Using Kinematic Analysis to Identify Loci of Improvement During Functional Motor Skill Training

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Abstract

Improvement in the efficiency, accuracy, and timeliness of a functional motor task likely correlates to an improvement in related motions of daily life. Task performance is divided into two phases based on the 3-D position of the spoon: gross motor phase during object transport, and fine motor phase during object acquisition.

Introduction

The functional motor task performed in this study mimics the daily living activity of feeding oneself. This task contains a fine motor phase of scooping the beans as well as a gross motor phase of transporting the beans/returning to the home cup. While previous studies have proven that repetition of a functional motor task results in overall improvement measured by average time and velocity when completing the task, it is uncertain whether both motor phases improve when defined by time and velocity profiles separately. It is hypothesized that as participants repeat a series of trials for this functional motor task, their time efficiency in transporting and returning will improve—shortening the amount of time spent in the gross motor phase with less improvement seen in the fine motor phase of the task.

Materials/Methods

Participants were seated in front of 4 cups. One cup was positioned closer to the participant and was filled with 30 beans. Using a spoon in their left hand, the participant scooped two and only two beans at a time and dispensed them into the empty three cups, moving from left to right for a total of 15 reaches (or 30 beans). This pattern of transporting beans was reset and repeated for 30 trials. 3D position and velocity data of the spoon was collected via an electromagnetic tracking system (MotionMonitor). The kinematic data was analyzed using MATLAB processing scripts.

Results

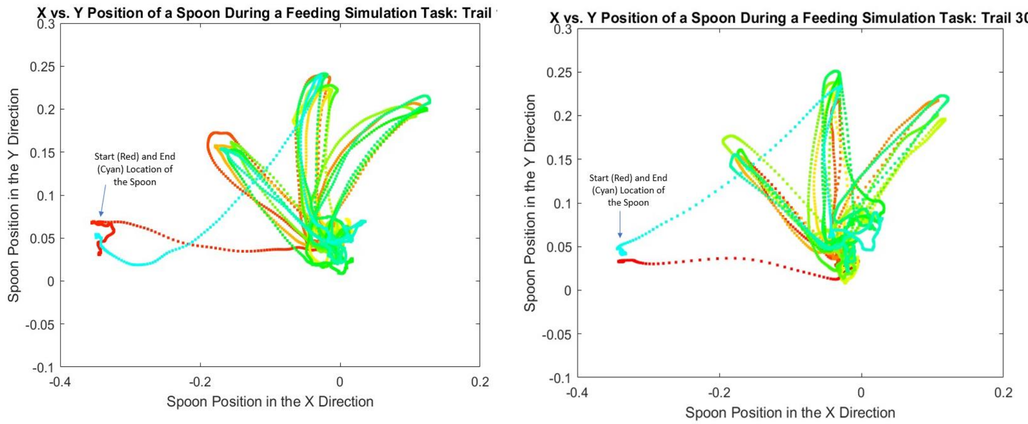

Figure 1. X vs. Y Position of a Spoon During a Feeding Simulation Task—Comparing First Trial to Last Trial
The left plot shows the participant's first trial of the feeding task with no prior practice, while the right plot shows their last (30^{th}) trial of the task, in which trials were taken one after the other with no breaks in between other than a moment to reset the beans into the home cup. Both trials featured 15 repetitions of scooping and dispensing beans. The position data was collected using a MotionMonitor, in which the sensor detected the spoon's location from pick up to set down (total trial times were 57.63 seconds for the first trial and 49.81 seconds for the second trial.) The rainbow spectrum shows the position of the spoon over time, in which the red dots represent the start of the trial (beginning with picking up the spoon) after which each dot changes in ROYGBIV order until the end of the trial, represented by the cyan dots. The sampling rate was set to 100.000 and the data capture period was 63.801.

Conclusion and Future Work

For the duration of this project, I had spent more time focusing on data collection and hands-on experience working with participants in the lab rather than working with post-processing. With the fast nature of the FURI project, I unfortunately ran out of time to do a thorough data analysis and was unable to support my hypothesis that improvement may be attributed to the fine and gross motor phases separately. The participant data, however, does show an improvement in time-to-complete the task and supports the use of repetition to learn a functional motor task. The position maps in Fig. 1 also show a more uniform path from the home cups to the reach cups, suggesting improvement in the gross motor phase of the functional motor task. It is also noted that using the color gradient to map the spoon position over time showed that this participant had the tendency to hesitate at the reach cup more during the later stages of the trials and thus struggles with the fine motor phase despite repetition. Future directions of this research include analyzing kinematic data from these two motor phases separately from one another to see if either only one or both phases improve with practice, supported by statistical analyses rather than visual conclusions.

References or Literature Cited

Kitago, Tomoko, and John Krakauer. "Motor Learning Principles for Neurorehabilitation." *Handbook of Clinical Neurology*, vol. 110, ser. 3rd, 2013. *3rd*.

Schaefer SY, Dibble LE, Duff K. Efficacy and Feasibility of Functional Upper Extremity Task-Specific Training for Older Adults With and Without Cognitive Impairment. Neurorehabil Neural Repair. 2015 Aug;29(7):636-44. doi: 10.1177/1545968314558604. Epub 2014 Nov 21. PMID: 25416739.

Winstein, CJ and Stewart, JC. "Conditions of Task Practice for Individuals with Neurologic Impairments." *Textbook of Neural Repair and Rehabilitation,* Vol. 2. Cambridge University Press, pp. 89–102, 2006.

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