Semantic processing impairment in individuals with schizotypal personality disorder features: A preliminary event-related potential study

Kui Wang [a], Yi Wang [a,b], Chao Yan [a,b], Yu-na Wang [a,b], Eric F.C. Cheung [c], Raymond C.K. Chan [a,*]

[a] Neuropsychology and Applied Cognitive Neuroscience Laboratory, Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China
[b] University of Chinese Academy of Sciences, Beijing, China
[c] Castle Peak Hospital, Hong Kong Special Administrative Region, China

ARTICLE INFO

ABSTRACT

Objective: This study aimed to examine semantic processing features in individuals with and without schizotypal personality disorder (SPD) features.
Methods: An implicit semantic task was used to examine the automatic spreading semantic activation process which is relatively free from the influence of attention. An explicit semantic task was used to examine the controlled semantic processing which requires high involvement of attention. Individuals with stable SPD features ($n = 17$) were those who scored higher than 36 on the schizotypal personality questionnaire (SPQ) at two time points. Individuals with unstable SPD features ($n = 15$) were defined as participants who scored higher than 36 at the baseline time point but lower than 36 at the second time point. Their performances in the two semantic tasks were then compared to 17 individuals without SPD features (scoring below 36 at both time points). Event-related potentials (ERP) were recorded when participants were performing the two tasks.
Results: Behavioral data, early ERP components and N400s were analyzed in each experiment. No between-group difference was observed in the implicit semantic task. In the explicit semantic task, the differences involved only the N400 component. When compared to the group without SPD features, participants with stable and unstable SPD features showed enhanced N400 effects (difference wave), while there was no difference between the two groups with SPD features. Moreover, the larger N400 effects were found to be due to less negative N400 amplitudes to related target words.
Conclusion: These findings suggest that individuals with SPD features were impaired in processing of context-related stimuli. The inhibition function to contextually unrelated materials in participants with SPD features appeared intact.

1. Introduction

Loose and aberrant associations are frequently observed in the speech of patients with schizophrenia (Andreasen and Grove, 1986). In order to understand the neurocognitive mechanism of the abnormal speech pattern, researchers frequently used semantic priming techniques to investigate the structure and function of semantic memory. Previous findings confirmed that patients with schizophrenia have problems with semantic processing, but the precise deficits are highly dependent on the specific experimental design. Under automatic

experimental conditions, patients with schizophrenia usually exhibit normal semantic priming effect (or increased semantic priming effect in patients with thought disorder), while under experimental conditions biasing towards controlled processing, a reduced semantic priming effect was instead found (Kuperberg et al., 2010). Healthy individuals with schizotypal personality features share many similar traits with patients with schizophrenia. Research on this special population is important, since it could offer insights for schizophrenia without contamination from the effects of medication and prolonged admission. Some recent studies also suggested that individuals with schizotypal personality disorder (SPD) features have impaired semantic processing (Johnston et al., 2008; Kiang and Kutas, 2005; Mohr et al., 2001; Voglmaier et al., 1997). However, the underlying mechanism is not fully understood (Kiang, 2010).

Behavioral priming effect refers to the phenomena that participants' response to a word (e.g., lion) would be faster and/or more accurate if it is preceded by a semantically congruent context (e.g. tiger) as opposed to a semantically incongruent one (e.g., bread). It has been suggested that different mechanisms could contribute to this effect (Neely,

1991). The automatic semantic activation model, a model of semantic memory, posits that one's semantic knowledge is stored in a network, with each node representing a specific concept and links between nodes representing semantic relationships (Collins and Loftus, 1975). According to this model, activation of one node (prime, e.g., tiger) would automatically spread to linked nodes (target, e.g., lion,), such that the processing of the target word would be quicker by partial preactivation from the prime, and as a result brings out the semantic priming effect in a semantic priming task. If participants are given enough time, they can employ strategies to facilitate the processing of target words (Neely, 1991). Expectancy generation and semantic matching are two examples. Expectancy generation refers to the situation when participants generate a set of lexical candidates (e.g., wolf, lion, cat) in response to a prime word (e.g., tiger), and their response to the target would be facilitated accordingly (Becker, 1980). Semantic matching refers to the condition in which participants use the combination of prime and target to bias decision-making (Neely et al., 1989). These two processes are controlled processes heavily influenced by attention.

The behavioral semantic priming effect has a counterpart in event-related potentials (ERPs). The target words which are semantically unrelated to previous context would elicit a negative component peaking at about 400 ms after stimulus onset. The context could be words, sentences or line drawings (Kutas and Federmeier, 2011). This negativity, labeled N400, has been found to be sensitive to the type of processes engaged: a larger N400 is observed in tasks involving attentive processing (e.g., in a semantic mapping task), while an attenuated N400 is often observed in tasks requiring automatic processing (e.g., when participants were asked to attend to filler material) (Holcomb, 1988).

With a relatively short stimulus onset asynchrony (SOA) (i.e., less than 400 ms) and a relatively small proportion of related prime-target pairs (less than about 33.3%), the priming effect is mainly attributed to automatic semantic activation (Neely, 1991). With a long SOA and a relatively large proportion of related prime-target pairs, the priming effect is mainly attributed to strategic processes (Neely, 1991). Additionally, it has been found that experimental task could also influence the attribution of semantic priming effect. For example, Kreher et al. (2009) adopted two semantic priming tasks with the same SOA of 350 ms and the same stimulus set in patients with schizophrenia. In the implicit semantic task favoring automatic spreading activation, participants were asked to monitor filler materials (kinds of food). In the explicit semantic task favoring controlled processes, the same participants were asked to judge whether the prime and target were semantically related. Although the two tasks used the same SOA and identical stimuli, different N400 patterns were observed in the two tasks. When compared to healthy controls, a relatively normal (or increased in positively thought-disordered patients) N400 effect was observed for the patient group in the implicit task, while a reduced N400 effect in the explicit task was observed instead. Therefore, a number of variables, namely SOA, the proportion of related prime-target pairs and the precise experimental task, have to be considered in experiments using the semantic priming paradigm.

The current study aimed to examine the neural mechanisms of semantic processing in individuals with SPD features. It has been observed that SPD features fluctuate with time (Raine, 2006). It would therefore be interesting to examine whether semantic processing features would also vary according to the stability of SPD features. Similar to the experimental design used by Kreher et al. (2009), we adopted an implicit task to investigate the automatic semantic activation processes and an explicit task to investigate the controlled processes. We were particularly interested in whether automatic semantic activation or controlled processes or both are impaired in individuals with SPD features. Based on previous studies in patients with schizophrenia, we hypothesized that implicit semantic processing is relatively intact in individuals with schizotypal personality disorder features, and that their controlled processing may be abnormal.

2. Methods

2.1. Participants

All participants were selected from an extensive sample pool of individuals with SPD features from a previous study (Zong et al., 2010). As reported in the said study, 55% of the subjects with a score in the top 10% of the SPQ distribution could be diagnosed as SPD according to DSM-III-R (Raine, 1991). Based on a large scale screening among Chinese university students, we found that individuals scoring higher than or equal to 36 on the SPQ made up the top 10th percentile (Zong et al., 2010). Therefore in the current study, 36 was taken as the cutoff point. Altogether 35 participants with a SPQ score higher than or equal to 36 points and 18 participants with a SPQ score lower than 36 agreed to participant this study with a payment of 20 RMB per hour. They came to the laboratory individually and completed the SPQ for a second time. Among the 35 participants with high SPD scores in the first time point, 20 (10 female) of them scored higher than or equal to 36 in the second time point. They were designated as having stable SPD features. The remaining 15 (eight female) who scored lower than the 36 in the second time point were designated as having unstable SPD features. No one in the third group (18 participants; 11 female) scored higher than or equal to 36 in the second time point and they were designated as having no SPD features.

The exclusion criteria for each group of participants were 1) neurological and psychiatric illness in themselves or their first-degree relatives; 2) history of traumatic brain injury; 3) history of substance abuse; 4) hearing, vision, or upper body motor impairment. All participants were right-handed according to the Annett handedness questionnaire (Annett, 1976) and all were native Chinese speakers.

Data of four additional participants (three with stable SPD features, one without SPD features) were discarded due to overwhelming αwave in the ERP data. The final dataset contained 17 individuals with stable SPD features, 15 individuals with unstable SPD features and 17 individuals without SPD features (Table 1). The three groups did not differ significantly with respect to age and gender.

2.2. Measures

2.2.1. Schizotypal personality questionnaire (SPQ)

The original SPQ (Raine, 1991) consists of a 74-item questionnaire assessing all nine symptoms of SPD, including ideas of reference, excessive social anxiety, odd beliefs or magical thinking, unusual perceptual experiences, odd or eccentric behavior, absence of friends, odd speech, constricted affect, and suspiciousness or paranoid ideation. The total internal reliability of the scale is high (0.91), while the internal reliabilities of the nine SPQ subscales are adequate (Cronbach's alpha ranges from 0.71 to 0.78, with a mean of 0.74). The test–retest reliability for the scale at a two-month interval was 0.82 (Raine, 1991, 2006; Raine et al., 1994). The present study used the Chinese version of the SPQ (Chen et al., 1997). This version has satisfactory psychometric properties, including a high internal consistency of the total SPQ score in both adults (0.90) and adolescents (0.93). Coefficient alpha for the nine subscales of the SPQ ranged from 0.58 to 0.79 in adults and 0.44 to 0.79 in adolescents (Chen et al., 1997).

2.2.2. Neuropsychological measures

A set of comprehensive neuropsychological tests was also administered to all participants. Intellectual functioning was estimated by the short form (information, arithmetic, similarity, and digit span subtests) of the Chinese version of the Wechsler Adult Intelligence Scale—Revised (WAIS-R) (Gong, 1992). This method of prorating has been used previously to estimate IQ in schizophrenia (Allen et al., 1997; Blyler et al., 2000; Gong et al., 1989). Sustained attention was assessed by the sustained attention to response task (SART) (Robertson et al., 1997), which is a computer test requiring the