

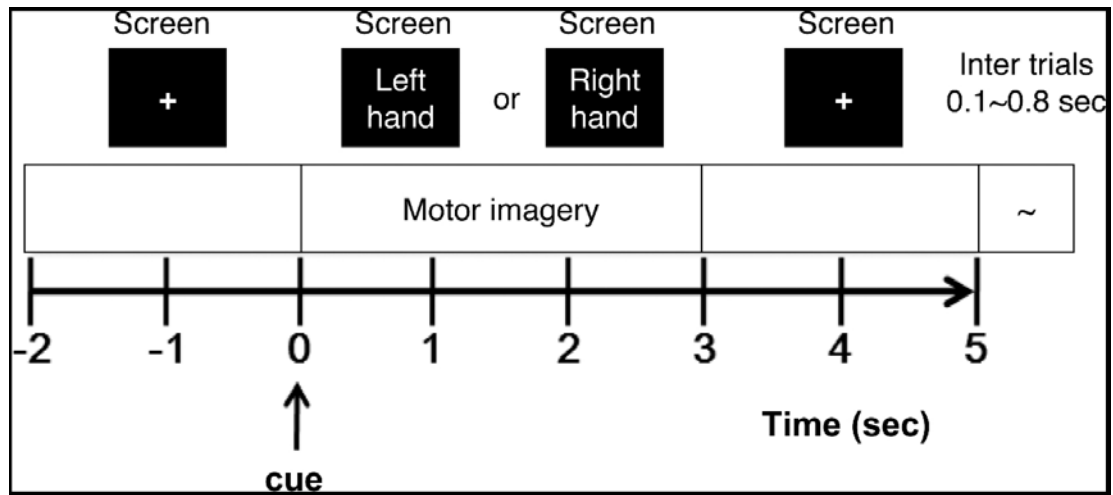
# MI-based BCI

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## Experimental paradigm

- Six types of non-task-related data: We recorded 6 types of noise data (eye blinking, eyeball movement up/down, eyeball movement left/right, head movement, jaw clenching, and resting state) for 52 subjects. Each type of noise was collected twice for 5 seconds, except the resting state, which was recorded for 60 seconds.
- Real hand movement: Before beginning the motor imagery experiment, we asked subjects to conduct real hand movements. Subjects sat in a chair with armrests and watched a monitor. At the beginning of each trial, the monitor showed a black screen with a fixation cross for 2 seconds; the subject was then ready to perform hand movements (once the black screen gave a ready sign to the subject). As shown in Fig. 2, one of 2 instructions (“left hand” or “right hand”) appeared randomly on the screen for 3 seconds, and subjects were asked to move the appropriate hand depending on the instruction given. After the movement, when the blank screen reappeared, the subject was given a break for a random 4.1 to 4.8 seconds. These processes were repeated 20 times for one class (one run), and one run was performed.
- MI experiment: The MI experiment was conducted with the same paradigm as the real hand movement experiment. Subjects were asked to imagine the hand movement depending on the instruction given. Five or six runs were performed during the MI experiment. After each run, we calculated the classification accuracy over one run and gave the subject feedback to increase motivation. Between each run, a maximum 4-minute break was given depending on the subject's demands.



### Data recording

EEG data were collected using 64 Ag/AgCl active electrodes. As shown in Fig. 1, a 64-channel montage based on the international 10-10 system was used to record the EEG signals with 512 Hz sampling rates. The EEG device used in this experiment was the Biosemi ActiveTwo system. The BCI2000 system 3.0.2 [7] was used to collect EEG data and present instructions (left hand or right hand MI). Furthermore, we recorded EMG as well as EEG simultaneously with the same system and sampling rate to check actual hand movements. Two EMG electrodes were attached to the flexor digitorum profundus and extensor digitorum on each arm.

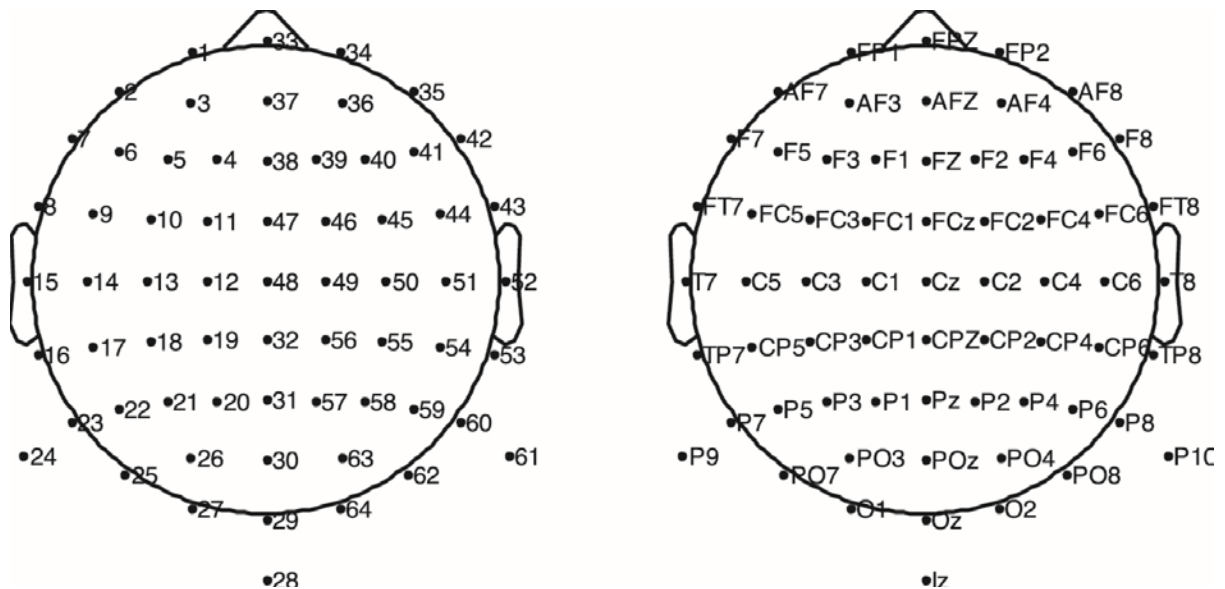


Figure 1. EEG Channel Configuration

EEG channel configuration—numbering (left) and corresponding labeling (right).

For each subject, EEG channel locations (3D coordinates) were collected with a 3D coordinate digitizer (Polhemus Fastrak). Electrode location was measured as the average of three measurements of the digitizer to obtain a stabilized position and prevent hand shaking.

## Data file description

The MATLAB structure of the EEG (1st to 64th channel) and EMG (65th to 68th channel) data (“\*.mat”) for each subject is shown below:

- rest: resting state with eyes-open condition
- noise:
  - - eye blinking, 5 seconds  $\times$  2
  - - eyeball movement up/down, 5 seconds  $\times$  2
  - - eyeball movement left/right, 5 seconds  $\times$  2
  - - jaw clenching, 5 seconds  $\times$  2
  - - head movement left/right, 5 seconds  $\times$  2
- imagery\_left: 100 or 120 trials of left hand MI
- imagery\_right: 100 or 120 trials of right hand MI
- n\_imagery\_trials: 100 or 120 trials for each MI class
- imagery\_event: value “1” represents onset for each MI trial
- movement\_left: 20 trials of real left hand movement
- movement\_right: 20 trials of real right hand movement
- n\_movement\_trials: 20 trials for each real hand movement class
- movement\_event: value “1” represents onset for each movement trial
- frame: temporal range of a trial in milliseconds
- srate: sampling rate
- senloc: 3D sensor locations
- psenloc: sensor location projected to unit sphere
- subject: subject's two-digit ID - “s#”
- comment: comments for the subject
- bad\_trial\_indices
  - - bad trials determined by voltage magnitude
  - - bad trials correlated with EMG activity