# How Individuals Control and Prevent Object Slip and Object Pose Simultaneously While Lifting an Object of Different Weight with Different Grip Forces

Jessica Feltovich, Marco Santello, Yen-Hsun Wu, Chris Blais

engineering is in our

school of biological and health systems engineering

SBHSE School of Biological and Health Systems Engineering

## Introduction

**Problem:**
How the brain and hand, specifically digits, communicate with one another to allow humans to pick up objects that may be more fragile than others, or that require different levels of force when grasping an object along with the force required to manipulate the object is something that has not been widely explored.

**Force Definitions:**

- **FG** (grip force) is what keeps the object from slipping, and has no correlation to the object's movement [1].
- **FM** (manipulation force) is the force that is responsible for the objects 3D position and 3D orientation control, also referred to as pose [1].

**Objective:**
This study aims to understand how humans prevent object slip and object pose simultaneously. We integrated electroencephalogram (EEG), a captrack system, motion capture devices, and electromyography (EMG) to study how subjects distribute finger forces during dexterous object manipulation.

## Methods

Subjects had to come in for two days of testing. The first day focused on gathering baseline force values these were used to define the minimum FG needed to prevent object slip, while the second day tested the effect of object weight on the coordination of grasp and manipulation force.

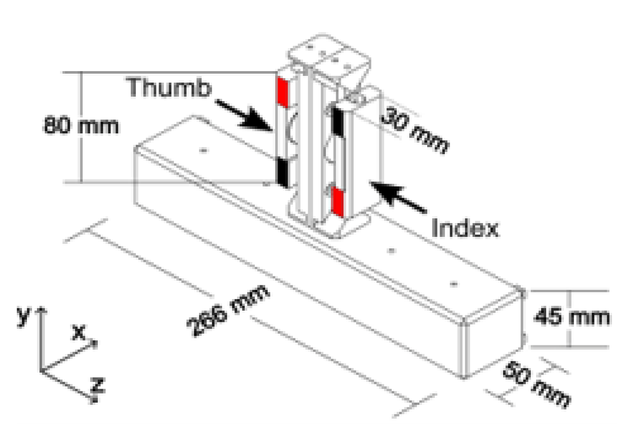



Figure 1: A diagram of the sensorized apparatus showing where the participants thumb and index finger are placed and the measurements of the device itself

Figure 2: The 8x8 electrode array (2 were needed) and the 2 different sizes of the 5x13 electrode arrays

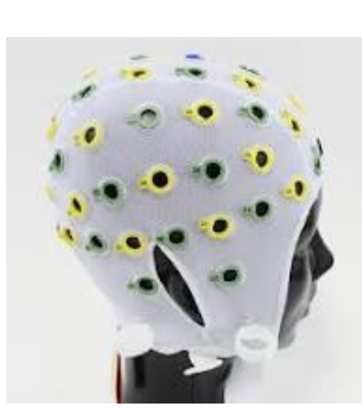


Figure 3: A 64 channel Acticap EEG showing the electrode placements on the head

## Results

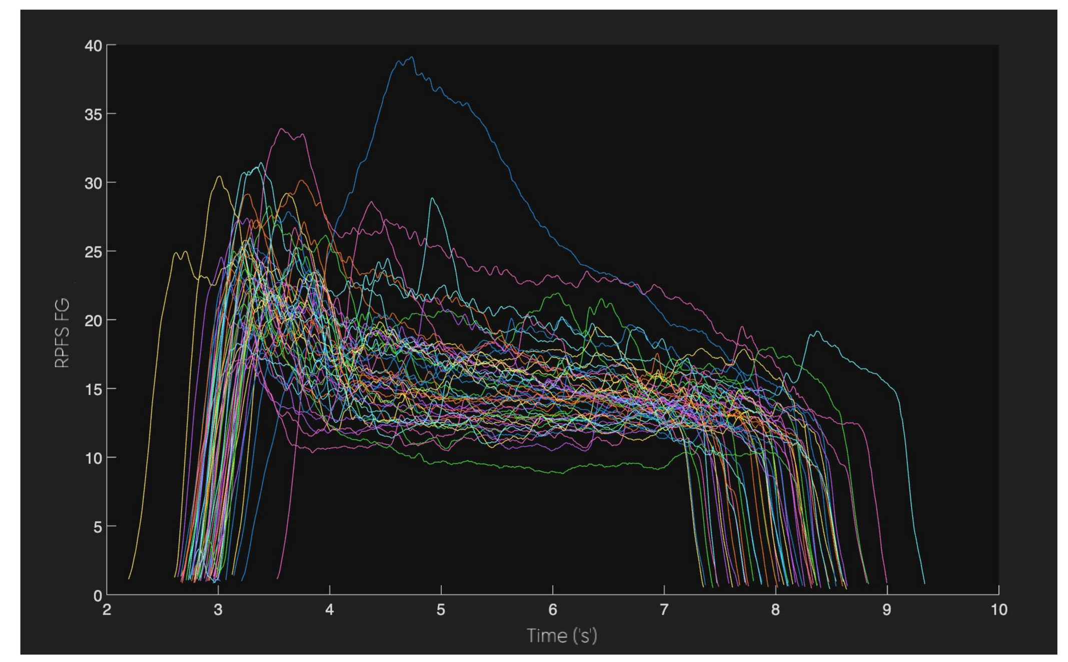
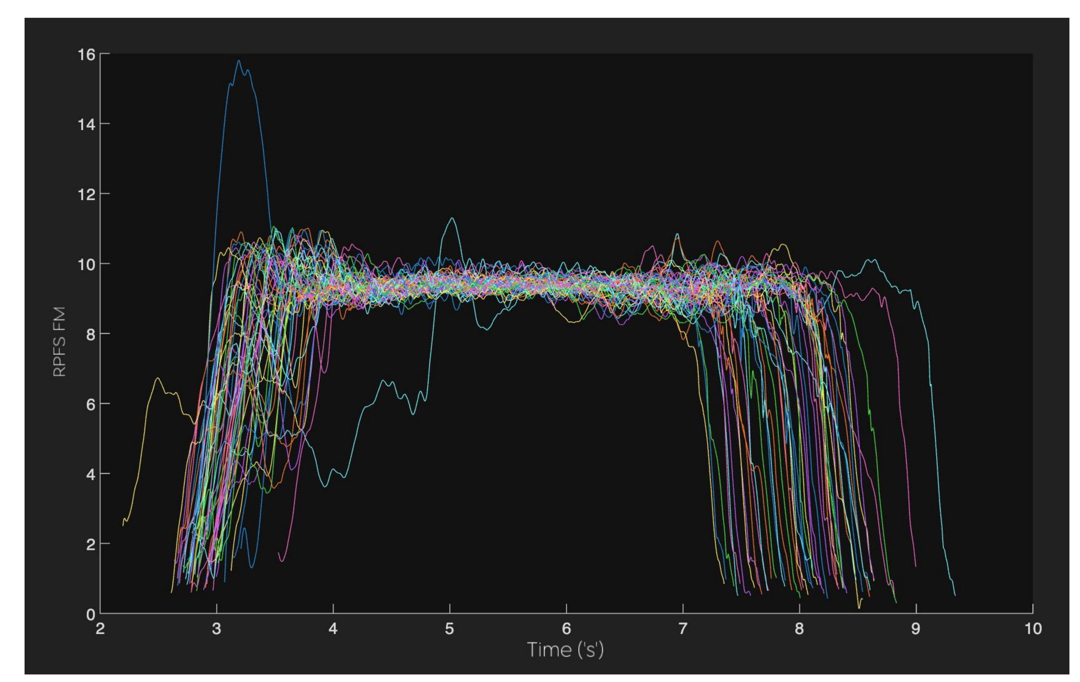


Figure 4: A graph representing the grasp force (N) of the right proximal Low fragility (RPFS) condition

Figure 5: A graph representing the manipulation force (N) of the right proximal low fragility (RPFS) condition



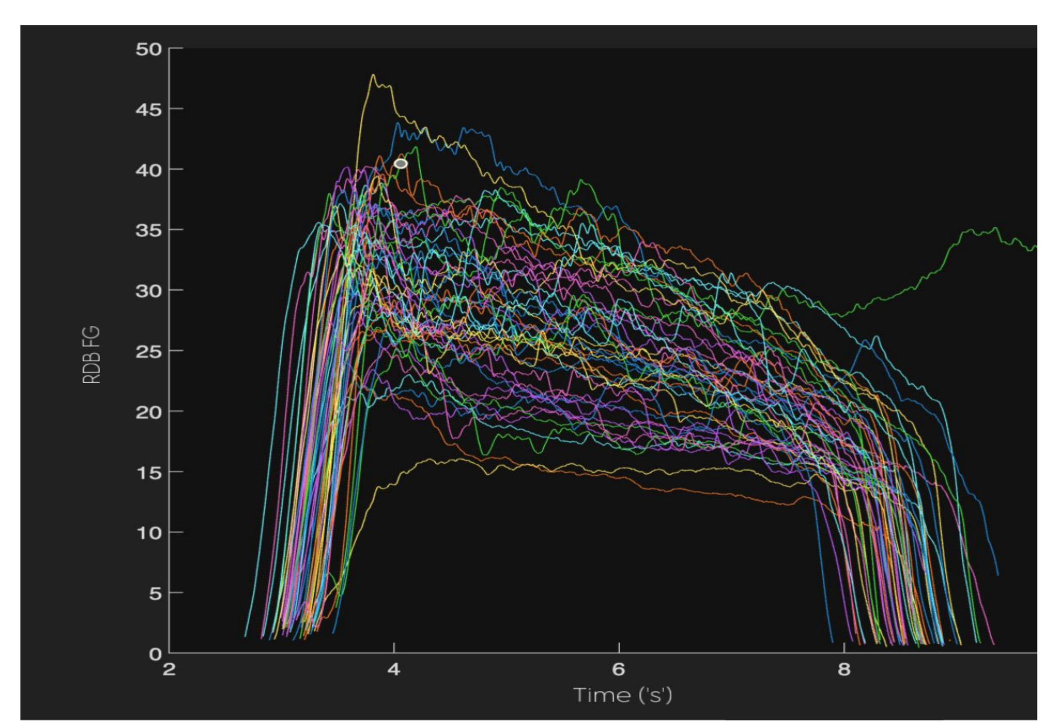
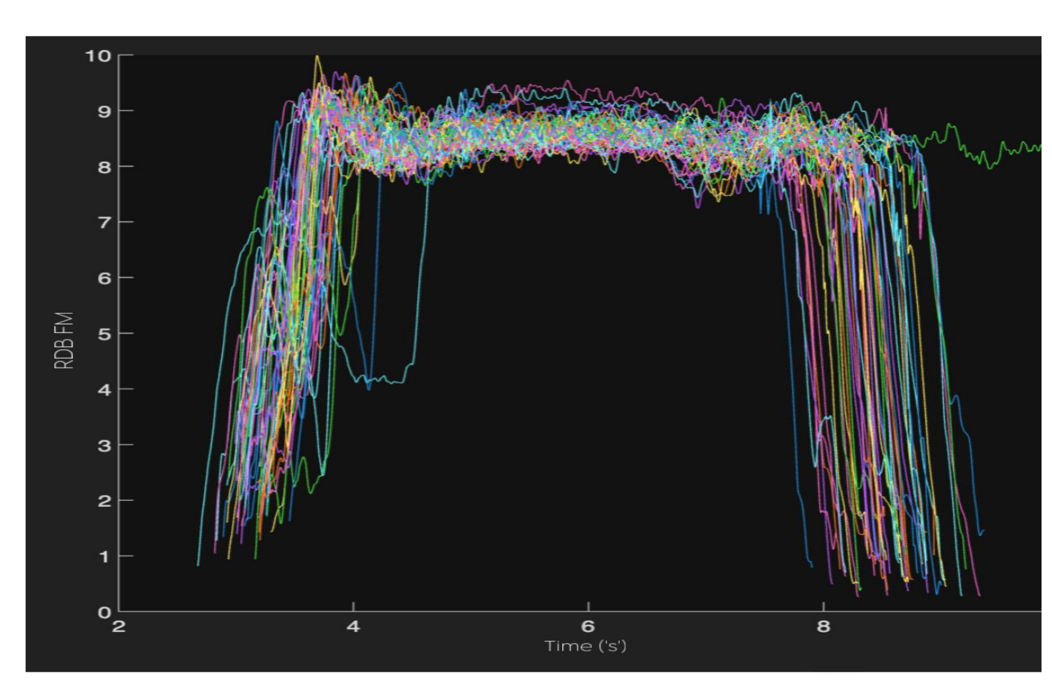


Figure 6: A graph representing the grasp force (N) of the right distal baseline (RDB) condition

Figure 7: A graph representing the manipulation force (N) of the right distal baseline (RDB) condition



## Results

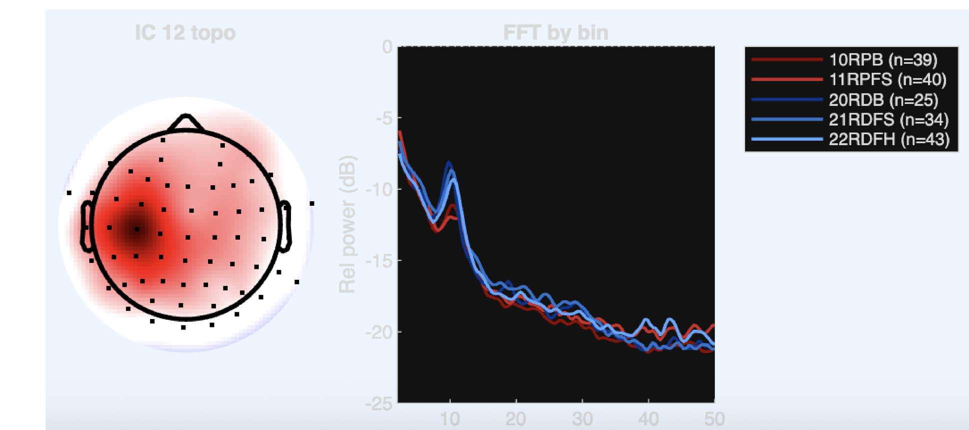


Figure 8: A visual representation of one subject that shows where the signals are being collected from in the brain. Along with relative power through different frequencies displayed for all conditions.

## Summary, Conclusions and Future Directions

- Motor control changes based on activity in the sensorimotor network

**EEG:**

- Peak in the alpha band frequency which is between 8-12 Hz
- Distal conditions require a higher starting power than proximal

**Finger Forces:**

- Subjects prioritize the force needed to pick up the object over the object's overall position and orientation
- Manipulation force appears to rely on somatosensory and visual feedback to a greater extent than grasp force.

**Next steps include:**

- Repeating the experiment on seven other subjects
- Further analysis of results from all ten subjects
- Process EMG data

## References

[1] Y.-H. Wu and M. Santello, "Distinct sensorimotor mechanisms underlie the control of grasp and manipulation forces for dexterous manipulation," *Scientific Reports*, vol. 13, no. 1, Jul. 2023, doi: https://doi.org/10.1038/s41598-023-38870-8.

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ASU Ira A. Fulton Schools of Engineering
Arizona State University