Psychiatry Research 220 (2014) 752–759

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Effect of semantic coherence on episodic memory processes in schizophrenia

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ARTICLE INFO

Article history:
Received 5 December 2013
Received in revised form
15 July 2014
Accepted 18 August 2014
Available online 24 August 2014

Keywords:
Schizophrenia
Episodic memory
Familiarity
Recollection
Semantic relatedness
Process dissociation procedure

ABSTRACT

Schizophrenia is associated with severe episodic retrieval impairment. The aim of this study was to investigate the possibility that schizophrenia patients could improve their familiarity and/or recollection processes by manipulating the semantic coherence of to-be-learned stimuli and using deep encoding. Twelve schizophrenia patients and 12 healthy controls of comparable age, gender, and educational level undertook an associative recognition memory task. The stimuli consisted of pairs of words that were either related or unrelated to a given semantic category. The process dissociation procedure was used to calculate the estimates of familiarity and recollection processes. Both groups showed enhanced memory performances for semantically related words. However, in healthy controls, semantic relatedness led to enhanced recollection, while in schizophrenia patients, it induced enhanced familiarity. The familiarity estimates for related words were comparable in both groups, indicating that familiarity could be used as a compensatory mechanism in schizophrenia patients.

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1. Introduction

Schizophrenia is associated with severe episodic memory disturbances (Heinrichs and Zakzanis, 1998; Aleman et al., 1999; Reichenberg and Harvey, 2007) that seem to be specific and cannot be fully explained by impairments in other areas of cognition, such as executive functioning or IQ level (Kopald et al., 2012). Episodic memory is the knowledge of personally experienced past events (Tulving, 1972). Two distinct phenomena that underlie episodic retrieval are familiarity and recollection (Mandler, 1980; Jacoby, 1991; Yonelinas, 1999, 2001, 2002). Familiarity is an automatic process that refers to the retrieval of episodic information without its temporospatial context, while recollection refers to the retrieval of contextual and associative details.

In schizophrenia, the literature has shown impairments in both recollection (Danion et al., 1999; Tendolkar et al., 2002; Lepage et al., 2006; van Erp et al., 2008) and familiarity (Martin et al., 2004; Guillaume et al., 2007; Weiss et al., 2008). While both of these processes can be impaired (for meta-analyses, see Achim and Lepage (2003), Pelletier et al.(2005)), deficits in familiarity are less consistently observed, suggesting that familiarity can potentially be used as a compensatory mechanism in schizophrenia patients (for a review see Libby et al. (2013)).

The evidence for these compensatory mechanisms comes from studies using the levels-of-processing paradigm (LOP). This paradigm provides a comparison of performances during deep semantic encoding versus shallow perceptual encoding, thereby measuring the benefit of semantic processing during the learning phase (Craik and Lockhart, 1972). Using this paradigm, it was shown that deep semantic encoding had a beneficial effect on episodic retrieval performance by enhancing recognition performances in both healthy controls (Toth, 1996; Yonelinas, 2002; Sheridan and Reingold, 2012) and schizophrenia patients (Ragland et al., 2003; Bonner-Jackson et al., 2005; Paul et al., 2005). However, while in healthy controls both familiarity and recollection processes benefited from semantic encoding (Toth, 1996; Yonelinas, 2002; Sheridan and Reingold, 2012), the enhanced overall recognition performance in schizophrenia patients was based on enhancement in familiarity alone (Ragland et al., 2006). Moreover, recent event-related potential (ERP) studies of recognition processes revealed increased amplitudes in the ERP familiarity-related potential in schizophrenia patients, reinforcing the idea that familiarity may be used as a compensatory mechanism in these individuals (Guillaume et al., 2012, 2013).

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http://dx.doi.org/10.1016/j.psychres.2014.08.034
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In addition to the use of deep semantic encoding, the semantic coherence of the to-be- learned stimulus itself is another factor that can contribute to episodic memory performance. Indeed, the literature strongly suggests that semantic memory influences episodic memory during both encoding and retrieval (for a review see Greenberg and Verfaellie (2010)). For example, a recent study using deep encoding (semantic categorization) showed that semantic coherence (i.e. the semantic relatedness between a category name and a pair of words) enhanced the recognition memory performance in healthy participants (Greve et al., 2007). The semantic congruency of a stimulus in a given context seems to promote successful episodic encoding, which leads to better subsequent recognition through enhanced semantic elaboration (conceptual binding) by creating an integrated stimulus-context unit (Schulman, 1974; Craik and Tulving, 1975). Moreover, the congruency effect may also emerge during retrieval, where the presentation of a retrieval cue is part of a congruous cue-target combination (Moscovitch and Craik, 1976). Therefore, the pre-existing conceptual knowledge has a beneficial effect on the recognition performance for both the item and episodic context memory through enhanced relational binding operations (Staresina et al., 2009).

In the study carried out by Greve et al. (2007), the benefit obtained during recognition memory performance of healthy participants was a result of the enhanced familiarity for the related word pairs. This positive effect of semantic coherence on recognition memory performance based on familiarity could indicate the possibility of an associative familiarity (Ford et al., 2010; Bastin et al., 2010; Rhodes and Donaldson, 2007; Algarabel et al., 2013). According to dual process account, items that form a pair are represented and processed separately during associative recognition tasks. However, two independent items can also be unitized and form a single higher-order representation, giving rise to holistic processing and increased familiarity-based retrieval (Algarabel et al., 2013; Rhodes and Donaldson, 2007).

To the best of our knowledge, the semantic coherence of the stimulus has not yet been manipulated in studies investigating familiarity and recollection processes in schizophrenia patients. In light of the previously discussed findings, we would expect that the positive effect of semantic coherence on familiarity-based recognition performance would occur in schizophrenia patients too. However, for semantic coherence to have a positive impact on recognition memory processes, the proper organization and functioning of semantic memory are essential, and schizophrenia is traditionally associated with semantic anomalies. These anomalies concern the strategic utilization of semantic context needed to activate the representations within semantic memory; the organization of semantic memory itself and its automatic activation seem to be spared (for a review see Mohammad and DeLisi (2013)). Moreover, in the presence of a particularly salient semantic context (e.g. strongly structured phrases or repeated words), schizophrenia patients do not manifest any abnormalities (Debruille et al., 2007; Kostova et al., 2003). For example, Debruille et al. (2007) used an explicit semantic categorization task in which the context was an invariant category name (“animal”) and the target words were either exemplars or non-exemplars of the category. The authors observed that, in schizophrenia patients, the amplitude of the ERPs correlate of semantic processing (i.e. the N400 component) was modulated by the relatedness in a similar manner as in the healthy controls. This suggests that schizophrenia patients are able to overcome context processing difficulties when the contextual information is salient and the processing of context is explicitly required by the task's demand.

The aim of our study was to investigate familiarity and recollection processes in schizophrenia patients by manipulating the semantic coherence of to-be-learned stimuli. For this purpose, we adapted the protocol of Greve et al. , which uses the process dissociation procedure (PDP) in an associative recognition task with deep semantic encoding. The PDP provides a calculation for the contribution of the automatic and controlled processes to the overall performance in a variety of domains such as memory (Jacoby, 1991). By applying the PDP to an associative recognition task, we can estimate the respective parts of familiarity (automatic) and recollection (controlled) processes underlying the recognition performance.

In associative recognition tasks, pairs of stimuli are presented, and the participants must distinguish among intact, recombined, and new pairs. A recombined pair is formed from old items that were presented in two previously encountered pairs and have now been rearranged to create a different pair. The PDP procedure uses inclusion and exclusion tasks that differ only by the instructions given to the participants for an old response. In the inclusion task, participants must respond “old” for both intact and recombined pairs, while in the exclusion task, they are instructed to respond “old” only for intact ones; recombined pairs are considered “new”. Therefore, the exclusion task requires recollection process to distinguish between recombined and intact pairs because both stimuli in a recombined pair are familiar, but the association between the items is new. By contrast, the inclusion task can be solely performed on the basis of familiarity. Consequently, the PDP measures familiarity and recollection processes through calculation of the probability of old responses for recombined pairs in inclusion vs. exclusion tasks.

In light of these previous studies, we hypothesized that, although the overall recognition performance of schizophrenia patients would be lower than that of healthy controls, semantic coherence would have a beneficial effect on the recognition performances of both groups. We expected that the correct response rates would be higher for related word pairs compared to those of unrelated ones in both healthy controls and schizophrenia patients. Moreover, we believed that the increase in recognition memory performances would be driven by an increase in familiarity estimates, since familiarity, rather than recollection, seems to mediate the interaction between semantic and episodic memory. We predicted that patients with schizophrenia would enhance, and possibly even normalize, their familiarity process estimates for the related compared to the unrelated condition through the combined use of deep encoding and semantic coherence of to-be-learned stimuli.

2. Methods

2.1. Participants

This study was carried out in accordance with the latest version of the Declaration of Helsinki. All participants gave informed written consent. Twelve schizophrenia patients aged 18–56 were recruited in the day care unit of the Psychological Medicine Department at University Malaya Medical Centre in Kuala Lumpur. The diagnosis of schizophrenia was based on the DSM-IV criteria (American Psychiatric Association, 1994). All of the patients were stabilized. They were assessed using the positive and negative syndrome scale for schizophrenia (PANSS; Kay et al., 1987) by the psychiatrist of the unit who was blinded to the aims of the experiment. Twelve healthy volunteers aged 22–60 were also recruited from the community as the control group. All of the participants had a psychiatric consultation and clinical interview with the psychiatrist before inclusion into the control group. They were free of any detectable psychiatric or neurological illness at the time of their inclusion. All of the participants were native English speakers. The socio-demographic and clinical characteristics of the two groups are presented in Table 1.

2.2. Material

The material consisted of a list of 864 words containing nouns of four to six letters with a frequency between 1 and 100 occurrences per million (Kucera and Francis, 1967). We created word pairs either semantically related to a given

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