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Brain Mapping of Cognitive Empathy in Neuroleadership Using Quantitative Electroencephalography (qEEG)

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Extended Abstract

Aim

The aim of this study is to investigate and brain map cognitive empathy in neuroleadership using quantitative electroencephalography (qEEG). The concept of empathy, defined as the ability to imagine and understand others' feelings, has become a topic of interest for social cognitive neuroscience researchers. Neuroimaging and functional magnetic resonance imaging (fMRI) studies have identified these concepts in certain areas of the cortex (Moriguchi et al., 2006).

Today, due to the rapid changes in various environmental components and systems, and the growing need to pay attention to leadership styles for various reasons, including technological progress in all dimensions, cognitive research in management has gained significantly more importance and necessity than it had at its inception (Hodgkinson& Sadler-Smith, 2018). Therefore, it seems that the cognitive development of neuroleadership, brain, and neuroscience has not been sufficiently considered.

In this study, we will discuss the use of neuroscience in leadership, various leadership capabilities, methods of information analysis, findings, and results presented in scientific literature about neuroleadership. We will evaluate and summarize its effects on brain mapping of cognitive empathy in neuroleadership using qEEG.

Methodology

The research method is based on the interpretation of two different phases of the brain maps of participants from the community are managers with a history of leading groups for at least 5-10 years and a maximum of 20-30 years. The first phase involved recording brain waves, and the second phase, conducted after an interval of three months of cognitive exercises, aimed at investigating the empathy component, especially in the brain cortex. This phase considered the SCARF model, clinical interviews, and interpretation of the two stages at the counseling center of Tehran University, with perceptual verification in 12 participants in 2022-2023.

Samples from among the managers were analyzed and interpreted using NeuroGuide software version 2018 to investigate the differences between the two phases in the participants. Electroencephalography, in synchronization and analysis with a higher degree of complexity, can be valuable in a longitudinal study to monitor many diagnoses (Cortez et al., 2015). On the other hand, methodological differences are very important for the new perspective proposed in electroencephalography (Freeman, 2004). Brain mapping was conducted according to the instructions in the table below and based on the approach of Quantitative Electroencephalography (QEEG) to understand the brain activity patterns of the participants, focusing on the cognitive development of neuroleadership capabilities.

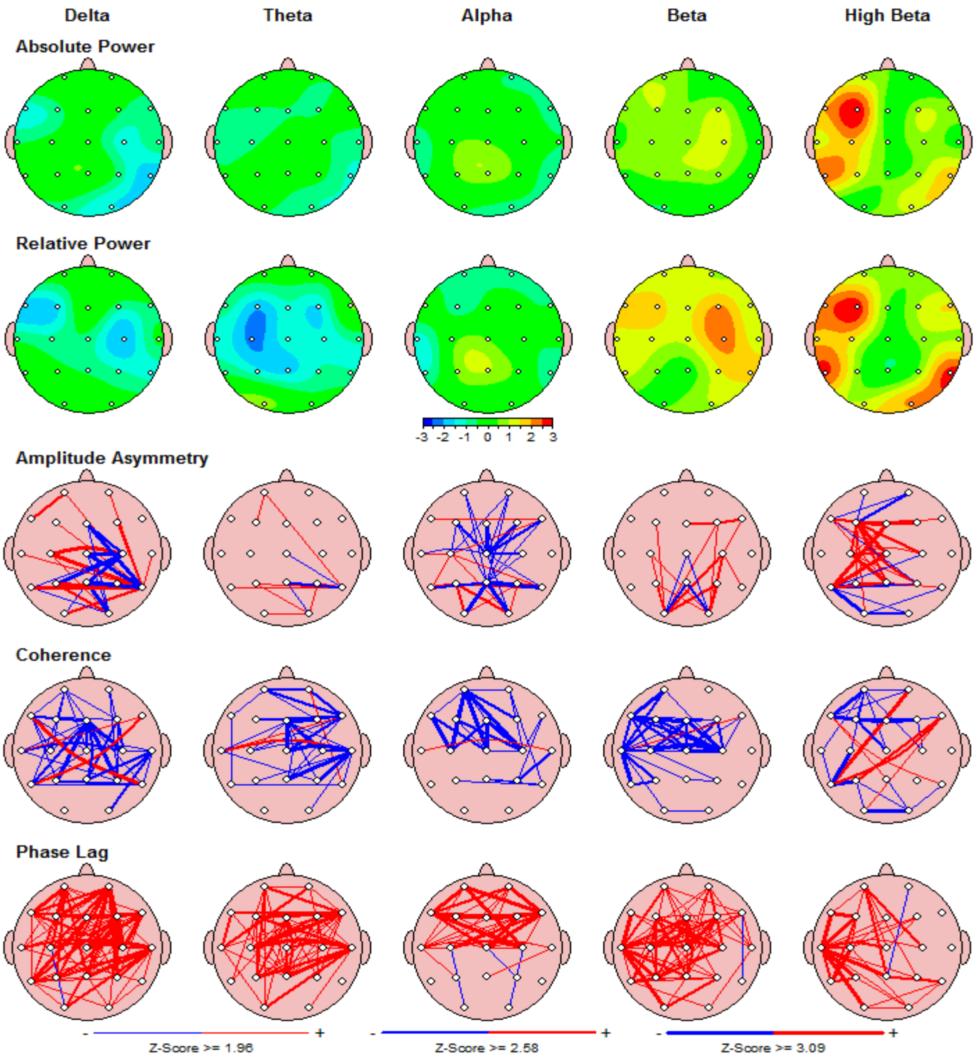
Table 1. A framework for developing cognitive capabilities (neuroleadership)

Measurement tools (after the intervention) QEEG of the second phase (**Clinical interview**) QEEG (2) +	Intervention time: (3 months)	Type of intervention	Wave type	Measurement tools (before intervention) QEEG of the first phase + (**In-depth interview**) QEEG (1)	Leadership capabilities (cognitive dimensions)
-Technical Information -Z Scored FFT information -Z Scored FFT Absolute Power -Z Scored FFT Relative Power -Z Scored FFT Power Ratio	Intervention time: (months 3)	Tasks based on the SCARF model, Meditation, eating fish, Listening to waves based on the participants' Clinical interview	Focusing on the Delta wave	Technical Information -Z Scored FFT information -Z Scored FFT Absolute Power -Z Scored FFT Relative Power -Z Scored FFT Power Ratio	Empathy Empathetic) (vitality
-Technical Information -Z Scored FFT information -Z Scored FFT Absolute Power -Z Scored FFT Relative Power -Z Scored FFT Power Ratio	Intervention time: (months 3)	Tasks based on the SCARF model, Meditation, eating fish, Listening to waves based on the participants' Clinical interview	Focusing on the Beta wave	-Technical Information -Z Scored FFT information -Z Scored FFT Absolute Power -Z Scored FFT Relative Power -Z Scored FFT Power Ratio	sympathy (Empathic joy)

Findings

Positive empathy predicted increased activation of the left dorsal (frontal pole) ($P<0.05$). Positive emotions and empathy (both negative and positive) in participants have shown activity changes when performing a pleasurable task. Transform (FFT) signal processing and analysis have been used to calculate the Discrete Fourier Transform (DFT) and its inverse, known as the Inverse Discrete Fourier Transform (IDFT). The findings of this study show a direct relationship between semantic processing, functions, and leadership in empathy according to the interpretation of brain maps. As mentioned, the research method involved using qEEG, and we conducted in-depth and specialized clinical interviews to deepen the study of human dimensions with a qualitative approach.

In the image below, we can see the FFT of the brain of one of the participants of the present study. The sub-table provides technical information related to the results of the composition or test method, divided into two halves, and shows the correlation between the two halves of the test measured from one of the participants, along with the retest data. The correlation coefficient is used in the program structure. Finally, the correlation coefficient between the scores obtained from the two tests is calculated to determine the similarity of the scores and is used as a reliability coefficient. It should be noted that the sampling rate is 250.



Z Scored Fast Fourier Transform

Conclusion

Positive emotions, such as goodwill, are uniquely associated with frontal EEG asymmetries in two brain regions (dorsal frontal and frontopolar frontal regions) previously implicated in empathic processes in participants. This argument is supported by previous research showing a relationship between frontal EEG asymmetry and various emotional and motivational states. There are two main theories about frontal EEG asymmetry: the valence hypothesis and the motivational hypothesis (Coan& Allen, 2004; Davidson, 2004; Cacioppo, 2004; Harmon-Jones, 2004).

In brief, the prefrontal cortex appears to underlie our internal representation of the "rules of the game" (Miller et al., 2002). The capacity hypothesis is based on the finding that greater relative activation of the right frontal lobe is associated with the experience of negative emotions, while greater relative activation of the left lobe is associated with the experience of positive emotions. However, data also suggest that greater relative activity in the left frontal lobe can be associated with anger and negative emotion.

More recent concepts of prefrontal electroencephalographic asymmetry incorporate these findings, and most researchers agree that frontal asymmetry reflects the activity of an approach-withdrawal motivational system, with greater relative activation of the left anterior cingulate. According to the frontal electroencephalography asymmetry literature, we hypothesized that individual variation in frontal electroencephalogram asymmetry caused by tasks generally evokes positive emotions and is associated with individual differences in the type and intensity of empathic expression.

In the context of neuroleadership, we find that the organizing principle of the brain is to minimize threats and maximize rewards. However, it should be noted that these research insights rarely reach beyond the laboratory environment. Bridging this gap to create cognitive empathy and turn it into an opportunity is crucial for the practical application of these findings.

Keywords: Brain Mapping, Cognitive Abilities, Cognitive Empathy, Quantitative Electroencephalogram, Neuroleadership.

Ethical Considerations

Due to the need to comply with ethical guidelines and the necessity of protecting the profiles of the participants and the results obtained from their brain wave recordings, only anonymous samples from the participants' brain maps and the comparisons between the first and second phases of qEEG recordings were used. This approach ensures the confidentiality of the participants while referring to scientific opinions and results to explain cognitive empathy brain mapping studies in neuroleadership using quantitative electroencephalography.

In this research, ethical considerations such as obtaining informed consent, ensuring voluntary participation in counseling sessions, providing full disclosure of the research objectives, explaining the implementation method, benefits, nature, and duration of the research, as well as the fact that the sessions were free of charge, have all been observed.

This article is an extract from a PhD thesis in public administration with a focus on organizational behavior, titled "Providing a Framework for the Cognitive Development of Neuroleadership" from the University of Tehran. It has been registered with the ethics committee of the Faculty of Psychology and Educational Sciences of the University of Tehran under the code of ethics IR.UT.PSYEDU.REC.1402.036. The online version of the ethics code related to the thesis/dissertation of the responsible author (first author) and the article derived from it is available at: (https://ethics.research.ac.ir/IR.UT.PSYEDU.REC.1402.036.1402.036). This can be accessed in the National System of Ethics in Biomedical Research of the Ministry of Health, Treatment, and Medical Education and is open to the public.

Conflict of Interest

In this study, publication ethics were adhered to. No commercial interests were involved, and the authors did not receive any financial compensation for presenting their work. This article maintains content originality and is derived from the thesis with originality number 114864/977 at the University of Tehran. The work has not been previously published elsewhere and is not simultaneously submitted to any other journal. All rights to use content, tables, images, etc., have been transferred to the publisher with the authors' permission.

References

Cacioppo, J. T. (2004). Feelings and emotions: roles for electrophysiological markers. *Biological Psychology*, *67*(1-2), 235-243. https://doi.org/10.1016/j.biopsycho.2004.03.009

Coan, J. A., & Allen, J. J. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. *Biological psychology*, *67*(1-2), 7-50. https://doi.org/10.1016/j.biopsycho.2004.03.002

Cortez, M. A., Baba, S., Bamaga, A., & Nenadovic, V. (2015). OP20–2281: Pre-Emptive EEG and synchronization analysis strategy for West syndrome. *European Journal of Paediatric Neurology*, *19*, S7. https://doi.org/10.1016/S1090-3798(15)30021-0

Davidson, R. J. (2004). What does the prefrontal cortex “do” in affect: perspectives on frontal EEG asymmetry research. *Biological psychology*, *67*(1-2), 219-234. https://doi.org/10.1016/j.biopsycho.2004.03.008

Freeman, W. J. (2004). Origin, structure, and role of background EEG activity. Part 1. Analytic amplitude. *Clinical Neurophysiology*, *115*(9), 2077-2088. https://doi.org/10.1016/j.clinph.2004.02.029

Miller, E. K., Freedman, D. J., & Wallis, J. D. (2002). The prefrontal cortex: categories, concepts and cognition. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *357*(1424), 1123-1136. https://doi.org/10.1098/rstb.2002.1099

Moriguchi, Y, Ohnishi, T., Lan, R. D., Maeda, M., Mori, T., Nemoto, K., Matsuda, H., & Komaki, G. (2006). Impaired self-awareness and theory of mind: an fMRI study of mentalizing in alexithymia”. *NeuroImage*, *32*(3), 1472-1482. https://doi.org/10.1016/j.neuroimage.2006.04.186

Harmon-Jones, E. (2004). Contributions from research on anger and cognitive dissonance to understanding the motivational functions of asymmetrical frontal brain activity. *Biological psychology*, *67*(1-2), 51-76. https://doi.org/10.1080/02699930903378305

Hodgkinson, G. P., & Sadler-Smith, E. (2018). The dynamics of intuition and analysis in managerial and organizational decision making. *Academy of Management Perspectives*, *32*(4), 473-492. https://doi.org/10.5465/amp.2016.0140

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