EJNPN_67_16R3_OA

Social and nonsocial cognitive functions in patients with schizophrenia: a comparative neuropsychological and neurophysiological study

Alia A. Saleh[a], Neveen M. El-Fayoumy[b], Sherif M. Gohar[a], Mohamed A.F. Khalil[a]

[a]Departments of Psychiatry, [b]Clinical Neurophysiology, Faculty of Medicine, Cairo University, Giza, Egypt

Correspondence to Mohamed A.F. Khalil, MBBCh, MSc, MD, 8 Mohi El-Deen Abo El-Ezz Street, Dokki - 12311, Giza, Egypt
Tel: +20 010 691 03693;
e-mails: maamska@kasralainy.edu.eg; maamska@yahoo.com

Received 13 August 2016
Accepted 9 January 2017

The Egyptian Journal of Neurology, Psychiatry and Neurosurgery 2017, XX: XX–XX

Background
Patients with schizophrenia suffer from cognitive deficits in seven domains in addition to social cognition. P300 latency and amplitude have been linked in these patients to basic cognitive deficits.
Objective
The aim of this study was to compare patients suffering from schizophrenia with healthy participants with regard to auditory event-related potential tests measured by P300.
Participants and methods
A total of 52 participants participated in this study and were divided into two groups. Group A included 27 patients with schizophrenia according to the *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., text revised (DSM-IV TR); those with current substance use, psychiatric disorders, or organic disorders were excluded. Group B included 25 healthy control participants with negative history of substance abuse and psychiatric disorders. Patients were assessed using the Positive and Negative Symptom Scale for severity of psychotic symptoms, Addenbrook's Cognitive Examination-Revised for basic cognition, Reading the Mind in the Eye Test for social cognition, P300, and electroencephalography.
Results
The two groups were different significantly with respect to Addenbrook's Cognitive Examination total and its subtests measuring attention–orientation, memory, language, visuospatial memory, and Reading the Mind in the Eye Test for social cognition scores with patients showing lower scores (P=0.000, 0.012, 0.000, 0.038, 0.041, and 0.001, respectively). The control group had higher amplitude of P300 and shorter latency than patients (P=0.003 and 0.005, respectively). P300 amplitude correlated positively with visuospatial memory (P=0.015). The Positive and Negative Symptom Scale general pathology scale correlated positively with duration of untreated psychosis (P=0.029) and with fluency (P=0.047).
Conclusion
Patients with schizophrenia differ from controls with respect to P300 scores.

Keywords:
cognitive deficits, P300, schizophrenia, social cognition

Egypt J Neurol Psychiatry Neurosurg XX:XX–XX

1110-1083

Introduction

Schizophrenia affects ~1% of the general population. It is characterized by positive symptoms such as delusions and hallucinations and negative symptoms such as blunted affect, lack of motivation, and reduced social relationships. In addition, studies have consistently identified neurocognitive deficits as clinically relevant core features that affect 75–85% of schizophrenia patients and may serve as predictors of social functioning, treatment strategies, and functional outcomes [1].

These deficits include impaired preattentive abilities, attention, memory, learning, conceptualization, organization, planning, self-monitoring, and flexibility of thinking.

In addition, the Measurement and Treatment Research to Improve Cognition in Schizophrenia study identified seven domains that represent the main domains of cognitive dysfunction in schizophrenia relevant to intervention, including speed of processing, attention/vigilance, working memory, verbal learning, visual learning, reasoning and problem solving, and social cognition [2].

Accordingly, cognitive deficits represent a core feature of schizophrenia that usually occur around the time of

onset, and remain stable for the remainder of the course of illness [3].

Moreover, cognitive deficits appear to play a major role that predicts the patient's ability to deal successfully with everyday activities, which include vocation and social networks in addition to acquisition of social skills and community functioning [4,5].

In the last few decades, the main focus of cognitive studies in schizophrenia has been on the previously mentioned cognitive domains, but recently social cognition has become an important field for exploration [6]. Social cognition represents a group of mental operations that include cognitive abilities that are needed to perceive, interpret, and generate responses to others' intentions, emotions, and behaviors [7].

Both basic and social cognitive deficits could be detected with specific neuropsychological and neurophysiological tests. Among these tests is the event-related potentials (ERPs) test, which is a quantitative measurement of neural activity. The P300 is a positive voltage deflection that peaks around 300 ms after the presentation of an infrequent target, novel, or otherwise salient stimulus. P300 amplitude is thought to reflect attentional resource allocation [8], phasic attentional shifts [9], working memory updating of stimulus context [10], or stimulus salience [11]. Its latency is thought to reflect processing speed or efficiency during stimulus evaluation. P3b is the P300 elicited by infrequent task-relevant target stimuli and reflects top–down allocation of attentional resources with a parietal scalp maximum. P3a is the P300 elicited by infrequent task-irrelevant deviant stimuli, which are either novel or otherwise salient [12]. It reflects 'bottom–up' orientation of attentional resources with a frontocentral scalp maximum [13].

Emerging studies suggest that patients with schizophrenia mostly have a reduction in P300 amplitudes compared with controls [14]. In addition, P300 abnormalities showed more reduction in amplitudes and longer latencies in patients with negative profile symptoms than those with positive profile symptoms [15]. On the other hand, another study revealed that P300 amplitudes are reduced in the prodromal stage of schizophrenia and remain even after the appearance of full-blown psychotic symptoms [16].

Previous studies have linked the increase in P300 latency and reduction in P300 amplitude in schizophrenic patients to the basic cognitive deficits that are associated with schizophrenia, mainly attention and working memory. However, to our knowledge, no studies have linked the changes in P300 to impairments in social cognition associated with schizophrenia.

This study aimed at comparing patients suffering from schizophrenia with age-matched and education-matched healthy participants with regard to performance in basic and social cognitive tests and auditory ERP tests as measured by P300.

Moreover, this study aimed at detecting the association between illness variables (age of onset, duration of illness, duration of untreated illness, prominence of positive and/or negative symptoms of schizophrenia) and severity of cognitive decline both socially and nonsocially and the neurophysiological quantitative measurement of cognitive decline as measured by P300 amplitude and latency.

Participants and methods

The present study was an observational, analytic, case–control study with convenient sampling technique conducted in the period from March 2015 to March 2016. An informed written consent (approved by the local scientific and ethics committee of the Department of Psychiatry, Faculty of Medicine, Cairo University) was obtained from all patients participating in the study. A total of 52 participants participated in this study and were divided into two groups. Group A included 27 patients fulfilling the diagnostic criteria for schizophrenia according to the *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., text revised (DSM-IV TR) as assessed by the Structured Clinical Interview for DSM-IV Axis I Disorders. Group B included 25 healthy control participants with negative current and past history of psychiatric disorders and substance abuse/dependence. The control participants volunteered to participate in the study following an announcement made among workers in Kasr Al Ainy Hospital, Faculty of Medicine, Cairo University. Participants aged 18–55 years, of both sexes, who had completed at least 6 years of formal education, and willing to participate in the present study were included. Patients with schizophrenia (group A) were all admitted to the Psychiatry and Addiction Medicine Hospital, Faculty of Medicine, Cairo University. Patients adhered to their antipsychotic medications for at least 6 months before assessment. Patients with substance dependence/abuse in the past 6 months, including opiates, amphetamines, cocaine, hallucinogens, cannabis, organic solvents, benzodiazepines, etc. were excluded. Further, patients treated with electroconvulsive therapy in the past 6 months, aggressive, excited patients, patients

with catatonic features, patients with sensory impairment that may interfere with cognitive testing, patients suffering from organic mental disorders and substance-induced mental disorders, and patients with comorbid medical illnesses that may affect cognitive functions (e.g. diabetes mellitus, terminal organ failure, autoimmune disease, and malignancies) were all excluded.

Participants were subjected to the following assessments:

Neuropsychological assessment

Sociodemographic data

Sociodemographic data including age, sex, marital status, educational level, and occupation were collected.

Structured Clinical Interview for DSM-IV Axis I Disorders [17]

Structured Clinical Interview for DSM-IV Axis I Disorders was used to confirm the diagnosis of 'first-episode psychotic disorder' and exclude the diagnosis of other axis I psychiatric disorders in an objective and structured manner.

Positive and Negative Symptom Scale [18]

It is a rating scale scored by the researcher according to his clinical judgment. Positive and Negative Symptom Scale (PANSS) is used to estimate the severity of psychotic symptoms in patients. The scale has three parts including a positive symptoms scale (P=1–7), a negative symptoms scale (N=1–7), and a general psychopathology scale (G1–16). Each item is rated from 0–6 (absent=0, minimal=1, mild=2, moderate=3, moderately severe=4, severe=5, and extreme=6). The validity and reliability of the PANSS have been established [18]. The scale was applied to the patient group twice, and was used to compare the severity of psychotic symptoms before and after electroconvulsive therapy.

Addenbrook's Cognitive Examination-Revised [19]

Addenbrook's Cognitive Examination-Revised (ACE-R) is a brief cognitive screening instrument that incorporates five subdomain scores (orientation/attention, memory, verbal fluency, language, and visuospatial memory). The ACE-R accomplishes standards of a valid screening test, sensitive to early cognitive dysfunction. Participants of this study (groups A, B) were subjected to cognitive testing using the ACE-R. Evidence suggests that the ACE-R is capable of providing information on a range of cognitive domains and of differentiating well between participants with and without cognitive impairment. Patients scoring less than 82/100 overall ACE-R score were considered to have significant cognitive impairment. An Arabic version was used in this study.

Reading the Mind in the Eye Test [20]

This test is a well-established theory of mind (ToM) tests that consists of 36 gray-scale photos of people taken from magazines. These photos are cropped and rescaled so that only the area around the eyes can be seen. Each photo is surrounded by four mental state terms, and the participant is instructed to choose the word that best describes what the person in the photo is thinking or feeling. Only one of the four items is deemed correct. Participants were instructed to select the most appropriate item within 20 s for each stimulus.

Neurophysiological testing

Cognitive event (auditory)-related potential

Patients participating in this study (groups A and B) were subjected to:

Cognitive ERP (auditory) (P300) tests, which were recorded from the central area of the right and left hemispheres of patients.

Disc electrodes were placed over the scalp after properly cleaning the skin with an adhesive gel. The active electrode was applied at Cz of the 10–20 international system of electrode placement. Both the reference and the ground electrodes were applied to the ear lobule and FPz, respectively.

The settings of the machine were as follows: high cut at 50 Hz, low cut at 0.1 Hz, and sensitivity of 100 UV/division. Electrode impedance was maintained below 5 kΩ. The hearing threshold for each participant was determined, and a total of 200 auditory stimuli (bursts) were presented to the ears through earphones. The traditional two-stimulus oddball was used that presented as an infrequent target in a background of frequent standard stimuli. The patient was instructed to respond mentally and physically by pressing a button to the target stimulus only and not to respond otherwise. Amplitude (μV) of the P300 wave is defined as the difference between the mean prestimulus baseline voltage and the largest positive-going peak of the ERP waveform within a time window. Latency (ms) is defined as the time from stimulus onset to the point of maximum positive amplitude within a time window. Both P300 amplitude and latency represent attentional processing of the target stimulus events, a phenomenon that appears related to memory processing. P300 peak latency is proportional to stimulus evaluation timing, is sensitive to task processing demands, and varies with individual differences in cognitive capability.

Standard electroencephalography

Standard awake electroencephalography (EEG) was performed on patients diagnosed with schizophrenia AQ6

(group B) at the Clinical Neurophysiology Unit, Faculty of Medicine, Cairo University Hospital, using Eb Neuro Galileo machine. Intermittent photic stimulation and hyperventilation were used as provocative techniques. Electrodes were placed according to the 10–20 international system of electrode placement using monopolar and bipolar montages. The EEG machine parameters were adjusted before the recording as follows: time constant 0.3 s, drawing speed 3.0 cm/s, high-filter 75 Hz, and gain 70 µm. The EEG tracings were analyzed carefully with regard to frequency, amplitude, and symmetry of background activity, as well as the presence of any abnormalities. The abnormalities were described as focal, generalized, or focal with secondary generalization. Epileptiform activity was considered lateralized if more than 80% of the discharges originated from one side.

Statistical analysis

Data were coded and processed using the statistical package SPSS, version 16. Data were summarized using mean and SDs, whereas frequencies (%) were used for categorical data. Comparisons between patients and controls were carried out using Student's *t*-test after testing for normality using the Kolmogorov–Smirnov test. On the other hand, Pearson's correlation test was used to study the correlation between different clinical variables.

Results

The two study groups were matched for age (P=0.948), sex (P=0.262), and educational level (P=0.226) as shown in Table 1.

Comparison between the two groups regarding cognitive functions revealed significant differences in ACE total and its subtests measuring attention–orientation, memory, language, visuospatial memory, and Reading the Mind in the Eye Test (RMET) for social cognition scores with patients showing lower scores (P=0.000, 0.012, 0.000, 0.038, 0.041, and 0.001, respectively) as shown in Table 1. The control group had higher amplitude of P300 and shorter latency than patients. Both differences were significant statistically (P=0.003 and 0.005, respectively) as shown in Table 1.

Correlating P300 parameters with both PANSS and cognitive functions in the patient group did not show significant results, except for correlating amplitude with visuospatial memory, which was positive (P=0.015) as seen in Table 2. Concerning illness clinical variables, the PANSS general pathology scale correlated positively with duration of untreated psychosis (P=0.029) and with fluency (P=0.047). However, the PANSS positive scale correlated positively with age of onset of schizophrenia (P=0.027). Other clinical variables did not correlate significantly with PANSS scores as shown in Table 2.

Nine patients (33.33%) showed diffuse slowing in the background EEG activity (background EEG activity≤7 c/s). No epileptogenic abnormalities or any other abnormalities were detected in any of the patients. Intermittent photic stimulation and hyperventilation added no abnormalities.

Discussion

Auditory ERP (P300) studies represent an important field of research that helps better understand the underlying neurophysiological abnormalities in schizophrenia. In addition, a recent study supports the idea that P300 amplitude and P300 latency represent important endophenotypes of schizophrenia, and other studies have concluded that the reduction in P300 amplitude

Table 1 Comparison between patients and controls with regard to demographic, neuropsychological, and neurophysiological data

	Patients (N=27)		Controls (N=25)		P
	Mean	SD	Mean	SD	
Age	33.5556	9.76782	33.4000	6.93421	0.948
Education years	9.3333	3.78357	10.7200	4.43959	0.226
ACE total	85.4815	7.99216	92.3600	4.32897	0.000*
ACE: attention–orientation	16.5926	1.73780	17.5600	0.71181	0.012*
ACE: memory	21.5556	3.16633	24.9600	1.51327	0.000*
ACE: fluency	9.5185	3.08059	10.1200	2.12760	0.420
ACE: language	24.5556	1.64862	25.3600	.95219	0.038*
ACE: visuospatial memory	13.2593	2.28023	14.3600	1.35031	0.041*
Reading the Mind in the Eye Test	16.4815	4.58568	20.2400	3.03150	0.001*
P300 amplitude	9.9630	4.67795	14.8000	6.29815	0.003*
P300 latency	379.56	50.33070	345.16	32.49446	0.005*

ACE, Addenbrook's Cognitive Examination. *P<0.005 is considered significant.

AQ3 **Table 2 Correlation between demographic, neuropsychological, and neurophysiological data in the patients group**

	PANSS positive symptoms	PANSS negative symptoms	PANSS general psychopathology	PANSS total	P300 latency	P300 amplitude
Age						
Pearson's correlation	0.345	0.302	0.281	0.361	0.031	−0.128
Significance (two tailed)	0.078	0.126	0.156	0.064	0.878	0.524
N	27	27	27	27	27	27
Age of onset						
Pearson's correlation	0.424*	0.142	0.193	0.295	−0.028	−0.136
Significance (two tailed)	**0.027**	0.481	0.336	0.135	0.891	0.500
N	27	27	27	27	27	27
Duration of illness						
Pearson's correlation	0.150	0.283	0.250	0.270	0.146	−0.067
Significance (two tailed)	0.454	0.153	0.208	0.174	0.468	0.739
N	27	27	27	27	27	27
Duration of untreated psychosis						
Pearson's correlation	0.145	−0.102	0.421*	0.242	0.131	−0.263
Significance (two tailed)	0.469	0.613	**0.029**	0.224	0.513	0.185
N	27	27	27	27	27	27
ACE: total						
Pearson's correlation	−0.094	−0.124	0.282	0.077	0.027	0.245
Significance (two tailed)	0.643	0.538	0.154	0.703	0.894	0.217
N	27	27	27	27	27	27
ACE: attention–orientation						
Pearson's correlation	−0.161	−0.116	0.090	−0.045	0.250	0.055
Significance (two tailed)	0.423	0.563	0.656	0.822	0.208	0.786
N	27	27	27	27	27	27
ACE: memory						
Pearson's correlation	−0.042	0.044	0.082	0.041	0.110	−0.074
Significance (two tailed)	0.835	0.829	0.684	0.839	0.584	0.714
N	27	27	27	27	27	27
ACE: fluency						
Pearson's correlation	0.037	0.021	0.385*	0.221	0.016	0.268
Significance (two tailed)	0.853	0.918	**0.047**	0.267	0.935	0.176
N	27	27	27	27	27	27
ACE: language						
Pearson's correlation	−0.171	−0.339	0.004	−0.161	0.008	0.132
Significance (two tailed)	0.395	0.083	0.985	0.422	0.968	0.510
N	27	27	27	27	27	27
ACE: visuospatial memory						
Pearson's correlation	−0.074	−0.189	0.283	0.065	−0.277	0.462*
Significance (two tailed)	0.714	0.345	0.153	0.748	0.161	**0.015**
N	27	27	27	27	27	27
Reading the Mind in the Eye Test						
Pearson's correlation	0.260	−0.143	0.341	0.229	0.183	0.320
Significance (two tailed)	0.190	0.477	0.082	0.251	0.360	0.104
N	27	27	27	27	27	27

ACE, Addenbrook's Cognitive Examination; PANSS, Positive and Negative Symptom Scale. *$P<0.005$ is considered significant.

may be used as a marker of an early-onset variant of schizophrenia [21,22].

Our study aimed to investigate the relationship between basic and social cognitive performance from one side and auditory ERPs as measured by P300 in patients with schizophrenia compared with healthy controls.

Data from the present study showed that both groups were well matched for age, sex, and education. However, there were higher percentages of unemployed and unmarried patients in the schizophrenia group. In fact, most of western studies report a rate of employment in schizophrenia patients between 10 and 20% [23]. These findings indicate that the patients of this sample were chronically ill and had a relatively high level of functional impairment. This may be attributed to the cognitive deficits present in schizophrenia, especially because unemployment represents one of the important baseline predictors of impaired cognitive functioning [24].

In this study, patients with schizophrenia showed poorer performance than controls in neurocognitive assessment (ACE-R). There were statistically significant differences between the mean scores of total and the cognitive subtests measuring attention–orientation, memory, language, and visuospatial memory (Table 1). These results are concordant with the results of a meta-analysis conducted to assess cognitive functioning in schizophrenia, where patients with schizophrenia showed a statistically significant poorer performance than controls on tests applied to assess working memory, attention, and executive functions [25].

With regard to social cognitive performance, patients with schizophrenia showed poorer performance than healthy controls on the RMET with a mean score of 16.48, which is consistent with the study conducted by Bora *et al.* [26] in which the mean score was 16.2. The above results support that social cognitive dysfunctions in schizophrenia are well-established findings, and patients with schizophrenia show impaired performance on measures evaluating several domains of social cognition, especially ToM [27–29].

As for P300 parameters, our study showed that there was smaller amplitude and longer latency in patients with schizophrenia compared with normal controls; this is consistent with the results of the meta-analysis conducted to investigate the difference between P300 ERP in patients with schizophrenia and healthy controls. Moreover, they concluded that there was a relationship between the decrease of P300 latency and the duration of illness [30]. In addition, similar findings have been concluded from a study conducted on an Egyptian sample comprised of 58 first-episode patients with schizophrenia and 53 controls [31].

No significant correlations were found between P300 parameters and cognitive functions in the patient group, except for a correlation between amplitude and visuospatial memory. This result may be in agreement with Gaspar *et al.* [32] who found that P300 amplitude is insensitive to working memory load in schizophrenia.

Extended latency and lower amplitude of the P300 wave were linked to patients with mild cognitive impairment [33].

To our knowledge, this study is the first to investigate the relationship between P300 parameters and social cognition in patients with schizophrenia. However, previous studies have reported changes in P300 to be related to social cognition component. The P300 was sensitive to participants' explicit categorization task and also revealed implicit categorization along the non-task-relevant dimension [34]. In addition, Bartholow *et al.* [35] reported that P300 amplitude was enhanced to sentences containing definitional as well as stereotypical incongruities with similar effects on P300 amplitude during processing of racial stereotype-incongruent trait words in a sequential priming task.

The present study has certain limitations. First, the study had a relatively small sample size. Second, the patients of the schizophrenia group were all under antipsychotic medications. In fact, studies investigating the effects of antipsychotics on P300 parameters are not well established and showed contradictory results. Some studies concluded that both P300 latency and amplitude were significantly enhanced following treatment [36,37]. Other meta-analyses show that there is no relationship between P300 amplitude effect size and antipsychotic medications [30]. Third, this study used only RMET as a measure for social cognition, which assesses mainly ToM, and did not investigate all the domains of social cognition that could be affected and associated with ERP abnormalities. Finally, intelligence of both groups should have been assessed to ensure that both groups are not different with respect to IQ.

Conclusion

In summary, this study replicates the findings of several studies that indicate the presence of social and nonsocial cognitive dysfunctions together with the presence of ERP abnormalities in the P300 amplitude and latency in schizophrenia. The relationship between ERPs and cognitive performance needs further investigation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Sharif-Razi M, Rabin MA, George TP. Schizophrenia, neurocognitive dysfunction, and substance-related disorders: a review. Psychiatr Times 2013; XX:XX–XX. AQ8

2 Nuechterlein KH, Barch DM, Gold JM, Goldberg TE, Green MF, Heaton RK. Identification of separable cognitive factors in schizophrenia. Schizophr Res 2004; 72:29–39.

3 Russell AJ, Munro JC, Jones PB, Hemsley DR, Murray RM. Schizophrenia and the myth of intellectual decline. Am J Psychiatry 1997; 154: 635–639.

4 Bowie CR, Reichenberg A, Patterson TL, Heaton RK, Harvey PD. Determinants of real-world functional performance in schizophrenia subjects: correlations with cognition, functional capacity, and symptoms. Am J Psychiatry 2006; 163:418–425.

5 Green MF. What are the functional consequences of neurocognitive deficits in schizophrenia? Am J Psychiatry 1996; 153:321–330.

6 MacLin MK. Social cognition: making sense of people. Kunda Z, editor. A Bradford book. Cambridge, MA: The MIT Press; 1999:602.

7 Green MF, Olivier B, Crawley JN, Penn DL, Silverstein S. Social cognition in schizophrenia: recommendations from the measurement and treatment research to improve cognition in schizophrenia new approaches conference. Schizophr Bull 2005; 31:882–887.

8 Polich J. Habituation of P300 from auditory stimuli. Psychobiology 1989; 17:19–28.

9 Soltani M, Knight RT. Neural origins of the P300. Crit Rev Neurobiol 2000; 14:199–224.

10 Donchin E, Coles MGH. Is the P300 component a manifestation of context updating? Behav Brain Sci 1988; 11:357–374.

11 Sutton S, Braren M, Zubin J, John ER. Evoked-potential correlates of stimulus uncertainty. Science (New York, NY) 1965; 150:1187–1188.

12 Friedman D, Cycowicz YM, Gaeta H. The novelty P3: an event-related brain potential (ERP) sign of the brain's evaluation of novelty. Neurosci Biobehav Rev 2001; 25:355–373.

13 Polich J. Updating P300: an integrative theory of P3a and P3b. Clin Neurophysiol 2007; 118:2128–2148.

14 Arnfred SM. Exploration of auditory P50 gating in schizophrenia by way of difference waves. Behav Brain Funct 2006; 2:1–6.

15 Liu Z, Tam WC, Xue Z, Yao S, Wu D. Positive and negative symptom profile schizophrenia and abnormalities in the P300 component of the event-related potential: a longitudinal controlled study. Psychiatry Res 2004; 132:131–139.

16 Ozgurdal S, Gudlowski Y, Witthaus H, Kawohl W, Uhl I, Hauser M, *et al.* Reduction of auditory event-related P300 amplitude in subjects with at-risk mental state for schizophrenia. Schizophr Res 2008; 105:272–278.

17 First MB, Gibbon M, Williams JBW, Benjamin LS. Structured Clinical Interview for DSM-IV Axis I Disorders (SCID I). New York, NY: Biometric Research Department; 1994.

18 Kay SR, Fiszbein A, Opler LA. The positive and negative syndrome scale (PANSS) for schizophrenia. Schizophr Bull 1987; 13:261–276.

19 Mioshi E, Dawson K, Mitchell J, Arnold R, Hodges JR. The Addenbrooke's Cognitive Examination Revised (ACE-R): a brief cognitive test battery for dementia screening. Int J Geriatr Psychiatry 2006; 21:1078–1085.

20 Baron-Cohen S, Jolliffe T, Mortimore C, Robertson M. Another advanced test of theory of mind: evidence from very high functioning adults with autism or Asperger syndrome. J Child Psychol Psychiatry 1997; 38:813–822.

21 Earls HA, Curran T, Mittal V. A meta-analytic review of auditory event-related potential components as endophenotypes for schizophrenia: perspectives from first-degree relatives. Schizophr Bull. 2016; 42:1504–1516.

22 Mathalon DH, Ford JM, Rosenbloom M, Pfefferbaum A. P300 reduction and prolongation with illness duration in schizophrenia. Biol Psychiatry 2000; 47:413–427.

23 Marwaha S, Johnson S. Schizophrenia and employment – a review. Soc Psychiatry Psychiatr Epidemiol 2004; 39:337–349.

24 Bergh S, Hjorthoj C, Sorensen HJ, Fagerlund B, Austin S, Secher RG, *et al.* Predictors and longitudinal course of cognitive functioning in schizophrenia spectrum disorders, 10 years after baseline: the OPUS study. Schizophr Res 2016; 175:57–63.

25 Fioravanti M, Bianchi V, Cinti ME. Cognitive deficits in schizophrenia: an updated metanalysis of the scientific evidence. BMC Psychiatry 2012; 12:64.

26 Bora E, Eryavuz A, Kayahan B, Sungu G, Veznedaroglu B. Social functioning, theory of mind and neurocognition in outpatients with schizophrenia; mental state decoding may be a better predictor of social functioning than mental state reasoning. Psychiatry Res 2006; 145:95–103.

27 Brune M. 'Theory of mind' in schizophrenia: a review of the literature. Schizophr Bull 2005; 31:21–42.

28 Green MF, Horan WP. Social cognition in schizophrenia. Curr Direct Psychol Sci 2010; 19:243–248.

29 Sprong M, Schothorst P, Vos E, Hox J, van Engeland H. Theory of mind in schizophrenia: meta-analysis. Br J Psychiatry 2007; 191:5–13.

30 Jeon YW, Polich J. Meta-analysis of P300 and schizophrenia: patients, paradigms, and practical implications. Psychophysiology 2003; 40:684–701.

31 Fawzy N, Gado O, Abdalla AM, Ibrahim WM. Auditory mismatch negativity, P300, and disability among first episode schizophrenia patients without auditory hallucinations. Egypt J Psychiatry 2015; 36:112–117.

32 Gaspar PA, Ruiz S, Zamorano F, Altayo M, Perez C, Bosman CA, *et al.* P300 amplitude is insensitive to working memory load in schizophrenia. BMC Psychiatry 2011; 11:29.

33 Medvidovic S, Titlic M, Maras-Simunic M. P300 evoked potential in patients with mild cognitive impairment. Acta Inform Med 2013; 21:89–92.

34 Ito TA, Cacioppo JT Electrophysiological evidence of implicit and explicit categorization processes. J Exp Soc Psychol 2000; 36:660–676.

35 Bartholow BD, Dickter CL, Sestir MA. Stereotype activation and control of race bias: cognitive control of inhibition and its impairment by alcohol. J Pers Soc Psychol 2006; 90:272–287.

36 Iwanami A, Okajima Y, Isono H, Shinoda J, Kasai K, Hata A, *et al.* Effects of risperidone on event-related potentials in schizophrenic patients. Pharmacopsychiatry 2001; 34:73–79.

37 Umbricht D, Javitt D, Novak G, Bates J, Pollack S, Lieberman J, *et al.* Effects of risperidone on auditory event-related potentials in schizophrenia. Int J Neuropsychopharmacol 1999; 2:299–304.

Author Queries???

AQ1: A running head short title was not supplied; please check if this one is suitable and, if not, please supply a short title of up to 40 characters that can be used instead.

AQ2: Please confirm whether the changes (shaded values given For P values are not allowed as per style) made to Tables [1 and 2] are correct.

AQ3: Please provide the significance of bold values in Table [2].

AQ4: Please confirm only one E-mail address per style.

AQ5: Please provide fax details for corresponding author.

AQ6: Please check and confirm whether the changes made to the unit '70 μm' in the section 'Standard electroencephalography' is correct.

AQ7: Please give manufacturer information for 'Eb Neuro Galileo machine, SPSS': company name, town, state (if USA), and country.

AQ8: Please provide the volume and page range for reference [1].