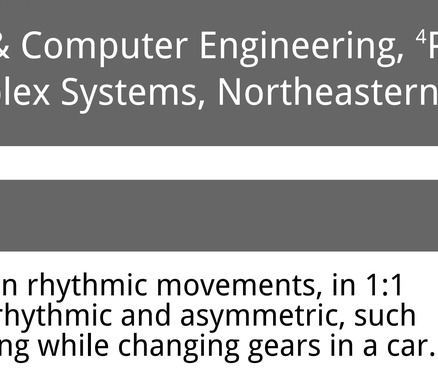
Session: 16 bimanual and 1 unimanual trial for each arm, 45 s each.

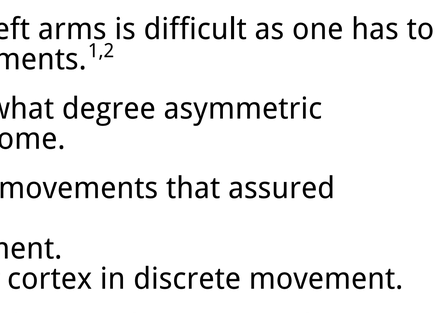
Experiment 1: 6 subjects performed the discrete task with the left arm and the rhythmic task with the right arm.

Experiment 2: To test if laterality impacted learning, 6 subjects performed with the arms reversed.

Experiment 3: To test if the many phase relations of the arms made the task too complex, 5 subjects performed with limited phase relations at discrete arm cue onset.

Experiment 4: To test if discrete task learning interfered with learning in the rhythmic task, 4 subjects performed with a fixed velocity for the discrete task.





Instructions:

Discrete Movement: "On randomly timed cue, move your arm to other target as quickly as possible."

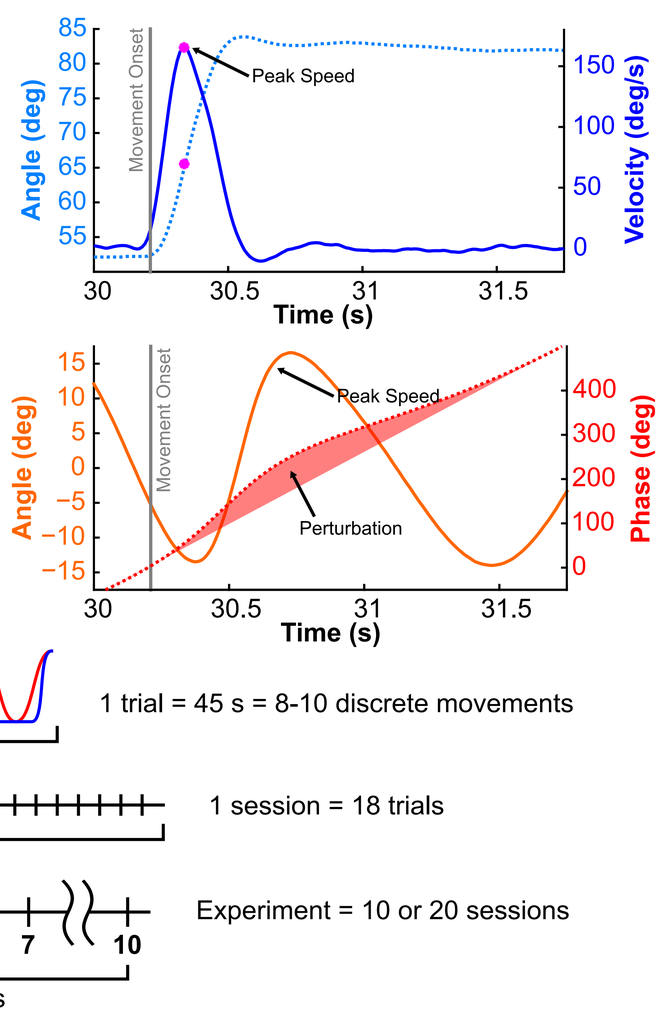
Rhythmic Movement: "Move your arm as smoothly as possible between the dots to the metronome beat of .75 Hz."

Goal: "Move your discrete arm as quickly as possible while keeping the rhythmic movement as smooth as possible."

Performance Measures:

Discrete Arm: Peak Speed (maximum speed during reaching movement)

Rhythmic Arm: Perturbation (RMS error between arm trajectory and sinusoid, using Hilbert phase)



Discussion

Perturbation of the rhythmic arm was not attenuated even after long practice. This asymmetry was not the result of hand dominance.

Perturbations of the rhythmic arm were neural, rather than mechanical in origin. They were also a result of the discrete movement, rather than an anticipatory effect.

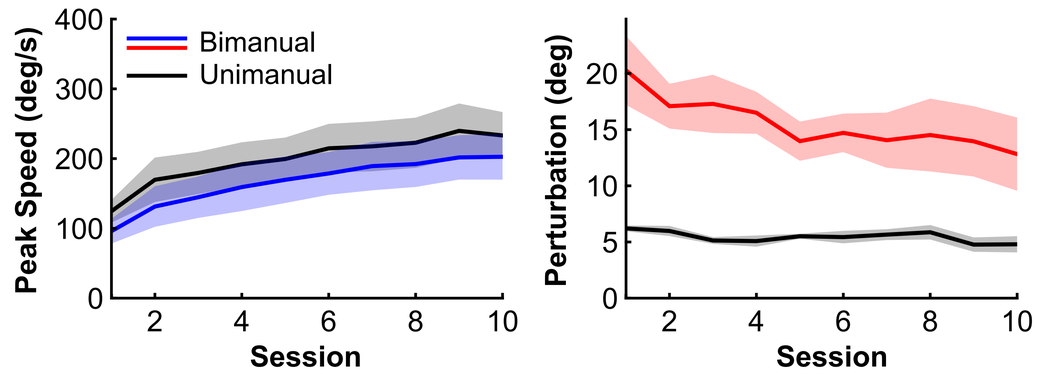
Even extended learning could not overcome the interhemispheric communication that limits the independent movement of the two arms.

References

(1) Gerloff C, Andres FG (2002) Bimanual coordination and interhemispheric interaction. Acta Psychologica 110(2-3):161-186.
(2) Obhi SS (2004) Bimanual coordination: an unbalanced field of research. Motor Control 8:111-120.
(3) Schaal S, Sternad D, Osu R, Kowato M (2004) Rhythmis arm movements are not discrete. Nature Neuroscience 7, 10, 1136-1143.

Results

Experiment 1: Right Arm Discrete

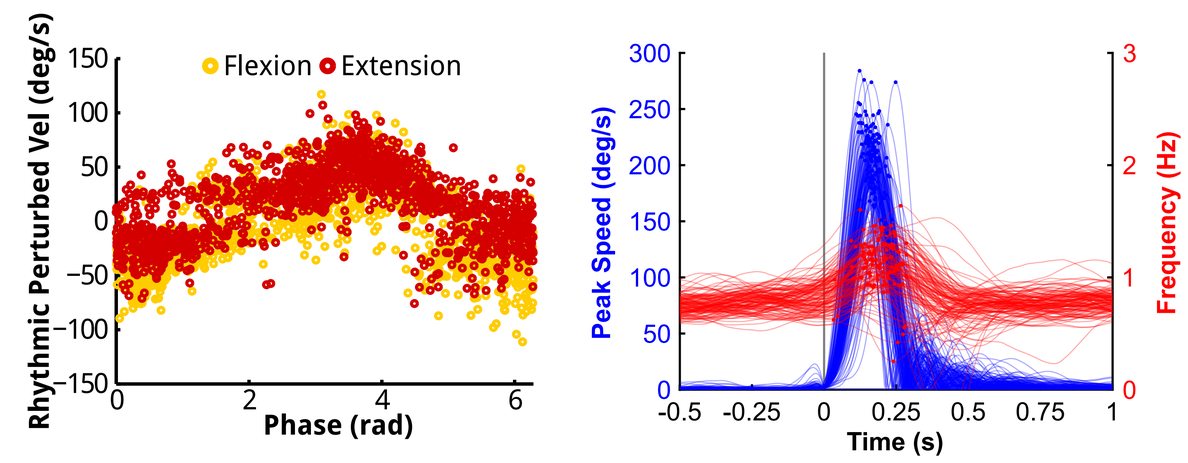


Peak Speed: Discrete peak speed increased in bimanual and unimanual trials (p=0.03) but remained different at the end of practice (p=0.01).

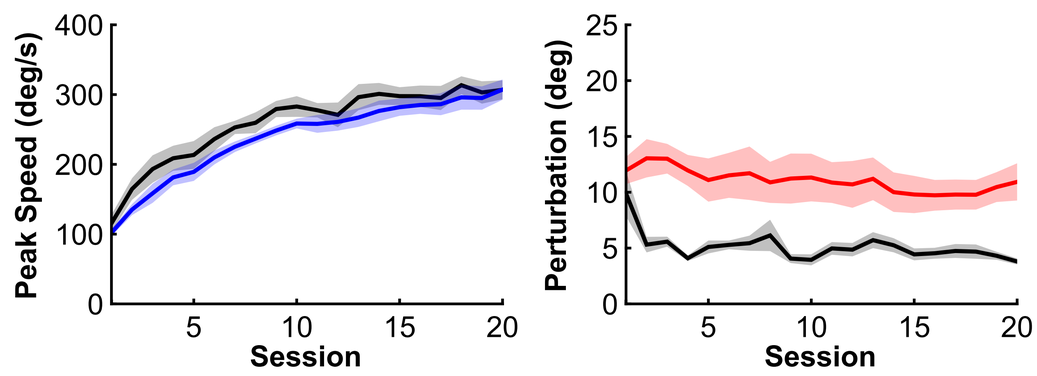
Perturbation: Perturbation decreased in bimanual trials for 5 of 6 subjects (p<0.001) but did not reach unimanual performance (p=0.005).

Phase Modulation: Perturbations varied by phase in both experiments but did not differ with flexion or extension of the discrete arm. Peak speed was not modulated by rhythmic arm phase.

Timing: Maximum perturbation occured after discrete movement onset.



Experiment 2: Left Arm Discrete

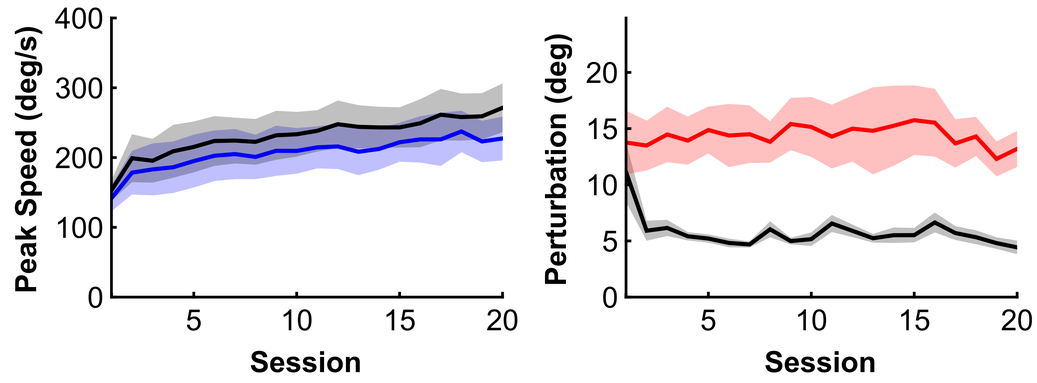


Peak Speed: When practicing twice as many trials, bimanual peak speed continued to increase (p<0.001) and approached unimanual peak speed at the end of practice (p=0.63).

Perturbation: In contrast, perturbation in rhythmic arm did not decrease and was greater than in unimanual condition (p<0.01).

Laterality: With longer practice only peak speed increased. There were no other laterality effects.

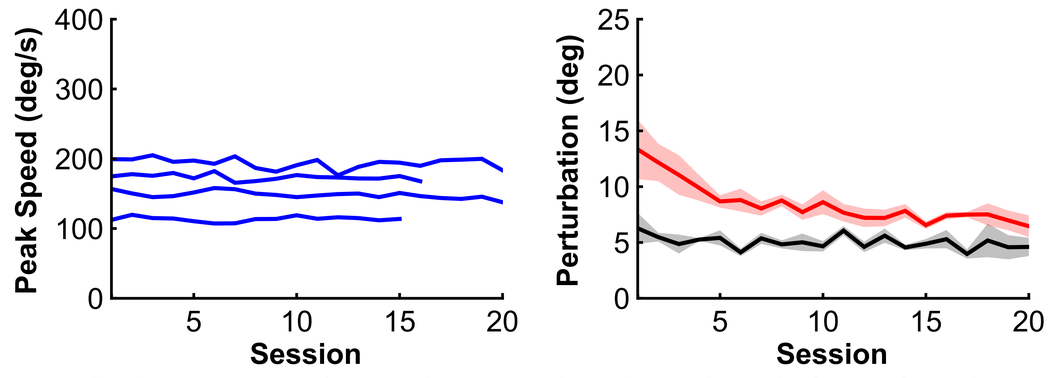
Experiment 3: Left Arm Discrete at Fixed Phase Relation



Peak Speed: Peak speed increased in unimanual and bimanual conditions (p=0.011).

Perturbation: Consistent with Experiment 2, the bimanual perturbation remained high.

Experiment 4: Left Arm Discrete at Fixed Peak Speed



Perturbation: Bimanual perturbation reduced significantly for 3 of 4 subjects (p<0.001), but still did not reach unimanual level (p<0.01).