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Intellectual factors in false memories of patients with schizophrenia

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ABSTRACT

The current study explored the intellectual factors in false memories of 139 patients with schizophrenia, using a recognition task and an IQ test. The full-scale IQ score of the participants ranged from 57 to 144 (M = 100, SD = 14). The full IQ score had a negative correlation with false recognition in patients with schizophrenia, and positive correlations with high-confidence true recognition and discrimination rates. Further analyses with the subtests' scores revealed that false recognition was negatively correlated with scores of performance IQ (and one of its subtests: picture arrangement), whereas true recognition was positively correlated with scores of verbal IQ (and two of its subtests: information and digit span). High-IQ patients had less false recognition (overall or high-confidence false recognition), more high-confidence true recognition, and higher discrimination abilities than those with low IQ. These findings contribute to a better understanding of the cognitive mechanism in false memory of patients with schizophrenia, and are of practical relevance to the evaluation of memory reliability in patients with different intellectual levels.

1. Introduction

True memory impairment is well established in patients with schizophrenia. A meta-analysis study suggested that patients with schizophrenia have generalized memory deficits, including impairments in verbal and nonverbal recognition (Aleman et al., 1999). Moreover, memory impairments in patients with schizophrenia have been linked to deficits in prefrontal and hippocampal brain activation (Ragland et al., 2015). There is, however, an ongoing debate regarding whether patients with schizophrenia have more false memories than do healthy controls (Elvevåg et al., 2004; Moritz et al., 2004; Moritz et al., 2006; Pernot-Marino et al., 2010). One potential reason for inconsistent findings in previous studies is that their samples differed in intellectual levels (see below for details). The effect of intelligence on false memories has been reported in healthy participants (Zhu et al., 2010) and in participants with intellectual disability (Carlin et al., 2012; Gudjonsson and Henry, 2003), but little is known about the intellectual factors in false memories of patients with schizophrenia.

Six previous studies used the Deese-Roediger-McDermott (DRM) paradigm to examine false memory in patients with schizophrenia and the results were mixed. In the DRM task, participants studied lists of semantically related words, and then took a recall and/or recognition test. DRM false memory refers to the false recall and/or recognition of semantically related unstudied lures (Roediger and McDermott, 1995). Results of the six studies seem to depend on the intellectual levels of the participants. Three of those studies using participants with average IQs found that patients and healthy controls did not differ in false memory (Lee et al., 2007; Moritz et al., 2004; Paz-Alonso et al., 2013). Specifically, in the study by Lee et al. (2007), patients with schizophrenia (n = 15, IQ = 101 ± 20) and healthy controls (n = 15, IQ = 107 ± 12) had average IQs as measured by the Wechsler Adult Intelligence Scale. In the study by Moritz et al. (2004), patients with schizophrenia (n = 20, IQ = 100 ± 7) and healthy controls (n = 20, IQ = 103 ± 12) had average verbal IQs as measured by the National Adult Reading Test (NART). In the study by Paz-Alonso et al. (2013), patients with schizophrenia (n = 30, IQ = 104 ± 8) and healthy controls (n = 30, IQ = 109 ± 9) had average verbal IQs as measured by the Wide Range Achievement Test (the word reading subtest).

However, the other three DRM studies using low-IQ patients with schizophrenia reported mixed results (Bhatt et al., 2010; Elvevåg et al., 2004; Huron and Danion, 2002). Two of them compared low-IQ patients with schizophrenia with medium-IQ healthy controls and found that patients had fewer false memories than controls (Elvevåg et al., 2004; Huron and Danion, 2002). In the study by Elvevåg et al. (2004),

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patients with schizophrenia (n = 22, IQ = 93 ± 14) had lower IQ scores than healthy controls (n = 25, IQ = 108 ± 12) as measured by a short version of the Wechsler Adult Intelligence Scale-Revised (WAIS-R). Similarly, in the study by Huron and Danion (2002), patients with schizophrenia (n = 30, IQ = 90 ± 14) had lower IQ scores than healthy controls (n = 30, IQ = 106 ± 20) also as measured by a short form of WAIS-R. In contrast, Bhatt et al. (2010) compared low-IQ patients with schizophrenia with low-IQ healthy controls and found that the former had more false memories. In their study, patients with schizophrenia (n = 26, WAIS-R IQ = 95 ± 10, and NART IQ = 107 ± 12) and healthy controls (n = 20, NART IQ = 107 ± 10) had similar verbal IQ scores as measured by NART.

In addition to the DRM paradigm, a semantic association memory task has been used by Moritz and colleagues in three studies to examine false memory of patients with schizophrenia (Moritz et al., 2005; Moritz and Woodward, 2002; Moritz et al., 2003). In this task, participants listened to 20 words and self-generated an associated word for each presented word, and then in a recognition test participants had to make judgment on studied, self-generated, semantically related unstudied, and semantically unrelated unstudied words in a recognition test. In three studies by Moritz et al. (2002, 2003, 2005) found that patients with schizophrenia had higher confidence in false recognition than healthy participants. However, the results for false recognition of semantically related unstudied words were inconsistent across the three studies. For example, Moritz et al. (2003) found that high-IQ patients with schizophrenia (n = 30, IQ = 113 ± 13) had higher false recognition than high-IQ healthy participants (n = 21, IQ = 113 ± 14 as measured by a vocabulary test), but Moritz et al. (2005) reported that patients with schizophrenia (n = 30, IQ = 102 ± 9) had similar false recognition as slightly higher-IQ healthy controls (n = 15, IQ = 111 ± 7 as measured by NART).

In sum, these inconsistent findings may be a result of using small samples of patients with schizophrenia with different intellectual levels. In addition, previous studies usually used verbal IQ tests or a short version of WAIS-R IQ test. Thus far, no study has examined the effect of intelligence (as measured by the full version of WAIS-R) on false memory in a relatively large sample of patients with schizophrenia. Moreover, it is unclear whether verbal or performance IQ (or a certain subtest of WAIS-R) is more likely to be associated with false memory in patients with schizophrenia. Although there is no direct evidence in patients with schizophrenia, the effect of IQ on false memory has been suggested by several previous studies of healthy participants (Butler et al., 2004; Zhu et al., 2010) and participants with intellectual disability (Carlin et al., 2012; Gudjonsson and Henry, 2003). For example, Zhu et al. (2010) found that misinformation false memory was negatively correlated with intelligence score as measured by WAIS-R in 557 college students, and its correlation with performance IQ was higher (more negative) than its correlation with verbal IQ. Moreover, Butler et al. (2004) suggested that DRM false memory had a negative correlation with the arithmetic subtest score from WAIS-R in 36 healthy older adults. In addition, children and adults with intellectual disabilities had more false memory as assessed by the Gudjonsson Suggestibility Scale than those with normal IQ scores as measured by Wechsler Intelligence Scale for Children-III and WAIS-R (Gudjonsson and Henry, 2003). Similarly, 18 children with intellectual disabilities produced more DRM false memories and had more difficulty in discriminating studied items from lures than did 18 mental-age-matched children based on IQ as measured by Kaufman Brief Intelligence Test (Carlin et al., 2012).

In order to explore the effect of intelligence on false memory in patients with schizophrenia, it is important to select a suitable false memory task because false memories in patients with schizophrenia and healthy participants may involve different cognitive mechanisms (Moritz et al., 2004). Unlike healthy participants, patients with schizophrenia are more likely to use the gist-based response strategy during recognition. Thus, we selected a visual variant of the DRM paradigm (i.e., a visual scenes false recognition task) designed specifically for pateints with schizophrenia, which uses strong contextual cues to encourage gist-based strategy during retreieval (Moritz et al., 2006). Compared with those verbal materials used in previous false memory studies (e.g., in traditional DRM studies), these visual scenic materials are more comparable to real-life situations and easier to understand for patients with schizophrenia (Moritz et al., 2006; Otgaar et al., 2014), and are associated with more reliable individual differences in false memory. In this task, participants saw four pictures with thematic scenes (e.g., a beach scene), which included many thematically related items (e.g., a swim ring), but also purposely excluded a few thematically related lures (e.g., a towel). In the study by Moritz et al. (2006), highly-educated patients with schizophrenia (n = 35, 15 ± 4 years of education) had similar false recognition for thematically related unstudied lures as highly-educated healthy controls (n = 34, 16 ± 4 years of education), but these patients had higher confidence in false recognition than healthy controls. However, these researchers did not report the intelligence scores of these participants. Comparing the average education level of patients with schizophrenia in their study with that of patients in a meta-analysis study (McGurk et al., 2007), it can be assumed that patients in their study had relatively higher intelligence than typical patients with schizophrenia. However, it is unclear if low IQ patients with schizophrenia had more or fewer false memories than those with high or medium IQ.

In the current study, we used a visual scenes false recognition task and the full version of Wechsler Adult Intelligence Scale-Revised in a relatively large sample of patients with schizophrenia. Our first goal was to explore whether intelligence was related to false recognition, high-confidence false recognition, and discrimination ability (e.g., the ability of discriminating studied items from foils, lures from foils, and studied items from lures) in patients with schizophrenia. Our hypotheses were guided by fuzzy trace theory, which has been influential in explaining false memories. According that theory, there are two kinds of memory traces: Verbatim memory for precise features and gist memory for the meaning of information (Brainerd and Reyna, 2002). Poor verbatim memory would lead to lower ability of discriminating unrelated foils from studied items, whereas poor gist memory would lead to lower ability of discriminating unrelated foils from lures. Moreover, greater reliance on gist memory than verbatim memory would lead to more false recognition. According to the fuzzy trace theory (Brainerd and Reyna, 2002), low-IQ patients with schizophrenia have both poor verbatim memory (i.e., feature presentation) and poor gist memory (i.e., meaning-based) than those with high-IQ, but low-IQ patients are more likely to rely on the gist information than those with high IQ (Carlin et al., 2012). Thus, we hypothesized that low-IQ patients with schizophrenia would have more false recognition (overall as well as high-confidence false recognition) and lower discrimination abilities than those with high IQ.

A second goal of this study was to identify which intelligence subtests' scores were correlated with false recognition in patients with schizophrenia. According to the activation/monitoring framework (Gallo and Roediger, 2002), patients (regardless of their IQ scores) have difficulties in sustained spreading of semantic/thematic activation during encoding (Elvevåg et al., 2004; Moritz et al., 2006), but low-IQ individuals have more source monitoring errors than those with high IQ (Carlin et al., 2012). Moreover, the semantic/thematic activation ability is more closely associated with verbal IQ (Joyce et al., 2009), whereas the source monitoring ability is more closely associated with performance IQ (Vinogradov et al., 1997). Therefore, we hypothesized that performance IQ would have a negative correlation with false recognition in patients with schizophrenia.

A third goal of this study was to compare the levels of false recognition in patients in our study and the study by Moritz et al. (2006), whose highly-educated patients took the same visual scenes false recognition test. Because we had a relatively large sample of patients, we could separate our sample into three groups based on their full IQ score (i.e., IQ < 90, IQ = 90–109, and IQ ≥ 110). Then, we could compare the level of false recognition among the three groups of patients in our study and those in the study by Moritz et al. (2006). We hypothesized that the level of false recognition in high-IQ patients in our sample would be similar to the highly-educated patients in the study by Moritz et al. (2006).

2. Methods

2.1. Participants

A total of 139 patients with schizophrenia (age = 29.0 ± 7.4 years, 85 males and 54 females) were enrolled from a hospital in Shangdong Province, China. They fulfilled the ICD-10 criteria for schizophrenia based on the diagnostic consensus of two experienced psychiatrists. Exclusion criteria for patients in this study included a history of other psychiatric disorders or severe head injury, currently having acute psychotic episodes or substance abuse, and failure to cooperate during the recognition and intelligence tests. All participants completed the visual false recognition task and the intelligence test. The full IQ score of the participants ranged from 57 to 144 (M = 100, SD = 14). The full IQ score was normally distributed, with skewness of − 0.17 (SE = 0.21) and kurtosis of 0.47 (SE = 0.41). Written consent was obtained from all participants. This study was approved by the Institutional Review Board of Beijing Normal University, China.

2.2. Visual scenes false recognition task

To assess true and false recognition, all participants were tested with the visual variant of DRM task using previously established and reliable materials (Moritz et al., 2006; Otgaar et al., 2014). First, participants were asked to remember all the items presented in four black-and-white visual scenes, which depict the themes of "beach", "funeral", "surveillance", and "classroom", respectively. For example, there were dozens of items depicted in the beach scene (e.g., sun, swim ring, and lifeguard). For each scene, the thematic word was also presented on the screen as a cue during its corresponding study and test phases. Each scene was presented for 40 seconds with an interval of 1 s. The order of presentation during study was the same for all participants (i.e., in the order of beach, funeral, surveillance, and classroom). Following the procedure of previous false memory studies (Gallo and Roediger, 2002), we used an arithmetic task as a 5-minute filler task. In this filler task, participants were asked to solve as many simple addition and subtraction problems (e.g., "1 + 8 = ?") as they could within 5 minutes. Next, participants took a self-paced recognition test. For each scene, participants had to judge 12 studied items (e.g., "sun" was presented in the beach scene), 8 lures (e.g., "towel" was unpresented but related to the theme of the beach scene), and 4 unrelated foils (e.g., "elephant" was unpresented and unrelated to the theme of the beach scene) based on what they saw in the original scene (see Fig. 1). The four sets of 24 words were presented in the same order as the presentation of the scenes (i.e., in the order of beach, funeral, surveillance, and classroom). But within each set, the 24 words were presented randomly. Following the procedure of Moritz et al. (2006), a four-choice procedure was used for judgment: old with confidence, old but without confidence, new with confidence, and new but without confidence.

The endorsement rate (judged as old, with and without confidence) for the studied, lure, and unrelated foil items represented true recognition (TR), false recognition (FR), and unrelated foils recognition (UN), respectively. Cronbach's alphas of this recognition test were 0.89, 0.87, and 0.82 for FR, TR, and UN, respectively. Moreover, the endorsement rate (judged as old with confidence) for the studied, lure, and unrelated items represented high-confidence true recognition (HCTR), high-confidence false recognition (HCFR), and high-confidence unrelated foils (HCUN), respectively. In addition, the discrimination performance of true memory was calculated as d′(T-U) = Z(TR) − Z (UN), which indicated a participant's performance to discriminate studied items from unrelated foils. The discrimination performance of false memory was calculated as d′(F-U) = Z(FR) − Z(UN), which indicated a participant's performance to discriminate lures from foils. Finally, the discrimination performance of true vs. false recognition was calculated as d′(T-F) = Z(TR) − Z(FR), which indicated a participant's performance to discriminate studied items from lures. Moreover, the discrimination performance of high-confidence true memory was calculated as d′(HCT-HCU) = Z(HCTR) − Z(HCUN), which indicated a participant's high-confidence performance to discriminate studied items from unrelated foils. The discrimination performance of high-confidence false memory was calculated as d′(HCF-HCU) = Z(HCFR) − Z (HCUN), which indicated a participant's high-confidence performance to discriminate lures from foils. Finally, the discrimination performance of high-confidence true vs. false recognition was calculated as d′(HCT-HCF) = Z(HCTR) − Z(HCFR), which indicated a participant's high-confidence performance to discriminate studied items from lures.

2.3. Intelligence test

The Wechsler Adult Intelligence Scale-Revised (Gong, 1992) was used to measure intelligence. There are eleven subtests (six verbal and five performance tests) in the Chinese adaptation of the Wechsler Adult Intelligence Scale-Revised (WAIS-RC). The verbal section includes tests of general information (tapping general information acquired from one's culture), similarity (abstract verbal reasoning and semantic knowledge), vocabulary (semantic knowledge and verbal comprehension), arithmetic (quantitative reasoning and mental manipulation), comprehension (ability to express abstract social conventions, rules and expressions), and digit span (working memory, attention, encoding, and auditory processing). The performance section includes picture completion (ability to quickly perceive visual details), picture arrangement (nonverbal reasoning and sequencing skills), block design (visual spatial processing and problem solving), object assembly (visual-motor problem-solving and organizational abilities), and digit symbol (visual-motor coordination and speed). This test has shown good reliability and validity in China (the test-retest reliability was 0.89). The split half reliabilities in specific tasks were between 0.82 and 0.94 (Gong, 1992). The full scale IQ score was used as the index of general intelligence in this study.

2.4. Statistical analysis

First, correlation analyses were used to examine the relations between full-scale IQ scores and true and false memories. Next, in order to identify which subtests' scores are related to false memories in patients with schizophrenia, further correlational analyses were conducted with the subtests' scores. Finally, patients were categorized into three groups according to their full-scale IQ scores: low-IQ (IQ < 90), medium-IQ (IQ = 90 ~ 109), and high-IQ (IQ ≥ 110) and compared in terms of their memory performance using ANOVA.

3. Results

3.1. Intellectual correlates of true and false memories in the total sample

Age had negative correlations with high-confidence true recognition, digit span, and digit symbol scores ($r = -0.18$, -0.18, and -0.23, $p < 0.05$), but age had no correlation with the other indices in the memory and IQ tests ($p > 0.05$). Sex had no influence on any index in the memory and IQ tests ($p > 0.05$), except that males had higher picture arrangement score than did females, $t(137) = 2.01$, $p < 0.05$, Cohen's $d = 0.34$. Therefore, age and sex were used as covariates for subsequent correlation analyses.

As shown in Table 1, the full IQ score had a positive correlation with high-confidence true recognition, and a negative correlation with false

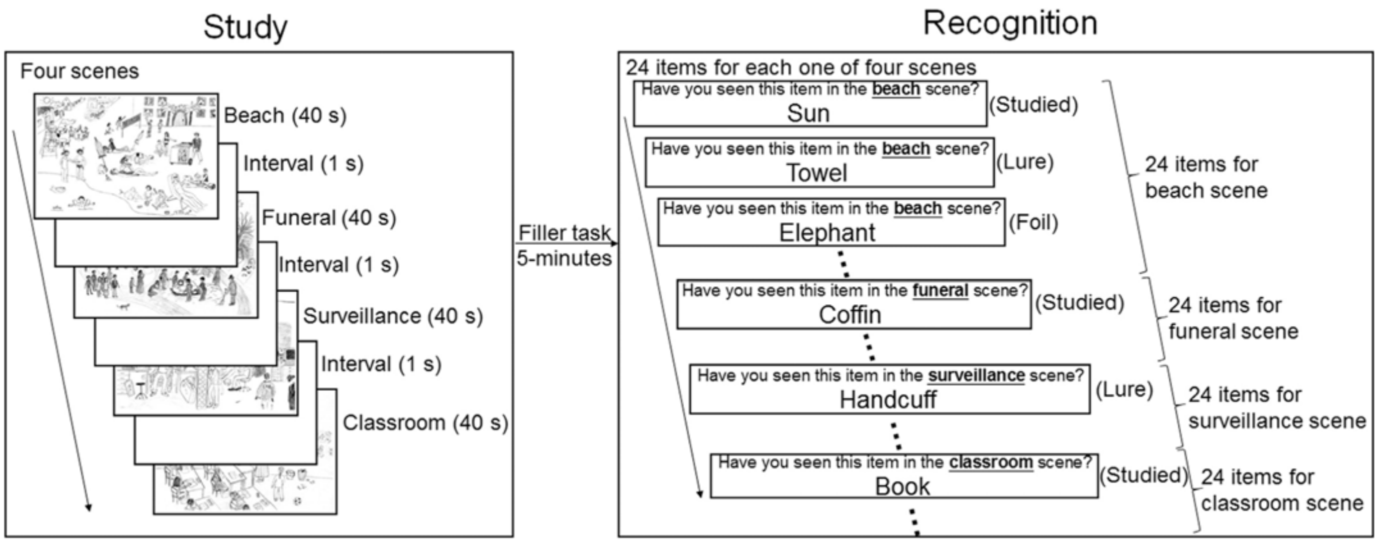

Fig. 1. Experimental procedure. s= second.

recognition ($p < 0.05$). In addition to the full IQ score, we explored whether true and false memories were correlated with the verbal and performance scale IQ scores and their subtests' scores. Although there was a positive correlation between true and false recognition ($r = 0.72$, $p < 0.001$), all significant intellectual correlations were positive for true recognition and negative for false recognition. True recognition had positive correlations with verbal IQ and its subtests (digit span and information), but false recognition had negative correlations with performance IQ and its subtest (picture arrangement) ($p < 0.05$). Although there was a positive correlation between high-confidence true and false recognition ($r = 0.74$, $p < 0.001$), all significant intellectual correlations were positive for high-confidence true memory and negative for high-confidence false memory. High-confidence true recognition had significant positive correlations with performance and verbal IQ, but high-confidence false recognition had only a significant negative correlation with one subtest of performance IQ (block design) ($p < 0.05$).

As shown in Table 1 and Fig. 2, the full IQ score had positive correlations with discrimination rates ($p < 0.01$). For the discrimination rates (recognized as old), positive correlations were found between d′(T-U) and d′(F-U) ($r = 0.88$, $p < 0.001$), and between d′(T-U) and d′(T-F) ($r = 0.38$, $p < 0.001$). But there was no correlation between d′(F-U) and d′(T-F) ($r = -0.10$, $p > 0.05$). All intellectual indices had significant positive correlations with three discrimination rates ($p < 0.05$), except for two non-significant correlations with d′(F-U) (i.e., digit span and block design, $p > 0.05$). For the discrimination rates with high-confidence (recognized as old with confidence), positive correlations were found between d′(HCT-HCU) and d′(HCF-HCU) ($r = 0.87$, $p < 0.001$), and between d′(HCT-HCU) and d′(HCT-HCF) ($r = 0.35$, $p < 0.001$). But there was no correlation between d′(HCF-HCU) and d′(HCT-HCF) ($r = -0.15$, $p > 0.05$). All intellectual indices had significant positive correlations with three discrimination rates ($p < 0.05$), except for four non-significant correlations with d′(HCF-HCU) (i.e., digit span, picture completion, picture arrangement, and block design) and a non-significant correlation between d′(HCT-HCF) and digit span ($p > 0.05$).

Table 1
Means and standard deviations of IQ scores and their partial correlations with true and false recognition in patients with schizophrenia after controlling for age and sex.

	Mean ± SD	TR 0.76 ± 0.15	FR 0.63 ± 0.22	HCTR 0.49 ± 0.22	HCFR 0.32 ± 0.23	d′(T-U) 1.84 ± 0.99	d′(F-U) 1.44 ± 0.92	d′(T-F) 0.44 ± 0.92	d′(HCT-HCU) 1.97 ± 1.17	d′(HCF-HCU) 1.38 ± 1.11	d′(HCT-HCF) 0.59 ± 0.57
Full IQ	100 ± 14	0.15	− 0.18*	0.25**	− 0.10	0.50***	0.33***	0.42***	0.43***	0.26**	0.36***
Perform IQ	94 ± 13	0.09	− 0.19*	0.20*	− 0.13	0.47***	0.32***	0.38***	0.37***	0.19*	0.37***
DSymbo	10 ± 2	0.11	− 0.11	0.14	− 0.09	0.40***	0.28**	0.30***	0.29***	0.19*	0.23**
ObjAss	8 ± 3	0.09	− 0.15	0.17	− 0.08	0.36***	0.25**	0.28***	0.32***	0.20*	0.28**
Block	10 ± 2	− 0.03	− 0.16	0.00	− 0.21*	0.26**	0.16	0.24**	0.21*	0.08	0.26**
PicArr	9 ± 2	− 0.01	− 0.19*	0.17	− 0.08	0.30***	0.19*	0.27**	0.28***	0.15	0.28***
PicComp	8 ± 2	0.06	− 0.08	0.20*	0.01	0.41***	0.34***	0.21*	0.24**	0.17	0.17*
Verbal IQ	103 ± 14	0.18*	− 0.15	0.26**	− 0.07	0.46***	0.30***	0.40***	0.41***	0.27**	0.30***
DSpan	10 ± 2	0.19*	0.00	0.11	− 0.07	0.19*	0.11	0.17*	0.22*	0.16	0.12
Compr	11 ± 3	0.13	− 0.16	0.23**	− 0.02	0.45***	0.30***	0.37***	0.31***	0.20**	0.24**
Arith	8 ± 3	0.15	− 0.16	0.22**	− 0.11	0.39***	0.23**	0.38***	0.44***	0.28**	0.35***
Vocab	12 ± 2	0.11	− 0.13	0.24**	0.00	0.47***	0.34***	0.33***	0.36***	0.28***	0.20*
Simil	11 ± 2	0.04	− 0.14	0.12	− 0.06	0.37***	0.26**	0.27**	0.27**	0.20*	0.16
Infor	11 ± 3	0.22*	− 0.02	0.25**	0.00	0.36***	0.24**	0.30***	0.35***	0.25**	0.23**

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Significant correlations are shown in bold. TR: true recognition, FR: false recognition; HCTR: high-confidence true recognition, HCFR: high-confidence false recognition; d′(T-U): performance of discriminating studied items from unrelated foils, d′(F-U): discriminating lures from unrelated foils, d′(T-F): discriminating studied items from lures; d′(HCT-HCU): high-confidence performance of discriminating studied items from unrelated foils, d′(HCF-HCU): high-confidence performance of discriminating lures from unrelated foils, d′(HCT-HCF): high-confidence performance of discriminating studied items from lures. Perform IQ: performance intelligence, DSymbo: digit symbol, ObjAss: object assembly, Block: block design, PicArr: picture arrangement, PicComp: picture completion; Verbal IQ: verbal intelligence, DSpan: digit span, Compr: comprehension, Arith: arithmetic, Vocab: vocabulary, Simil: similarity, Infor: information.

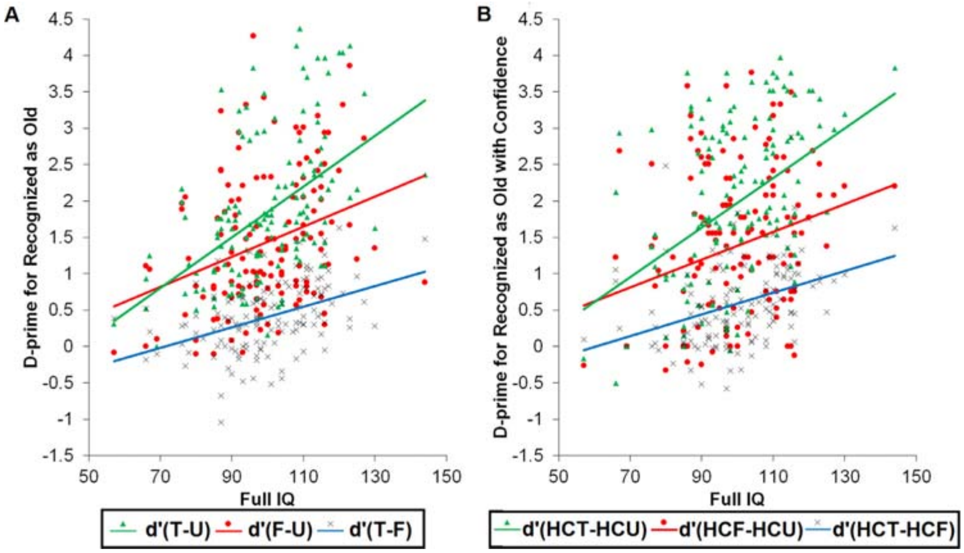

Fig. 2. Scatter plots and regression lines of D-prime memory indices as a function of full IQ score. (A) D-prime for recognized as old. The performance of discriminating studied items from unrelated foils d′(T-U), discriminating lures from unrelated foils d′(F-U), and discriminating studied items from lures d′(T-F). (B) D-prime for recognized as old with confidence. The high-confidence performance of discriminating studied items from unrelated foils d′(HCT-HCU), discriminating lures from unrelated foils d′(HCF-HCU), and discriminating studied items from lures d′(HCT-HCF).

3.2. Differences between patients with low, medium, and high IQ

Next, we examined differences in memory performance between patients with low, medium, and high intelligence. Based on two cut-off points of the full IQ score (i.e., 90 and 110) (Wechsler, 1981), 139 patients with schizophrenia were divided into three groups: 30 patients with low IQ (range 57 ~ 89), 71 patients with medium IQ (range 90 ~ 109), and 38 patients with high IQ (range 110 ~ 144). There was no sex or age difference between these three groups ($p > 0.05$). The means and standard deviations of indices in the recognition test for patients with three different intellectual levels are shown in Table 2. As compared with low-IQ and medium-IQ patients, high-IQ patients had fewer false alarms for lures and foils, more high-confidence true recognition, and higher discrimination abilities ($p < 0.05$). Moreover, medium-IQ patients had higher d′(T-U) and d′(HCT-HCU) than those with low IQ ($p < 0.05$). For all three groups of patients, true recognition was higher than false recognition, and false recognition was higher than foil recognition (i.e., TR > FR > UN; HCTR > HCFR > HCUN); the ability of discriminating studied items from foils was higher than the ability of discriminating lures from foils, and the ability of discriminating lures from foils was higher than the ability of discriminating studied items from lures (i.e., d′[T-U] > d′[F-U] > d′[T-F]; d′[HCT-HCU] > d′[HCF-HCU] > d′[HCT-HCF]) ($p < 0.001$). See Table 2 and Supplemental Material Table S1 for details.

Table 2
The means and standard deviations of major indices in the recognition test for patients with low IQ (IQ < 90), medium IQ (IQ = 90 ~ 109), and high IQ (IQ ≥ 110).

	Low-IQ (L)	Medium-IQ (M)	High-IQ (H)	Comparisons between L, M, and H ($p < 0.05$)
TR	0.75 ± 0.14	0.75 ± 0.14	0.78 ± 0.15	n.s.
FR	0.67 ± 0.20	0.64 ± 0.21	0.56 ± 0.23	L & M > H
UN	0.36 ± 0.25	0.27 ± 0.21	0.14 ± 0.14	L & M > H
HCTR	0.45 ± 0.25	0.48 ± 0.22	0.56 ± .019	L < H
HCFR	0.37 ± 0.28	0.33 ± 0.23	0.25 ± 0.18	L > H
HCUN	0.15 ± 0.20	0.09 ± 0.15	0.04 ± 0.06	L & M > H
d′(T-U)	1.25 ± 0.70	1.71 ± 0.92	2.55 ± 0.91	L < M < H
d′(F-U)	1.07 ± 0.89	1.37 ± 0.89	1.84 ± 0.89	M & L < H
d′(T-F)	0.18 ± 0.44	0.33 ± 0.43	0.71 ± 0.41	M & L < H
d'(HCT-HCU)	1.35 ± 1.17	1.87 ± 1.13	2.63 ± 0.91	L < M < H
d'(HCF-HCU)	0.98 ± 1.31	1.40 ± 1.06	1.66 ± 0.98	L < H
d'(HCT-HCF)	0.37 ± 0.56	0.47 ± 0.49	0.97 ± 0.52	L & M > H

Note: TR: true recognition, FR: false recognition, UN: unrelated foils; HCTR: high-confidence true recognition, HCFR: high-confidence false recognition, HCUN: high-confidence unrelated foils; d′(T-U): performance of discriminating studied items from unrelated foils, d′(F-U): discriminating lures from unrelated foils, d′(T-F): discriminating studied items from lures; d′(HCT-HCU): high-confidence performance of discriminating studied items from unrelated foils, d′(HCF-HCU): high-confidence performance of discriminating lures from unrelated foils, d′(HCT-HCF): high-confidence performance of discriminating studied items from lures. n.s. = not significant.

4. Discussion

The current study found intellectual factors in false recognition of patients with schizophrenia. In the total sample, false recognition had a negative correlation with full IQ (especially for performance IQ); but true recognition had a positive correlation with verbal IQ. High-confidence false recognition had a negative correlation with the block design score, while high-confidence true recognition had positive correlations with the full IQ score, both performance and verbal scores, and several subtest scores (picture completion, picture comprehension, arithmetic, vocabulary, and information). The discrimination abilities in patients with schizophrenia had positive correlations with several intellectual scores.

Consistent with our first hypothesis, correlation analyses found that low-IQ patients with schizophrenia had more false recognition and lower discrimination abilities than those with high-IQ. As shown in Fig. 2, IQ scores had relatively higher (more positive) correlations with d′(T-U) than with d′(F-U). Using the fuzzy trace theory to interpret our results, it seems that low-IQ patients had both poor verbatim memory (i.e., lower d′[T-U]) and poor gist memory (i.e., lower d′[F-U]) than those with high IQ. Moreover, low-IQ patients were more likely to rely on gist information (i.e., smaller difference between d′[T-U] and d′[F-U] for low-IQ patients) than those with higher IQ (i.e., larger difference between d′[T-U] and d′[F-U] for high-IQ patients). As compared with high-IQ patients, the greater reliance on gist memory in low-IQ patients led to more false recognition.

In the total sample of patients with schizophrenia, as predicted, false recognition was negatively correlated with performance IQ. Interestingly, false recognition was also negatively correlated with a subtest of performance IQ (i.e., picture arrangement). In this task, participants had to place a series of pictures in the correct order to tell a sensible story. Previous studies suggested that picture arrangement is a measure of frontal lobe function (Kato et al., 2016; McFie and Thompson, 1972). For example, low picture arrangement scores were correlated with decreased regional cerebral blood flow in the frontal lobe (Kato et al., 2016). Moreover, participants with low frontal lobe functioning were found to have more false memories than those with high frontal lobe functioning (Butler et al., 2004; Curran et al., 1997; Schacter et al., 1996). Consistent with these previous studies, we found that patients with schizophrenia with low picture arrangement scores had more false memories than those with high picture arrangement scores. However, high-confidence false memory in our study had a negative correlation with a subtest of performance IQ (i.e., block design) only. In this task, participants had to rearrange blocks with colors to match a pattern. Previous studies found that participants with low block design scores were more likely to be overconfident than those with high block design scores (Hansson et al., 2008), and patients with schizophrenia were more overconfident in false memory than healthy controls (Moritz et al., 2008; Moritz et al., 2006). It may explain why we found that patients with low block design scores were overconfident in false memory.

Consistent with findings of Moritz et al. (2004), there was a positive correlation between false recognition and true recognition in patients with schizophrenia, suggesting their use of gist-based response strategy during recognition. However, different from the negative correlations between IQ and false recognition, we found that true recognition had positive correlations with verbal IQ and two of its subtests (i.e., information and digit span). The information subtest performance relies on the retrieval of general knowledge (Ruiz et al., 2007; Stedman and Clair, 1998), and digit span reflects short-term memory (Aleman et al., 1999). Thus, it is plausible that recognition of studied items from visual scenes requires similar memory storage ability in patients with schizophrenia. Moreover, high-confidence true recognition had positive correlations with verbal IQ (and four of its subtests [information, vocabulary, comprehension, and arithmetic]), and performance IQ (and one of its subtests [picture completion]). Information, vocabulary, and comprehension reflect the verbal comprehension ability; arithmetic subtest measures the mental manipulation ability; and picture completion subtest measures the ability to perceive visual details. Previous studies found that metacognition (i.e., greater understanding of one's own mind) in patients with schizophrenia had positive correlations with verbal comprehension, arithmetic ability, and visual memory (Lysaker et al., 2005; Lysaker et al., 2007). Moreover, memory confidence is an important aspect of metacognition (Moritz et al., 2008). Thus, patients with high scores on these intellectual tests had more high-confidence true recognition than those with low scores. These findings suggested that true and false memory in patients with schizophrenia might arise from different cognitive mechanisms. For patients with schizophrenia, true memory may mainly depend on their verbal ability, but their false memory may mainly depend on their performance ability.

Our findings of false recognition for visual scenes in patients with schizophrenia extended the previous study of Moritz et al. (2006), by distinguishing these high-IQ patients from those with medium- and low-IQ scores. The results of high-IQ patients (IQ ≥ 110) in our study were consistent with those in the study by Moritz et al. (2006). Using a sample of highly-educated patients with schizophrenia, Moritz et al. (2006) reported their endorsement rates for studied, lure, and foil items (i.e., about 75%, 50%, 10%, respectively). Similarly, for the high-IQ patients with schizophrenia in our study, the endorsement rates for studied, lure, and foil items were about 78%, 56%, and 14%, respectively. More importantly, we found that low and medium-IQ patients (IQ < 110) had more false recognition (about 65%) and foil recognition (about 30%) than those with high IQ. In addition, low-IQ patients (IQ < 90) had more high-confidence false recognition and foil recognition than those with high IQ. It has been suggested that patients with schizophrenia with relatively lower IQ scores have acquiescence response bias (likely to say yes) in the recognition test (Carlin et al., 2012).

Regarding to the relation between IQ and false memory, our findings from patients with schizophrenia were consistent with several previous studies using in nonclinical and other clinical samples (Borsutzky et al., 2010; Gudjonsson and Henry, 2003; Zhu et al., 2010). As described earlier in the introduction, intelligence (especially performance IQ) had a negative correlation with false memory in healthy participants (Zhu et al., 2010). Moreover, individuals with intellectual disabilities had more false memory than healthy controls with normal IQ (Gudjonsson and Henry, 2003). In addition, intelligence also had a negative correlation with false memory in patients with rupture of anterior communicating artery aneurysms (Borsutzky et al., 2010). It suggests that false memory reflects deficient intellectual processing in both healthy individuals and patients (Schacter et al., 2011).

These findings have several implications and suggestions for future studies. First, intelligence factor should be considered when judging the trustworthiness of eyewitness memory of patients with schizophrenia (Gudjonsson and Henry, 2003). Although true memory impairment is prevalent in patients with schizophrenia, low-IQ patients with schizophrenia are more likely to be unreliable eyewitnesses (i.e., more false memory) than are those with high IQ. It should be noted that the current findings were based on recognition performance, so future studies should examine the role of IQ in eyewitness recall in patients with schizophrenia. Second, IQ should also be considered when deciding what type of cognitive behavioral intervention to use for patients with schizophrenia. As shown in our study, low-IQ patients had more severe impairments in memory discrimination rates than high-IQ patients. Moreover, previous studies suggested that source-monitoring training could be used to improve memory discrimination abilities (Martell and Evans, 2005). Thus, future studies should explore whether source-monitoring cognitive training is more effective for low-IQ patients than those with high IQ. Finally, the relations between false memory, intelligence, and psychopathological symptoms in patients with schizophrenia need further explorations. Using the visual scene false recognition task, Moritz et al. (2006) reported that there was no correlation between memory indices and psychopathological symptoms (e.g., delusion, suspiciousness, and hallucinations) in patients with schizophrenia. Therefore, the current study did not examine their relations with psychopathological symptoms, but future studies could explore whether high-IQ patients with schizophrenia are less likely than medium- or low-IQ patients to have symptoms that are theoretically related to recognition deficits.

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Conflicts of interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.05.007.

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