# Big Data of 4-classes SSVEP

Participants

Fifty-four healthy subjects (ages 24-35; 25 females) participated in the experiment. Thirty-eight subjects were naive BCI users. The others had previous experience with BCI experiments. None of the participants had a history of neurological, psychiatric, or any other pertinent disease that otherwise might have affected the experimental results. The subjects were seated comfortably in a chair with armrests at 60 ($\pm$ 5) cm in front of a 21-inch LCD monitor (refresh rate: 60 Hz; resolution: 1,600 $\times$ 1,200). The approximate horizontal and vertical visual angles were 37.7 and 28.1 degrees, respectively. During the experiment, subjects were instructed to relax their muscles and minimize their eye and muscle movements.

EEG data recording

EEG signals were recorded with a sampling rate of 1,000 Hz and collected with 62 Ag/AgCl electrodes. The EEG amplifier used in the experiment was a BrainAmp (Brain Products; Munich, Germany). The channels were nasion-referenced and grounded to electrode AFz. Additionally, an EMG electrode recorded from each flexor digitorum profundus muscle with the olecranon used as reference. The EEG/EMG channel configuration and indexing numbers are described in Fig. 1. The impedances of the EEG electrodes were maintained below 10 kΩ during the entire experiment.
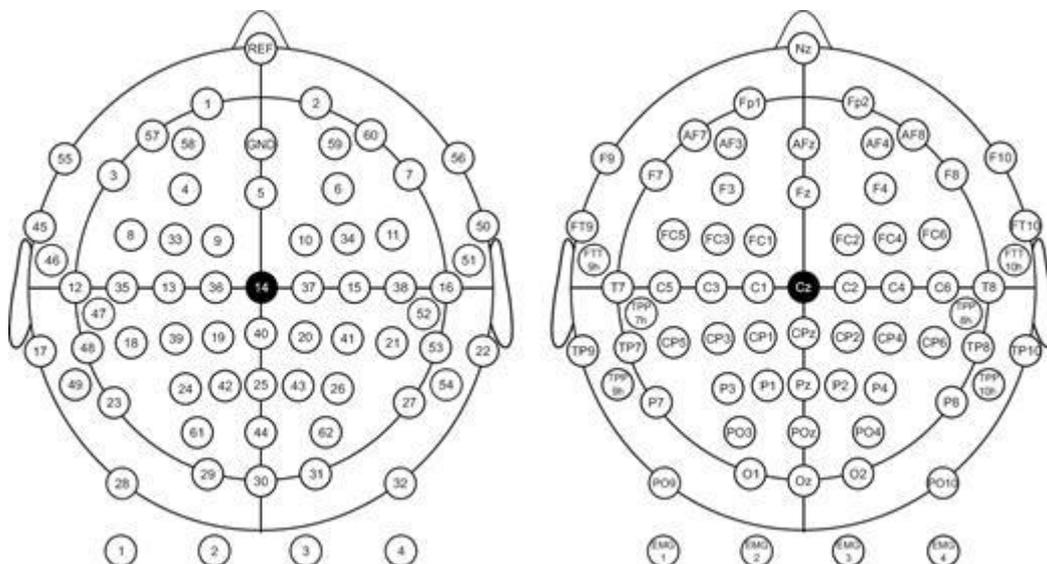
SSVEP paradigm

Four target SSVEP stimuli were designed to flicker at 5.45, 6.67, 8.57, and 12 Hz and were presented in four positions (down, right, left, and up, respectively) on a monitor. The designed paradigm followed the conventional types of SSVEP-based BCI systems that require four-direction movements [40]. Participants were asked to fixate the center of a black screen and then to gaze in the direction where the target stimulus was highlighted in a different color (see Fig. 2C). Each SSVEP stimulus was presented for 4 s with an ISI of 6 s. Each target frequency was presented 25 times. Therefore, the corrected EEG data had 100 trials (4 classes × 25 trials) in the offline training phase and another 100 trials in the online test phase. Visual feedback was presented in the test phase; the estimated target frequency was highlighted for 1 s with a red border at the end of each trial.
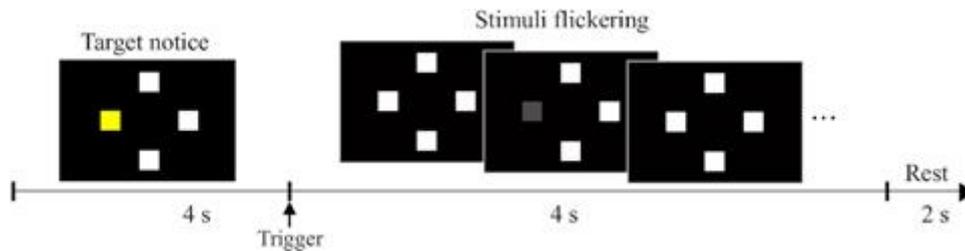
Table 1:

Questionnaire prior to experiments

Questionnaire I	
Personal Information	
1	Age
2	Gender (Male = 0, Female = 1)
3	BCI experience (number of experiences; naive = 0)
4	Right-handed = 0, Left-handed = 1, Ambidexter = 2
Physiological and psychological condition	

Questionnaire I						
1	How long have you slept?					
	(1~4 h = 1, 5~6 h = 2, 6~7 h = 3, 7~8 h = 4, >8 h = 5)					
2	Did you drink coffee in the last 24 hours?					
	(in hours since last consumption; none = 0)					
3	Did you drink alcohol in the last 24 hours?					
	(in hours since last consumption; none = 0)					
4	Did you smoke in the last 24 hours?					
	(in hours since last consumption; none = 0)					
5	Condition checklists	Low				High
	-Comfort	1	2	3	4	5
	-Motivation	1	2	3	4	5
	-Concentration	1	2	3	4	5
	-Eye fatigue	1	2	3	4	5
	-Drowsiness	1	2	3	4	5
	-Physical condition	1	2	3	4	5
	-Mental condition	1	2	3	4	5

Subjects were asked to supply their personal information and to report their physiological and psychological condition.

Table 2:

Questionnaire during the experiments

Questionnaire II						
Paradigm: ERP, MI or SSVEP						
Phase (offline training or online test)						
1	Are you able to participate in the following experiment?					
2	Condition check list	Low				High
	-Comfort	1	2	3	4	5
	-Motivate	1	2	3	4	5
	-Concentration	1	2	3	4	5
	-Eye fatigue	1	2	3	4	5
	-Drowsiness	1	2	3	4	5
	-Physical condition	1	2	3	4	5
	-Mental condition	1	2	3	4	5
3	Did you ever doze off or fall asleep during the experiment?					
	(number of times; none = 0)					
4	Was it easy to perform the given tasks?					
5	How many attempts have you missed?					
	(number; none = 0)					
6	Expected accuracy for this experiment (%)					

Subjects were asked to provide information regarding their current condition and self-evaluate their accuracy in the previous experiment.

Table 3:

Experimental procedures

	Experimental procedure	Required time (min)	Cumulative time (min)
Prep. (33)	Instructions, self-assessment with questionnaire I	5	5
	EEG and EMG electrode placement	25	30
	Acquisition of artificial noise data	3	33
ERP (36)	Resting state data	1	34
	ERP speller in offline phase	12	46
	Resting state data	1	47
	Questionnaire II	2	49
	Short break	3	52
	Resting state data	1	53
	ERP speller in online phase	13	66
	Resting state data	1	67
	Questionnaire II	2	69
	Break	10	79
Motor-imagery (51)	Impedance check	5	84
	Resting state data	1	85
	Motor-imagery task in offline phase	22	107
	Resting state data	1	108

	Experimental procedure	Required time (min)	Cumulative time (min)
	Questionnaire II	2	110
	Short break	3	113
	Resting state data	1	114
	Motor-imagery task in online phase	22	136
	Resting state data	1	137
	Questionnaire II	2	139
	Break	10	149
SSVEP (51)	Impedance check	5	154
	Resting state data	1	155
	SSVEP task in offline phase	20	175
	Resting state data	1	176
	Questionnaire II	2	178
	Short break	3	181
	Resting state data	1	182
	SSVEP task in online phase	20	202
	Resting state data	1	203
	Questionnaire II	2	205
	Total		205