Emergence of Neural Activity in Hand Preshaping to Grasp using Noninvasive EEG

Anna Cetera, Maryam Kafikang, Demetrios Petrou, Reza Abiri

To cite this version:

Anna Cetera, Maryam Kafikang, Demetrios Petrou, Reza Abiri. Emergence of Neural Activity in Hand Preshaping to Grasp using Noninvasive EEG. The Society for Neuroscience, Nov 2022, San Diego (Californie), United States. 2022. hal-03953352

HAL Id: hal-03953352
https://hal.science/hal-03953352
Submitted on 24 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Emergence of Neural Activity in Hand Pre-shaping to Grasp Using Noninvasive EEG Methods

Anna Cetera1, Maryam KafiKang2, Demetrios Petrou2, Reza Abiri1
1Dept. of Electrical, Computer, and Biomedical Engineering, University of Rhode Island, Kingston, RI, USA
2Dept. of Computer Science and Statistics, University of Rhode Island, RI, USA

Introduction

Hand dexterity and grasp disability in patients with spinal cord injury has devastating impacts on their lifestyle1. 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 device, they lack dexterity, generalizability, and are cost-intensive1. This creates difficulties and prevents accessibility for employing these devices in larger patient populations2. 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 electromyograph (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.

Methods

Design of Protocol: The structure of the protocol remained constant as the instructions for object interaction changed on 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 2) were selected from the five tasks that were IRB approved. Task one solely involves object observation of one of the two objects (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 perform a reach-and-grasp task with object presented (Figure 2). To eliminate the possibility of four tasks were performed 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).

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.

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. Eleven was selected based on the results from the pilot study and its location above the motor cortex.

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/enable 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. 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.

Acknowledgements

Research reported in this presentation was supported by the Rhode Island Institutional Development Award (IDeA) Network of Biomedical Research Excellence from the National Institute of General Medical Sciences of the National Institutes of Health under grant number P20GM103430 and by a start up fund from the University of Rhode Island.

Bibliography