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Studying The Impact Of Philosophical Metacognition Training On Students' Brain Performance

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Abstract
Metacognition as 'knowing about knowing' includes various kinds of cognitive process like self-awareness, self-regulation, and self-monitoring. Current research studied the effects of philosophical metacognition training on students' brain performance. This research is a kind of semi-experimental research with two groups of the experiment and control. The sample includes 30 girl students studied at industrial school in 2022-2023. Training authentic understanding were done to 15 students in the experimental group. 10 students of both groups were volunteered to do EEG test. After using 19 channels recorder, EEG waves were analyzed and reported. In order to assess brain activity a task was designed based on Heidegger's hermeneutical phenomenology. Analyzing the data and comparing two groups was performed by utilizing the software of Mat lab and Loretta. The results showed that the performance of the students with authentic understanding is different from the students with inauthentic understanding. The areas like Precuneus in people with authentic understanding had less activation that confirmed previous findings about less activation in areas like the anterior medial prefrontal cortex related to high metacognition accuracy. So, we can consider high accuracy in authentic understanding. Since metacognition accuracy can be considered as an important issue that can be trained, and because of limitation in sample volumes, repeating the experiment is suggested.

Keywords: *metacognition, EEG, metacognition training, Education.*

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I. Introduction

Metacognition is defined as 'knowing about knowing' which includes various kinds of cognitive process like self-awareness, self-regulation, and self-monitoring[1]. Concurrent evidence suggests that frontopolar Brodmann area 10, and more generally the anterior prefrontal cortex (aPFC), supports the human ability to monitor and reflect on cognition and experience[2]. Also, some studies revealed the anterior PFC, including the dorsal anterior cingulate cortex (dACC) and lateral frontopolar cortex (lFPC), were more activated after the initial decision[3].

On the other hand, a recent meta-analysis analyzed 47 neuroimaging investigations on metacognition and recognized a domain-general network associated with high vs. low confidence ratings in decision-making and memory tasks. This network includes the medial and lateral prefrontal cortex (mPFC and lPFC), precuneus, and insula. The right anterior dorsolateral PFC (dlPFC) was explicitly involved in decision-making tasks, and the bilateral parahippocampal cortex was distinct to memory tasks. Also, prospective judgments were associated with the posterior mPFC, left dlPFC, and right insula, whereas retrospective judgments were associated with the bilateral parahippocampal cortex and left inferior frontal gyrus, where are linked to our memory and experiences[4].

According to Heidegger, in authentic understanding world disclosed; also on him, every interpretation is essentially grounded in fore-structure: fore-having, fore-sight, and fore-conception[5]. Then we do not have any conception without any assumption. So, he rises authentic understanding that Dasein becomes aware of its assumptions. Current research regards to become awareness to these fore-structures.

Molenberghs and his colleagues (2016) found that higher metacognitive accuracy was associated with decreased activation in the anterior medial prefrontal cortex, an area previously connected to metacognition on perception and memory[6]. On the other hand, that is compatible with authentic understanding on Heidegger's viewpoint in which awareness of fore-structures, postpone them and let pondering. So, the question is: will philosophical metacognition training improve students' brain performance? In other words, will we be witness the decrease of students' brain activation in the areas related to memory?

Many researchers including Dobie[7] and Otte[8] have used metacognition training for the treatment of depressing and schizophrenia. Other studies show the positive effects of metacognition training on driving[9] and

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academic motivation[10] and performance[11]. Current research tracks the changes of metacognition training in the brain to clarify improvement of brain performance.

II. Related works

Many researchers studied metacognition using fMRI. Benjamin Baird and his colleagues directly compared intraindividual variability in the metacognitive ability for perceptual decisions and memorial judgments and used resting-state functional connectivity(rs-fcMRI) to connect this variability to the connectivity of the medial and lateral regions of aPFC. The metacognitive ability for perceptual decisions was associated with greater connectivity between lateral regions of aPFC and right dorsal anterior cingulate cortex, bilateral putamen, right caudate, and thalamus. In contrast, the metacognitive ability for memory retrieval predicted more excellent connectivity between medial aPFC and the right central precuneus and intraparietal sulcus/inferior parietal lobule. These results indicate that an individual's ability for accurate introspection in the domains of perception and memory is related to the functional integrity of unique neural networks landed in the medial and lateral regions of the aPFC.[2]

Molenberghs and his colleagues believe that one crucial aspect of metacognition is the ability to evaluate one's performance accurately. People differ in their metacognitive ability and are too confident when evaluating their performance, leading to poor decision-making with potentially disastrous consequences. In an fMRI study, they investigated neural support of these processes, and inter-individual differences in metacognitive ability and effects of trial-by-trial variation in subjective feelings of confidence when making metacognitive assessments. Then participants' performance was evaluated in a high-level social and cognitive reasoning task. The results showed that higher metacognitive accuracy was associated with decreased activation in the anterior medial prefrontal cortex, an area previously connected to metacognition on perception and memory. Also, confidence about one's choices was associated with increased activation in reward, memory, and motor-related areas, including the bilateral striatum and hippocampus. In contrast, less confidence was associated with activation in areas connected with negative affect and uncertainty, including the dorsomedial prefrontal and bilateral orbitofrontal cortex. This study indicated that positive affect was related to higher confidence, thereby biasing metacognitive decisions towards overconfidence. In support, behavioral analyses disclosed that increased confidence was associated with lower metacognitive accuracy[6].

Fleur and his colleagues in a meta-analysis analyzed 47 neuroimaging investigations on metacognition and recognized a domain-general network associated with high vs. low confidence ratings in decision-making and memory tasks. This network includes the medial and lateral prefrontal cortex (mPFC and lPFC), precuneus, and insula. The right anterior dorsolateral PFC (dlPFC) was explicitly involved in decision-making tasks, and the bilateral parahippocampal cortex was distinct to memory tasks. Also, prospective judgments were associated with the posterior mPFC, left dlPFC, and right insula, whereas retrospective judgments were associated with the bilateral parahippocampal cortex and left inferior frontal gyrus. At last, emerging evidence suggests a role of the right rostrolateral PFC (rlPFC), anterior PFC (aPFC), dorsal anterior, precuneus, cingulate cortex (dACC) in metacognitive sensitivity[4].

Fleming and his colleagues (2012) show that activity in the right rostrolateral prefrontal cortex (rlPFC) meets three constraints for a role in metacognitive aspects of decision-making. Right rlPFC indicated more significant activity during self-report than a matched control condition, activity in this region correlated with reported confidence, and the strength of the relationship between activity and confidence predicted metacognitive ability across individuals. Also, they show that functional connectivity between the right rlPFC and both contralateral PFC and visual cortex rose during metacognitive reports[12]. In another study, Vaccaro and Fleming (2018) found preferential engagement of the right anterior dorsolateral prefrontal cortex in meta decision experiments and bilateral parahippocampal cortex in metamemory experiments. By comparing the results to meta-analyses of mentalizing, they obtain evidence for typical engagement of the ventromedial and anterior dorsomedial prefrontal cortex in both metacognition and mentalizing, proposing that these areas may keep second-order representations for thinking about the thoughts of oneself and others[13].

The current philosophical approach to metacognition with studying these areas tracks changes in the performance of the brain after training metacognition.

III. Research Method

This research is a kind of semi-experimental research with two groups of the experiment and control. The sample includes 30 girl students studied at industrial school in 2022-2023. Training authentic understanding were done to 15 students in the experimental group. Neufeld (2012) believes stablishing the signs can challenge students to discover their own signs and find the important regions of their own. On him, as they are starting to sign their own path, they engage in their own world in a new and exciting mode14. And it is the teaching method for training metacognition in this research. Regarding financial limitation, 10 students of both groups were volunteered to do EEG test. After using 19 channels recorder, EEG waves were analyzed and reported. In order

to assess brain activity a task was designed based on Heidegger's hermeneutical phenomenology. (I. e. It was used the success rate of students in postponing pre-structures and pondering- which is the way of authentic Dasein). This task includes 10 questions was shown during 15 minutes. (Questions like 'Why are they studying?', after pondering 30 seconds, they should choose one of the two answers by showing one or two fingers: '1- Because all students are studying 2- other reasons'). The students got two score when they chose their own special reasons (authentic) else they got one (inauthentic). Then they were classified in two groups of authentic understanding (above 15) and inauthentic understanding (under 15). Analyzing the data and comparing two groups was performed by utilizing the software of Mat lab and Loretta. (Recording and analyzing the data for recognizing engaged brain areas was done at Ferdowsi University of Mashhad.)

IV. Research findings

The students' brain signals were recorded in 250 Hz. The location of these channels were demonstrated in figure1.

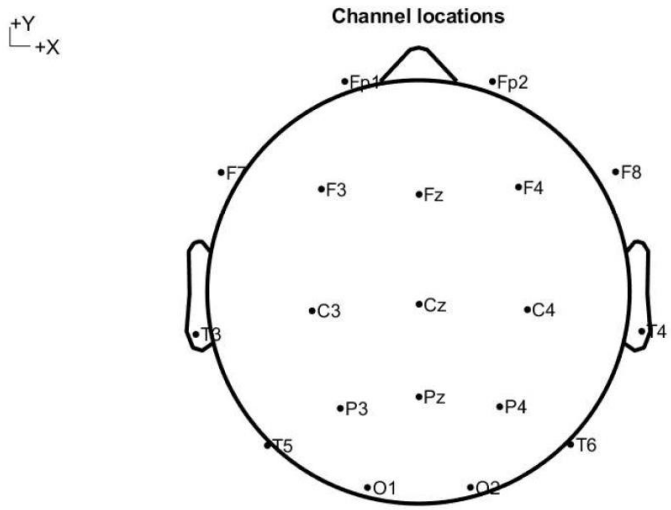

Figure1- Channel locations

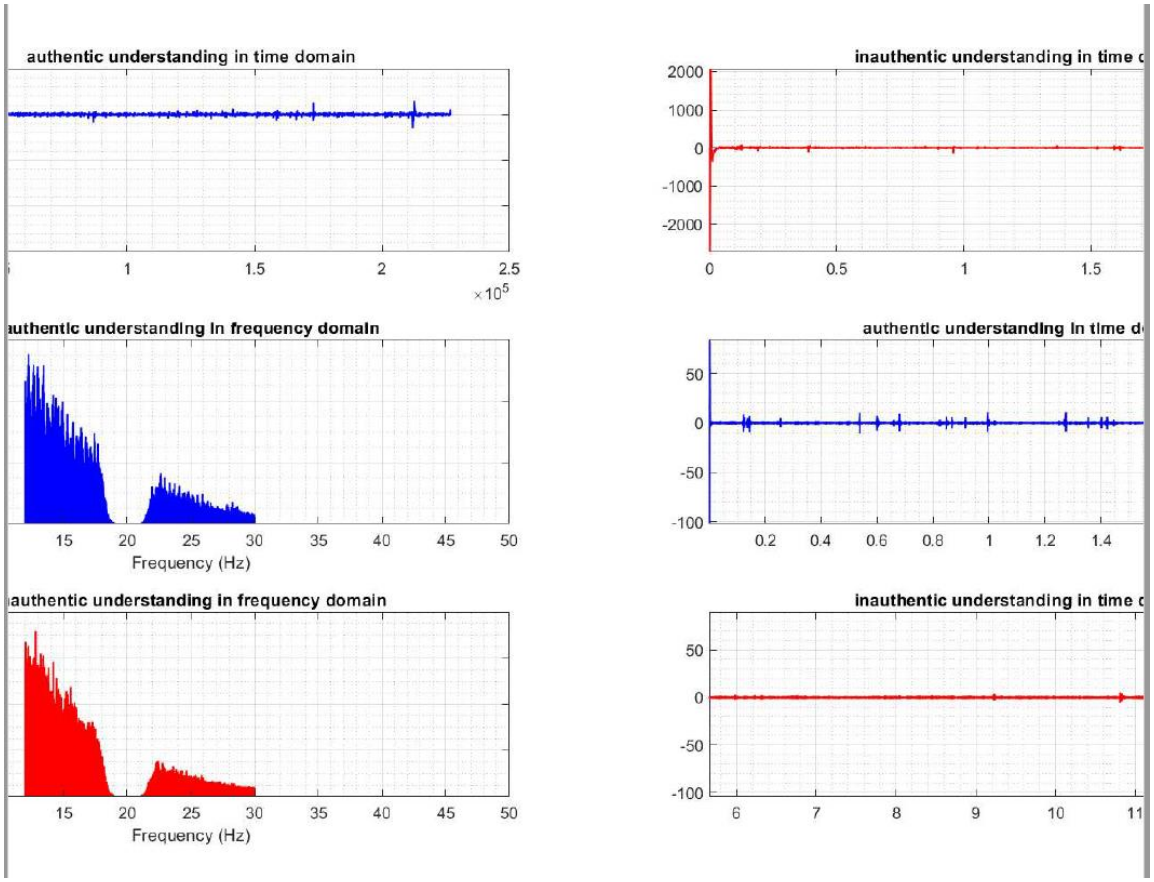

Figure 2- Comparing signals in two people with authentic and inauthentic understanding

The analysis of the data in these two groups shows that the performance of the students with authentic understanding is different from the students with inauthentic understanding.

Regards to the limitation in sample volume, leave one up and SVM model are used for determining discrimination of two groups and its accuracy. The results proved that with accuracy of 94.1176% two groups in 17 channels were discriminated as shown in table 2.

Accuracy	%94.1176
Sensitivity	%100
Specificity	%88.2353

Tabel 2- The discrimination of two groups

Using ttest2 function for comparing two groups proved meaningful difference of 95% in average, variance, and skewness of Beta signals as shown in table 3.

Features	P-value
mean	0.028619
var	0.000403
sk	0.022551

Table 3- average, variance, and skewness p-value

As considered, p-values in comparing two groups for average, variance, and skewness are less than 0.05. So, the difference between the performance of students with authentic and inauthentic understanding were proven.

Also, the comparison between two groups with Loretta software, as shown in table 4, proved that the areas below left hemisphere in students with authentic understanding was less activated than ones with inauthentic understanding (T=2, p=0.05). It is needed to mention that there was not any meaningful difference in other frequency bands.

	Structure	***Lobe***	***x, y, z (mm)***	***t-score***	***Brodmann area***
	Precuneus	*Parietal Lobe*	*-30, -75, 35*	*2.15*	*19*
	Precuneus	*Parietal Lobe*	*-25, -75, 35*	*2.13*	*19*
Low Beta	*Precuneus*	*Parietal Lobe*	*-35, -85, 35*	*2.11*	*19*

	Precuneus	*Parietal Lobe*	*-30, -85, 35*	*2.11*	*19*
	Precuneus	*Parietal Lobe*	*-35, -80, 35*	*2.10*	*19*

Table 4- Comparing Beta signals in two groups with authentic and inauthentic understanding

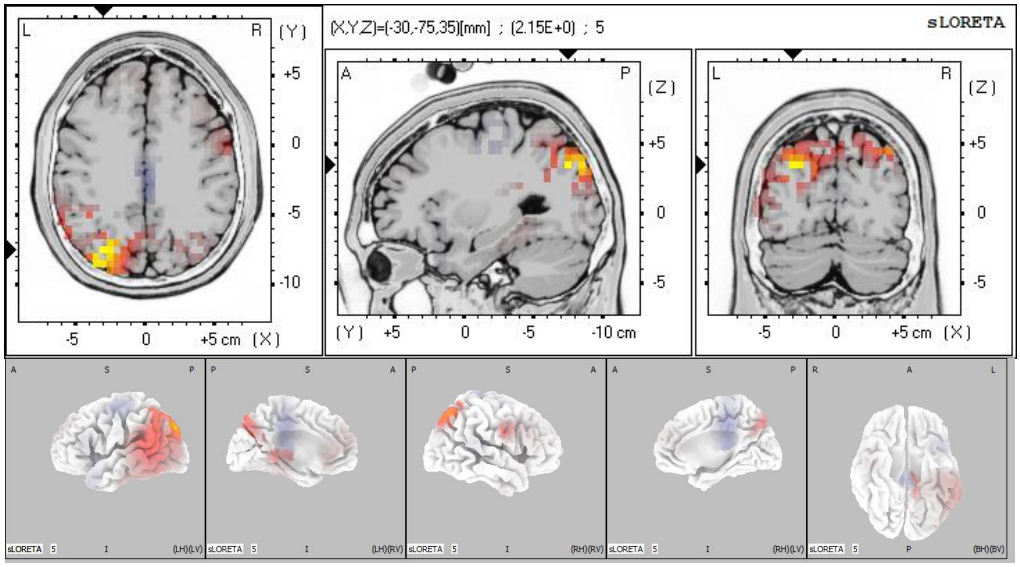

Figure 3- The areas activated during the task

As shown in the table 4, the areas like Precuneus in people with authentic understanding had less activation that confirmed previous findings about less activation in areas like the anterior medial prefrontal cortex related to high metacognition accuracy. So, we can consider high accuracy in authentic understanding.

V. Conclusion

Metacognition as 'knowing about knowing' includes various kinds of cognitive process like self-awareness, self-regulation, and self-monitoring. Current research studied the effects of metacognition training on students' brain performance. The results showed that the performance of the students with authentic understanding is different from the students with inauthentic understanding. As regarded according to Baird and his colleagues, metacognitive ability for memory retrieval predicted more excellent connectivity between medial aPFC and the right central precuneus and intraparietal sulcus/inferior parietal lobule. On the other hand, Molenberghs and his colleagues (2016) found that higher metacognitive accuracy was associated with decreased activation in the anterior medial prefrontal cortex, an area previously connected to metacognition on perception and memory. Current research proved the decrease in activity of other areas related to memory like Precuneus in authentic understanding. So, in authentic understanding on Heidegger's viewpoint, we can witness higher metacognitive accuracy when one postpones his fore-structures (fore-having, fore-sight, and fore-conception). Since metacognition accuracy can be considered as an important issue that can be trained, and because of limitation in sample volumes, repeating the experiment is suggested.

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