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# Emergence of Neural Activity in Hand Pre-shaping to Grasp Using Noninvasive EEG Methods

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Translational Neurorobotics  
Laboratory

## Introduction

Hand dexterity and grasp disability in patients with spinal cord injury has devastating impacts over their lifespan<sup>[1]</sup>. Restoration of hand dexterity is the highest priority among this population. While some invasive brain-machine interfaces (BMI) are customized to assist such patients to perform reach-and-grasp tasks with a robotic system, they lack dexterity, generalizability, and are cost inefficient<sup>[2]</sup>. This creates difficulties and prevents accessibility for employing these devices in larger patient populations<sup>[3]</sup>. The purpose of this study is to develop a noninvasive BMI platform that has the ability to predict planned grip types and different pre-shaping actions based on electroencephalogram (EEG) recordings from a new, low-cost eight channel EEG headset (Unicorn Hybrid Black). This is an expanded dataset from a previously conducted pilot study that included a preliminary protocol that consisted of left/right power grip classification based on EEG recordings utilizing the mentioned headset.

**Pilot Study:** Internal data collection for our pilot study included a preliminary protocol that consisted of 5 blocks, each block with two separate (for left and right hands) EEG recordings (with Unicorn Hybrid Black Noninvasive EEG headset) when the human subjects were instructed to consecutively preform a power grip for a specified duration of time.

**Results:** The power of the  $\delta$  (delta) band for feature extraction and classification was selected based on the significance of slow oscillations recorded within the premotor cortex from invasive BMI studies<sup>[1]</sup>. Brain activity recorded from EEG channels C3 and C4 were used to distinguish between power grips from the left/right hands. This yielded a classification percent accuracy of 55% (C3) and 80% (C4) using thresholding methods. Results of this pilot study validated the headset as a promising noninvasive device as the data set expands.

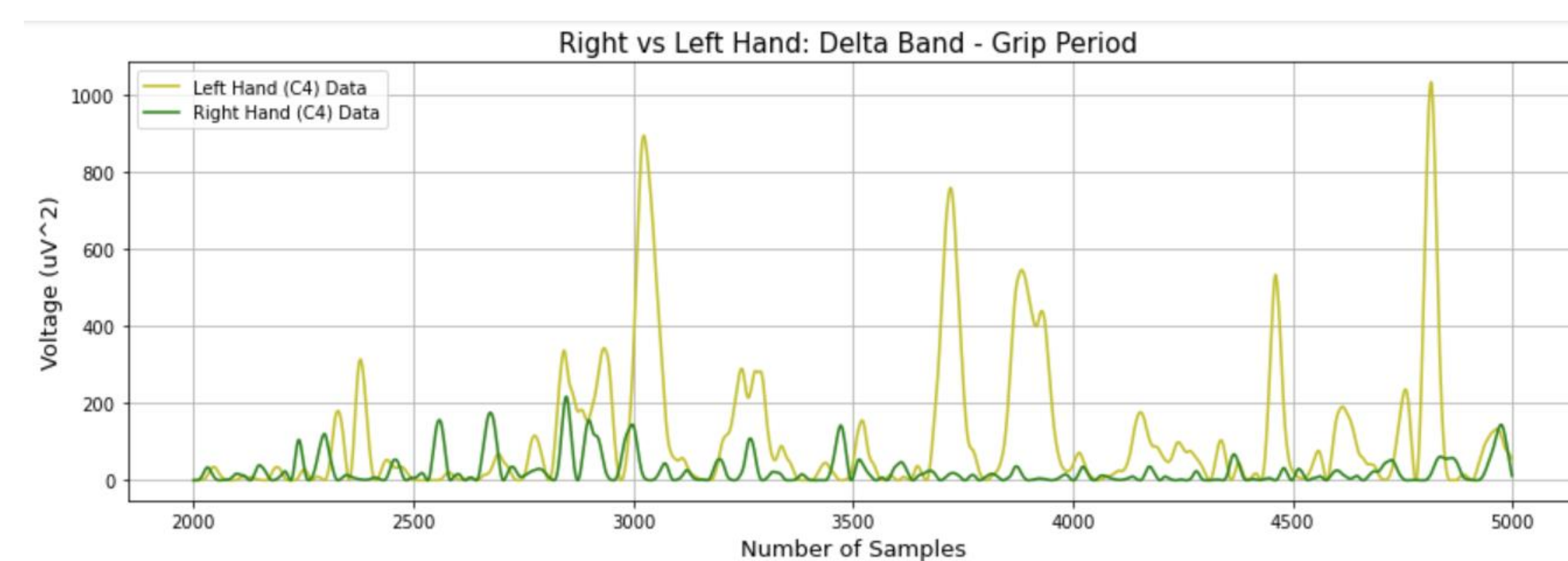


Figure 1. Selected feature (power of the delta band from channel C4) for left/right hand power grip classification

Expanding upon the pilot study data set, this study includes a more diverse, larger human subject population along with two new selected grip types for this study (precision and transverse cylindrical grips). The synchronized hardware/software developed platform facilitates the tasks that are designed within the new protocol in order to investigate whether brain engages in pre-shaping during these tasks. Said tasks involve the observation and reach-and-grasp tasks of objects that require different grip types at specific times. The developed platform serves as a proof-of-concept for noninvasive EEG-based neuro-prosthetic devices.

## Methods

**Design of Protocol:** The structure of the protocol remained constant as the instructions for object interaction changes upon selected tasks. The human subject was asked to sit in a neutral position with palms face down, 30cm from the center of the object (Figure 3c). Neural activity was collected during two different tasks (task 1 and task 3 were selected from the five tasks that were IRB approved). Task one solely involves object observation of one of the two objects (object A – black pen or object B – water bottle) presented for seven seconds with no knowledge of future reach-and-grasp tasks (to avoid data bias). Object A requires a precision grip while Object B requires a transverse cylindrical grip. Task 3 involves object observation for three seconds until the sound of an audio cue, at which they were instructed to preform a reach-and-grasp task with object presented (Figure 2). To eliminate the possibility of further data bias, no object was presented between object A and object B, and selection of object A and B were randomized. Each task was repeated 3 times for each human subject, where each task consisted of 5 runs, with each run consisting of two trials (where one trial was the presentation of either object A or object B).

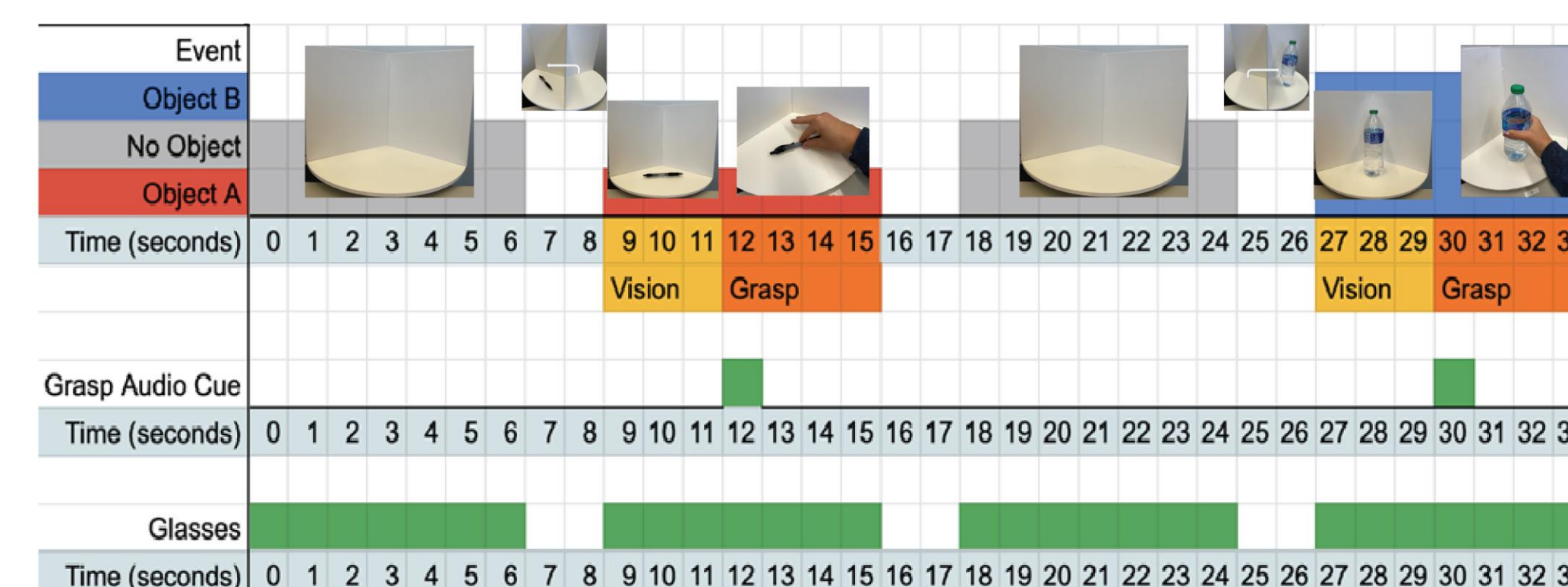


Figure 2. Protocol design of one run during task three (reach-and-grasp task) with onset / offset of other external components of the experimental platform

**Design of Platform:** The presentation of object A, object B, and no object required a 3D – designed motorized turn table that was sectioned into 3 parts (Figure 3d). The motor driver/motor (TB6600 4A 9-42V Stepper motor driver / Bipolar 1.7A Nema 17 Stepper Motor) is PC - controlled by a developed software written in Python that ensured synchrony between all hardware/software components, as well as event logging necessary for the processing of EEG signals. The human subjects were asked to wear a pair of developed “smart eyeglasses,” also controlled by the PC to enable/disable object visibility due to its capability of becoming transparent/opaque using a smart film. A simple graphical user interface was additionally developed to be in sync at the time of data collection (Figure 3a). RGB-D cameras are set up for future data collection.

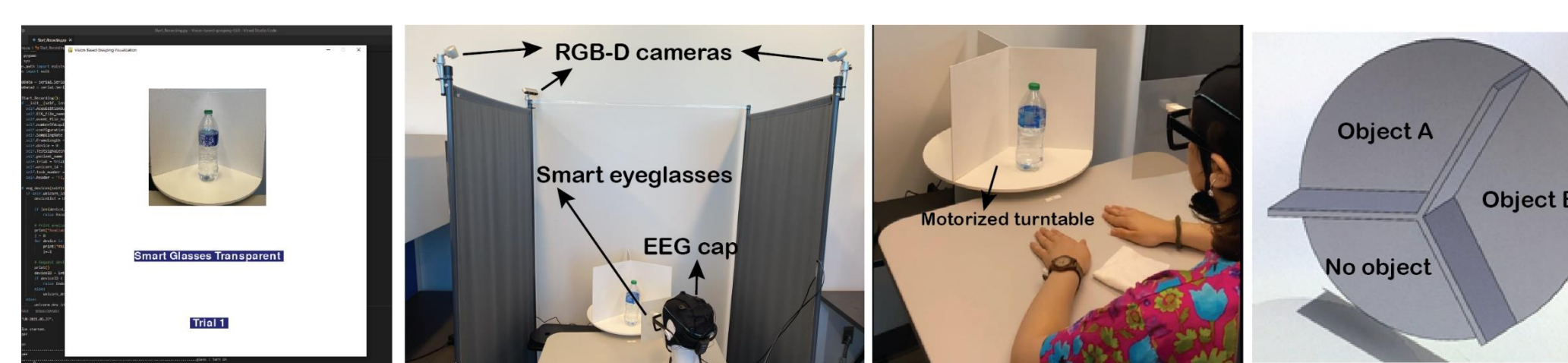


Figure 3. The completed experimental platform with its components

## Results

**Data Collection:** EEG signals were acquired using the 8 channel Unicorn Hybrid Black headset with wet electrode setup (manufactured by g.tec) at a sampling rate of 250 Hertz. Quality testing of EEG signals were performed prior to each task through Unicorn Suite software environment (g.tec).

**Data Processing:** Raw EEG data was extracted based on the object that was presented (object A or object B) in the event logging file. Neural data from object A and object B was averaged amongst each trial for all human subjects. Filters such as a 60Hz notch filter for noise elimination and Butterworth bandpass filters of varying frequency ranges enabled extraction of different brainwaves for analysis. Figure 4 plots the delta bands (0.5 – 4 Hertz) and beta bands (12 – 30 Hertz) in response to different objects during different tasks for one trial. Electrode channel C3 was selected based on the results from the pilot study and its location above the motor cortex<sup>[1]</sup>.

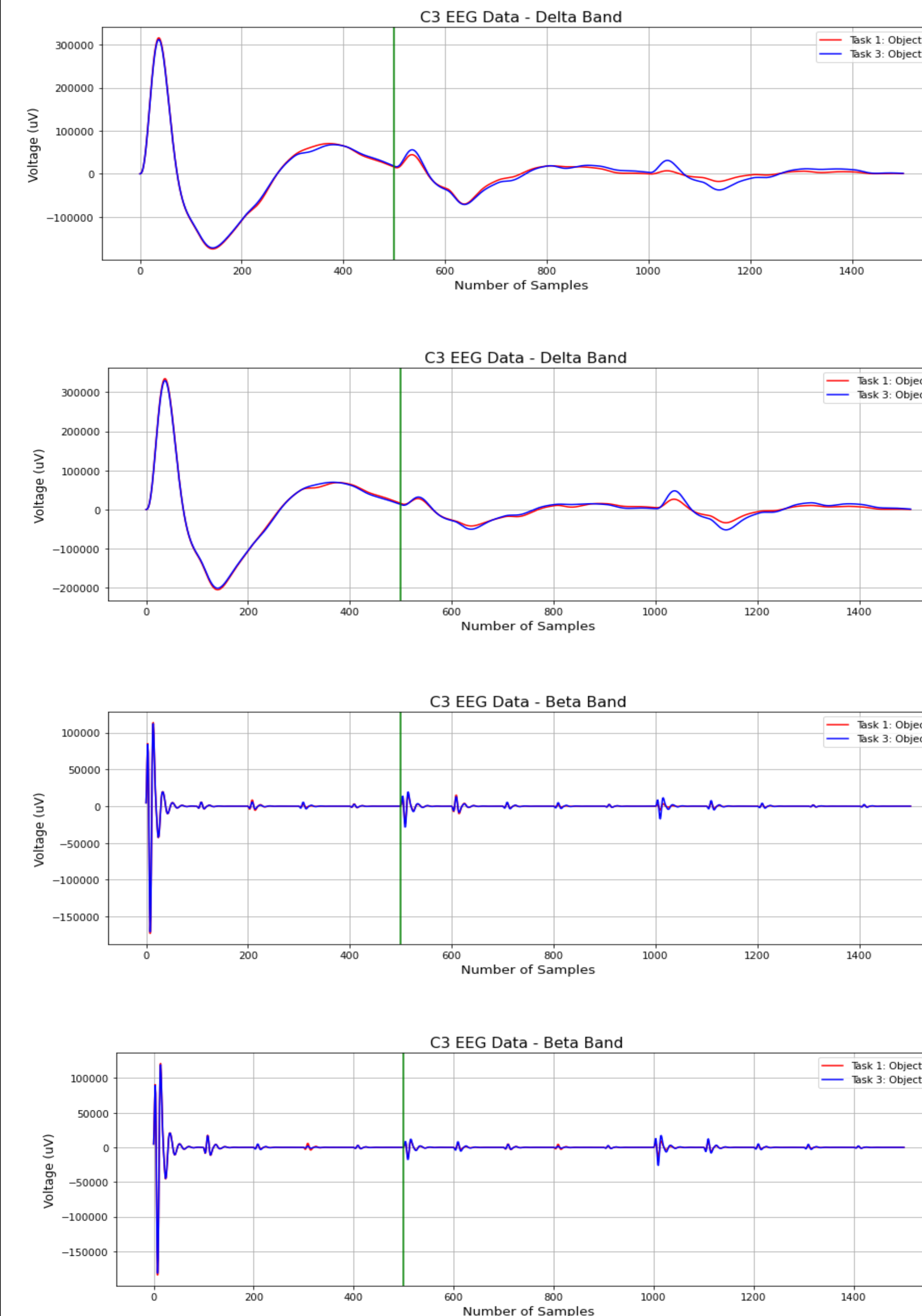


Figure 4. Extracted delta/beta bands during task 1 and task 3 are plotted against each other during presentation of either object A (logged as 1) / object B (logged as 2) over the duration of one trial. The green line indicates the onset of the audio cue.

## Conclusions

Upon observation, there is a greater negative amplitude of neural activity within the delta band at the initial moment the “smart eyeglasses” become transparent, enabling the vision of object B (water bottle) in comparison to object A (pen). Additionally, during observation – only with no movement intention (task 1) and observation with movement intention (task 3), both the delta and beta bands of each object follow a similar response shape with respect to the object. We are unable to make a conclusion with certainty based on these results as we are in the beginning stages of processing the EEG data collected, as well as collecting more data from human subjects. However, this may indicate that the brain engages in pre-shaping / follows similar emergence of neural activity during the trial upon specific object presentation.

The addition of other filters and other signal processing techniques have yet to be implemented, as well as the investigation of different electrode channel locations at different moments in time during the trial. As our system becomes increasingly robust and our dataset expands, we hope to find a definitive correlation between the emergence of brain activity for reach-and-grasp tasks with/without intention of grasping. Decoding the emergence of neural activity non - invasively during this period will enable the manipulation of assistive robotic devices in the near future.

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