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INTER-HEMISPHERIC CONNECTIVITY UPON ANALYSIS OF EEG COHERENCE ON DIFFERENT VISIONINFORMATION PRESENTATION SEQUENCE

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Abstract:

Learning and memory used to explain the relationship between messages are from a visual stimulus, how people use recognition memory for the response. Recognition memory is a part of the memory process, this response is based on the on the relevance of information retrieval between context and experience. Few studies have studied the relationship between recognition memory and inter-hemispheric coherence of the picture-word or word-picture presentation sequence. This study conducts an Oddball method, to record the event-related potentials (ERP) and the band of rhythm when the picture or word presented in a different sequence. Behavioral response results show word-picture present sequence with a higher recognition memory effect.P300 has maximum activation in the prefrontal response, which active Delta band of rhythms. Both picture-word and word-picture has significantly coherence inter- hemispheric. The results show that the more fully memory retrieval information, recognition memory will remain more solid, faster response, and with higher accuracy. Presentation sequence of the word-picture information retrieval of recognition memory has a good effect. The ERP rhythm of recognition memory was within the range of delta band, and there was a significant correlation of inter-hemispheric. The study also highlights implications for recognition memory research and for practice.

Keywords: Recognition Memory, Coherence, EEG

Introduction

Recorded scalp potential using EEG signals that reflect the mental states such as object recognition, visual processing and decision making [1]. EEG has already been used successfully by the different studies, e.g., motor performances damaged in certain injuries, aging memory, phonological/semantic processing of word, linguistic and meaningful nonlinguistic sound in memory and visual attention [2], [3], [4], [5], [6], [7]. Several studies demonstrated that stimulus sequence context can modulate brain responses to target stimuli, e g., [8], [9], [10].
The dual-process theory explains the relationship between information processing and memory cognitive process [11]. And holds the recognition memory involves recollection and familiarity with two different memory extraction processes. Recollecting memory refers to objects that have been remembered or touched and recognize from our brain, whereas familiarity is based on sensory information [12]. The “old” target means which can be identified from the context, which also refer to our memory; however if the situation cannot be recognized, it usually means

"knowledge" [11]. Previous studies on the of recognition memory on old/new effects typically use event-related potential (ERP) as a reference index [13], [14].This ERP effect typically elicits in old/new memories about 300-400ms post-stimulus, last 300-600ms after the visual stimulation onset [15]. Event related potential (ERP) are the measurement of brain responses to specific cognitive, sensory or motor events, and often associated with the delta response [16], [17], [18].And also produce a 300ms positive peak after onset of the stimulus, this response is called P300 component [17]. In general, P300 amplitude reflects the memory formed encoding and storage process, and recognition memory sequence position changes [19]. The oddball paradigm was first used in event-related potential (ERP) research by researcher [20], and also the most commonly used method in recognition memory research. ERP is a direct measurement of nerve activity, so this method is good converging evidence in the examination of differences between groups or patients with brain lesions [20].

Paller, et al.[21]stated that human memory can predict subsequent memory effects through ERP elicited by words stimuli. Picture naming is semantically mediated, through semantic representation of object names, the semantic structure from pictures reproduced [21].Humphreys, et al. [22] stated naming and semantic categorizations of images require access to the semantic system, but the picture provides direct mapping and concept recognition. Synonymous with word and pictures in addition to brain function semantic conversion, the other is directly through the mapping and concept recognition.

Previous studies have found that the semantic event-related potential effect is a bimodal distribution in the picture-word research, with the main electrode position starting at about 100 ms. The signature signal of the phonological effect appears later than the semantics [23].On the examining of pictures affect recognition memory compared to words. If the item is familiar, the activation state occurs in the frontal lobe approximately 300 to 500 ms after stimulation [24]. Frontal lobe in recognition memory decision has been associated with several important roles. The frontal lobe is responsible for response inhibition, inhibition is important for individually based on the familiar [18], [25]. McCauley, et al. [26] study on picture-word matching task, the use of compound and phrasal stress distinction found that most subjects on preference of compound words, but reaction in brain function have the same sensitivity. And incongruent compound stress elicited N400 on centro-praietal, while incongruent phrasal stress elicited P600 on posterior positivity. In general, human brain memory frequency range from 1 to 500Hz, the high frequency response and coupling between different frequencies is the most important key role for the brain memory process, low frequency range of 1-4Hz of the prefrontal lobe represents the spatial memory [27].

The results of these studies are inconsistent. Picture-word of recognition memory stimulus response is 100ms, 300 to 500ms, N400 or P600? The recognition memory response is in the frontal, parietal or other regions? What range of the rhythm on the familiar item and relation of the inter-hemispheric? The first aim of this study is to understand the P300 in oddball ERP experiment of recognition memory. What pattern will appear of the frontal lobes? Then examine the EEG coherence of the recognition memory inter-hemispheric. Few study is examine the different effect of the word-picture presentation sequence or picture-word presentation sequence in recognition of memory.

Materials and Methods

Participants

Fifteen college students were elective courses in information technology volunteered for the experimental sessions. The mean age was 20 years. All participants had normal vision, right handed, with normal or corrected-to-normal vision and physically healthy. Before testing all subjects completed questionnaires on education, and health background.

Procedure

Subjects learned about a section of information technology in the elective course, which included word and images terminology used in computer components. All subjects complete the elective course, after two months take the recognition memory test. All participants were seated in front of a computer monitor in around-attenuated room. Experiments were designed with E Prime™, commonly used in cognitive experiments. The experiment presented target information in a random presentation. The visual stimulus presented across experiments contained 2 categories with different sequences. Each subject had to participate in an experiment with 16 trials. Participants were instructed to continually push the keyboard reflect the correct visual according to the presentation.

Electroencephalographic (EEG) data acquisition

A 16 channels Emotive™ EPOC acquisition system recorded EEG data at a sampling rate of 128 Hz and filtered from 0.1 to 4Hz. EEG, referenced to linked mastoid, was recorded from fours parietal electrodes, over left and right hemispheres at AF3、AF4、FC5 and FC6.

2.4. EEG data processing

EEG data were filtered in delta band (0.1 to 4 Hz) bands using EEGLAB [4] functions toolbox. For each frequency, EEG coherence was estimated from power and cross spectra. The coherence was calculated for the electrode combinations AF3-AF4 and FC5-FC6. Inter-hemispheric coherence was computed as [28]

$$\mathrm{coh}(f) = \frac{G_{xy}(}{G_{xy}(f)(} \quad (1)$$

The quotient is a real number between 0 and 1 that measures the correlation between 'x' and 'y' electrode node at the frequency f. The significant level is based on the Rosenberg, et al., [29] threshold notation as

$$\text{threshold} = \quad 1 - \left[1 - \frac{\alpha}{100} \right. (2)$$

Where ‘n’ is total number of epochs.

Results

Behavioral Results

The correct responses rate of the picture-word presentation sequence is 0.67(*SD*=0.30), and reaction time is 1413.88(*SD*=350.46) ms. the correct responses rate of the word-picture presentation sequence is 0.70(*SD*=0.38), and reaction time is 1322.59(*SD*=301.22) ms.

Table 1: Behavioral statistics.

Correct rate of the picture-word presentation sequence	Response time of the picture-word presentation sequence	Correct rate of the word-picture presentation sequence	Response time of the word-picture presentation sequence

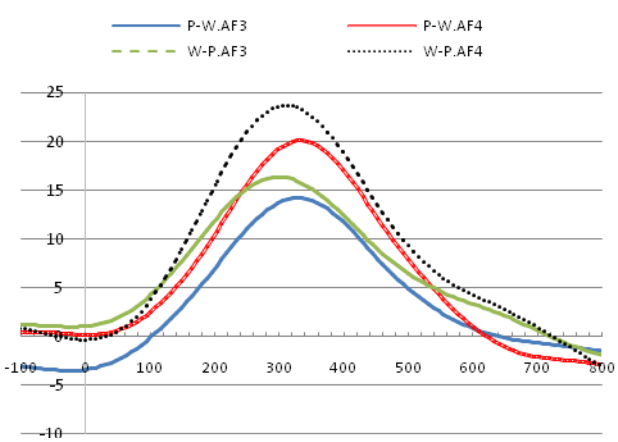
0.67	1413.88	0.70	1322.59
(0.30)	(350.46)	(0.38)	(301.22)

Non-parametric tests

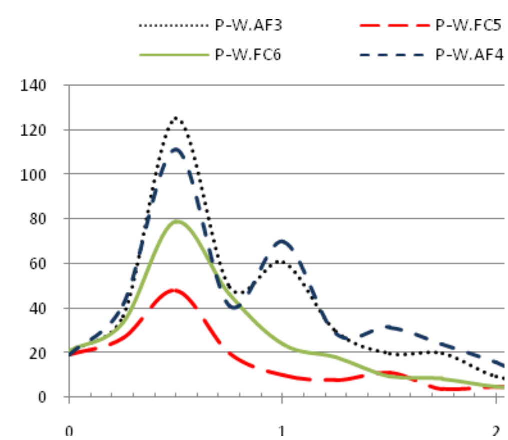
Since the number of subjects in this experiment was less than 30, the event-related potentials were tested using non-parametric statistical method. A Mann-Whitney test indicated that word-picture was greater for AF3 (*Mdn*=2.5) than for picture-word was (*Mdn*=1.33), U = 6465, p = .004< .05, r = .26.For AF4 word-picture was greater (*Mdn*=3.06)than for picture-word was (*Mdn*=2.65), U = 6934, p = .034<.05,r = .019.

P300Amplitude and Delta rhythm

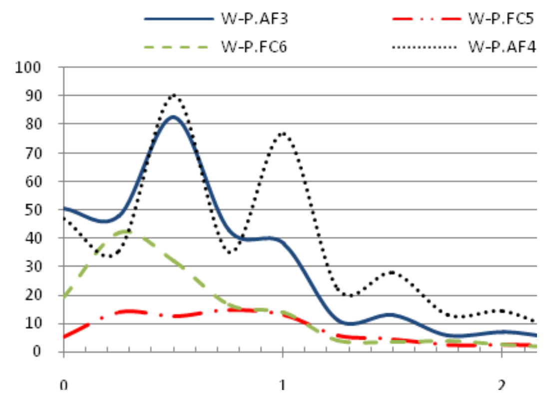
The ground average of maximum peak to peak P300 component of recognition memory (Figure 1, (a)).On the picture-word stiumuls sequence, the P300 component wave potential of the left frontallobeelectrode AF3 is 14.23*uv*, and timelatenceis from 109 ms to 625 *ms*. At right frontal lobe electrode AF4, the P300 maximum peak potential is 20.04 *uv*,and timelatenceis from 54*ms* to 718*ms*.On the word-picture stiumuls sequence, the P300 component wave potential of the left frontallobeelectrode AF3is 16.30*uv*, andtime latence is from 39 *ms* to 718*ms*.At right frontal lobe electrode AF4, the P300 maximum peak potential is 24.67*uv*,and timelatenceis from 40*ms* to 720*ms*.
The delta band On the picture-word presentation sequence at the left frontal AF3, FC5 or right frontal AF4, FC6 electrode point is between 0 and 1.5Hz(Figure 1, (b)). However the delta band for the word-picture presentation sequence at the left frontal AF3, FC5 or right frontal AF4, FC6 electrode is between 0 and 1.5Hz (Figure 1, (c)). Transform form time domain to frequency of AF3, AF4, FC5, and FC6 on picture-word and word-picture presentation sequence



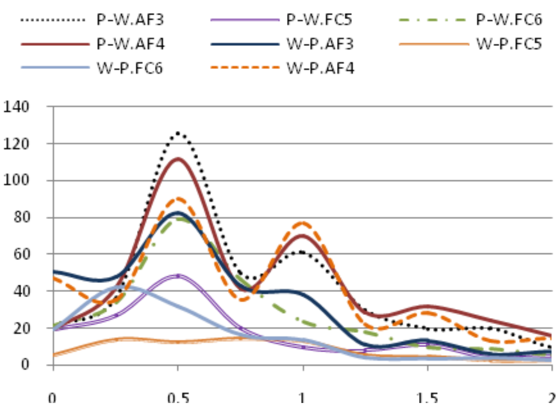
(a) P300 componen*t*



(c) P-W delta band



(b) W-P delta band



(d) Frequency Doman

Figure 1: The P300amplitude and delta rhythm of the recognition memory (a) The P300 at delta band in different presentation sequence; (b) The delta rhythm of the P-W on frontal electrodes; (c) The delta rhythm of the W-P on frontal electrodes. (d) From the time domain to the frequency domain.

Inter-hemispheric Coherence

According to the threshold formula, the confidence level of the inter-hemispheric EEG coherence is 0.181036, and in the rhythm range is between 0 to 2Hz (Figure 2). On the picture-word presentation sequence, the frequency correlation of the FC5-FC6 (Figure 2, (a))has significant level at 1.5 to 1.8 Hz. On AF4-AF3 (Figure 2, (b)) has significant level between 0.1to 2Hz.

On the word-picture presentation sequence, the frequency correlation of the FC6-FC5 (Figure 3, a) has significant level at 0.25 Hz and 1.5 Hz to 1.8 Hz. On F4-AF3 between 0.1 to 2Hz has significant level (Figure 3, (a)).

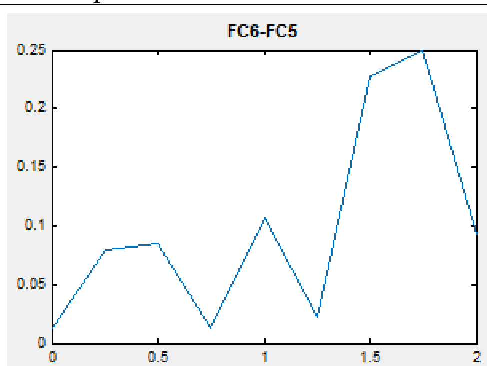
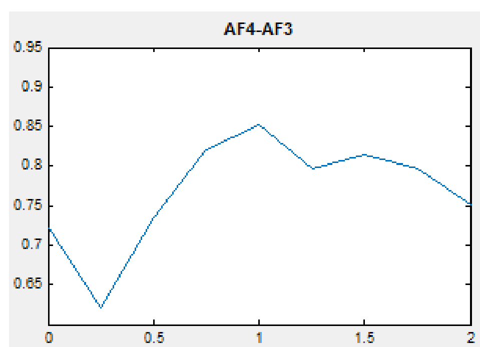
	Inter *hemispheric*	Inter *hemispheric*
Picture-word	 **(a)** FC5-FC6	 **(b)** AF4-AF3

Figure 2: The inter-hemispheric coherence of the picture-word presentation sequence

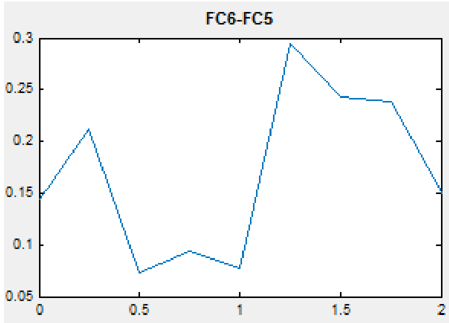
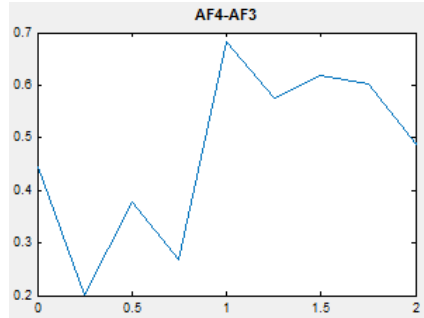
	Inter *hemispheres*	Inter *hemispheres*
Word-picture	 **(a)**	 **(b)**

Figure 3: The inter-hemispheric coherence of the word-picture presentation sequence

Discussion

Behavioral analysis results of correct responses rate of the word-picture presentation sequence (0.70) is higher than picture-word presentation sequence (0.67). The results show that the word before the picture in the recognition of memory will improve the correct rate, and also has a good memory effect. Response time of the word-picture presentation sequence (1322.59 *ms*) is lower than picture-word presentation sequence (1413.88 *ms*). The results show that the preceding narrative of the word will more clearly show the semantic meaning.

The oddball paradigm experiment is actual elicit the P300 ERP response in the frontal lobe (Figure 1.a), and the rhythm of this response is in the delta band (0.1-4 Hz). This result is the same as [16],[17],[18] studies. The maximum amplitude of P300 appears in the right frontal lobe of the sequence of word-picture presentation sequence.

It was also found that picture-word presentation sequence of recognition memory did occur at 0.5 Hz and 1 Hz at the left (AF3) and right frontal lobe (AF4) response (Figure 1.(c)). This result is same as [18] studies.In the word-picture presentation sequence, the right frontal lobe (AF4) recognition memory response did show bimodal potentials at 0.5 Hz and 1 Hz (Figure 1.(b)).

Inter-hemispheric ERP analysis results show that word-picture AF3is greater than picture-word. This result shows that the word-picture presentation sequence of the recognition memory in the left hemisphere of the frontal lobe is higher than the picture-word presentation sequence.

Previous studies suggest that the frontal lobe is the central decision-making response of the recognition memory[23],[24],[25], [30]. ERP analysis in front of the results show that the rhythm of the response range is in the delta band (0.1-4Hz), thus on the inter-hemispheric coherence analysis rhythm selected between 0.1 to 2Hz. According to the formula (1) the different electrodes in the Inter-hemispheric at different rhythm coherence analysis, then the significance of Inter-hemispheric frontal rhythm was analyzed according to the threshold formula (2). The results show that the frontal lobe (AF3-AF4) of the inter-hemispheric showed a significant in both the picture-word presentation and the word-picture presentation

Conclusions

The first aim of this study is to understand the phenomenon of recognition memory P300 in the oddball ERP paradigms. The results show that there is a maximum amplitude of the right frontal lobe in the different information presentation(Figure 1, (a)). And the maximum amplitude of the right frontal lobe appears in the word-picture information presentation sequence.The results show that the recognition memory from the visual stimulus response will be activated in the right frontal lobe AF4. The second aim is the rhythmic range for the recognition memory response.The results show that whatever information present sequence, the delta rhythm is between 0 to 1.5 *Hz* and the maximum power rhythm is at 0.5 *Hz* (Figure 1, (b, c)). Observed the picture-word presentation sequence of the left and right brain frontal lobe(AF3,AF4) thereare two higherpower bimodal, the first is 0.5*Hz* the other is at 1*Hz*.

However in theword-picture presentation sequence showsthe right frontal lobe AF4 has higherpower at 0.5*Hz* and 1*Hz* (Figure 1, (b)).This visual stimulus, which shows any combination of word and picture follow the visual stimulus response to the recognition memory.The oddball ERP paradigms as a result of using different stimulus strategies. Different rhythmic correlations are found in main rhythms of the frontal lobe electrode include FC5-AF3, and AF4-AF3, which are between 0 to 1.5 *Hz*.

Future research can also use the autoregressive model to analyze the rhythms coherence, if there has more detail resolution.Moreover, we can use depth learning theory to analyze the brain nerve electrode network of the visual stimulation response pattern to understand brain function activities.

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