Ultra high-density EEG for interictal migraine and controls: stimuli description and matlab codes
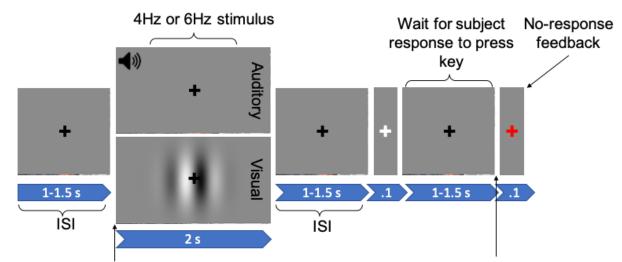
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This document explains the visual and auditory stimuli we have used for the ultra high density EEG recording of 17 migraine patients during the interictal period, and 18 age- and gender-matched healthy participants. In this dataset, we used a custom-designed EEG cap with ultra-high-density coverage (approximately 14 mm inter-electrode distance) over visual, parietal, and frontal regions [1]. This helps us to achieve a high spatial resolution of recording from the visual and auditory regions in the brain. In [2], it is shown that ultra high-density EEG caps capture more neural information, compared to the standard EEG systems with less spatial resolution. The dataset and all of the stimuli matlab files of our study are available in [3]. Please see the readme.txt file in [3] for more information.

SSVEP: Steady state visually evoked potentials (SSVEP) are signals that are natural responses to visual stimulation at specific frequencies [4]. This technique is used widely with EEG research regarding vision and attention. SSVEPs are useful in research because of the excellent signal-to-noise ratio [5] and relative immunity to artifacts [6]. Steady state approach can be used for multiple sensory modalities, such as auditory stimulation, which makes it easier to compare visual and auditory processing in the brain.

For the visual condition, gaussian filtered vertical sine-wave gratings alternated contrast sinusoidally at 4Hz or 6Hz for 2s.

SSVEP/SSAEP trial (with pressing key) [7,8]:

Label 1 → Onset of 4Hz stimulation)
Label 2 → Onset of 6Hz stimulation)
Label 11 → key pressed after 4Hz stimulation)
Label 22 → key pressed after 6Hz stimulation)

In terms of the epoch labels, we have used labels "1" and "2" for pointing to the onset of the 4Hz and 6Hz stimuli respectively, and "11" and "22" for pointing to the end of the 1-1.5s interval in which a feedback is received (pressed key), after the 4Hz and 6Hz stimuli respectively. There are two text files, "SubIDvis_migraine.txt" and "SubIDaud_migraine.txt", for each subject in the dataset, which contain the response time in the feedback task: first line of each file contains the labels of the task ("1" or "2"), the second line shows the trials with a feedback task, where non-zero numbers indicates the type of the trial in which the response was received from the subject, e.g., "1" for the 4Hz stimulation and "2" for the 6Hz stimulation. The third line in these files include the response time (in seconds) in the feedback tasks.

We have also designed the SSVEP/SSAEP trials, where no key is pressed. The structure of these trials are the same as the ones with pressing key (shown above), but with no feedback (no key pressing) after the visual/auditory stimulation.

SSAEP: SSAEP trials are similar to SSVEP, but instead of the grating pattern, a fixation cross is shown on the screen and 1kHz tones are modulated by a 4Hz or 6Hz frequency for 2s. Similar labeling system is used here, as it is used in SSVEP.

Resting state: The resting state trials include a single black fixation cross at the center of a grey screen for the duration of the scan. Each trial is 2 minutes and we have six blocks of resting state trials. Label "1" indicates the start of the block and label "2" indicates the end of each block.

Some hints on how to use the matlab codes:

These codes have comments which helps you understand what is going on in each part of the code.

First you need to download and install the matlab toolbox named as Psychtoolbox [9-11] from here:
http://psychtoolbox.org/download.html#installation

The following codes have been tested on computers with windows OS. You may face some issues with the keyboard inputs if you change the operating system.

Files named "vis_SSVEP.m" and "aud_SSAVEP.m":
In line 7: you specify the name/ID for the subject
In line 14: you can specify the number of blocks/sessions through which a train of trials will be recorded.
In line 15: you can specify the temporal frequency of visual/auditory stimulus (1=4Hz, 2=6Hz)
In line 16: you can specify the trial types (0=without pressing button, 1=with pressing button)

In line 65 for SSAEP you can change the tone carrier frequency.
In lines 76 and 78 for SSVEP you can play with the spatial characteristics of the Gabor pattern (spatial frequency, width of the Gaussian filter, etc)

Files named "Resting_migraine.m":
In line 7: you can specify the number of blocks/trials for the resting state recording.
In line 45 and 54: you can change the start/end labels of the resting state blocks.

References:

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