89

Integrated Feedback for Individuals with Motor Impairments

Deanna Kennedy, Pilwon Hur, and Li Zeng

T3: TEXAS A&M TRIADS FOR TRANSFORMATION

A President's Excellence Fund Initiative

INTRODUCTION

- Motor impairments are often evident in neurological conditions such as cerebral palsy, multiple sclerosis, Parkinson's disease, and stroke.
- Individuals with motor impairments often have difficulty with activities of daily living (ADL) that require coordinated use of both sides of the body, force control, balance, and learning new motor tasks[1].
- The serious consequences and the potential medical costs that result from motor impairments is a major public health concern.
- Current interventions to improve motor control in individuals with motor impairments include exercise and/or movement strategy training, witch have had limited success[2].
- There is an immediate need to develop and explore new tools and techniques to enhance motor control in individuals with motor impairments.
- The use of augmented feedback information is emerging as an effective method to improve motor control and learning in healthy and aging populations[3-6].
- Augmented information provides an individual with salient extrinsic feedback that supplement the information that is naturally available in the testing environment.
- The primary goal of the current project is to provide online augmented information to improve motor control in populations with motor impairments.
- Our working hypothesis is that training and rehabilitation tasks that use augmented information to facilitate online error detection and correction will improve motor control and learning in populations with motor impairments.

PURPOSE

An experiment was designed to determine the extent to which individuals with Parkinson's disease (PD) are capable of using integrated feedback information to coordinate bimanual force patterns.

To determine if individuals with PD exhibit increased interference between the limbs as compared to healthy young and older adults.

METHODS

Task

•Subjects were asked to rhythmically produce a pattern of isometric forces on a left side force transducer with the left hand that was coordinated with the pattern of isometric forces produced on a right sided force transducer with the right hand in a 1:1 and 1:2 pattern (See Fig. 1). Muscle activity from the first dorsal interosseous (FDI, Fig. 2) was recorded & EMG-EMG coherence between the two hands were calculated.

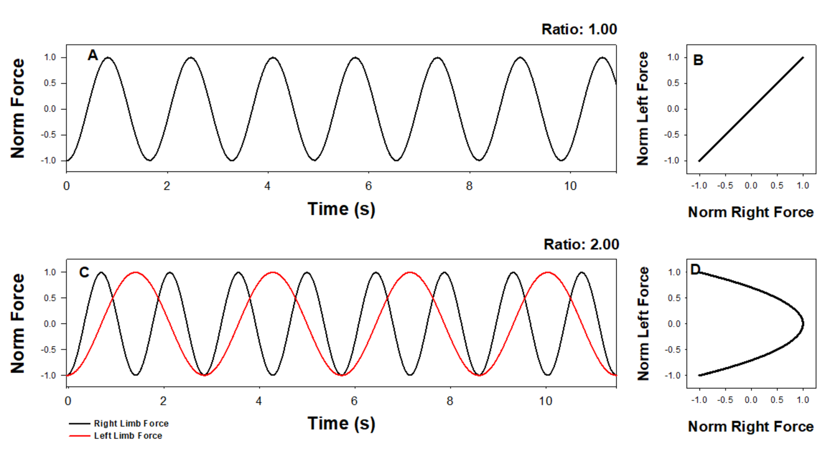

Figure 1. Illustration depicting the simulated goal coordination pattern and corresponding Lissajous template for the 1:1 (A,B) and 1:2 (C,D) task.

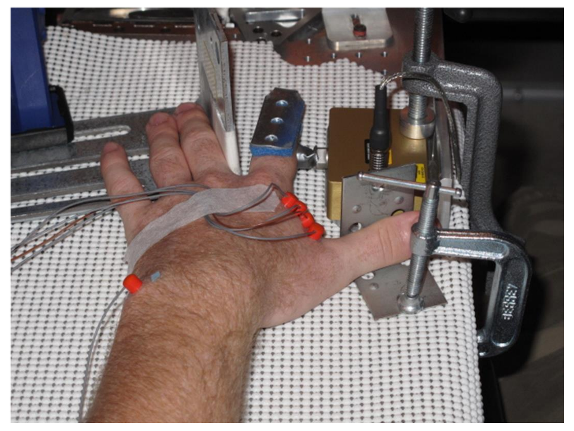

Figure 2. Illustration of the experimental arrangement

Display Information

• The Lissajous display involved a goal template and a cursor indicating the forces produced with both limbs. The cursor moved from left to right as force was produced with the right arm and from bottom to top as force was produced by the left. The template illustrated the specific pattern of force requirements needed to produce the goal coordination pattern (see Fig 1 B,C).

Additional Experiments

- Experiments are ongoing (delayed due to COVID-19) to assess other tasks (movement and balance), feedback information (augmented reality) and populations with motor impairments.

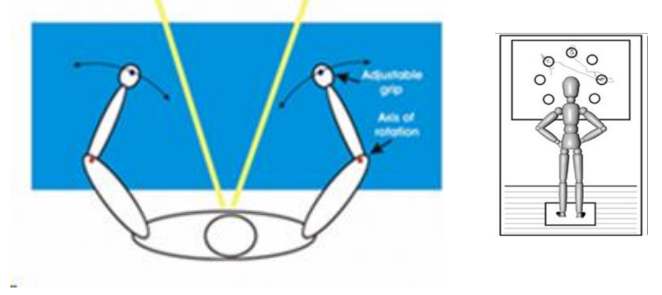

Figure 3 Illustration depicting additional experiments for T3 project

CONCLUSIONS

- The results indicated very effective temporal performance of the bimanual force task for all 3 groups (young, older, and PD).
- Individuals with PD performed the goal coordination patterns as well as young and older adults when provided Lissajous feedback.
- For the young and older groups consistent and identifiable distortions in the left limb forces that could be associated with production of force in the contralateral limb were detected. No such association could be identified in the PD group.
- The non-dominant limb was significantly less harmonic than the right limb for the young and older groups whereas both limbs were significantly less harmonic for the PD group compared to the young and older groups.
- The distortions in force production was greater and more disruptive (i.e. reduced harmonicity, phase angle plots) in PD than young and older adults.
- It appears that the left and right limbs are tightly coupled in young and older adults (i.e., EMG-EMG coherence) whereas individuals with PD may be controlling the limbs independently (i.e., low harmonicity values for both limbs in 1:1 task). More data and experiments are needed to confirm this possibility.

REFERENCES

1. Van den Berg, C., et al. (2000). Coordination disorders in patients with Parkinson's disease: A study of paced rhythmic forearm movements. *Exp Brain Res* 134: 174-186.
2. Goodwin, V.A., et al. (2008). The effectiveness of exercise interventions for people with Parkinson's disease: A systematic review and meta-analysis. *Mov Disord* 23: 631-640.
3. Boyle, J.B., et al. (2015). A novel approach to enhancing limb control in older adults. *Exp Brain Res* 233: 2061-2071.
4. Kennedy, D.M., et al. (2016). Bimanual force control: Cooperation or interference? *Psychol Res* 80: 209-220.
5. Kennedy, D.M., et al. (2013). The role of auditory and visual models in the production of bimanual tapping patterns. *Exp Brain Res* 224: 507-518.
6. Leinen, P., et al. (2016). Life span changes: Performing a continuous 1:2 bimanual coordination task. *Hum Mov Sci* 46: 209-220.

Figures

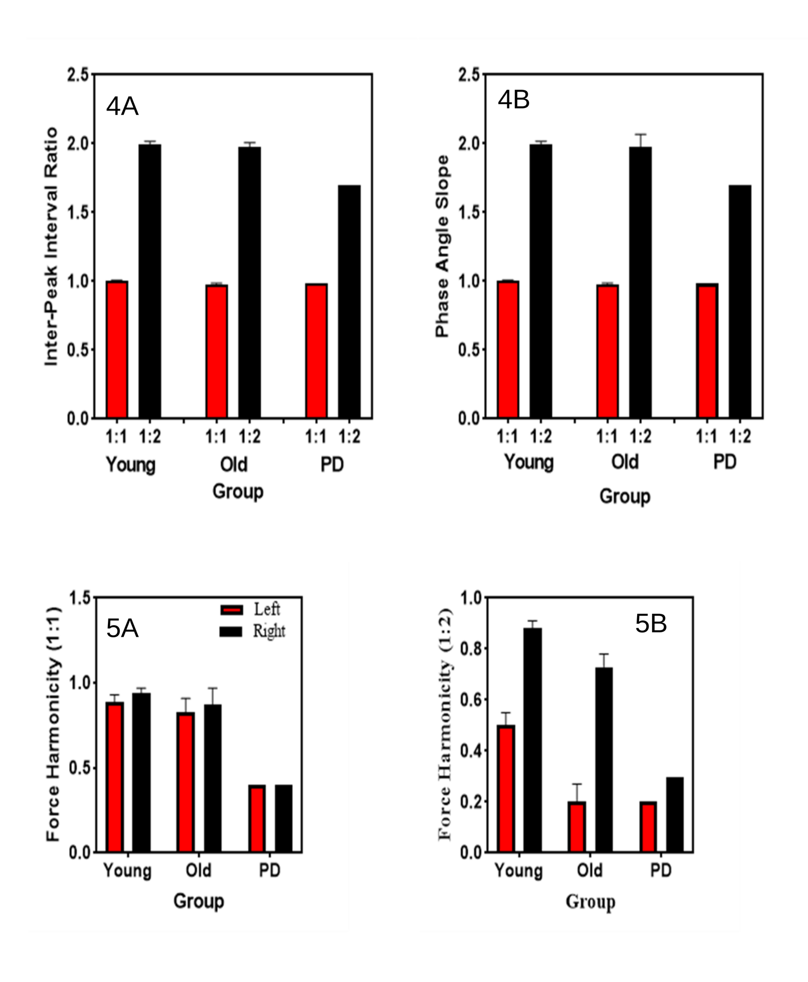

Figure 4 Mean inter-peak interval ratio (A) and phase angle slope ratio by group. Error bars represents standard error. Note, PD results are based upon preliminary data whereas data collection was completed for young and older adults. Both bimanual measures indicate that participants in all three groups were able to perform the goal ratio. Figure 5 Mean force harmonicity for the 1:1 (A) and 1:2 (B) tasks by group.

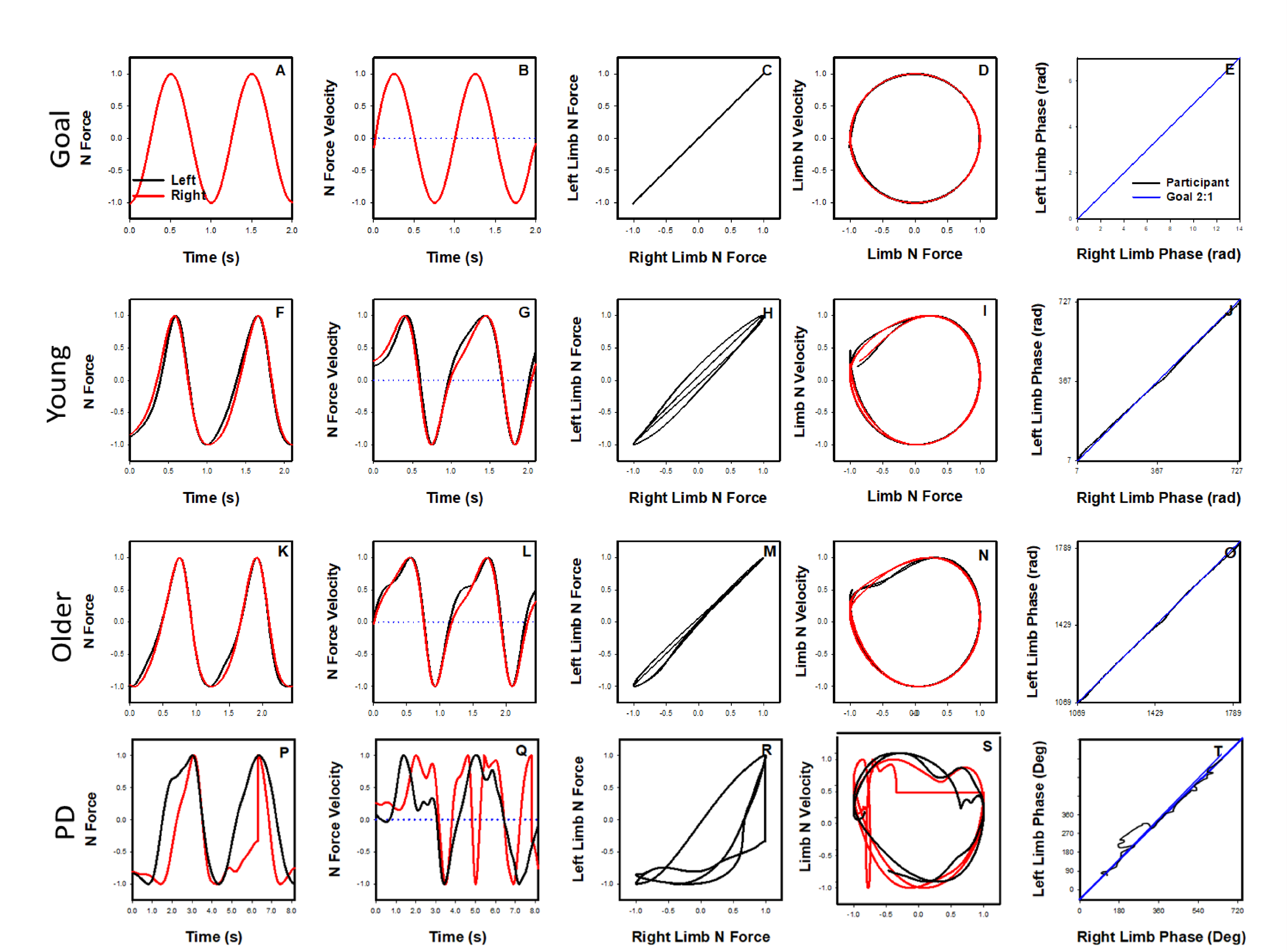

Figure 6. Example of one cycle of the goal 1:1 (A-E) coordination pattern and examples of a young (F-J), older (K-O), and PD (P-T) participant's performance on one cycle of the 1:1 task. The figure includes left and right limb force (A,F,K,P), force velocity (B,G,L,Q), Lissajous plots (C,H,M,R), force-force velocity plots (D,I,N,S), and relative angle phase plots (E,J,O,T). Note, that the force-force velocity plots have the left (red) and right (black) limbs overlaid.

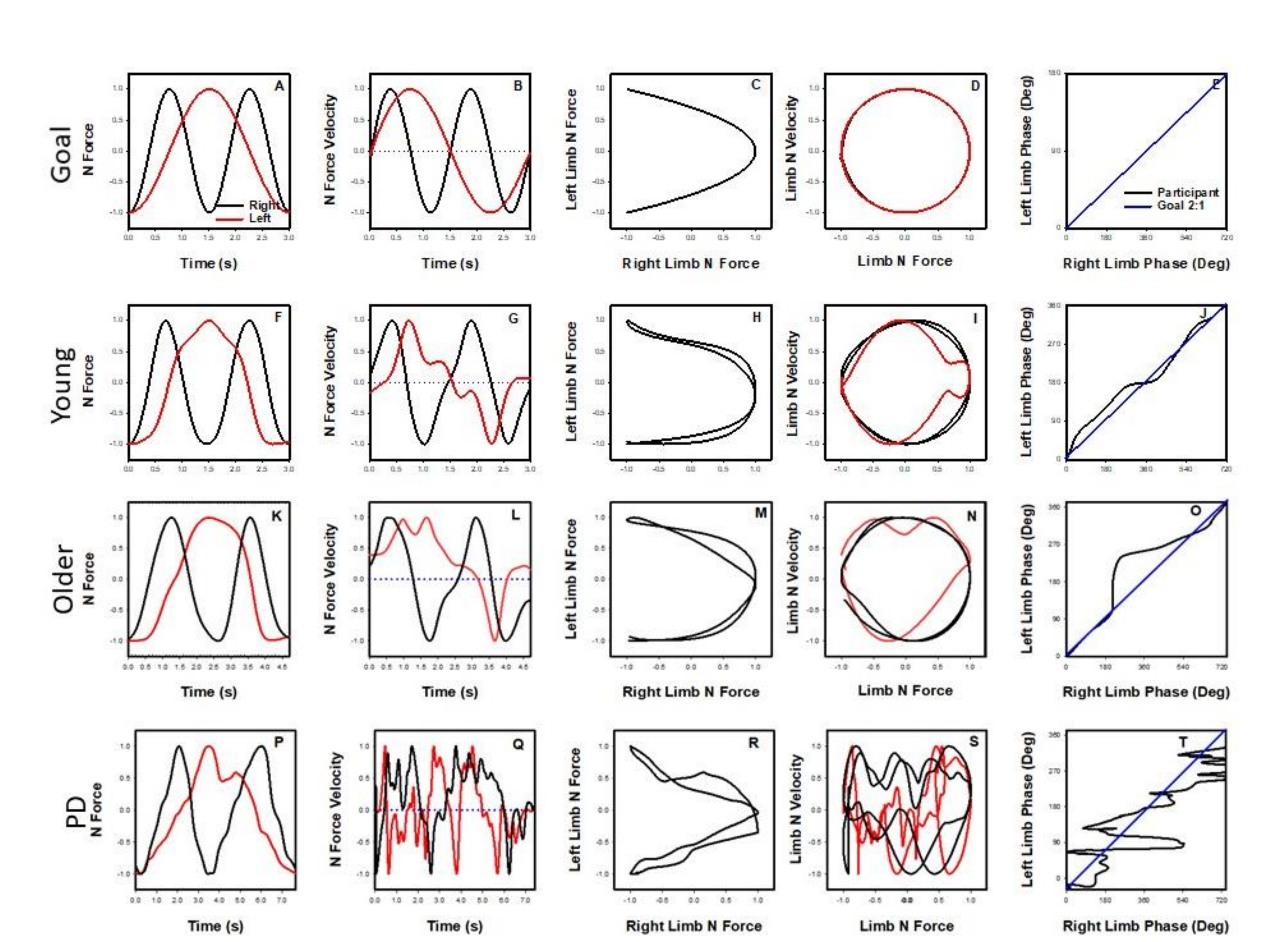

Figure 7. Example of one cycle of the goal 1:2 (A-E) coordination pattern and examples of a young (F-J), older (K-O), and PD (P-T) participant's performance on one cycle of the 1:2 task. The figure includes left and right limb force (A,F,K,P), force velocity (B,G,L,Q), Lissajous plots (C,H,M,R), force-force velocity plots (D,I,N,S), and relative angle phase plots (E,J,O,T). Note, that the force-force velocity plots have the left (red) and right (black) limbs overlaid.

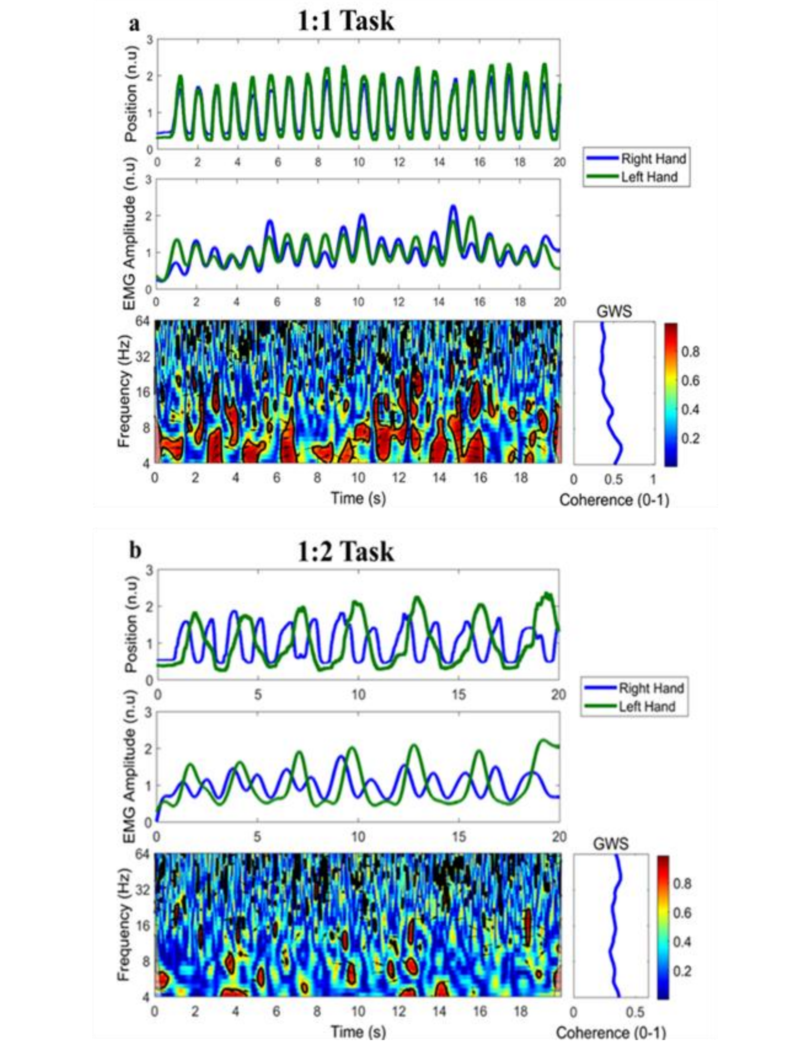

Figure 8 Sample left and right limb force time series for one participant in the 1:1 (A) and (B) tasks (A) The EMG Amplitude, EMG-EMG Wavelet Spectrum, and the EMG-EMG time-averaged Wavelet Spectrum is provided. Note that the 1:2 task required the right limb to produce two patterns of force for every one pattern produced by the left limb