Validity and Reliability of Event Related Potential in Subacute Stroke

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Research Article

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Abstract

The aim of this study was assess the test-retest reliability of the ERP and resting EEG test in subacute stroke patients. Additionally, we compared the validity of the EEG, ERP test to MMSE (Mini-Mental State Exam) and MoCA (Montreal Cognitive Assessment) to use it as an objective tool to evaluate cognitive function. We recruited 20 patients with subacute ischemic stroke who were 19 years of age or older and had an MMSE score of 20 or higher. All participants were tested K-MMSE (Korean Mini Psychostatistics Test) and K-MoCA (Korea-Montreal Cognitive Assessment). The resting-state EEG and P300 wave using an auditory and visual oddball paradigm were measured at baseline and once again in 24 hours. We calculated the brain symmetry index (BSI) and directional BSI (BSIdir) over different frequency bands and delta/alpha ratio (DAR). The intra-rater reliability and validity of the P300 latency, amplitude, BSI, BSIdir and DAR were measured by intra-class correlation (ICC) analysis and by Pearson`s correlation coefficient analysis, respectively. P300 latency showed excellent ICC level (auditory P contralesional, ICC = 0.918, visual P contralesional, ICC = 0.972, visual Pz, ICC = 0.945). In the visual ERP (latency), there was a significant correlation between Cz, C ipsilesional and Mini-Mental State Exam (MMSE) and C ipsilesional and Montreal Cognitive Assessment (MoCA). The P contralesional and Pz latency of visual ERP showed significant reliability, and the Cz and C ipsilesional of visual latency showed effectiveness in reflecting the cognitive function. Thus, these montages could be used as a basis for future studies.

Introduction

Cognitive impairment is observed in 12%-56% of stroke patients, and one in three patients exhibit persistent cognitive impairment despite adequate treatment [1]. Cognitive impairment after stroke may disrupt functional recovery and rehabilitation [2]. In clinical settings, cognitive impairment after ischemic stroke is usually diagnosed using neuropsychiatric examinations (e.g., Korean Wechsler Adult Intelligence Scale). However, these examinations yield different results depending on patient compliance, and are often complex and time-consuming. Therefore, researchers need an objective method that can help assess cognitive impairment regardless of patient compliance [3]. Event-related potential (ERP) is a potential derived from the electrical activities of the cerebrum, which appears for a certain time after auditory or visual stimulation [4]. ERP allows non-invasive analysis of the electrophysiological phenomena induced by cerebral cortex stimulation for the evaluation of brain function [5]. ERP is a reproducible electrophysiological response to external stimuli and indicates the brain activity related to various cognitive processes, such as selective attention, memory, or decision making [6]. ERP can be analyzed for the polarity peak or latent time that appears over time after stimulation, and values such as N100, P200, and P300 can be calculated. N100 and P200 provide information on selective attention, and P300 is commonly used in cognitive studies to provide information on cognitive function[7]. An extended latency and decreased amplitude of P300 leads to reduced cognitive function in subacute stroke[3].

Electroencephalogram (resting-state EEG) evaluates brain signals with the eyes opened, and is widely used to assess the brain function[8]. Neuronal oscillations are suggested as a biomarker associated with behavioral recovery after stroke[9]. Resting-state EEG in ischemic stroke patients reveals delta (0.5-4 Hz) and theta (4–8 Hz) waves with increased power and alpha (8–12 Hz) waves with reduced power[10]. Power spectral analysis (resting EEG analysis) can be performed to calculate the delta/alpha ratio (DAR), which typically increases in stroke patients[11]. Among the data obtained through resting EEG analysis, brain symmetry index (BSI) can be used to assess the prognosis after ischemic stroke. BSI is higher in stroke patients than in healthy adults, and this is related to stroke severity[12].

Currently, there is no Korean study on the use of parameter tests such as resting EEG in stroke patients. Thus, we aimed to assess the reliability of the resting EEG test. We investigated the test-retest reliability of the DAR, BSI, and amplitude and latency of auditory and visual ERP from EEG. Additionally, we compared the validity of the resting EEG test to MMSE (Mini-Mental State Exam) and MoCA (Montreal Cognitive Assessment) to use it as an objective tool to evaluate cognitive function in subacute stroke patients.

Materials And Methods

< Insert figure. 1>

Participants

The study participants were 20 patients admitted to the Department of Rehabilitation Medicine at Chungnam National University Hospital from June 2020 to February 2021 and who satisfied the inclusion and exclusion criteria. The inclusion criteria included (1) adults over the age of 19 years; (2) patients diagnosed with ischemic stroke through imaging tests such as Computed Tomography or Magnetic Resonance Imaging; and (3) those with Korean-mini mental stat examination (K-MMSE) scores of 20 points or higher. The exclusion criteria included patients with neurogenic disorders, major depressive disorder, schizophrenia, bipolar disorder, dementia, and severe liver, kidney, heart, and respiratory diseases.

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Resting-state EEG

To measure the resting-state EEG, participants were asked to sit on a chair and focus on a point displayed on a flat-screen for three minutes. The participants were asked to stare without falling asleep and think about things as much as possible.

Auditory and visual ERP

The ERP measurements were conducted in a quiet room with the participants sitting on a chair and looking at a screen. P300 was obtained using Synamp2 (Compumedics, Victoria, Australia) and Oddball paradigm. In Auditory ERP, two types of stimuli were provided: standard tone at 80% (1,000 Hz) and target tone at 20% (2,000 Hz). In Visual ERP, two types of stimuli were provided: 80% non-target circle and 20% target square. In Auditory ERP, a total of 300 stimulations with 50-ms durations per pulse, 2,500-ms interval between pulses, and a stimulation pressure of 90 dB was provided. All auditory stimuli were generated via computer speakers. In visual ERP, a total of 200 stimulations with 50-ms durations per pulse and 2,500-ms intervals between pulses was provided. Before recording, all participants were trained to distinguish between different tones and shapes and were asked to press a button as soon as possible when they heard a high tone or saw a square shape.

Recording-EEG and ERP

EEGs were recorded using a PC-based Neuroscan NuAmps data acquisition system (Compumedics, Victoria, Australia) and Ag-Agcl electrodes placed according to the 10–20 International System. An EEG was recorded continuously according to the electrode position (10–20 system). F3, Fz, F4, C3, CZ, C4, P3, PZ, P4. Electrodes were referenced to the ground on the forehead (GOD). Electrooculography (EOG) activity was recorded via two electrodes placed over the outer canthi and a pair of electrodes placed above and below the left eye. The impedance of each electrode was less than 5 kΩ for the entire session.

After the examination, F3 and 4, C3 and 4, and P3 and 4 were switched according to the stroke side, and the hemispheres with and without stroke were denoted as ipsilesional (IL) and contralesional (CL), respectively.

Preprocessing-EEG

Offline analysis was conducted using the editing module of the Curry Neuroimaging Suite (version 7.0.10). For bandpass filtering, a low filter with a frequency of 0.5 Hz or higher and a notch filter of 60 Hz was used. The high filter was turned off. Artifact reduction was conducted using HEOG, VEOG, Rt. EMG, Lt. EMG (flexor carpi radialis muscle). The threshold was − 100–100 μV. Independent component analysis (ICA) was conducted for reduction.

Preprocessing-ERP

Offline analysis was conducted using the editing module of Curry Neuroimaging Suite (version 7.0.10). Pre-processing included bandpass filtering between 1–20 Hz. Continuous EEG was conducted with 100 ms of pre-stimulation and 500 ms of post-stimulation. Baseline corrections were performed based on the average EEGs within 100 ms immediately before each epoch. Segments with noises or amplitudes greater than 75 μV were excluded when calculating the average value.

Analysis-EEG

The analysis results were noted as IL and CL according to the lesion. DAR was defined as the ratio of delta power to alpha power. For all channels (c), the output of delta and delta frequency bands (f = 1,…, 4 Hz and 8, ..., 12 Hz, respectively) were determined as the average spectral power Pc(f) over this range. The DAR was calculated as follows[11].

$$DAR_c = \frac{\langle P_c(f)\rangle_{f=1,\ldots,4Hz}}{\langle P_c(f)\rangle_{f=8,\ldots,12Hz}}$$

Global DAR was averaged across all N EEG channels[11].

$$DAR = \frac{1}{N}\sum_{C=1}^{N} DAR_c$$

In addition to all available channels, the affected (DARAH) and unaffected DARs (DARUH) were calculated with a central electrode[11].

BSI was defined as the difference in spectral power between the left (CL) and right channels (CR). The difference was normalized over a 1–25 Hz range as follows[12].

$$BSI_{cp} = \left\langle \left| \frac{P_{c_R}(f) - P_{c_L}(f)}{P_{c_R}(f) + P_{c_L}(f)} \right| \right\rangle_{f=1,\ldots,25Hz}$$

The values were normalized over the pair cp of all channels.

$$BSI = \frac{2}{N}\sum_{cp=1}^{N/2} BSI_{cp}$$

The BSI value ranged from 0 to 1, with 0 indicating symmetry and 1 indicating asymmetry. To interpret the directionality of the asymmetry, the directed version (BSIdir) was supplemented[13]. The absolute value of the numerator was omitted in BSIdir. The BSIdir sign was chosen so that values between 0 and 1 reflected greater cortical forces in the affected hemisphere compared to the unaffected hemisphere. In opposite cases, a value between − 1 and 0 was chosen.

$$BSI_{dir_{cp}} = \left\langle \frac{P_{c_R}(f) - P_{c_L}(f)}{P_{c_R}(f) + P_{c_L}(f)} \right\rangle_{f=1,\ldots,25Hz} \qquad BSI_{dir} = \frac{2}{N}\sum_{cp=1}^{N/2} BSI_{dir_{cp}}$$

Analysis-ERP

The analysis results were noted as IL and CL according to the lesion. P3 maximum latency was defined as the time from the start of the stimulus to the point of positive amplitude[14]. The peak amplitude was chosen as the amplitude[14], and the time window was chosen based on the average of the overall data of all sessions.

Cognitive test

K-MMSE and Korean-Montreal Cognitive Assessment (K-MoCA) were conducted when participants were transferred to the Department of Rehabilitation Medicine. K-MMSE comprises 30 criteria to evaluate orientation, memory, attention and calculation ability, language, and spatial-temporal construction ability. The test was conducted one-on-one with the examiner. There was no time limit. Each item was worth one point. If the given task was performed correctly, one point was assigned. A point of 0 was assigned when the participant failed to conduct the given task. The K-MoCA was developed to evaluate mild cognitive impairment. K-MOCA evaluated cognitive functions such as executive ability, attention, concentration, memory, vocabulary, visual-spatial ability, abstraction, calculation, and orientation. The maximum score was 30 points. A score of 23 points or higher was considered normal. If the participant had less than six years of education, an extra point was given.

Ethical procedure

This study was approved by the Chungnam National University Hospital institutional review board (IRB number: 2020-03-014-001). The study’s purpose and method were explained to all participants in detail. A written consent form was obtained from every participant. All studies were performed in accordance with relevant guidelines/regulations. In addition, research was conducted in accordance with the Declaration of Helsinki.

Statistics

The amplitude and latency of each montage of auditory and visual ERP were recorded. The mean and standard deviation for each montage from the results of the two measurements were calculated. In the reliability analysis, Pearson
$sc \text{ or } relationcoefficientwasmeasuredf \text{ or } DAR, BSI, audi \rightarrow ry, visualP300amplitude, \text{ and } latency, whichweremeasuredtwice \rightarrow evaluatet$
s correlation coefficient, K-MMSE, and K-MoC were used for DAR, BSI, auditory, visual P300 amplitude, and latency.

A p-value of < 0.05 was considered statistically significant. Following the classification of ICC levels in a previous study, ICCs < 0.50, 0.50–0.75, 0.75–0.90, and > 0.90 were considered poor, good, moderate, and excellent, respectively[15].

Results

Demographic and clinical characteristics

A total of 20 participants with seven men and 13 women were included in this study. The mean age of the participants was 63.2±10.3 years. A total of 14 and 6 patients stroked on the right and left side, respectively, and 6 and 14 patients had cortex and subcortex lesions, respectively. The mean score for K-MMSE was 25.8±3.1. The mean score for K-MoCA was 22.4±3.0. MMSE, MoCA, EEG, and ERP were conducted on an average of 17.05±5.0 days after stroke onset (Table 1). We calculated the mean and standard deviation of latency and amplitude of the first and second tests for auditory and visual ERP (Table 2, 3).

ICC-Resting-state quantitative EEG

In reliability analysis of resting-state EEG, significant reliability was observed for DAR (ICC=0.447), DARAH (ICC=0.451), BSIdir (ICC=0.713), and BSIdirtheta (ICC=0.713) (Table 4). DAR and DARAH were showed a poor ICC level, and BSIdir and BSIdirtheta had a moderate ICC level.

ICC-ERP

In auditory ERP (latency), F CL (ICC=0.822), Fz (ICC=0.780), C CL (ICC=0.780), C IL (ICC=0.781), P CL (ICC=0.918), and Pz (ICC=0.786) showed significant reliability. (Table 5). F CL, Fz, C CL, C IL, and Pz had a good ICC level, and P and CL had an excellent ICC level.

In addition, C CL (ICC=0.648), Cz (ICC=0.568), C IL (ICC=0.636), and Pz (ICC=0.574) showed significant reliability for amplitude. (Table 6). C CL, Cz, C IL, and Pz had a moderate ICC level.

In visual ERP, all channels including F CL (ICC=0.846), Fz (ICC=0.611), F IL (ICC=0.583), C CL (ICC=0.811), Cz (ICC=0.744,), C IL (ICC=0.689), P CL (ICC=0.972), Pz (ICC=0.945), and P IL (ICC=0.891) showed significant reliability for latency (Table 6). P CL, and Pz had an excellent ICC level, and F CL, C CL, and P IL had a good ICC level. Additionally, Fz, F IL, Cz, and C IL showed a moderate ICC level.

In visual ERP, Fz (ICC=0.626), C CL (ICC=0.574), Cz (ICC=0.564), C IL (ICC=0.636), P CL (ICC=0.708), Pz (ICC=0.696), and P IL (ICC=0.625) showed significant reliability for amplitude (Table 7, 8). Fz, C CL, Cz, C IL, P CL, Pz, and P IL showed a moderate ICC level.

Concurrent Validity of Resting-state quantitative EEG/ERP

The correlations between the K-MMSE and K-MoCA scores, as well as the values measured in the montages that showed significant results in validity and reliability analyses were assessed. The correlation between the first and second ERPs was also investigated. (Table 9, 10, 11, 12)

In the validity analysis of MMSE and MoCA of resting-state EEG, there was no significant correlation in the first ERP. In the second ERP, there was a significant correlation between BSIdirtheta and MMSE orientation, between DAR, MoCA total, and MoCA recall, between DARAH and MoCA total, MoCA abstraction, and

MoCA recall, and between BSIdirtheta, and MoCA orientation.

In the auditory ERP, latency was not significantly correlated to the first ERP. In the second ERP, F CL was significantly correlated with MMSE language, and C CL was significantly correlated with MoCA total, MoCA abstraction, and MoCA recall.

In the first auditory ERP (amplitude), there was a significant correlation between C CL and MMSE recall, between Cz and MMSE recall, between C CIL and place. In the second auditory ERP, there was a significant correlation between C CL and MMSE place, between C CL and MMSE recall, between Cz and MMSE total, between Cz and MMSE recall, between C IL and MMSE place, between C IL and MMSE recall, and between C IL and MoCA abstraction. (Table 13, 14, 15, 16, 17, 18, 19, 20)

In the first visual ERP (latency), there was a significant correlation between Cz and MMSE (sum) and between C IL and MMSE (sum), attention & calculation, language, MoCA (sum), visuospatial and executive (MoCA), and attention (MoCA). In the second visual ERP, there was a significant correlation between C IL and visuospatial and executive (MoCA) and between P IL and attention (MoCA).

The first visual ERP (amplitude) revealed a significant correlation between Fz and copying (MMSE), between P CL and language (MMSE), naming (MoCA), attention (MoCA), between Pz and MMSE (sum), attention & calculation (MMSE), naming (MoCA), and between P IL and copying (MMSE). In the second visual ERP (amplitude), there was a significant correlation between Cz and visuospatial & executive (MoCA), between P CL and recall (MoCA), between Pz and naming (MoCA), attention (MoCA), and between P IL and place (MMSE), visuospatial & executive (MoCA), and attention (MoCA). (Table 21, 22, 23, 24, 25, 26, 27, 28)

Discussion

In this study, we conducted resting-state EEGs, auditory ERPs, and visual ERPs in ischemic stroke patients to assess test-retest reliability of the three tests. We assessed the correlation between cognitive function and significantly reliable montages to evaluate concurrent validity.

In the resting-state quantitative EEG, the test-retest reliability was significant for DAR (ICC = 0.447), DARAH (ICC = 0.451), BSIdir (ICC = 0.713), and BSIdirtheta (ICC = 0.724) with a moderate level of reliability for BSIdir and BSIdirtheta, and poor level of reliability for DAR and DARAH.

In test-retest reliability, excellent ICC level was observed for P CL (ICC = 0.918), visual ERP latency P CL (ICC = 0.972), and Pz (ICC = 0.945) of auditory ERP latency. In addition, test-retest reliability was higher in the visual ERP than in the auditory ERP.

In the visual ERP (latency), Cz and MMSE (sum) were negatively correlated, showing higher MMSE (sum) for short latency. Moreover, C IL was negatively correlated with MMSE (sum) and MoCA (sum). Thus, the shorter the latency, the higher the MMSE and MoCA scores. Thus, measuring these montages of visual ERP showed high correlations with cognitive function in stroke patients. In the concurrent validity test with MMSE, C IL had higher values than Cz, more correlated with Cz than C IL.

In a study conducted by Hall et al. in 2006, latency and amplitude of auditory P300 were measured in 40 healthy monozygotic twin pairs. ICC of latency and amplitude was 0.88 and 0.86, respectively, with latency having a higher ICC level. Similarly, in this study, we compared the latency and amplitude of auditory and visual ERPs. There were 6 and 4 reliable channels for the latency and amplitude of auditory ERP, respectively. Conversely, there were 9 and 7 reliable channels for the latency and amplitude of visual ERP, respectively, showing a higher number of reliable channels. Additionally, the ICC level was higher for latency than for amplitude.

Cognitive decline after ischemic cerebral infarction is a common sequela and manifests as a deficit in attention, memory, information process speed, language, conceptual thinking, working memory, and executive functions[17]. As there is a lack of studies that have conducted multi-modal EEG and evaluated each montage and cognitive function, our findings can suggest directions for future studies.

The mean age of the participants was 63.2 ± 10.3 years. The mean Fz, Cz, and Pz latencies of the auditory ERP were 252.3 ± 72.3, 273.4 ± 55.6, and 320.8 ± 76.4 ms, respectively. In a previous study conducted by Kim et al. in 1997, the mean Fz, Cz, and Pz in participants aged 60–69 years was 378.44 ± 32.9, 378.44 ± 32.99, and 378.63 ± 33.02 ms, respectively, which was longer than that in our study[18]. Similarly, Hong et al. in 2013 reported an auditory P300 latency of 311.3 ± 37.0 ms in healthy individuals, which was longer than our finding. In our study, the Cz amplitude of the auditory ERP was 1.5 ± 0.85 μV, which is greater than 4.95 ± 3.35 μV for the auditory P300 amplitude in healthy individuals in a study by Hong et al[19]. This suggests that patients with subacute stroke have smaller amplitudes of Cz compared to those in healthy individuals.

In another study by Dejanovic, M., et al. in 2015, the Fz, Cz, and Pz latencies of the auditory ERP were 423.5 ± 37.6, 429.9 ± 40.6, and 433.8 ± 35.0 ms, respectively, which were delayed compared to those in our study. Moreover, the Fz, Cz, and Pz amplitudes of the auditory ERP were 8.17 ± 3.47, 8.44 ± 3.16, and 6.76 ± 2.74 μV, respectively, with greater potentials than those in our study[3].

Limitations and Future directions

Although we observed reliable and constant results for resting-state EEGs, and the auditory and visual P300 amplitude and latency, our sample size was small.

Furthermore, this study was conducted on patients with subacute supratentorial ischemic stroke. Therefore, the findings cannot be generalized to patients with chronic or infratentorial ischemic stroke. Further studies on different patient populations are warranted.

The study participants had K-MSSE scores of greater than 20 points. Thus, the findings may not be applicable to patients with lower MMSE scores. In future studies, patients with more severe stroke need to be evaluated to assess the neuronal correlation between the resting-state EEG, ERP, and cognitive function.

Lastly, we maintained the temperature and humidity at constant levels.

Conclusion

Herein, we evaluated the consistency and reliability of cognition-related EEG data in stroke patients. The P CL and Pz latency of visual ERP showed significant reliability, and the Cz and C IL of visual latency showed effectiveness in reflecting the cognitive function. Thus, these montages could be used as a basis for future studies.

Declarations

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. All data generated during this study are included in this published article.

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Tables

Table 1
Demographics

Characteristics	Total (n = 20)
Gender (male/female, n)	7/13
Age (mean ± SD)	63.2 ± 10.3
Time poststroke (days)	17.05 ± 5.0
Stoke side	
Right	14
Left	6
Stroke lesion (n)	
Cortex	6
Subcortex	14
MMSE	25.8 ± 3.1
MoCA	22.4 ± 3.0

Table 2
Mean, standard deviation of auditory ERP latency and amplitude

	1st latency	2nd latency	Average latency	1st amplitude	2nd amplitude	Average amplitude
F CL	249.7 ± 95.9	261.1 ± 100.5	255.4 ± 94.5	1.8 ± 1.3	2.2 ± 1.1	2.0 ± 0.9
Fz	242.1 ± 71.8	262.5 ± 81.4	252.3 ± 72.3	2.1 ± 1.4	2.1 ± 1.2	2.1 ± 1.0
F IL	246.0 ± 66.9	237.1 ± 72.6	241.5 ± 56.5	2.2 ± 1.3	2.1 ± 1.0	2.1 ± 1.0
C CL	361.7 ± 78.2	343.6 ± 109.8	352.7 ± 89.2	1.5 ± 0.8	1.6 ± 0.8	1.5 ± 0.8
Cz	267.4 ± 63.2	279.5 ± 73.4	273.4 ± 55.6	1.5 ± 0.7	1.5 ± 1.0	1.5 ± 0.8
C IL	265.6 ± 79.8	249.7 ± 83.8	257.6 ± 77.2	1.8 ± 0.9	1.7 ± 0.8	1.8 ± 0.8
P CL	316.4 ± 98.5	322.1 ± 102.7	319.3 ± 98.7	2.4 ± 1.1	2.3 ± 1.2	2.3 ± 1.0
Pz	319.9 ± 86.7	321.7 ± 75.0	320.8 ± 76.4	2.2 ± 1.2	2.0 ± 1.1	2.1 ± 1.0
P IL	318.5 ± 87.1	304.9 ± 106.6	311.7 ± 85.7	2.3 ± 1.0	2.5 ± 1.3	2.4 ± 0.9

ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional;

Table 3
Mean, standard deviation of visual ERP latency and amplitude

	1st latency	2nd latency	Average latency	1st amplitude	2nd amplitude	Average amplitude
F CL	244.3 ± 69.5	251.1 ± 78.6	247.7 ± 70.7	2.3 ± 1.1	2.1 ± 1.2	2.2 ± 0.9
Fz	238.4 ± 57.6	224.6 ± 50.6	231.5 ± 48.6	2.2 ± 1.0	2.3 ± 1.4	2.3 ± 1.1
F IL	265.4 ± 77.1	250.1 ± 81.4	257.7 ± 71.4	2.2 ± 1.1	2.2 ± 1.3	2.2 ± 1.0
C CL	279.5 ± 100.8	272.8 ± 87.7	276.1 ± 89.8	1.2 ± 1.1	1.1 ± 0.9	1.1 ± 0.9
Cz	279.7 ± 95.5	255.5 ± 82.1	267.6 ± 82.9	1.3 ± 0.9	1.1 ± 0.7	1.2 ± 0.7
C IL	280.5 ± 109.4	252.7 ± 79.8	266.6 ± 87.1	1.5 ± 0.9	1.6 ± 0.9	1.6 ± 0.8
P CL	342.1 ± 104.8	319.7 ± 96.6	330.9 ± 100.0	2.8 ± 1.4	2.9 ± 1.1	2.9 ± 1.2
Pz	346.9 ± 93.7	334.7 ± 96.1	340.8 ± 93.6	2.6 ± 1.2	2.4 ± 0.9	2.5 ± 1.0
P IL	326.3 ± 86.0	298.1 ± 91.7	312.2 ± 86.2	2.7 ± 1.4	2.9 ± 1.3	2.8 ± 1.2

ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional;

Table 4
Reliability of resting-state EEG

		1st EEG								
		DAR	DAR_{AH}	DAR_{UH}	BSI	BSI_{delta}	BSI_{theta}	BSIdir	$BSIdir_{delta}$	$BSIdir_{theta}$
2nd EEG	DAR	.447*	0.326	.467*	-0.118	-0.089	0.167	0.206	0.107	0.214
	DAR_{AH}	0.398	0.328	.459*	0.073	0.134	0.295	0.117	0.100	0.163
	DAR_{UH}	0.363	0.264	0.353	-0.178	-0.217	0.106	0.300	0.187	0.281
	BSI	0.067	0.031	-0.004	0.131	0.144	0.115	0.340	.479*	0.431
	BSI_{delta}	-0.296	-0.324	-0.191	0.294	0.163	0.076	0.379	0.324	0.420
	BSI_{theta}	-0.025	0.039	-0.058	0.336	0.050	0.397	0.166	0.354	0.293
	BSIdir	0.007	0.140	-0.144	-0.055	0.083	0.142	.713**	.505*	.575**
	$BSIdir_{delta}$	-0.106	-0.003	-0.266	-0.292	-0.164	0.022	0.271	0.219	0.380
	$BSIdir_{theta}$	0.005	0.160	-0.266	0.142	0.020	0.434	.732**	.615**	.724**

*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation.

DAR, Delta/Alpha Ratio; AH, affected hemisphere; UH, unaffected hemisphere; BSI, Brain Symmetry Index

Table 5
Reliability of auditory ERP (latency)

		1st EEG								
		F CL	Fz	F IL	C CL	Cz	C IL	P CL	Pz	P IL
2nd ERP	F CL	.822**	.522*	.550*	0.106	0.013	-0.268	0.044	-0.028	-0.103
	Fz	.559*	.780**	.571**	0.121	0.226	-0.328	0.342	0.341	0.212
	F IL	0.210	0.293	0.329	0.059	0.276	0.040	0.136	0.304	0.353
	C CL	-0.076	0.152	-0.113	.780**	-0.192	-0.134	0.050	0.138	0.024
	Cz	0.286	0.336	-0.064	0.118	0.324	-0.066	0.008	-0.098	-0.137
	C IL	0.068	-0.028	0.133	-0.037	0.042	.781**	-0.238	-0.133	-0.093
	P CL	-0.181	0.034	0.026	-0.183	0.038	0.035	.918**	.659**	.669**
	Pz	-0.082	0.003	-0.040	-0.030	-0.116	0.129	.552*	.786**	.800**
	P IL	0.307	.468*	-0.266	-0.012	0.432	-0.089	0.006	0.039	-0.097

*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation

ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional;

Table 6
Reliability of auERP, all channels including F CLditory ERP (amplitude)

		1st EEG								
		F CL	Fz	F IL	C CL	Cz	C IL	P CL	Pz	P IL
2nd ERP	F CL	0.188	0.184	0.144	-0.022	0.162	0.364	0.110	0.053	0.175
	Fz	0.066	0.335	0.071	-0.123	0.211	0.168	0.036	0.071	-0.050
	F IL	0.025	-0.019	0.333	-0.180	-0.136	0.345	0.121	-0.402	-0.305
	C CL	0.177	-0.036	0.243	.648**	.557*	.690**	0.162	0.162	-0.144
	Cz	.448*	0.358	0.400	.644**	.568**	0.187	0.373	.491*	-0.031
	C IL	0.342	0.181	.542*	0.231	0.349	.636**	-0.235	-0.212	-0.284
	P CL	-0.135	-0.169	-0.352	0.089	0.126	-0.135	0.418	.502*	0.303
	Pz	0.013	0.045	-0.256	0.154	0.084	-0.292	0.429	.574**	.512*
	P IL	-0.138	0.144	-0.079	-0.050	-0.109	-0.243	0.439	0.276	0.237
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation										
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional										

Table 7 is not available with this version.

Table 8
Reliability of visual ERP (amplitude)

		1st ERP								
		F CL	Fz	F IL	C CL	Cz	C IL	P CL	Pz	P IL
2nd ERP	F CL	0.336	0.430	0.242	0.165	.537*	-0.018	-0.107	0.088	0.062
	Fz	0.374	.626**	0.419	-0.027	0.388	-0.015	-0.439	-0.044	0.099
	F IL	-0.010	0.255	0.338	-0.039	0.191	0.034	-0.162	0.098	0.004
	C CL	0.167	-0.079	-0.055	.574**	.651**	0.000	-0.064	-0.318	-0.050
	Cz	0.257	0.134	-0.099	0.145	.564**	-0.039	-0.198	0.009	0.144
	C IL	-0.208	0.086	-0.001	0.042	-0.226	.636**	0.185	.558*	0.315
	P CL	-0.128	-0.149	-0.287	0.114	0.032	-0.001	.708**	.521*	0.122
	Pz	-0.020	0.027	-0.374	0.168	-0.039	-0.061	.672**	.696**	0.176
	P IL	0.299	0.038	-0.377	0.368	0.128	0.322	0.261	0.147	.625**
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation										
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional										

Table 9
Validity of resting-state EEG (1st test) with MMSE

	MMSE(total)	**Time**	**Place**	**Registration**	**Attention & Calculation**	**Recall**	**Language**	**Copying**
DAR	0.250	0.344	0.236	0.027	0.132	0.132	0.103	-0.239
DAR_{AH}	0.255	0.315	0.308	0.136	0.061	0.279	0.003	-0.211
BSIdir	-0.083	-0.259	-0.068	-0.147	0.032	-0.139	0.141	0.121
$BSIdir_{theta}$	-0.279	-0.331	-0.194	-0.210	-0.208	-0.202	0.136	0.131
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
DAR, Delta/Alpha Ratio; AH, affected hemisphere; BSI, Brain Symmetry Index								

Table 10
Validity of resting-state EEG (2nd test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
DAR	0.246	0.322	0.248	0.269	-0.038	0.192	0.148	0.017
DAR_{AH}	0.263	0.226	0.236	0.339	-0.020	0.348	0.052	0.057
BSIdir	-0.061	-0.308	-0.037	0.116	-0.010	-0.033	0.004	0.291
$BSIdir_{theta}$	-0.288	− .497*	-0.333	-0.136	-0.079	-0.165	-0.021	0.258
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
DAR, Delta/Alpha Ratio; AH, affected hemisphere; BSI, Brain Symmetry Index								

Table 11
Validity of resting-state EEG (1st test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
DAR	0.253	-0.056	0.007	0.077	0.147	0.203	0.258	0.164
DAR_{AH}	0.350	-0.065	0.151	0.056	-0.016	0.343	0.396	0.222
BSIdir	0.253	0.049	0.314	0.076	0.038	0.099	0.424	-0.186
$BSIdir_{theta}$	0.097	0.024	0.204	-0.011	-0.040	-0.014	0.360	-0.314
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
DAR, Delta/Alpha Ratio; AH, affected hemisphere; BSI, Brain Symmetry Index								

Table 12
Validity of resting-state EEG (2nd test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
DAR	.457*	0.009	0.123	0.171	-0.027	0.332	.515*	0.105
DAR_{AH}	.465*	-0.078	0.104	0.079	-0.050	.448*	.629**	0.094
BSIdir	0.134	0.053	0.321	0.043	0.010	0.163	0.245	-0.372
$BSIdir_{theta}$	-0.040	-0.109	0.071	-0.041	0.216	-0.099	0.148	− .527*
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
DAR, Delta/Alpha Ratio; AH, affected hemisphere; BSI, Brain Symmetry Index								

Table 13
Validity of auditory ERP (latency, 1st test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
F CL	0.125	-0.085	0.198	0.158	0.112	0.248	-0.233	0.096
Fz	0.033	-0.139	0.226	0.144	-0.055	0.170	-0.128	0.153
C CL	0.217	0.276	0.160	0.053	0.034	-0.219	-0.319	0.217
C IL	0.055	-0.190	0.031	-0.104	0.155	0.057	0.137	-0.080
P CL	-0.237	-0.152	-0.106	0.060	-0.352	-0.042	0.046	0.059
Pz	-0.138	0.011	-0.016	0.084	-0.247	-0.233	0.066	0.267
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 14
Validity of auditory ERP (latency, 2nd test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
F CL	-0.251	-0.213	0.041	0.113	-0.250	0.046	− .488*	0.125
Fz	-0.203	-0.179	-0.018	0.162	-0.209	-0.106	-0.291	0.301
C CL	0.358	0.345	0.379	0.431	0.170	0.199	0.071	-0.196
C IL	0.265	-0.058	0.169	0.256	0.221	0.204	0.073	0.218
P CL	-0.329	-0.230	-0.295	0.004	-0.324	-0.076	-0.010	-0.055
Pz	-0.102	-0.094	-0.115	-0.081	-0.081	-0.180	0.203	0.061
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 15
Validity of auditory ERP (latency, 1st test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
F CL	0.138	-0.225	0.022	0.144	0.206	0.249	0.117	-0.136
Fz	0.173	-0.092	-0.115	0.026	0.022	0.317	0.093	-0.021
C CL	0.275	-0.241	0.132	-0.108	-0.010	0.343	0.385	0.154
C IL	-0.072	0.300	-0.122	-0.026	-0.179	-0.118	-0.178	0.159
P CL	0.016	0.138	0.097	-0.145	-0.360	-0.068	0.071	0.109
Pz	0.041	0.340	0.156	-0.058	-0.331	-0.140	-0.109	0.034
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 16
Validity of auditory ERP (latency, 2nd test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
F CL	-0.134	-0.391	-0.030	-0.127	0.055	0.077	0.060	-0.213
Fz	-0.018	-0.077	-0.050	-0.117	-0.134	0.020	0.110	-0.122
C CL	.501*	-0.022	0.431	0.092	-0.032	.491*	.515*	0.016
C IL	0.045	0.299	0.141	0.105	-0.062	0.062	-0.255	-0.022
P CL	-0.179	0.120	-0.038	-0.238	-0.312	-0.298	-0.038	-0.068
Pz	0.024	0.411	0.201	0.073	-0.170	-0.363	-0.190	-0.233
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 17
Validity of auditory ERP (amplitude, 1st test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
C CL	-0.282	0.110	-0.170	-0.105	-0.064	− .718**	0.000	-0.145
Cz	-0.337	-0.035	-0.349	-0.118	0.002	− .735**	-0.039	-0.113
C IL	-0.173	-0.163	− .515*	0.306	0.140	-0.422	-0.206	0.327
Pz	-0.125	0.132	0.103	-0.301	-0.176	-0.376	0.247	-0.030
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 18
Validity of auditory ERP (amplitude, 2nd test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
C CL	-0.413	-0.120	− .537*	0.000	-0.138	− .651**	-0.150	0.206
Cz	− .545*	-0.069	-0.253	-0.270	-0.363	− .710**	-0.236	0.048
C IL	-0.414	-0.012	− .595**	-0.031	-0.209	− .622**	-0.099	0.193
Pz	0.226	0.194	0.316	-0.039	-0.047	0.098	0.362	0.163
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 19
Validity of auditory ERP (amplitude, 1st test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
C CL	-0.022	-0.044	0.102	0.005	0.088	-0.144	-0.034	0.096
Cz	-0.214	-0.042	-0.013	-0.144	-0.008	-0.338	-0.042	-0.043
C IL	-0.295	-0.104	0.021	-0.220	0.046	-0.289	-0.093	-0.309
Pz	0.006	0.295	0.010	0.177	-0.145	-0.073	-0.212	0.330
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 20
Validity of auditory ERP (amplitude, 2nd test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
C CL	-0.312	-0.207	-0.099	-0.151	0.193	-0.425	-0.144	-0.112
Cz	-0.312	-0.096	-0.133	-0.233	-0.027	-0.392	-0.246	0.203
C IL	-0.400	-0.165	-0.060	-0.172	0.340	− .681**	-0.346	-0.293
Pz	0.345	0.314	0.259	0.401	-0.072	0.173	0.170	0.285
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 21
Validity of visual ERP (latency, 1st test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
F CL	0.153	0.042	0.010	-0.026	0.142	0.198	-0.033	0.099
Fz	-0.010	0.011	-0.195	-0.068	0.045	0.001	-0.068	0.162
F IL	-0.147	-0.136	-0.421	0.030	-0.112	0.189	0.004	-0.182
C CL	-0.222	-0.178	-0.136	0.273	-0.209	-0.022	-0.049	-0.292
Cz	− .514*	-0.408	-0.405	-0.065	-0.365	-0.293	-0.106	-0.024
C IL	− .636**	-0.405	-0.280	-0.104	− .545*	0.000	− .552*	-0.300
P CL	0.084	-0.008	0.232	0.014	-0.213	0.352	0.219	-0.028
Pz	0.046	-0.152	0.196	-0.102	-0.129	0.397	0.083	-0.056
P IL	0.174	0.019	0.243	-0.171	-0.038	0.368	0.201	0.007
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 22
Validity of visual ERP (latency, 2nd test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
F CL	0.016	0.016	0.015	-0.083	-0.132	0.101	0.150	0.150
Fz	-0.225	-0.019	0.050	-0.363	-0.300	-0.211	0.050	0.107
F IL	-0.215	0.060	-0.056	-0.072	-0.388	0.001	0.079	-0.212
C CL	-0.211	-0.144	-0.048	0.214	-0.233	-0.045	-0.142	-0.097
Cz	-0.217	-0.341	-0.152	-0.101	-0.109	-0.106	-0.054	0.185
C IL	-0.251	-0.411	-0.190	-0.316	-0.078	0.253	-0.189	-0.364
P CL	0.048	0.016	0.190	-0.010	-0.212	0.246	0.194	-0.004
Pz	-0.010	-0.110	0.161	-0.228	-0.153	0.277	0.084	-0.058
P IL	0.228	0.225	0.351	-0.189	-0.071	0.204	0.402	-0.025
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 23
Validity of visual ERP (latency, 1st test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
F CL	0.004	-0.047	-0.297	0.117	-0.019	-0.193	0.202	-0.032
Fz	-0.243	-0.187	-0.400	0.010	0.158	-0.367	-0.060	0.011
F IL	-0.294	-0.289	-0.356	-0.182	0.275	-0.385	-0.006	-0.411
C CL	-0.199	-0.122	0.009	-0.398	-0.299	0.110	0.237	0.003
Cz	-0.436	-0.136	-0.042	-0.412	-0.154	-0.234	0.039	-0.165
C IL	− .559*	− .648**	-0.212	− .663**	-0.091	-0.073	0.007	-0.053
P CL	0.305	0.067	-0.055	0.228	-0.045	0.245	0.131	0.137
Pz	0.239	0.056	-0.135	0.178	-0.069	0.185	0.087	0.008
P IL	0.198	0.259	-0.235	0.247	-0.111	0.067	-0.055	0.124
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 24
Validity of visual ERP (latency, 2nd test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
F CL	0.076	-0.067	-0.126	0.163	0.084	-0.073	0.187	0.041
Fz	-0.119	-0.152	-0.233	0.030	0.032	-0.134	-0.094	0.349
F IL	-0.173	-0.287	-0.188	-0.124	0.092	-0.134	0.025	0.118
C CL	-0.290	-0.002	-0.135	-0.316	-0.369	-0.023	0.001	0.036
Cz	-0.338	0.057	-0.076	-0.193	-0.280	-0.188	-0.100	0.088
C IL	-0.375	− .506*	-0.080	-0.257	0.208	-0.102	-0.159	-0.134
P CL	0.304	0.086	-0.099	0.224	-0.061	0.174	0.158	0.106
Pz	0.274	0.030	-0.129	0.225	-0.069	0.114	0.210	0.003
P IL	0.316	0.426	-0.050	.470*	-0.076	-0.015	-0.125	0.116
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 25
Validity of visual ERP (amplitude, 1st test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
Fz	-0.163	0.204	-0.135	-0.103	-0.072	-0.248	-0.006	− .519*
C CL	-0.194	-0.363	-0.396	0.150	0.093	-0.018	-0.355	0.096
Cz	-0.083	0.038	-0.183	0.256	0.108	-0.355	-0.134	-0.021
C IL	-0.246	-0.242	-0.343	-0.355	-0.068	-0.126	0.144	-0.196
P CL	-0.237	0.040	-0.003	0.076	-0.290	0.082	− .500*	-0.136
Pz	− .468*	-0.101	-0.185	-0.311	− .450*	-0.057	-0.313	-0.348
P IL	-0.424	-0.023	-0.393	-0.050	-0.289	-0.430	0.055	− .463*
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 26
Validity of visual ERP (amplitude, 2nd test) with MMSE

	MMSE(total)	Time	Place	Registration	Attention & Calculation	Recall	Language	Copying
Fz	-0.007	0.120	-0.126	0.078	0.140	-0.062	-0.148	-0.332
C CL	-0.036	-0.137	-0.228	0.130	0.112	-0.216	0.063	0.212
Cz	0.042	0.020	0.070	0.083	0.052	-0.182	0.195	-0.013
C IL	-0.057	-0.022	-0.282	-0.240	0.057	0.006	0.078	-0.138
P CL	-0.116	0.004	-0.055	0.065	-0.014	-0.020	-0.312	-0.216
Pz	-0.283	0.008	-0.294	0.040	-0.195	-0.038	-0.337	-0.307
P IL	-0.439	-0.243	− .589**	0.145	-0.175	-0.301	-0.205	-0.259
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 27
Validity of visual ERP (amplitude, 1st test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
Fz	-0.060	-0.223	0.127	-0.071	0.277	-0.200	-0.225	0.211
C CL	-0.378	-0.182	-0.276	-0.316	-0.050	-0.098	0.076	-0.437
Cz	-0.134	0.046	0.215	-0.238	-0.216	0.048	0.020	0.091
C IL	-0.056	-0.272	0.032	-0.035	0.350	-0.072	0.160	-0.232
P CL	-0.260	-0.421	− .503*	− .467*	-0.194	0.101	0.315	0.351
Pz	-0.360	-0.346	− .489*	-0.404	-0.029	-0.234	0.002	0.244
P IL	-0.204	-0.339	-0.017	-0.303	0.321	-0.172	0.062	-0.145
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Table 28
Validity of visual ERP (amplitude, 2nd test) with MoCA

	MoCA(total)	Visuospatial & Executive	Naming	Attention	Language	Abstraction	Recall	Orientation
Fz	-0.118	0.016	0.192	-0.102	-0.024	-0.229	-0.308	-0.072
C CL	-0.010	0.188	0.225	0.045	-0.226	-0.075	0.242	-0.178
Cz	0.244	.463*	0.352	0.041	-0.411	0.124	0.215	0.184
C IL	-0.051	-0.168	-0.246	0.033	0.319	-0.207	0.066	-0.074
P CL	-0.099	-0.164	-0.324	-0.365	-0.344	0.023	.581**	0.269
Pz	-0.414	-0.351	− .671**	− .586**	-0.045	-0.168	0.159	0.321
P IL	-0.332	− .510*	-0.349	− .516*	0.213	-0.159	0.310	-0.196
*, p < 0.05 by Pearson correlation; **,p < 0.01 by Pearson Correlation								
ERP, event-related potential; F, frontal; C, central; P, parietal; CL, contralesional; IL, ipsilesional								

Figures

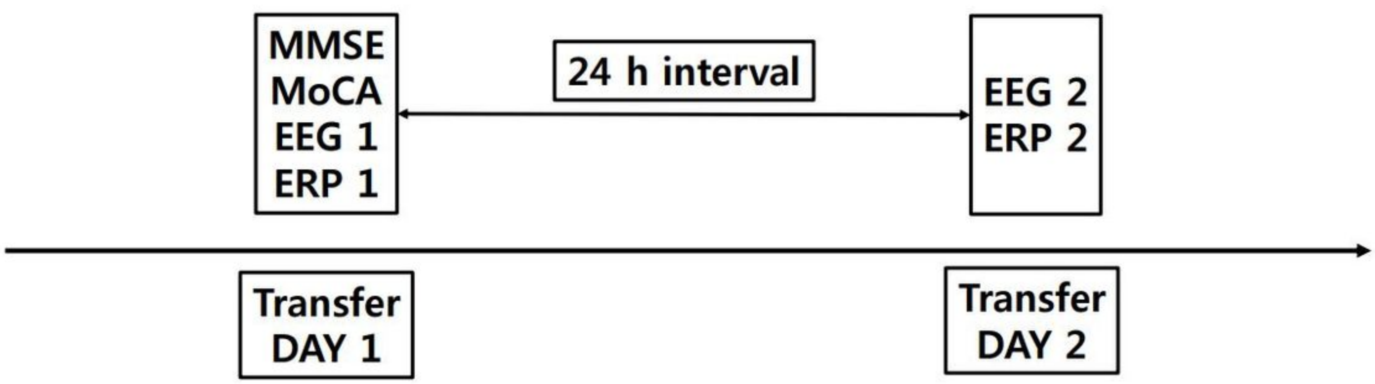

Figure 1

Caption not included with this version.

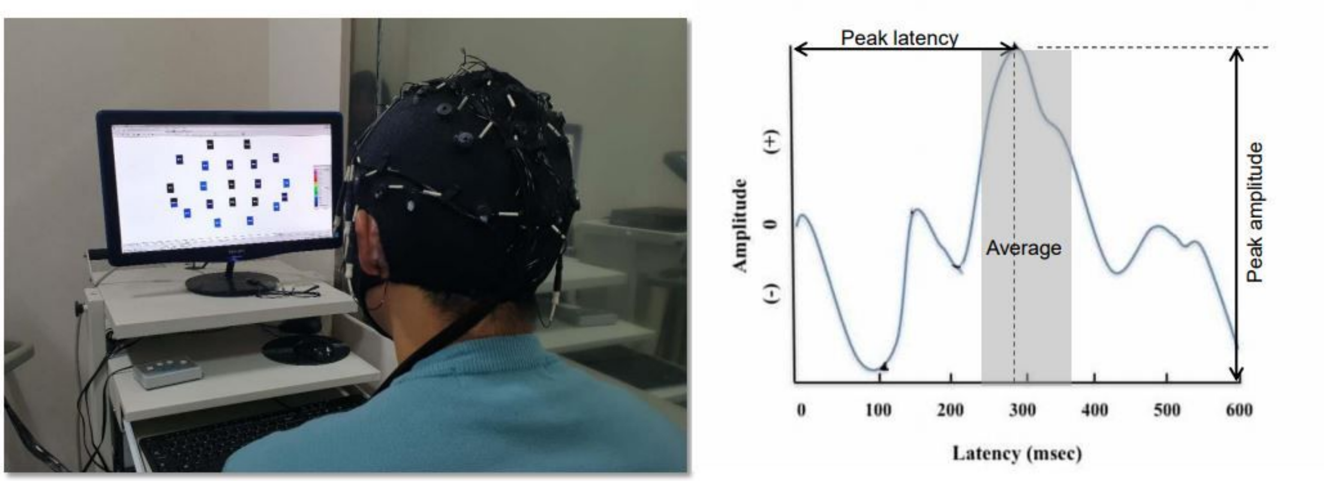

Figure 2

Caption not included with this version.