Challenges and opportunities of having surface EMG and high-density surface EMG in one BIDS BEP

Introduction

The Brain Imaging Data Structure (BIDS) is a standardized framework for organizing and describing neuroimaging and related data. Extension of BIDS to new modalities is usually processed with a Bids Extension Proposal (BEP). BIDS is currently one of the data storing standards that neuro-data archives such as OpenNeuro.org accept.

Following the GitHub issue for extending BIDS specifications to high-density surface electromyography (hd-sEMG), a suggestion arose to make this BEP more inclusive for both surface EMG and hd-sEMG. Here we aim to discuss the potential advantages and drawbacks of developing BIDS standards for sEMG and hd-sEMG together. But first, let's review and compare the main features of each modality.

sEMG vs. hd-SEMG

Surface electromyography (sEMG) and high-density surface electromyography (HD-sEMG) are both non-invasive techniques used to measure the electrical activity produced by muscles during contraction. While they share some similarities, there are also key differences between the two methods in terms of electrode configuration, spatial resolution, and applications.

Electrode configuration

sEMG typically employs a small number of electrodes placed on the skin above the muscle of interest. These electrodes are spaced several centimeters apart, and the signals detected are averaged to produce a single output.

hd-sEMG, on the other hand, uses a larger number of closely spaced electrodes arranged in a grid or array configuration. This enables more detailed detection of muscle activity and provides a richer dataset for analysis.

sEMG sensors usually record a bipolar signal, that is, voltage differences between the two electrodes spaces ~1cm apart on the muscle. hd-sMEG systems, on the other hand, use a monopolar recording, which incorporates a common reference on a bone acting as a common ground for the electrodes. As a result, the sEMG and hd-sEMG electrodes cannot be grouped together for downstream post-processing and require further curation to be comparable.

Spatial resolution

The spatial resolution of sEMG is relatively low due to the limited number of electrodes and their relatively large distance from each other. This may result in cross-talk, where the electrical activity of neighboring muscles is detected by the electrodes, leading to less accurate measurements.

HD-sEMG offers higher spatial resolution as it employs more electrodes in close proximity. This allows for better differentiation between the electrical activity of different muscle fibers and reduces the impact of cross-talk. As a result, HD-sEMG can provide more accurate and detailed information about muscle activation patterns.

Applications

sEMG is widely used in various applications, such as clinical rehabilitation, sports science, ergonomics, and human-machine interface development. It is a popular choice due to its ease of use, low cost, and relatively fast setup time. However, its limited spatial resolution may restrict its utility in certain situations.

HD-sEMG, with its higher spatial resolution and improved accuracy, is increasingly being used in research and clinical applications that require more detailed information about muscle activation patterns. These include the study of muscle fatigue, muscle fiber recruitment, and muscle coordination. Additionally, HD-sEMG is particularly useful in situations where neighboring muscles have similar activation patterns, such as in the study of hand or facial muscles.

While both surface EMG and high-density surface EMG are valuable tools in the assessment of muscle activity, their differences in electrode configuration, spatial resolution, and applications should be taken into consideration when selecting the appropriate method for a specific research question or clinical application. HD-sEMG offers greater detail and accuracy, but also requires more complex data analysis and may be more expensive and time-consuming to set up.

Unified/separate BEP for sMEG and hd-sEMG

Developing BIDS standards for hd-sEMG and sEMG together versus having separate standards for each modality has pros and cons. Here, we outline the advantages of each approach.

Advantages of unified BEP for sEMG and hd-sEMG

1. Consistency: A unified standard for both modalities ensures consistent data organization, making it easier for researchers to work with and compare data across different studies.
2. Resource efficiency: Developing a single standard reduces the time and effort required for development, maintenance, and user education compared to having separate standards.
3. Interoperability: Combining the standards may promote better interoperability between the two modalities, facilitating data sharing and collaborative research.
4. Enhanced data analysis: With a unified standard, advanced analytical techniques could be developed to work with both modalities, potentially leading to more comprehensive insights.

Advantages of a separate BEP for each sEMG and hd-sEMG

5. Modality-specific optimization: Separate standards allow for the development of optimized organization and descriptions tailored to the unique requirements of each modality.
6. Clarity: Having separate standards can simplify documentation and make it easier for users to understand and implement the appropriate standard for their specific modality.
7. Flexible updates: Separate standards offer greater flexibility in making modality-specific updates or modifications, allowing each standard to evolve independently as new techniques or best practices emerge.

The disadvantages of each approach can be easily derived from the advantages of the other approach. It is finally up to the BIDS community to weigh the pros and cons of each route and choose one.