Readme for Brain-Computer Interface EEG Data (last updated June 17, 2019)

This brain-computer interface data repository consists of 62 subject datasets and was collected under the support of NIH AT009263 (PI: Bin He), NSF CBET-1264782 (PI: Bin He), and NIH F31NS096964 (PI: Bradley Edelman). The data are made public as a service to the scientific community and may be used for any research and/or non-commercial purpose at the user's own risk. No technical support will be provided on the use of the data.

The data has been published in Edelman et al. [1], which should be cited in any publications if the data would be used in whole or in part.

[1] Edelman BJ, Meng J, Suma D, Zurn C, Nagarajan E, Baxter BS, Cline CC, He B*, "Noninvasive neuroimaging enhances continuous neural tracking for robotic device control," Science Robotics, **4**, eaaw6844 (2019).
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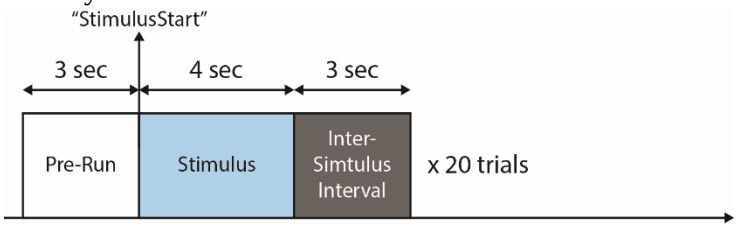
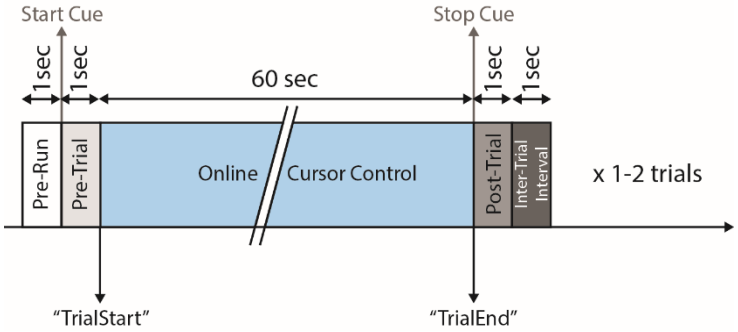
Data Types

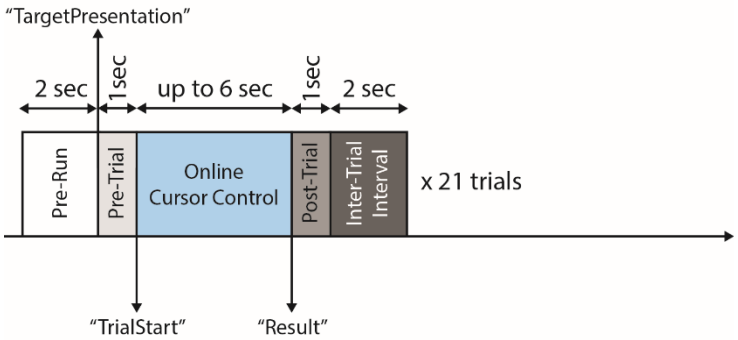
Motor Imagery (MI): Runs consisted of 10 randomly presented trials per task. Each trial consists of three seconds of rest followed by four seconds of a visually cued MI task:



CP BCI: Runs consisted of one or two 60 second trials of online cursor control separated by a one second inter-trial interval:



DT BCI: DT BCI runs consist of 21 trials, with targets presented in random order. Each trial began with a two second rest period, followed by a one second preparation period in which the target was presented to the user. Users were then given up to 6 seconds of online cursor control to attempt to hit the indicated target. A one-second post-trial period was appended to each trial to display the result (if any) and a two-second inter-trial interval bridged two successive trials. The first trial of each run was used as calibration and the cursor did not move.



Data Folders

Train_DT (n = 11):
11 naïve individuals participated in one baseline, eight training, and one evaluation session. The eight training sessions consisted of only DT BCI runs using sensor space decoding. Only the baseline and evaluation session motor imagery and BCI data are provided.

Train_CP (n = 11):
11 naïve individuals participated in one baseline, eight training, and one evaluation session. The eight training sessions consisted of only CP BCI runs using sensor space decoding. Only the baseline and evaluation session motor imagery and BCI data are provided.

Train_sCP (n = 11):
11 naïve individuals participated in one baseline, eight training, and one evaluation session. The eight training sessions consisted of only CP BCI runs using source space decoding. Only the baseline and evaluation session BCI data are provided.

The baseline and evaluation sessions for the Train_DT, Traing_CP, and Train_sCP subject folders consist of the following runs (in order:

- 1 x Left vs. Right MI
- 1 x Both Hands vs. Rest MI
- 2 x CP BCI LR
- 2 x CP BCI UD
- 2 x CP BCI 2D
- 2 x DT BCI LR
- 2 x DT BCI UD
- 2 x DT BCI 2D

* LR – horizontal control, UD – vertical control, 2D – two-dimensional control
** The Train_sCP subject folders do not include the motor imagery EEG runs

ESI_Exp (n = 16):
16 individuals with BCI experience participated in up to three CP BCI sessions. Decoding was performed in the sensor and source space, randomized across runs.

ESI_Naive (n = 13):
13 naive individuals participated in a single CP BCI session. Decoding was performed in the sensor and source space, randomized across runs.

Each session for the ESI_Exp and ESI_Naive subject folders consists of the following runs (in order):

- 4 x CP BCI LR
- 4 x CP BCI UD
- 4 x CP BCI 2D

* The order of sensor and source decoding runs was randomized within session and balanced across subjects.

EEG Information

- 128 channels (biosemi128.xyz), downsampled to 256 Hz, re-referenced to the average of all electrodes
- EEG was cleaned using the artifact subspace reconstruction (ASR) method (https://sccn.ucsd.edu/wiki/Artifact_Subspace_Reconstruction_(ASR))

Standard eeg structure fields

eeg.filename – The current eeg file
eeg.filepath – The folder containing the current eeg file
eeg.subject – Subject ID within current folder
eeg.session – "Task Type"_"Control Dimension"_"Time Point"
eeg.run – Run # within the current session
eeg.fs – EEG sampling rate
eeg.pnts – Total number of EEG time points
eeg.times – EEG sampling times in seconds
eeg.numchan – Number of EEG channels
eeg.chanlocs – EEG channel location information
eeg.cleanchannelmask – Indicates clean (1) and artifactual (0) channels identified by the ASR method. Artifactual channels were spherically interpolated.
eeg.rank – Rank of the EEG data matrix (equal to the number of 1's in eeg.cleanchannelmask)
eeg.data – Cleaned and preprocessed EEG data
eeg.event – Event structure containing trial structure information

Fields specific to MI data sets

eeg.event (there are 20 events that pertain to the 20 trials)
    eeg.event.latency – Time of event (timepoints)
    eeg.event.duration – Duration of event (timepoints)
    eeg.event.type – Type of event (always "StimulusStart")
    eeg.event.command – Command for event ("Imagine Left" vs "Imagine Right", "Imagine Both" vs "Rest")
eeg.interstimulusinterval – Duration in seconds of time between two successive stimulus presentations
eeg.simulusduration – Duration in seconds of a stimulus presentation

Fields specific to DT data sets

eeg.event (there are at minimum 42 events that pertain to the 21 trials)
    eeg.event.latency – Time of event (timepoints)
    eeg.event.position:
        - if "TargetPresentation" type, position of target ("left", "right", "up", or "down")
        - if "TrialStart" type, always "1"
        - if "Result" type, position of target in which the cursor hit, if any
    eeg.event.duration – Duration of event (timepoints)
    eeg.event.type – Type of event
        - "TargetPresentation" – Every trial
        - "TrialStart" – Every trial
        - "Result" – Only for those trials in which a target (correct or incorrect) is hit
eeg.prerunduration – Duration in seconds of time period before recurring trial structure begins
eeg.pretrialduration – Duration in seconds of target presentation before online cursor control
eeg.maxtrialduration – Maximum duration of online cursor control
eeg.posttrialduration – Duration in seconds of time between the end of one trial and the inter trial interval
eeg.intertrialinterval – Duration in seconds of time between the end of one trial and beginning of another

eeg.decodingdomain – The domain used for online neural decoding in the current run

Fields specific to CP data sets

eeg.event (there are 2 events that pertain to the start and end of each trial)
- eeg.event.latency – Time of event (timepoints)
- eeg.event.duration – Duration of event (timepoints)
- eeg.event.type – Type of event
  - "TrialStart" – Every trial
  - "TrialEnd" – Every trial

eeg.prerunduration – Duration in seconds of time period before recurring trial structure begins
eeg.pretrialduration – Duration in seconds of "start" cue
eeg.trialduration – Duration in seconds of online cursor control (60 seconds)
eeg.posttrialduration – Duration in seconds of "stop" cue, before the intertrial interval
eeg.intertrialinterval – Duration in seconds of time between the end of one trial and the beginning of another
eeg.decodingdomain – The domain used for online neural decoding in the current run
eeg.cursorpos – Cursor position (normalized x and y coordinate) time series for the entire run
eeg.targetpos – Target position (normalized x and y coordinate) time series for the entire run
eeg.postimes – Cursor sampling times in seconds

Notes

The following datasets produced an error during ASR cleaning and are only cleaned with the other processing steps descirbed above

- Train_DT S05_CP_LR_BASELINE_R01
- Train_DT S05_CP_LR_EVAL_R02