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High Frequencies in QEEG Are Related to the Level of Insight in Patients With Schizophrenia

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Abstract

Lack of insight is a neurocognitive problem commonly encountered in patients with psychotic disorders that negatively affects treatment compliance and prognosis. Measurement of insight is based on self-report scales, which are limited due to subjectivity. This study aimed to determine the correlation between resting state beta and gamma power in 23 patients with schizophrenia and insight. It was observed that as beta and gamma power measured via qualitative electroencephalography (qEEG) increased the level of insight decreased. Negative correlation was found in F3, C3, Cz for gamma activity and in F3 and C3 for beta activity. This finding indicates that resting state qEEG could be used to evaluate the level of insight in patients with schizophrenia.

Keywords

schizophrenia, insight, qEEG, beta, gamma

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Introduction

Insight is a pivotal component of the psychic apparatus. From the clinical point of view, insight is indicative of the capacity to acknowledge one's own psychiatric problem as well as other brain diseases/injuries.[1,2] Whether or not insight is a cognitive task remains a contentious issue; however, data do support the notion that it is primarily a function of cognition.[3] Although not included in the diagnostic criteria for any specific disorder, lack of insight is a common problem encountered in patients with psychotic disorders. Insight can be subcategorized as illness insight, which refers to attributing symptoms to an illness, and treatment insight, which refers to acknowledgement of the need for treatment.[4] Several authors argue against a simple cognitive account of insight, and they claim that lack of insight is the result of a complex interaction between biological, psychological, and social factors, which hampers ultimately the ability to self-examine or reflectivity. From a biological point of view insight can be evaluated as a form anosognosia; however, a psychological explanation could argue that it should be considered as a denial process.[5] In that sense insight may not be understood using a single approach and could indeed be a modular phenomenon encompassing several factors.[6]

Regardless of whether insight is a symptom, a neurocognitive deficit or a relational phenomenon, it has important implications for treatment and prognosis in psychiatric patients. For instance, the level of insight was reported to be correlated to psychotic symptoms, treatment compliance, and quality of life (QoL).[7] In addition, longitudinal studies have shown that the baseline level of insight is predictive of a decrease in the severity of psychiatric disease.[8] Moreover, as the level of insight increases, so does patients' QoL.[9] Perhaps most importantly, insight is associated with treatment compliance, which makes it easier to fight against the symptoms of psychiatric illness. In contrast, lack of insight is an associated clinical feature of psychosis. It was shown that during the acute phase of psychosis, patients have difficulty understanding their condition, and then become aware of their psychiatric problem immediately after the psychotic episode ends.[10]

In summary, insight is defined as a patient's capacity to evaluate his or her own psychological status. In accordance with this definition several insight scales have been developed. The most widely used of these scales is the Schedule for Assessing the Three Components of Insight,[6] which measures the 3 components of insight: awareness of illness, acknowledgement of psychotic symptoms, and compliance with treatment. Additionally, there are other scales that are used to evaluate only a single component of insight, such as the Insight and Treatment Attitudes Questionnaire,[11] which evaluates a patient's agreement with the need for treatment, and the Beck Cognitive Insight Scale, which evaluates a patient's self-reflectiveness and

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overconfidence in their interpretations of their experiences.[12] Based on those different interpretations and scales, one might conclude that there are more than one types of insight and a correct measurement of insight requires a correct definition of the problem and what is intended to be measured.

A biological correlate or biomarker of insight would not only eliminate the confusion due to multiple definitions of insight but also eliminate inaccuracies that can arise due to the use of self-report questionnaires. In other words, asking someone to evaluate the accuracy of his or her own self-evaluation is quite paradoxical. Despite this paradox, to the best of our knowledge few data on biological correlates of insight are available.[13-15] As such, it was hypothesized that one of the most reliable, replicable, easy to apply, noninvasive, and inexpensive tools for identifying a biomarker of insight could be qualitative electroencephalography (qEEG).

The present study we aimed to identify a qEEG marker for insight in schizophrenia patients. The study was based on the hypothesis that beta-gamma power might be correlated with the level of insight, as insight is generally considered a neurocognitive problem and the beta-gamma band, which includes frequencies >12 Hz, is strongly associated with cognitive processes. For instance, several studies showed that gamma oscillations are related to numerous cognitive functions, including sensory integration, attention, and memory.[16-20] In addition, alterations in gamma oscillation were observed in patients with neuropsychiatric disorders that are highly associated with cognitive decline. For instance, Alzheimer's patients show a loss of gamma oscillations compared with healthy controls[21,22] and schizophrenia is associated with low evoked gamma activity,[17] although resting gamma activity in the left parieto-temporal lobe was higher in patients with schizophrenia than in controls.[23] Interestingly, elevated gamma activity is also linked to social problems in mice.[16] These data suggest that resting gamma activity might be a biomarker for neurocognitive problems such as insight. Although fewer in number than gamma band studies, some studies reported impaired beta synchronization in schizophrenia patients. For instance, schizophrenia patients exhibit decreased beta activity during perception and working memory,[24-26] and reduced phase synchrony in the beta band.[27]

Materials and Methods

Participants

This retrospective study included 23 patients diagnosed as schizophrenia that were identified in our outpatient clinic database. The diagnosis was based on *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (*DSM-IV*) criteria and all patients were of paranoid type. A magnetic resonance imaging (MRI) was performed to rule out other brain disease for all patients. Mean age of the 23 schizophrenia patients (20 male and 3 female) was 39 years (range: 18-66 years). Seven participants were university graduates, 16 received high school education, and the rest received only primary school education. Duration of illness was at least 6 months, 11 of them were hospitalized previously. All patients were medication free for at least 3 weeks at the time of qEEG acquisition. All patients were previously medicated with at least 1 antipsychotic. The level of insight was measured using the Schedule for Assessing the Three Components of Insight.[6] In addition, patients were administered the Scales for the Assessment of Negative (SANS) and Positive (SAPS) Symptoms.[28,29] The study protocol was approved by the Uskudar University Ethics Committee.

We also obtained resting EEG from 11 individuals without a history of neuropsychological disorder as control group (mean age = 37.5 years, range = 18-55 years, 5 males).

qEEG

All qEEG data were recorded in a quiet, dimly lit room. Patients sat calmly with eyes closed during the recording time of 3 minutes. In all, 19 electrodes were placed on the scalp, based on the international 10-20 system. Linked mastoid electrodes (A1-A2) were used for reference during acquisition. The data sampling rate was 500 Hz, and the acquired signals were band-pass filtered at 0.15-70 Hz and notch filtered at 50 Hz. Data artifacts were eliminated manually off-line for each patient. Data were averaged across the recording epochs for each electrode, and the absolute power (percentage of total power) was computed for the gamma band (30-50 Hz) and beta band (12-25 Hz).

Neuroguide Deluxe v.2.5.1 (Applied Neuroscience, Largo, FL) software was used for qEEG analysis. First, gamma and beta powers were calculated for the 11 electrodes (F3, F4, Fz, P3, P4, Pz, C3, C4, Cz, T3, and T4), which correspond to the central regions of frontal, temporal, central, and parietal brain regions and found to be artifact free after examining EEG files across patients. The correlation between beta-gamma power, insight score and Positive and Negative Syndrome Scales was calculated using nonparametric correlation analysis in SPSS. Then, the resulting *P* values were adjusted using the Benjamini-Hochberg method.

Results

qEEG gamma power at Cz, F3, and C3 electrodes and beta power at F3 and C3 were significantly correlated to insight score (see Table 1). The patients that had higher beta-gamma power at these locations had lower insight scores; this negative correlation is depicted in the Figure 1. The correlation between positive and negative symptoms, and beta-gamma power did not reach the level of significance (all correlation coefficients <0.22 and *P* values >.15). These findings indicated that the correlation between beta-gamma power and insight was not mediated by disease severity.

We subsequently checked if the schizophrenia group differed significantly from the control group on the 6 electrode-band pairs that we found a correlation between absolute gamma/beta power and insight. The analysis showed that there was significant between group difference for gamma power in C3 ($P = .003$), and the difference approached significance for gamma power in Cz ($P = .06$) and beta power in F3 ($P = .007$).

Table 1. Nonparametric Correlations Between Resting Beta and Gamma Absolute Power, and Insight Scale Score.

	F3	F4	Fz	C3	C4	Cz	P3	P4	Pz	T3	T4
Gamma											
Correlation	−0.38	−0.26	−0.35	−0.40	−0.25	−0.46	−0.34	−0.16	−0.27	−0.18	0.09
P	.01*	.08	.02	.01*	.11	.003*	.03	.3	.08	.24	.56
Beta											
Correlation	−0.42	−0.26	−0.34	−0.42	−0.28	−0.37	−0.33	−0.13	−0.21	−0.09	0.13
P	.006*	.1	.03	.006*	.07	.02	.03	.39	.18	.56	.39

Corr: Correlation coefficient (Kendall's tau). "*" represents significance according to the Benjamini-Hochberg procedure.

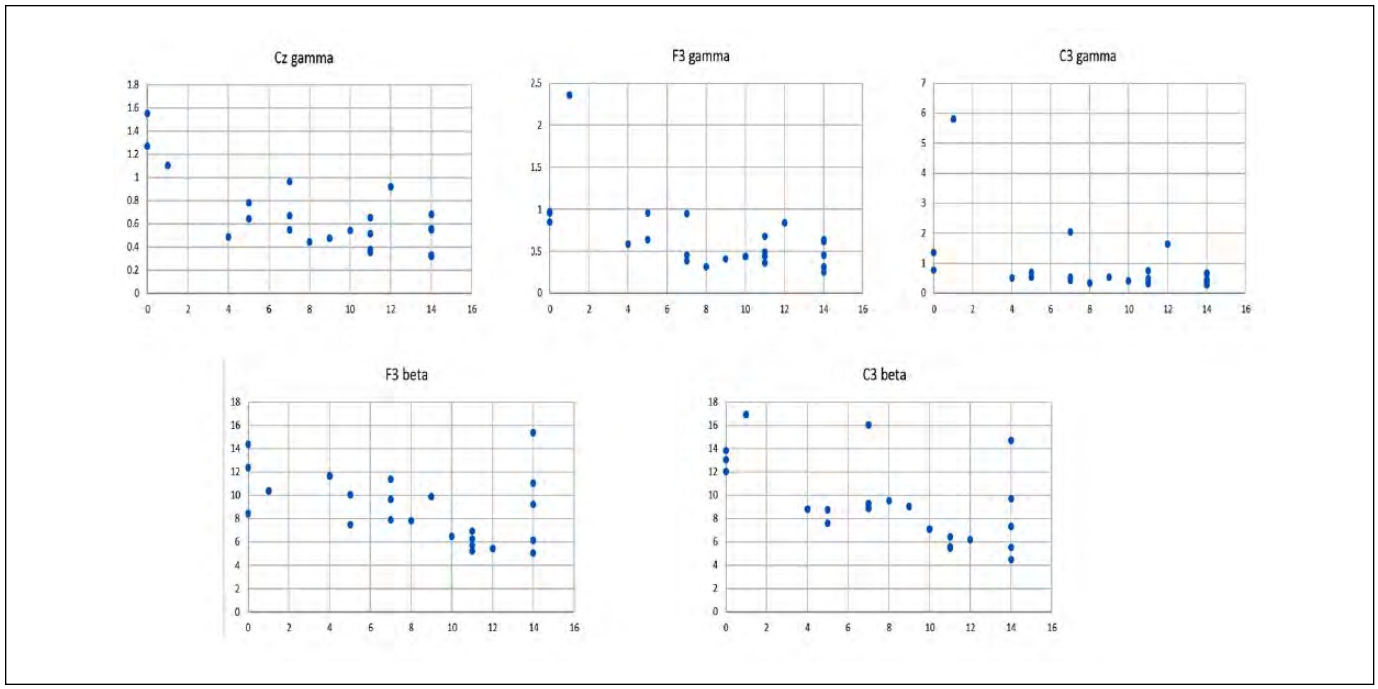

Figure 1. Scatterplots for the correlation between insight scale score and gamma absolute power (correlations were calculated nonparametrically).

The controls had lower absolute gamma or beta powers as compared with patients with schizophrenia (Table 2).

Discussion

The present findings show that schizophrenia patients with higher beta-gamma power had a lower level of insight. Interestingly, beta-gamma power was not associated with the severity of illness (SANS and SAPS scores), but only with insight. To the best our knowledge the present study is the first to report a correlation between an electrophysiological measure and insight. The present findings have 2 major implications. First, the findings imply that qEEG could be used as an index of insight. Instead of self-report insight questionnaires, qEEG could be used to provide an objective measure of insight. qEEG is a noninvasive, time-efficient method widely used as an aide in the differential diagnosis of some psychiatric disorders, including depression and attention-deficit/hyperactivity disorder (ADHD).[30-32] Moreover, the present findings show that qEEG can also be used to identify subtypes of clinical disorders with different insight levels. Additional research will be required to further delineate the prognostic differences between high gamma and low gamma subtypes in schizophrenia.

The second major implication of the present study's findings is that beta-gamma activity is correlated to insight; however, identifying the cause for this correlation will require additional research. In general, gamma oscillations were found to be decreased in schizophrenia; however, symptoms are generally associated with an increase in gamma activity. For instance, Lee et al[33] reported that reality distortion and disorganization are associated with increased gamma activity in right hemisphere (see also Uhlhaas and Singer,[34] for a review). These mixed results could be explained in 2 ways: (*a*) Although gamma activity is generally decreased in schizophrenia locally increased gamma

Table 2. Group Differences (Mann-Whitney *U* Test) Between Patients and Controls in 6 Electrode-Band Pairs Found to Be Correlated to Insight Scores.

	C3-Gamma	F3-Gamma	Cz-Gamma	F3-Beta	C3-Beta
Z score	−2.85	−0.94	−1.90	−1.82	−1.23
P	.003	.363	.06	.07	.23

activity may be responsible for reality distortion and lack of insight. Focal increases in high frequency oscillations was also proposed as mechanism that could produce other positive symptoms such as hallucinations.[34] Such local increased have been previously linked to decreased GABAergic interneuron activity, which is required for gamma oscillations.[33,35] (*b*) It is possible that schizophrenia patients with increased beta-gamma oscillations represent a distinct subtype of disease with a unique cognitive profile characterized by disturbed cognitive processes. On the other hand, use of the Schedule for Assessing the Three Components of Insight in the present study did not differentiate between cognitive and non-cognitive aspects of insight, which could be considered a limitation of the study; therefore, the differential relationship between insight subtypes and gamma power should be studied further.

The present study has 2 more primary limitations. The patient group was small and as such, the generalizability of the present findings need to be confirmed via additional larger scale studies. Another limitation is the retrospective design; longitudinal studies could help determine if gamma power is an important prognostic indicator in schizophrenia patients. Although insight is a complex neuropsychological concept that is difficult to measure and quantify, the present findings indicate that if confirmed by future studies, beta and gamma power might be useful as a neuro-biomarker for insight. Because of the limitations discussed above, additional research is warranted to further clarify whether or not qEEG beta-gamma power could be used to measure insight.

Author Contributions

Mehmet Kemal Arikan contributed to conception and design, contributed to interpretation, drafted and revised manucript, gave final approval. Barış Metin contributed to conception and design, contributed to interpretation, drafted and revised manucript, gave final approval. Sinem Zeynep Metin contributed to conception, contributed to interpretation, revised manucript, gave final approval. Emine Elif Tülay contributed to conception, contributed to interpretation, revised manucript, gave final approval. Nevzat Tarhan contributed to conception, contributed to interpretation, revised manucript, gave final approval.

Declaration of Conflicting Interests

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References

1. Robertson K, Schmitter-Edgecombe M. Self-awareness and traumatic brain injury outcome. *Brain Inj*. 2015;29:848-858.
2. Ham TE, Bonnelle V, Hellyer P, et al. The neural basis of impaired self-awareness after traumatic brain injury. *Brain*. 2014;137(pt 2):586-597.
3. Amador XF, Strauss DH, Yale SA, Gorman JM. Awareness of illness in schizophrenia. *Schizophr Bull*. 1991;17:113-132.
4. Chakraborty K, Basu D. Insight in schizophrenia: a comprehensive update. *Ger J Psychiatry*. 2010;13:17-30.
5. Vohs JL, George S, Leonhardt BL, Lysaker PH. An integrative model of the impairments in insight in schizophrenia: emerging research on causal factors and treatments. *Expert Rev Neurother*. 2016;16:1193-1204.
6. David AS. Insight and psychosis. *Br J Psychiatry*. 1990;156:798-808.
7. Marková IS. *Insight in Psychiatry*. New York, NY: Cambridge University Press; 2005.
8. Wiffen BD, Rabinowitz J, Fleischhacker WW, David AS. Insight. Demographic differences and associations with one-year outcome in schizophrenia and schizoaffective disorder. *Clin Schizophr Relat Psychoses*. 2010;4:169-175.
9. McEvoy JP. The relationship between insight in psychosis and compliance with medications. In: Amador XF, David AS, eds. *Insight in Psychosis*. 2nd ed. New York, NY: Oxford University Press; 2004:291-305.
10. Poyraz BÇ, Arikan MK, Poyraz CA, et al. Clinical and cognitive insight in patients with acute-phase psychosis: association with treatment and neuropsychological functioning. *Nord J Psychiatry*. 2016;70:528-535.
11. McEvoy JP, Apperson LJ, Appelbaum PS, et al. Insight in schizophrenia. Its relationship to acute psychopathology. *J Nerv Ment Dis*. 1989;177:43-47.
12. Beck AT, Baruch E, Balter JM, Steer RA, Warman DM. A new instrument for measuring insight: the Beck Cognitive Insight Scale. *Schizophr Res*. 2004;68:319-329.
13. Buchy L, Barbato M, MacMaster FP, et al. Cognitive insight is associated with cortical thickness in first-episode psychosis. *Schizophr Res*. 2016;172:16-22.
14. Buchy L, Makowski C, Malla A, Joober R, Lepage M. A longitudinal study of cognitive insight and cortical thickness in first-episode psychosis. *Schizophr Res*. 2018;193:251-260.
15. Clark SV, Mittal VA, Bernard JA, Ahmadi A, King TZ, Turner JA. Stronger default mode network connectivity is associated with poorer clinical insight in youth at ultra high-risk for psychotic disorders. *Schizophr Res*. 2018;193:244-250.
16. Featherstone RE, McMullen MF, Ward KR, Bang J, Xiao J, Siegel SJ. EEG biomarkers of target engagement, therapeutic effect, and disease process. *Ann N Y Acad Sci*. 2015;1344:12-26.

17. Başar E. Brain oscillations in neuropsychiatric disease. *Dialogues Clin Neurosci*. 2013;15:291-300.
18. Başar E, Güntekin B. Chapter 19. Review of delta, theta, alpha, beta and gamma response oscillations in neuropsychiatric disorders. *Suppl Clin Neurophysiol*. 2013;62:303-341.
19. Headley DB, Paré D. In sync: gamma oscillations and emotional memory. *Front Behav Neurosci*. 2013;7:170.
20. Başar-Eroglu C, Strüber D, Schürmann M, Stadler M, Başar E. Gamma-band responses in the brain: a short review of psychophysiological correlates and functional significance. *Int J Psychophysiol*. 1996;24:101-112.
21. Aron L, Yankner BA. Neurodegenerative disorders: neural synchronization in Alzheimer's disease. *Nature*. 2016;540:207-208.
22. Başar E, Emek-Savaş DD, Güntekin B, Yener GG. Delay of cognitive gamma responses in Alzheimer's disease. *Neuroimage: Clin*. 2016;11:106-115.
23. Mitra S, Nizamie SH, Goyal N, Tikka SK. Evaluation of resting state gamma power as a response marker in schizophrenia. *Psychiatry Clin Neurosci*. 2015;69:630-639.
24. Barr MS, Farzan F, Tran LC, Chen R, Fitzgerald PB, Daskalakis ZJ. Evidence for excessive frontal evoked gamma oscillatory activity in schizophrenia during working memory. *Schizophr Res*. 2010;121:146-152.
25. Pachou E, Vourkas M, Simos P, et al. Working memory in schizophrenia: an EEG study using power spectrum and coherence analysis to estimate cortical activation and network behavior. *Brain Topogr*. 2008;21:128-137.
26. Uhlhaas PJ, Singer W. High-frequency oscillations and the neurobiology of schizophrenia. *Dialogues Clin Neurosci*. 2013;15: 301-313.
27. Uhlhaas PJ, Linden DE, Singer W, et al. Dysfunctional long-range coordination of neural activity during Gestalt perception in schizophrenia. *J Neurosci*. 2006;26:8168-8175.
28. Andreasen N. *The Scale for the Assessment of Negative Symptoms (SANS)*. Iowa City, IA: University of Iowa; 1983.
29. Andreasen N. *The Scale for the Assessment of Positive Symptoms (SAPS)*. Iowa City, IA: University of Iowa; 1984.
30. Snyder SM, Hall JR. A meta-analysis of quantitative EEG power associated with attention-deficit hyperactivity disorder. *J Clin Neurophysiol*. 2006;23:440-455.
31. Snyder SM, Rugino TA, Hornig M, Stein MA. Integration of an EEG biomarker with a clinician's ADHD evaluation. *Brain Behav*. 2015;5:e00330.
32. Thibodeau R, Jorgensen R, Kim S. Depression, anxiety, and resting frontal EEG asymmetry: a meta-analytic review. *J Abnorm Psychol*. 2006; 115:715-729.
33. Lee KH, Williams LM, Haig A, Gordon E. "Gamma (40 Hz) phase synchronicity" and symptom dimensions in schizophrenia. *Cogn Neuropsychiatry*. 2003;8:57-71.
34. Uhlhaas PJ, Singer W. Abnormal neural oscillations and synchrony in schizophrenia. *Nat Rev Neurosci*. 2010;11: 100-113.
35. Williams S, Boksa P. Gamma oscillations and schizophrenia. *J Psychiatry Neurosci*. 2010;35:75-77.