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Explicit and implicit memory in female college students with schizotypal traits: An event-related potential study

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ABSTRACT

The explicit and implicit memory of nonclinical individuals with schizotypal traits was investigated using event-related potentials. Explicit and implicit memory was measured with continuous recognition and categorization tasks, respectively. On the recognition task, the control group demonstrated a greater old/new effect in response to the old than to the new words during the 250–750 ms post-stimulus period, whereas schizotypal trait group did not exhibit an old/new effect during the 550–650 ms period. The control group demonstrated faster response times to the old than to the new words, whereas the schizotypal group demonstrated longer response times to the old than to the new words. On the categorization task, both groups showed old/new effects during the 250–550 ms after stimulus onset and responded more rapidly and with fewer errors to the old than to the new words. These results suggest that individuals with schizotypal traits have impaired explicit but preserved implicit memory.

1. Introduction

Deficits in memory are among the most severe cognitive impairments associated with schizophrenia and have been recognized as a core problem in this condition (Dickinson et al., 2008; Heinrichs and Zakzanis, 1998; Saykin et al., 1991). Memory deficits have been observed not only in chronic patients but also in first-episode patients (Albus et al., 1997), as well as in healthy first-degree biological relatives of schizophrenic patients (Sponheim et al., 2004).

Typically, memory is divided into explicit and implicit domains (Schacter et al., 1993; Squire and Zola-Morgan, 1991). Explicit memory refers to the intentional or conscious recollection of events or facts, whereas implicit memory is defined in terms of stored knowledge that does not require intentional conscious recollection. Recall/recognition tests and priming are widely used to measure explicit and implicit memory, respectively (Rugg, 1995; Swick, 1998), and it has been established that the neuroanatomical substrates underlying explicit and implicit memory differ. The structures in the medial temporal and the prefrontal cortex play crucial roles in explicit memory (Haxby et al., 1996; Squire, 1992), whereas the prefrontal cortex and basal ganglia seem to be involved in implicit memory (Donaldson et al., 2001; Fletcher et al., 2001).

Previous studies have consistently reported that explicit verbal memory is impaired in schizophrenic patients (Censits et al., 1997; Dickinson et al., 2008; Heinrichs and Zakzanis, 1998; Saykin et al., 1991). For example, Bozikas et al. (2006) investigated explicit verbal memory using the California Verbal Learning Test (CVLT) and found that patients with schizophrenia showed significantly more impairments than did normal controls on tasks involving immediate free recall, immediate cued recall, delayed cued recall, and recognition. Explicit verbal memory deficits in patients with schizophrenia have attracted particular attention, as recent neuroimaging studies reported associations between explicit verbal memory impairments and structural/functional abnormalities in the left medial temporal areas of those with schizophrenia (Nestor et al., 2007; Sanfilipo et al., 2002; van Erp et al., 2008). For example, van Erp et al. (2008) observed significant correlations between left hippocampal volume and the performances of schizophrenic patients on the CVLT.

Unlike explicit verbal memory, the implicit verbal memory of patients with schizophrenia seems to remain intact (Besche-Richard et al., 2005; Danion et al., 2001; Gras-Vincendon et al., 1994; Quelen et al., 2005). For example, Gras-Vincendon et al. (1994) investigated the implicit memory of patients with schizophrenia using stem-completion and procedural memory tasks and failed to find any significant differences between schizophrenic patients and normal controls. Additionally, Danion et al. (2001) investigated implicit memory using an artificial grammar-learning task and found that both schizophrenic patients and normal controls categorized more grammatical than non-grammatical letter-strings as correct. Besche-Richard et al. (2005) also observed no significant differences between schizophrenic patients and normal controls with respect to semantic priming on a double lexical decision task.

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Event-related potentials (ERPs), the electrical brain activity time-locked to external events, have been widely used to investigate memory due to the high temporal resolution associated with this technique. Numerous studies have shown that the ERPs elicited by repeated items (old) are generally more positive-going than those elicited by items presented for the first time (new): this has been referred to as the old/new effect or the repetition effect. The old/new effect, which has been observed in both explicit and implicit memory tasks (Boehm et al., 2005; Friedman et al., 1992; Swick, 1998), usually begins at about 250–300 ms and lasts about 700–800 ms after stimulus onset (Kayser et al., 2010).

A number of studies have used ERPs to investigate the explicit verbal memory of schizophrenic patients and have reported a reduced old/new effect (i.e., reduced difference-amplitudes between new and old stimuli) in this population (Baving et al., 2000; Kayser et al., 2009; Tendolkar et al., 2002). For example, Baving et al. (2000) investigated explicit verbal memory using a paired-associate word learning task and observed a reduced old/new effect at parietal sites in schizophrenic patients compared with normal controls at 250–400 ms post-stimulus. Additionally, Kayser et al. (2009) found a significantly reduced old/new effect at lateral temporoparietal sites in schizophrenic patients.

Implicit verbal memory in schizophrenic patients has also been examined using ERPs (Kreher et al., 2009; Matsumoto et al., 2005; Matsuoka et al., 1999), but these studies, unlike the behavioral studies on implicit memory, have reported inconsistent findings. For example, Matsuoka et al. (1999) investigated the repetition priming effect among schizophrenic patients using a semantic categorization task and found a significantly reduced repetition effect among the schizophrenic patients compared with members of the normal control group. Matsumoto et al. (2005) also used a semantic categorization task to evaluate the implicit memory of schizophrenic patients with and without thought disorders. They found that patients without thought disorders and normal controls demonstrated comparable old/new effects about 250–500 ms after stimulus onset, but that patients with thought disorders demonstrated a significantly reduced old/new effect. In addition, Kreher et al. (2008) reported that schizophrenic patients with thought disorders exhibited increased semantic priming at 300–400 ms post-stimulus, whereas patients without thought disorders and healthy controls showed comparable semantic priming performances on a semantic categorization task. Furthermore, Kiang et al. (2008) observed that reduced semantic priming was significantly correlated with such psychotic symptoms as delusions and hallucinations in schizophrenic patients. These results indicate that deficits in implicit memory are not observed in all schizophrenic patients, but only in those with thought disorders or severe psychotic symptoms.

Given that schizophrenia is highly heterogeneous and that several variables including antipsychotic drugs and length of illness or hospitalization can affect neuropsychological performance, patients with schizotypal personality disorder (SPD) and non-clinical individuals with schizotypal traits have been viewed as representing a promising endophenotypic approach to understanding schizophrenia (Siever and Davis, 2004). Indeed, SPD and schizophrenia share common genetic (Lin et al., 2005), neuroimaging (Dickey et al., 2002; Moorhead et al., 2009), and neuropsychological (Noguchi et al., 2008; Siever and Davis, 2004) abnormalities. For example, Moorhead et al. (2009) observed reduced volume in the temporal lobe gray matter in SPD patients, and deficits in explicit verbal memory and learning have also been observed in SPD patients and individuals with schizotypal traits (Mitropoulou et al., 2005; Voglmaier et al., 2000).

To our knowledge, no ERP studies investigating the explicit and implicit memory of non-clinical individuals with schizotypal traits have been conducted. Therefore, we used ERPs to investigate the explicit and implicit verbal memory of non-clinical college students with psychometrically defined schizotypal traits. We used a continuous recognition task and a categorization task to measure explicit and implicit memory, respectively. The primary objectives of this study were to investigate whether individuals with schizotypal traits showed deficits in explicit and/or implicit memory and, if so, whether these deficits were reflected in their ERPs. Based on previous findings, we expected that those with schizotypal traits would show impaired explicit but preserved implicit memory and that impairments in explicit memory would be reflected in a reduced old/new effect, i.e., reduced difference-amplitudes between new and old words, in the continuous recognition task.

2. Methods

2.1. Participants

A total of 34 female college students were recruited from a pool of 610 students based on their scores on the Korean version of the Schizotypal Personality Questionnaire (SPQ; Moon et al., 1997; Raine, 1991). The SPQ is a 74-item self-administered questionnaire with a "yes/no" response format. All items answered "yes" are scored as one, therefore, the total range of scores is 0–74. The schizotypal trait group ($n = 17$) was composed of those with scores ≥36 (score range: 36–53) on the SPQ (i.e., the highest 3% of the distributed scores) and the control group ($n = 17$) consisted of those who obtained average scores (±SD) (score range: 14–23) on this instrument. The Structured Clinical Interview for DSM-IV-Non Patients (SCID-NP; First et al., 1996) was administered to ensure that none of the participants had a history of psychiatric, medical, or neurological disorders or of drug/alcohol abuse. All participants were right handed, and none was taking medications at the time of testing. All participants provided written informed consent after receiving a complete description of the study, and they were paid for their participation. The study was approved by the Sungshin Women's University Institutional Bioethics Review Board.

2.2. Continuous recognition and categorization tasks

A continuous recognition task was administered to measure explicit memory. A total of 380 Korean words with a cumulative frequency range in the 30–70th percentiles were used as stimuli. The stimulus words were nouns for various animals and plants. These stimuli were arranged into two blocks of trials. In each block, 50 words were presented only once (new), and 140 words were repeated following one to five intervening words (old). Participants viewed a series of words continuously and were required to press one response button when the word was old and to press a different button with the other hand when the word was new. The buttons assigned for these two responses were counter-balanced across participants.

A total of 380 Korean words referring to plants or animals with a cumulative frequency range in the 30–70th percentiles were presented during the categorization task, which was administered to assess implicit memory. The stimuli were arranged into two blocks of trials. Each block consisted of 50 words that were presented only once and 140 words that were repeated following one to five intervening words. Participants were required to judge whether each word referred to a plant or an animal and to respond by pressing one button if the word referred to a plant and a different button if the word referred to an animal. The buttons assigned for these two responses were counter-balanced across participants. The stimulus words used in the categorization task were different from those used in the continuous recognition task.

The stimuli were presented on a computer monitor in foveal vision for 200 ms and subtended a vertical visual angle of 2.29° and a horizontal visual angle of 3.43°. A crosshair (+) was displayed on the screen for 500 ms as a fixation point prior to the presentation of each stimulus, and the inter-stimulus interval was 2000 ms. Participants were instructed to respond as quickly and accurately as possible, and responses were accepted from stimulus onset until the next crosshair onset (1500 ms). Prior to the experimental session, a block of 10 practice trials was administered to ensure that the instructions were understood.

The recognition and categorization tasks were administered in different sessions, and the order in which the two tasks were performed was counter-balanced across participants.

2.3. Electrophysiological recording procedures

Electroencephalographic activity (EEG) was recorded using a 64-channel Geodesic Sensor Net connected to a 64-channel, high-input impedance amplifier (Net Amp 300: Electrical Geodesics, Eugene, OR) in an electrically shielded and soundproofed experimental room. Each electrode was referenced to Cz, and individual electrodes were adjusted until impedances were less than 50 kΩ (Tucker, 1993). Eye movements and blinks were monitored with electrodes placed near the outer cantus and beneath the left eye.