

Research in China on event-related potentials in patients with schizophrenia

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Abstract: Event-related potentials (ERPs) are objective electrophysiological indicators that can be used to assess cognitive processes in the human brain. Psychiatric researchers in China have applied this method to study schizophrenia since the early 1980s. ERP measures used in the study of schizophrenia include contingent negative variation (CNV), P300, mismatch negativity (MMN), error-related negativity (ERN) and auditory P50 inhibition. This review summarizes the main findings of ERP research in patients with schizophrenia reported by Chinese investigators.

1. Introduction

Event-related potentials (ERPs) are neuroelectrophysiological phenomena that reflect the cognitive activities of the brain. The methods for assessing ERPs are relatively simple and inexpensive. Researchers in China used this method to study schizophrenia starting in 1982. Searches of Pubmed, the Database of Chinese Technical Periodicals (VIP), the Wanfang Data System, and the Qikanchina.net system, identified 173 papers about ERPs in schizophrenia by mainland Chinese authors, including nine papers published in English. In China, ERPs used in the study of schizophrenia include contingent negative variation (CNV); P300; Mismatch negativity (MMN); N400; error-related negativity (ERN); and auditory P50 inhibition. Among these ERPs, P300 and auditory P50 inhibition are used most widely. The present review summarizes the ERP studies in schizophrenia from China focusing on the work with P300 and auditory P50 inhibition.

2. CNV

When recording CNV, the combined sequential warning-command stimuli consists of a pure sound as a warning stimulus (S1) and a flashing light as a command stimulus (S2) 1-2s after S1. After receiving S1, the subject is alerted to S2 and presses the button after S2. After S1, a series of negative deflection potentials are recorded on the scalp; the potential switches to positive after the subject presses the button to stop S2 and subsequently returns to baseline. The continuous negative deflection potential between S1 and S2, the CNV, reflects the psychological preparation activities of the subject. This measure is closely correlated with psychological activities such as anticipation, attention, arousal, memory, motivation, preparation and decision; it is a composite wave that reflects the psychological activities during increased cognitive load.

CNV was the first ERP used in the study of schizophrenia. In 1982, Jiang and colleagues used paired sound and light stimuli to evoke CNV and found that the variance in the CNV wave was greater in patients with schizophrenia, that the maximum potential of CNV waveforms were 28% decreased compared to those in normal subjects, and that the post-imperative negative variation (PINV) was prolonged. Subsequent studies found that treatment of the disease was associated with more stable CNV waveforms and increased amplitude of the CNV waveform. Zhang and colleagues studied children with schizophrenia and also found delayed latency of CNV at starting point A, a decreased average amplitude of CNV waveforms, and a prolonged PINV. But eight weeks of treatment with olanzapine did not significantly improve these parameters. Thus the ability of antipsychotic treatment to improve the characteristics of CNV in patients with schizophrenia remains uncertain.

3. P300

P300 is the positive composite electric potential recorded at the late stage of the testing period (the peak occurs about 300ms after presenting the stimuli) when the subject identifies a target stimulus from among a large number of non-target stimuli. For P300 to occur, the subject must actively monitor the target
stimuli and remember the number of times the stimulus occurs or react to each occurrence of the stimulus by pressing a key. P300 reflects the participation of selective attention in the process of the context-dependent learning.

Reports about the application of P300 account for more than 50% of ERP studies in schizophrenia in China. The most common method of evoking P300 employed is the auditory oddball method, but visual oddball,[5] somatosensory oddball,[6] and working memory assignment[7,8] methods are also employed. In addition to the latency and amplitude of P300, other indices such as N1, P2 and N2 are also considered. The subjects of the studies include patients in acute and residual phases of schizophrenia as well as sick children,[8] older patients[9] and high-risk populations.[10, 11] Recently, these studies have often included patients in their first episode of schizophrenia.

Similar to reports from other countries, reports on P300 latency in patients with schizophrenia in China have been inconsistent. Some studies find significantly increased P300 latency compared to controls[12] and other studies[13] find no significant difference. Also like international studies, almost all studies about the P300 amplitude reported from China find a significantly decreased P300 amplitude in both the acute and residual phases of illness compared to normal controls.

Multiple-channel recordings highlight the asymmetry of the P300 topograph among patients with schizophrenia.[14] Wu and colleagues[15] reported a relationship between P300 topography, clinical signs, and therapeutic effect: among patients with prominent negative symptoms they found significant post-treatment improvements in the P300 in the prefrontal region, the bilateral central region and the right parietal region but among patients with prominent positive symptoms post-treatment improvement was only seen in the left temporal region. Zhuang and colleagues[16] reported that the changes in the P300 topograph in patients with schizophrenia were predominantly in the left temporal region.[16] To address the problem of distortion of the EEG through skull transduction, Wang and colleagues[13] combined a 64-channel high-density EEG recording with an EEG source localization technique (i.e., low-resolution electromagnetic tomography, LORETA) to compare the auditory P300 of 19 first-episode, drug-naive patients with schizophrenia to that of 25 healthy volunteers. They found marked asymmetry in the bilateral hemispheric localization of P300 in the patient group: the 29 voxels with significant differences in the current density of P300 were concentrated in the left insula, left superior temporal gyrus and left postcentral gyrus. These findings suggest that the neural structures related to reduced P300 amplitude in first-episode schizophrenia are located in the left superior temporal gyrus and adjacent regions.[13]

3.1 P300 as a marker of cognitive functioning

P300 is considered an objective marker of cognitive functioning. Several researchers have assessed the relationship of neuropsychological test results and P300 in patients with schizophrenia. Sun and colleagues[17,18] reported that both the amplitude of P300 and overall intelligence were lower in patients with schizophrenia than in normal controls, that the P300 latency in the patient group was negatively correlated with both verbal and performance IQ, and that the P300 amplitude was positively correlated with verbal IQ and total IQ. Jie and colleagues[19] studied patients with chronic schizophrenia and found that P300 latency was negatively correlated with performance IQ and with the frequency of both perseverative and non-perseverative errors; they also found that the P300 amplitude was positively correlated with short-term memory and with the frequency of non-perseverative errors. Peng and colleagues[20] compared P300 findings with results of the Matrics Consensus Cognitive Battery in patients with chronic schizophrenia and found that P300 latency at the Pz location was negatively correlated with symbol coding and with maze and visual memory while P300 amplitude was positively correlated with symbol coding, spatial span, and visual memory.

Zhao and colleagues[7] recorded P300 while testing working memory in patients with schizophrenia by assigning them delay-match and n-back tasks. During the coding phase the N1 and P2 waves in patients were lower than in controls but the P300 wave was higher in patients. During the retrieval phase the P1, N1 and P2 waves were lower in the patients group than in the control group but the P300 wave was higher and the latency period was longer. They hypothesized that the increase of P300 amplitude in the prefrontal-central region of patients was the result of decreased efficiency of working memory.[7] A study by Wang and colleagues[21] supported this finding: they found that the P300 peak in the central region of patients was significantly higher than that of controls when performing the n-back task at three different levels, and that the P3 peak in the parietal region of patients was significantly higher than that of controls when performing the 2-back task, suggesting that there was working memory damage in patients. The damages to short-term storage capabilities may be related to the low physiological efficiency in the parietal lobe and to the decreased storage volume available for working memory.[21]

3.2 P300 and psychopathological symptoms

Many researchers have reported that the abnormal P300 in patients was closely associated with negative symptoms. Liu and colleagues[22] classified patients with schizophrenia according to the PANSS score and found that patients with predominantly negative symptoms had prolonged latency and reduced amplitude of P300.
Comparison of P300 in patients with predominantly positive symptoms versus those with predominantly negative symptoms found longer latency in the N1, P2, N2 and P3 waves and a decreased amplitude of the P300 in the negative symptom group. Peng and colleagues reported that compared to a normal group, the P300 amplitudes in all three symptomatic subtypes of patients (predominantly negative, positive, or mixed symptoms) were significantly reduced but the P300 latency was only significantly prolonged in the negative symptom group.

The correlation between P300 and positive symptoms such as auditory hallucinations and aggressive behavior has also been studied. Compared to patients without auditory hallucinations, those with auditory hallucinations have prolonged P300 latency and decreased amplitude of the P300 wave. Moreover, the score for auditory hallucinations was positively correlated with P300 latency and negatively correlated with the amplitude of the P300 wave. Other researchers reported that the difference of P300 amplitude between patients with and without auditory hallucinations was greatest in the left temporal lobe. Previous studies using the Modified Overt Aggression Scale (MOAS) found that compared to male patients with schizophrenia without a history of aggressive behavior those with a history of aggression had delayed P300 and a decreased P300 amplitude in the central parietal region, suggesting that patients with aggressive behaviors suffer more severe cognitive dysfunction.

### 3.3 P300 and other biological indices

Previous studies investigated the correlation between the P300 and exploratory eye movements in patients with schizophrenia. Du and colleagues reported that the latencies of N2 and P3 waves in patients were negatively correlated with the ‘number of eye fixation’ score (NEF) and with the ‘responsive search score’ (RSS) while the P3 amplitude was positively correlated with NEF and RSS. Another study reported a 76.2% concordance between abnormal P300 and abnormal exploratory eye movement parameters.

Serum homocysteine (Hcy) and nerve growth factor (NGF) are believed to be involved in the regulation of cognitive functioning in patients with schizophrenia. Several studies report that serum Hcy is increased in patients in their first episode of schizophrenia, negatively correlated with the amplitude of P300 at Fz, and positively correlated with P300 latency at Pz; this supports hypotheses about the link between imbalances in Hcy metabolism and cognitive dysfunction in patients with schizophrenia. Serum NGF levels in first-episode patients with schizophrenia are significantly decreased and positively correlated with the amplitude of P300 at Fz; this suggests that NGF may be involved in the modulation of P300 in patients with schizophrenia.

The effect of genetic factors on the P300 in patients with schizophrenia has been a recent research focus. Shi and colleagues assessed P300 in 60 unmedicated patients and found that the latencies at Cz and Pz were related to the functional polymorphism Arg38Gln of neuregulin 1 (NRG-1): the latencies of individuals with the Arg/Arg or Arg/Gln genotype were longer than the latencies of those with the Gln/Gln genotype. Wang and colleagues studied the genes related to dopamine metabolism and found that the combined action of two single nucleotide polymorphisms (SNPs) in the intron of catechol-O-methyltransferase (COMT) and aldehyde dehydrogenase 3B1 (ALDH3B1) are associated with increased susceptibility to paranoid schizophrenia and with the P300 latency in both patients and healthy individuals. In a study of 540 patients with paranoid schizophrenia and 660 healthy individuals they found that the rs4633-T allele of COMT was associated with susceptibility to paranoid schizophrenia, hallucinations and delayed P300 latency in individuals who had the rs3751082-A allele of the ALDH3B1 gene but not in individuals carrying the rs3751082 G/G allele of the ALDH3B1 gene.

### 3.4 The effect of different types of interventions on P300

Wang and colleagues assessed changes in P300 latency and amplitude during the course of treatment in patients with schizophrenia and in patients with depression. They found improvement in clinical status in the patients with schizophrenia was associated with few changes in P300, but in patients with depression symptomatic improvement following antidepressant treatment was associated with shortened latency and increased amplitude of the P300. Yu and colleagues followed patients with schizophrenia and depression for two years; both had abnormal P300 during the acute phase of the illness that resolved over time in the depressed patients but not in the patients with schizophrenia, suggesting that the P300 abnormalities in schizophrenia are stable over time. This was confirmed in subsequent studies among patients with schizophrenia that found no differences in P300 amplitude and latency before and after treatment with medication. However, other studies that followed up first-episode patients report that changes in the amplitude of P2 and P3 are associated with changes in the clinical status of the patient.

Many studies compare the effect of different antipsychotic medications on the P300 of patients with schizophrenia. Most of these studies find little difference between the different medications: risperidone versus quetiapine, risperidone versus chloridremazine, risperidone versus chlorpromazine, risperidone versus quetiapine, aripiprazole versus quetiapine, and olanzapine versus risperidone. There are, however, some studies that report a relative beneficial
effect on P300 of treatment with risperidone or aripiprazole.\textsuperscript{46-48} Tang and colleagues compared the effect of risperidone and chlorpromazine on the P300 of patients with schizophrenia and found that although risperidone was superior to chlorpromazine in terms of neurocognitive functioning (assessed using the Wechsler Memory Scale), there was no significant difference between the two groups in P300.\textsuperscript{42,49} Other studies compare the effects of different dosages of clozapine on the P300: Liu and colleagues\textsuperscript{50} divided 87 patients with schizophrenia into three groups and treated them with high, medium and low dosages of clozapine for six weeks; only the high dose group showed a significant increase in the amplitude of P300. Zhou and colleagues\textsuperscript{51} treated 30 children 6-15 years of age with a diagnosis of schizophrenia with olanzapine for 8 weeks and found that the P300 latency at Pz was shortened and the amplitude of the P300 at Fz, Cz, Pz and Oz were increased with treatment.

The effect of antipsychotic medications on the P300 of first-episode patients may be affected by the duration of untreated psychosis (DUP). Wang and colleagues\textsuperscript{52} divided 18 drug-naïve patients into a short DUP group (n=8) who had less than 2 years of untreated psychosis and a long DUP group (n=10) with more than 2 years of untreated psychosis. The P300 amplitude in both groups was less than in a normal control group but after 2 months of treatment the short DUP group showed significant improvement in the P300 amplitude in both hemispheres while in the long DUP group the P300 amplitude in the left tempo-frontal gyrus showed no improvement.\textsuperscript{52} To confirm the results from this relatively small sample the author increased the sample to 70 individuals, used the Nottingham Onset Schedule to assess the duration of the DUP, and divided the long and short DUP groups by the median value of the DUP; based on the results of the 50 patients who completed two months of drug treatment, the improvement in the amplitude of P300 was only seen in the short DUP group.\textsuperscript{53}

Other researchers have investigated the effect of other, non-antipsychotic medications on the P300 in patients with schizophrenia. Venlafaxine has been shown to partially improve the P300 in patients with chronic schizophrenia in the residual phase of illness.\textsuperscript{54} Gao and colleagues\textsuperscript{55} randomly divided 67 female patients with schizophrenia being treated with risperidone into an intervention group (n=32) that received adjunctive treatment with conjugated estrogen (0.625 mg/day) and a control group (n=35) that received no adjunctive treatment; after three months of treatment they found that the intervention group had significantly decreased latency and significantly greater wave amplitude of the P300 in the Cz and Pz locations. Han and colleagues\textsuperscript{56} compared the P300 results for 36 patients receiving modified ECT and a control group taking medication; after 1-2 weeks of mECT therapy there was already a decrease in the latency at P3 and N2-P3 and an increase in the P300 amplitude at N2-P3, but the changes in the medication-alone control group did not appear until the 8th week of treatment; suggesting the mECT is more rapidly effective on P300 than medication. Gao and colleagues\textsuperscript{57} compared the effect of five consecutive days of treatment with repetitive transcranial magnetic stimulation (rTMS) in the prefrontal lobe on 21 male patients with schizophrenia to that of sham rTMS on 22 patients and found that rTMS increases serum prolactin and increases the amplitude of the P300 at the P2 and P3 locations.

4. Mismatched negativity (MMN)

When a series of standardized stimuli are presented the occasional occurrence of a variant will be unconsciously processed without the involvement of active attention. MMN is the ERP reflecting the automatic (i.e., pre-attentional) processing of variant stimuli; it is a negative deflection with a latency of 150-250 ms which is considered the pre-attention component of ERP.

Lou and colleagues\textsuperscript{58} compared the MMN in 45 patients in their first episode of schizophrenia with 40 healthy controls and followed the changes in MMN in the patient group after 5 weeks of treatment and after 12 weeks of treatment. They found longer latencies and lower amplitudes of the MMN in the patient group, a negative correlation between the amplitude of the MMN and the PANSS score in the patient group, and decreased latency and increased amplitude of the MMN after 12 weeks of treatment. Zhou and colleagues\textsuperscript{59} compared 23 children aged 6-15 with a diagnosis of schizophrenia to 23 normal children of the same age and found that MMN waves had a decreased amplitude in the patient group which increased after eight weeks of treatment. These studies show that the abnormalities of MMN in patients with schizophrenia are reduced as symptoms improve with treatment. The findings of Peng and colleagues,\textsuperscript{60} who reported that changes in the MMN wave in patients with schizophrenia treated with risperidone show a negative correlation with changes in the score on the PANSS, suggest that the MMN may be a viable biological marker for treatment effect.

5. N400

N400 is a negative wave component that occurs 400 ms after stimulation. Unexpected words or sentences are used to evoke N400; for example, if the last word ‘coffee’ in the sentence ‘Every morning I drink a cup of coffee.’ was changed into ‘stocking’, the word stocking would evoke a clear negative wave with a peak at about 400 ms after the stimulus, the N400 wave. The N400 is used to study disordered thinking in patients with schizophrenia.

Zhang and colleagues\textsuperscript{61} studied the N400 using
a semantic categorization task in 19 patients with schizophrenia and a control group. They found that in both groups the negative ERP at 300-600 ms after the stimuli was greater in amplitude when unrelated stimuli were presented but in the patient group the amplitude of the N400 when related stimuli were presented was greater than in the control group, suggesting that patients have a disorder in the management of linguistic information. Recently, Chen and colleagues [62,63] compared the N400 (evoked by presenting Chinese idioms with correct and incorrect final words) in 56 patients with first-episode schizophrenia to those of 62 health controls. They found that (a) the N400 latencies in the Cz, Pz and Fz were significantly delayed in the patient group and the N400 amplitudes at the three locations were significantly reduced; (b) in the patient group the N400 latency was positively correlated with PANSS scores while the N400 amplitude was negatively correlated with PANSS score; (c) in the patient group after three months of treatment with risperidone the N400 latency was decreased and the N400 amplitude was increased, suggesting that the N400 is a ‘state marker’ in schizophrenia that changes as the clinical status changes. Similarly, Zhu and colleagues [64] found that the delayed latency and decreased amplitude of N400 at Pz in patients with schizophrenia were partially improved following treatment with combined olanzapine and brainwave therapy.

6. Error-related negativity (ERN)

ERN is a negative deflection potential that occurs at the time of making a mistake that can be recorded in the prefrontal area. ERN reflects a high-level cognitive function—the self-monitoring mechanism of the brain to react to incorrect behaviors. Patients with schizophrenia have several kinds of errors in their thinking and behavior; lack of insight is a common erroneous cognition that suggests the presence of disorders in the self-monitoring mechanism. Chinese researchers have used the visual stimulation model developed by Eriksen Flanker to evoke ERN in patients with schizophrenia: Tang and colleagues [65] compared 16 first-episode patients with 25 healthy persons and found that ERN latency was delayed and ERN amplitude was decreased in the patient group; using the LORETA analysis methods they were able to determine that the significant reduction in activity in the patient group occurred in the insular, superior temporal gyrus, middle temporal gyrus and inferior parietal lobule. [65] Yang and colleagues [66] compared the ERN between patients with schizophrenia, patients with obsessive compulsive disorder and controls; they found that compared to controls the amplitude of the ERN was significantly lower in patients with schizophrenia and significantly greater in patients with obsessive compulsive disorder, suggesting that the ERN measure could be used to assist in the differentiation of these two mental disorders.

7. Auditory P50 inhibition

The most basic and simplest mechanism used by the central nervous system to deal with overwhelming external stimuli is gating or filtering, generally called ‘sensory gating’ (SG). This mechanism greatly reduces the individual’s response to low-information stimuli and maintains the individual’s sensitivity to high-information stimuli. Deficits in the SG in patients with schizophrenia may be related to the wide range of cognitive symptoms that occur in these patients. SG is primarily evaluated using auditory P50 inhibition that is evoked by the condition and testing stimulus paradigm or the stimulus train paradigm. Some researchers [68,69] have compared these two paradigms and found that in both patients and controls the results of the two methods are not highly correlated (i.e., the results vary). Since the majority of researchers employ the conditioning and testing stimulus paradigm to evoke auditory P50 inhibition, we will limit our discussion to this method.

Because the study of SG started much later in China than elsewhere, most of the available studies focus on patients in their first episode of illness. Almost all studies report that compared to the results in healthy controls the amplitude of S1-P50 is decreased in patients with schizophrenia and the amplitude of S2-P50 is increased. So the S2/S1 ratio is increased and the S1-S2 difference is decreased. But none of these SG indices are correlated with clinical measures such as the PANSS score. [68-73] There is no significant difference in the latencies of S1 and S2 between patients and controls. [72-74] Wang and colleagues [75] found similar results in a study that compared SG P50 between 137 patients with schizophrenia who were clinically stable and 153 healthy controls. Su and colleagues [76] evaluated the ability of the S2/S1 ratio from the auditory P50 inhibition assessment to differentiate 56 patients with schizophrenia from 22 healthy controls: the area under the ROC curve of the ratio was 0.743; when using 34 as the cut-off point the sensitivity was 96.4% and the specificity was 45.5%; when using 50 as the cut-off point the sensitivity was 80.4% and the specificity was 50.0%. These results suggest that the S2/S1 ratio may help in the differential diagnosis of schizophrenia.

Treatment studies and studies with first degree relatives support the suggestion that decrements in auditory P50 inhibition is a stable biological marker of schizophrenia. Several treatment studies lasting three months or longer with multiple assessments of auditory P50 inhibition [77-79] and employing a variety of antipsychotic medications (chlorpromazine [79], sulpiride, [80] risperidone, [80-82] and clozapine) [79, 80] consistently report no significant improvement in auditory P50 inhibition with treatment. The sole exception was with clozapine in which one study [80] found no improvement in auditory P50 inhibition with treatment and another study [79] did report improvement.
In 2011 Chen and colleagues[74] divided 56 male first-degree relatives of patients with schizophrenia, suggesting that it may be a marker for susceptibility to the disorder.

Finally, researchers from many countries have been interested in the high rate of smoking among individuals with schizophrenia, often 2-fold to 4-fold higher than in community members. In the 1990’s, Alder and colleagues[84] reported that smoking or nicotine could temporarily improve the SG functioning of patients with schizophrenia, but there had been no studies about the long-term effects of smoking on SG functioning. In 2011 Chen and colleagues[83] divided 56 male first-episode, drug-naive patients with schizophrenia into a prior smoker group (n=18) and a non-smoker group (n=38); using the conditioning and testing stimulus paradigm to test the auditory P50 inhibition (while prohibiting smoking in the hour prior to testing to exclude the acute effect of smoking) they found that the amplitude of the S1 was significantly higher in the smoker group than in the non-smoker group and the S2/S1 ratio was significantly lower (similar to the ratio in normal controls), suggesting that smoking has a partial therapeutic effect in ameliorating the SG deficits of patients.

8. Future directions

There is a long history of studying electrophysiological indices like ERPs in patients with schizophrenia. The impression of clinicians is that these methods lack disease-specificity and are difficult to use to determine the diagnosis and prognosis of individual patients. The main reason for this is that schizophrenia is a very complicated disease with substantial heterogeneity while ERP is a relatively simple index.

Currently, ERP is usually used in clarifying the underlying pathophysiological mechanisms of schizophrenia, particularly those related to cognitive deficits. Schizophrenia is one kind of cognitive disorder in which many complicated clinical symptoms result from the abnormal processing of the information produced by sensory stimuli. Positive signs may be related to the brain’s inability to control or filter normal information; negative symptoms reflect an inability to integrate emotion, motivation, perception and cognition. In neuropsychological tests stimuli are the inputs, observed behaviors are the outputs, and the brain is the ‘black box’ that needs to be understood. Electrophysiological indices like ERPs can help clarify what goes on in the black box; that is, how the brain responds to the sensory stimuli, integrates the information, and initiates a response. Therefore, ERPs are very helpful in understanding the pathophysiological mechanisms associated with the cognitive processing in patients with schizophrenia. It is the essential technology needed to understand the long pathway between the very minor structural abnormalities in the brain to the prominent clinical symptoms observed in persons with schizophrenia.

Some abnormal ERP indices occur both in patients with schizophrenia and in their first-degree relatives, so they are more stable markers of the core phenotype than the clinical symptoms of patients. Using these markers may be a better way to assess the genetic mechanism of schizophrenia.

Rapid development of fMRI in the last 20 years and high hopes for its potential contributions has resulted in greatly reduced interest in ERP technology. However, researchers have discovered that the limitations of temporal resolution of fMRI seriously affects its utility for more comprehensive assessments of brain functioning and, thus, that ERP indices are essential to assessing the pathophysiological mechanisms associated with schizophrenia. Among all the biological indices of mental functioning being considered, only electrophysiological indices can provide temporal resolution in milliseconds, completely matching the speed of cognitive activities. The combination of ERP and neuroimaging techniques has become a new trend in the study of schizophrenia.

Conflict of interest

The authors report no conflict of interested related to this review.

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**Erratum**

The doi number published with the Review from the first issue for the 2012 volume entitled “Brainnetome of schizophrenia: focus on impaired cognitive function” [Shanghai Arch Psychiatry 2012; 24(1): 3-10.] was incorrect. The publisher apologizes for this mistake. The correct doi number is as follows: 10.3969/j.issn.1002-0829.2012.01.001