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Value-Directed Remembering in First-Episode Schizophrenia

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Objective: Memory deficits in individuals with schizophrenia are well-established, but less is known about how schizophrenia affects metacognitive processes such as metamemory. We investigated metamemory ability using the value-directed remembering task, which assesses the degree to which participants use value cues to guide their learning of a list of items (i.e., their memory selectivity). ***Method:*** Participants were patients undergoing treatment following a recent first episode of schizophrenia ($n = 20$) and demographically comparable healthy controls ($n = 18$). Participants viewed six lists of 24 words where each word was paired with either a low value (1–3 points) or a high value (10–12 points), and they were instructed to maximize their score on free recall tests given after each list. After the final free recall test, participants completed a recognition test where they gave remember/know judgments. ***Results:*** On tests of free recall, patients showed reduced memory selectivity relative to healthy controls. On the recognition test, patients failed to show an effect of value on recognition of nonrecalled words, in contrast to healthy controls, who showed a significant value effect that was characterized by greater "remember" judgments. Patients initially overestimated their memory capacity but were able to adjust their estimates to be more accurate based on task experience. Patients' self-reports of memory selectivity were unrelated to their actual memory selectivity. ***Conclusions:*** Patients with first-episode schizophrenia had substantial impairments on the value-directed remembering task, but areas of preserved metamemory ability were also observed. These findings have potential implications for cognitive training interventions.

Key Points

Question: In situations where they are faced with more information than they are able to remember, do individuals with schizophrenia show deficits at prioritizing the information that is most important? ***Findings:*** Individuals with schizophrenia did prioritize important information in memory, but they were less adept at doing so than healthy controls. ***Importance:*** As people with schizophrenia often struggle with memory problems, they may be able to maximize their memory by learning to prioritize the most important information; development of this skill could become a part of cognitive training they receive as part of their clinical care. ***Next Steps:*** Future research should explore whether patients who have had schizophrenia for a longer period of time show similar deficits, and whether patients show improved ability to prioritize important information in memory when they are given specific strategies for doing so.

Keywords: metamemory, metacognition, schizophrenia, recall, recognition

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Schizophrenia is a psychiatric disorder characterized by a variety of signs and symptoms as well as impaired occupational or social functioning (American Psychiatric Association, 1994). While much of the research on schizophrenia has traditionally focused on psychosis as a defining feature and intervention target, neurocognitive deficits associated with schizophrenia have detrimental effects on patients' lives and have become an increasing focus for intervention efforts (Green, 1998, 2001; Green et al., 2019). One of the most severe neurocognitive deficits is in the domain of learning and memory (Saykin et al., 1991, 1994). Recall memory deficits are large; recognition memory, while impaired, appears relatively less impaired than recall memory, suggesting that both encoding and retrieval processes are affected (Aleman et al., 1999; Paulsen et al., 1995). Consistent with these behavioral findings, patients with schizophrenia have been found to have neural differences in brain regions that contribute to learning and memory. For example, compared to healthy controls, patients with schizophrenia have been shown to have greater hippocampal cell disorganization (Conrad et al., 1991; Kovelman & Scheibel, 1984), reduced hippocampal volume (Nelson et al., 1998; van Erp et al., 2016), and reduced frontal lobe cortical thickness (Kuperberg et al., 2003; van Erp et al., 2018).

While the memory deficits associated with schizophrenia are well documented, somewhat less is known about how schizophrenia affects metamemory (Hoven et al., 2019; Izaute & Bacon, 2010). Metamemory is a type of metacognition that depends on knowledge about memory (Metcalfe & Shimamura, 1994). This knowledge can include knowledge about one's own memory as well as knowledge about how memory works more generally. Examples include knowing one's own memory capacity or the circumstances under which memory failure is likely to occur. Patients with schizophrenia have been shown to exhibit metamemory deficits in the ability to assign the correct source to a memory (Brébion et al., 2012; Waters et al., 2004) and in making confidence judgments about their memories (Moritz & Woodward, 2002; Moritz et al., 2003; Seabury et al., 2021).

Metamemory deficits, such as high confidence in inaccurate memories, may contribute to core schizophrenia symptoms such as delusions (Moritz & Woodward, 2005). Additionally, metamemory performance can have a functional impact. Knowledge about memory can be used to improve memory performance, such as when a learner judges information to be not well learned and devotes more time to studying it (Nelson & Narens, 1990). Similarly, when a learner is faced with more information than they are able to remember, metamemory ability can assist the learner in focusing on the information that is most important (Castel et al., 2012). Thus, metamemory deficits in schizophrenia could exacerbate functional deficits resulting from impaired memory.

One task that has been used to study metamemory in the laboratory is the value-directed remembering task (Castel et al., 2002). In this task, participants are presented with one or more lists of items to remember for a future test, and during encoding, each item is paired with a point value. Participants are told that if they remember an item, they will be awarded the points associated with that item, and are instructed to maximize their score. As such, the value-directed remembering task yields measures of memory capacity, that is, how many items the participant is able to remember, as well as memory selectivity, that is, how well the participant is able to focus their memory resources on the higher value items. In the original version of the task, participants learned lists of words and were evaluated with tests of free recall, but the task has also been used to study other types of memory, such as memory for picture–location associations (Siegel & Castel, 2018a, 2018b) and recognition memory (Castel et al., 2007; Cohen et al., 2017; Hennessee et al., 2017, 2018).

Prioritization of high-value items in memory during the value-directed remembering task has been shown to be robust to experimental manipulations that reduce recall, such as limiting encoding time (Middlebrooks et al., 2016) and having participants perform a secondary task during encoding (Middlebrooks et al., 2017). Moreover, a number of studies using the value-directed remembering task have demonstrated that healthy older adults, despite having lower memory capacity than healthy younger adults, nonetheless typically have comparable or superior memory selectivity (Castel et al., 2002, 2007, 2009; Castel, Humphreys, et al., 2011). These findings suggest that memory capacity and memory selectivity are dissociable, and that older adults may compensate for diminished capacity by focusing their limited memory resources on the most important information. On the other hand, studies using the value-directed remembering task with patient populations have identified several groups that show impaired memory selectivity relative to healthy controls that is disproportionate to memory deficits, including individuals with childhood traumatic brain injury (Hanten et al., 2004), childhood attention-deficit/hyperactivity disorder (Castel, Lee, et al., 2011), and behavioral variant frontotemporal dementia (Wong et al., 2019). In Alzheimer's disease, both memory performance and selectivity are impaired to a similar degree (Castel et al., 2009; Wong et al., 2019). Thus, the relationship between memory impairment and selectivity varies across different patient groups, and understanding this relationship in schizophrenia may provide insights into this disorder. Furthermore, future cognitive interventions may be informed by demonstrating deficits in memory selectivity in schizophrenia and whether these patients can update encoding strategies when confronted with feedback about their memory performance.

Neuroimaging studies using the value-directed remembering task have implicated the frontal and temporal lobes in supporting task performance in both healthy young adults (Cohen et al., 2014) and healthy older adults (Cohen et al., 2016). Additionally, value-directed remembering task performance in healthy younger and older adults is correlated with the integrity of white matter connecting the frontal lobe with more posterior regions of the brain (Hennessee et al., 2019; Reggente et al., 2018). These studies, along with the patient studies cited above, strongly suggest that the frontal lobe plays an important role in supporting value-directed remembering. The specific cognitive and metacognitive processes that it supports during this task, however, are not fully known. Successful task performance likely depends on the ability to maintain the goal of maximizing one's score, awareness of one's memory capacity, and adoption of different encoding strategies for high- and low-value items.

In the present study, we investigated the hypothesis that patients with first-episode schizophrenia would show impairment on the value-directed remembering task compared to control participants, given other metamemory deficits shown by patients with schizophrenia. An understanding of how individuals with schizophrenia perform on this task could lead to the development of cognitive training that assists these patients with maximizing their limited memory capacity. Words paired with point values were presented to a group of patients with first-episode schizophrenia and a group of demographically comparable healthy controls. We evaluated participants' memory selectivity by looking at how the values paired

with each word during encoding affected (a) performance on free recall tests given after each word list and (b) performance on a recognition test given after all the previous study–test cycles had been completed.

During the recognition test, we had participants make remember/know judgments for items that they marked as recognized (Gardiner, 1988; Rajaram, 1993; Tulving, 1985). In this paradigm, a "remember" judgment indicates recognition of an item that is accompanied by conscious recollection of the encoding episode, whereas a "know" judgment indicates recognition that is not accompanied by conscious recollection and is based on a feeling of familiarity. Patients with chronic or first-episode schizophrenia as well as individuals at high risk for developing psychosis, produce fewer "remember" but not "know" responses compared to healthy controls (Huron et al., 1995; Lee et al., 2018; van Erp et al., 2008), suggesting that impairment in the recollection component of episodic memory is associated with vulnerability to schizophrenia. Prior work using the remember/know procedure during a recognition test of value-directed remembering found that, in healthy young adults, "remember" responses but not "know" responses were more frequent for high-value than low-value items (Hennessee et al., 2017). By having participants perform remember/know judgments for items previously paired with low- or high-value words, we were able to investigate whether value affects recollection and familiarity judgments differently in patients and healthy controls.

We were also interested in looking at how self-reports of memory capacity and selectivity in patients with first-episode schizophrenia aligned with their actual performance. It is likely that having a more accurate representation of one's memory capacity facilitates performance on the value-directed remembering task, as holding the belief that one can retain more items than one is actually able to retain could lead to attempting to learn too many items and thus failure to focus on the most valuable items. Prior research using a "gambling" version of the value-directed remembering task has indicated that healthy older adults initially bet that they can recall many more words than they are able to recall, but with task experience become better calibrated (McGillivray & Castel, 2011). Similarly, healthy older adults performing a version of the value-directed remembering task in which they are given feedback on how many words they were able to recall after each list are initially very overconfident in their estimates of their memory capacity, but with task experience, both their memory selectivity and capacity estimates improve (Siegel & Castel, 2019). We therefore collected self-reports of recall ability to determine (a) how patients' estimates of their memory capacity compare to healthy controls' estimates and (b) whether experience with the task changes these estimates.

With regard to self-reported memory selectivity, prior work using the value-directed remembering task has indicated that the extent to which healthy participants report being sensitive to item value during encoding corresponds with the effect of value on their recall performance (Cohen et al., 2017). Similar results have been obtained in patients with Alzheimer's disease (Wong et al., 2019). In contrast, in patients with behavioral variant frontotemporal dementia, self-reported value sensitivity during encoding has been found to be unrelated to their actual value sensitivity, such that patients who reported being sensitive to value were no more selective than patients who reported being insensitive to value (Wong et al., 2019). In the present study, we therefore collected self-reports of memory selectivity by having participants respond to a posttest question asking them whether they did anything differently to learn high- versus low-value items in order to determine (a) the extent to which first-episode schizophrenia patients self-report using differential encoding during this task and (b) whether these self-reports are related to their actual sensitivity to value.

Method

Participants

Twenty first-episode schizophrenia patients and 18 healthy controls participated in the study. Patients were recruited from the UCLA Aftercare Research Program, an outpatient clinic for first-episode schizophrenia (Nuechterlein, Subotnik, et al., 2020; Nuechterlein, Ventura, et al., 2020). All patients received treatment that included case management, symptom monitoring, group therapy, and antipsychotic medication. Inclusion criteria for the patient group were: (a) onset of a first psychotic episode within 24 months of program entry; (b) a diagnosis of schizophrenia, schizoaffective disorder depressed type, or schizophreniform disorder (Diagnostic and Statistical Manual of Mental Disorders, 4th Edition [DSM-IV]; American Psychiatric Association, 1994); (c) 18–35 years of age; and (d) sufficient fluency in English to avoid invalidating research measures. Exclusion criteria for the patient group were: (a) premorbid IQ less than 70 and (b) a *DSM-IV* diagnosis of substance dependence or abuse within the 6 months prior to the first psychotic episode or evidence that substance abuse triggered the psychotic episode and makes the schizophrenia diagnosis ambiguous. Healthy control participants were recruited either through online advertisements or via direct contact on the basis of participation in prior research. Healthy controls had no history of significant psychiatric disorder and had no history of a psychotic disorder or bipolar disorder among their first-degree relatives. For all participants, a history of neurological disorder or head injury resulting in loss of consciousness for more than 15 min was exclusionary.

Demographic and clinical information for study participants is provided in Table 1. The patient group and the control group did not differ significantly in terms of age, parental education, gender, or race/ethnicity. Diagnoses for participants in the patient group were as follows: schizophrenia, $n = 18$; schizoaffective disorderdepressed type, $n = 1$; schizophreniform disorder, $n = 1$. At the time of testing, five patients reported using alcohol and two patients reported using marijuana. Patients who reported using alcohol reported an average of three drinks per week (range 0.5–6). Patients who reported using marijuana reported an average of two doses per week (range 1–3). All of the patients were taking prescription antipsychotic medications. Five patients were prescribed olanzapine, three patients were prescribed paliperidone palmitate, three patients were prescribed aripiprazole, three patients were prescribed clozapine, three patients were prescribed risperidone, one patient was prescribed ziprasidone, one patient was prescribed iloperidone, and one patient was prescribed clozapine and risperidone. All patients were outpatients at the time of testing. Study procedures were approved by the UCLA Institutional Review Board and all participants provided written informed consent. Patients were tested at the UCLA Aftercare Research Program clinic, and healthy controls were tested at the UCLA Cognitive Neuroscience Laboratory. Study participants were compensated $50 for the 90-min session.

Table 1
Participant Characteristics

Characteristic	HC	SZ	t or χ^2	p	d or V
Age (years)	22.5 (2.7)	21.9 (2.5)	$t = 0.77$	.448	$d = 0.25$
Range	19–30	18–28			
Parental education (years)	13.4 (2.6)	14.4 (2.9)	$t = 1.16$	.254	$d = 0.38$
Range	7.5–21	6.5–18			
Gender (% female)	22.2	15.0	$\chi^2 = 0.33$	.566	$V = .09$
Race/ethnicity			$\chi^2 = 2.42$	.659	$V = .25$
% Hispanic or Latino	44.4	35.0			
% Asian	22.2	15.0			
% Black	11.1	15.0			
% White	22.2	25.0			
% Other	0.0	10.0			
MCCB overall composite	—	34.0 (12.1)			
Range	—	3–58			
Illness duration (days)	—	605.6 (233.0)			
Range	—	222–1,122			
BPRS total	—	39.4 (11.4)			
Range	—	25–77			
SANS total	—	9.1 (4.1)			
Range	—	0–16			
SAPS total	—	6.6 (3.9)			
Range	—	0–12			

Note. Values presented as *M* (*SD*) or percentage. HC = healthy control; SZ = schizophrenia; MCCB = MATRICS Consensus Cognitive Battery (Nuechterlein et al., 2008); BPRS = Brief Psychiatric Rating Scale (Ventura et al., 1993); SANS = Scale for the Assessment of Negative Symptoms (Andreasen, 1984a); SAPS = Scale for the Assessment of Positive Symptoms (Andreasen, 1984b). Duration of illness was calculated as the number of days between the date of first psychotic symptoms lasting longer than 1 week and the date of testing. The SANS total was calculated by summing the global scores from the affective flattening, alogia, avolition–apathy, and anhedonia–asociality subscales. The SAPS total was calculated by summing the global scores from the hallucinations, delusions, bizarre behavior, and thought disorder subscales.

Materials

We selected 288 words from Toglia and Battig's (1978) word norms to use as stimuli in the study. All words were nouns 4–8 letters in length and contained 1–2 syllables. The selected words were rated as highly familiar (range 5.5–7 on a 1–7 scale), moderate to high on concreteness and imagery (range 4–6.5 on a 1–7 scale), and moderate in pleasantness (range 2.5–5.5 on a 1–7 scale). Half of the words were randomly selected to be presented during the study phase and the remaining half were used as foils during the recognition test. The words selected for presentation during the study phase were used to construct six lists of 24 words per list. Split-half reliability coefficients for the measures of correct recall, correct recognition, and selectivity index were as follows: $r = .93$, $r = .93$, $r = .52$.

Procedure

Prior to beginning the value-directed remembering task, participants were given detailed instructions about the procedure and their task goals. They were told that they would see a series of words paired with point values and that the values indicated the number of points they would receive for remembering the words. Participants were told that their goal was to get as high of a score as possible and that to do this they may want to focus more on the higher value items. After receiving task instructions, participants completed six practice trials and were given the opportunity to ask questions about the task.

Each trial began with a 2 s value cue presented as a number inside a gold circle resembling a coin, which indicated to the participant how many points the upcoming word was worth. Values were either low (1, 2, or 3) or high (10, 11, or 12). After a variable fixation period (3 s–6.75 s), participants viewed the to-be-remembered word for 3.5 s followed by 1.5 s of fixation. After each value–word pair was presented, participants completed a brief vowel/consonant task during which they were presented with 2–6 letters for 1 s each and had to press a button on the keyboard indicating whether the letter was a vowel or a consonant. Each trial ended with a 1.5 s blank screen.

Participants were presented a total of six word lists with 24 words per list (12 low value and 12 high value). The values assigned to the words and the order of the word lists were counterbalanced across participants. Each list began with 10 s of fixation. At the end of each list, participants completed 15 s of the vowel/consonant task before completing a 60 s free recall test during which they recalled out loud as many words as possible from the list they had just seen. Following each free recall test, participants were given feedback on their performance on the value-directed remembering task (number of points earned on the previous list) and the vowel/consonant task (percent accuracy during the previous list).

After completing all six study–test cycles, participants were given a recognition test. During the recognition test, participants viewed all 144 words that were presented during the study phase as well as 144 words that had not been presented. For each word, the participant indicated whether or not they had seen the word during the study phase by marking it as "old" or "new." For words marked as "old," participants were prompted to make a remember/know judgment. Participants received detailed instructions about making the remember/know judgments prior to beginning the recognition task, which were created by Cohen et al. (2017) based on those used by Rajaram (1993; see Appendix). After receiving these instructions, participants were asked to explain the difference between a "remember" judgment and a "know" judgment, to ensure

participants paid attention to the instructions and to allow the experimenter to correct any misunderstandings. Recognition trials were self-paced and the words were presented in a fixed, pseudorandomized order.

Questionnaires

Before completing the value-directed remembering task, participants completed a demographic questionnaire and a pretest questionnaire, which asked them to estimate how many words from a list of 24 they would be able to recall. At the end of the session, participants were given a posttest questionnaire, which again asked them to estimate how many words from a list of 24 they would be able to recall. This questionnaire also asked whether they did anything differently to learn the high-value words compared to the low-value words.

Data Analysis

Statistical analyses were performed using IBM SPSS Statistics (Version 25). Cohen's *d* and 95% confidence intervals for Cohen's *d* were calculated using JASP (Version 0.15). One participant in the patient group was unable to complete the recognition test due to computer error. This participant was included in the analyses of recall data and self-report data but was not included in the analysis of recognition data. Another participant in the patient group did not provide a posttest estimate of memory capacity. This participant was included in the analyses of recall data, recognition data, and self-reported memory selectivity, but was excluded from the analysis of self-reported memory capacity.

Transparency and Openness

This article reports original data. Sources for the materials used in this study have been cited and/or acknowledged. Data, analysis code, and research materials are available upon request. This study was not preregistered.

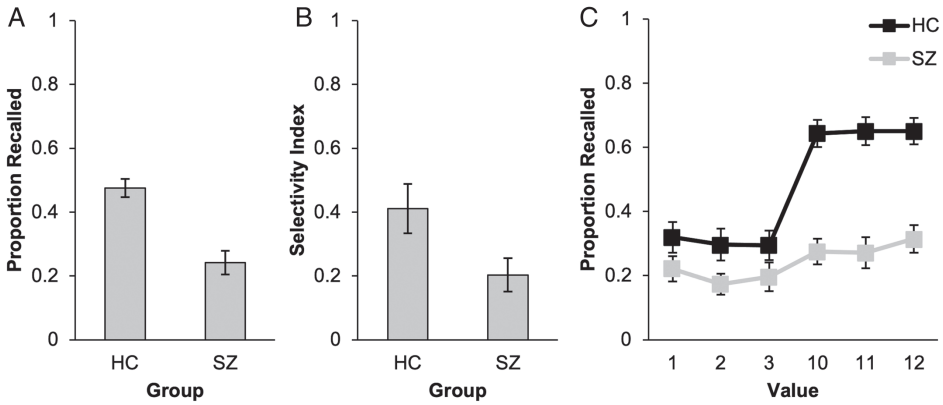
Results

Free Recall Test Performance

Free recall test performance is shown in Figure 1. Overall, individuals with schizophrenia showed reduced memory capacity compared to control participants, $t(36) = 4.96$, $p < .001$, $d = 1.61$, 95% CI [0.87, 2.34] (Figure 1A). Patients recalled an average of 5.80 words per list ($SD = 3.96$), and controls recalled an average of 11.42 words per list ($SD = 2.88$). The number of intrusions did not vary across the two groups, $t(36) = 0.19$, $p = .848$, $d = 0.06$, 95% CI [−0.58, 0.70].

We investigated participants' use of the value cues to guide their learning of the words by analyzing participants' selectivity index scores and their recall by item value. For each participant, we computed the selectivity index using the formula [(actual score − chance score)/(ideal score − chance score)], where the ideal score reflects the maximum points that could be earned given the number of items recalled (see Castel et al., 2002). This measure estimates how close a participant's point score is to their best possible score given their memory capacity and ranges from −1 to +1, with 0 indicating insensitivity to value and +1 indicating maximal selectivity for high-value items. The average selectivity index for the patient group was significantly lower than the average selectivity index for the control group, $t(36) = 2.27$, $p = .029$, $d = 0.74$, 95% CI [0.08, 1.39] (Figure 1B). Although the patients' average selectivity index was reduced compared to that obtained by the controls, it was significantly greater than zero, $t(19) = 3.91$, $p < .001$, $d = 0.88$, 95% CI [0.35, 1.39]. This indicates that although the patient group was impaired on the task, their performance was better than chance. The proportion of items recalled at each point value level is shown in Figure 1C. A 2 (group: patients, controls) × 2 (value: low, high) analysis of variance (ANOVA) revealed a main effect of group, $F(1, 36) = 24.56$, $p < .001$, $\eta_p^2 = .41$, a main effect of value, $F(1, 36) = 42.69$, $p < .001$, $\eta_p^2 = .54$, and a Group × Value interaction, $F(1, 36) = 14.62$, $p < .001$, $\eta_p^2 = .29$. As can be seen in the figure, the effect of value on recall was much greater in the control group, $t(17) = 5.42$,

Figure 1
Free Recall Test Performance



Note. (A) Mean proportion of items recalled by each group. (B) Mean selectivity index score for each group. (C) Mean proportion of items recalled by each group as a function of item value. Error bars represent ±1 standard error. HC = healthy control; SZ = schizophrenia.

$p < .001$, $d = 1.28$, 95% CI [0.64, 1.90], than in the patient group, $t(19) = 3.37$, $p = .003$, $d = 0.75$, 95% CI [0.25, 1.25].

Recognition Test Performance

The effects of value on recognition memory were investigated through analysis of data from the remember/know recognition test that participants completed after finishing the six study–test cycles. Analysis of recognition data was limited to items that were not recalled during the prior free recall tests, as recalling an item likely strengthens memory for that item, and participants from both groups recalled more high-value than low-value items. Data from the recognition test are shown in Figure 2. We began by examining hit rate, calculated as the proportion of target items correctly identified as "old." A 2 (group: patients, controls) × 2 (value: low, high) ANOVA revealed a main effect of group, $F(1, 35) = 4.60$, $p = .039$, $\eta_p^2 = .12$, a main effect of value, $F(1, 35) = 14.26$, $p < .001$, $\eta_p^2 = .29$, and a Group × Value interaction, $F(1, 35) = 12.87$, $p = .001$, $\eta_p^2 = .27$. In the control group, we observed a significant effect of value on recognition hit rate, $t(17) = 3.92$, $p = .001$, $d = 0.93$, 95% CI [0.36, 1.47], such that high-value items were correctly recognized at a higher rate than low-value items. In contrast, in the patient group, the recognition hit rate for high-value items was not different than the recognition hit rate for low-value items, $t(18) = 0.24$, $p = .815$, $d = 0.06$, 95% CI [−0.40, 0.50]. The rate of false alarms to foil items did not differ significantly across groups, $t(35) = 1.22$, $p = .231$, $d = 0.40$, 95% CI [−0.25, 1.05].

We next investigated the effects of group and value on the proportion of target items that were correctly identified as "old" and given a "remember" judgment. A 2 (group: patients, controls) × 2 (value: low, high) ANOVA revealed a main effect of value, $F(1, 35) = 11.86$, $p = .002$, $\eta_p^2 = .25$, and a Group × Value interaction, $F(1, 35) = 6.09$, $p = .019$, $\eta_p^2 = .15$. In the control group, we observed a significant effect of value on "remember" responses, $t(17) = 3.13$, $p = .006$, $d = 0.74$, 95% CI [0.21, 1.25], such that the proportion of high-value items given a "remember" response was greater than the proportion of low-value items given a "remember" response. In contrast, in the patient group, we did not observe an effect of value on "remember" responses, $t(18) = 1.27$, $p = .220$, $d = 0.29$, 95% CI [−0.17, 0.75]. The groups did not differ significantly on false alarms marked as "remember," $t(35) = 1.26$, $p = .217$, $d = 0.41$, 95% CI [−0.24, 1.06].

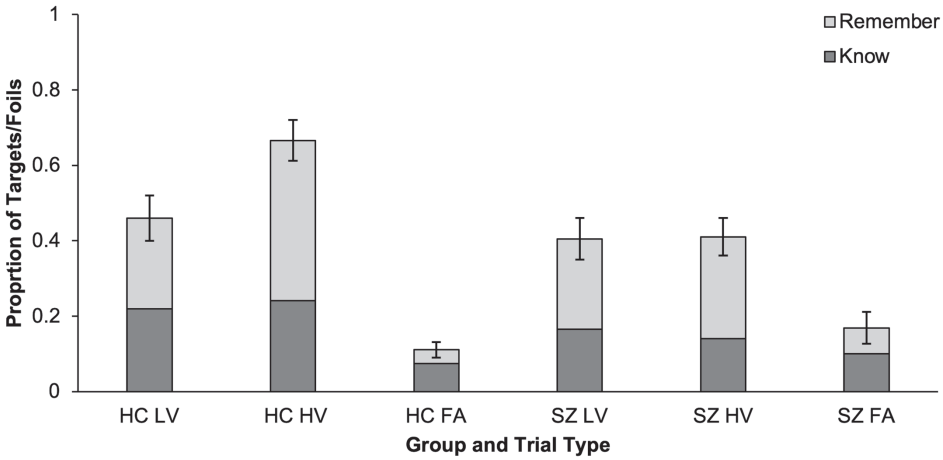
We next conducted parallel tests on the proportion of target items that were correctly identified as "old" and given a "know" judgment. A 2 (group: patients, controls) × 2 (value: low, high) ANOVA revealed a Group × Value interaction, $F(1, 35) = 4.23$, $p = .047$, $\eta_p^2 = .11$. In the control group, there was no effect of value on "know" responses, $t(17) = 1.12$, $p = .279$, $d = 0.26$, 95% CI [−0.21, 0.73]. In the patient group, there was a marginal effect of value on "know" responses, $t(18) = 2.09$, $p = .051$, $d = 0.48$, 95% CI [0.00, 0.95], such that the proportion of low-value items given a "know" response was marginally greater than the proportion of high-value items given a "know" response. The groups did not differ significantly on false alarms marked as "know," $t(35) = 0.68$, $p = .504$, $d = 0.22$, 95% CI [−0.43, 0.87].

Self-Reported Memory Capacity

Pre- and posttest calibration scores were calculated for each participant based on their responses to the questionnaire items, asking them to estimate how many words from a list of 24 they would be able to recall. Pretest calibration was computed as the participant's pretest estimate minus their average recall, and posttest calibration was computed as the participant's posttest estimate minus their average recall. The ideal calibration score is zero, indicating that the participant recalled on average as many items as they estimated that they could. Positive calibration scores indicate overconfidence in recall ability and negative calibration scores indicate underconfidence.

Average pre- and posttest calibration scores for both groups are shown in Figure 3. The average pretest calibration score in the patient group was significantly greater than the average pretest

Figure 2
Recognition Test Performance



Note. Recognition test performance as a function of group and trial type, broken down by items marked as "remember" versus items marked as "know." Error bars represent ±1 standard error. HC = healthy control; SZ = schizophrenia; LV = low value; HV = high value; FA = false alarm.

calibration score in the control group, $t(35) = 3.23$, $p = .003$, $d = 1.06$, 95% CI [0.37, 1.75], indicating that the patient group was significantly more overconfident at the beginning of the testing session. Analysis of posttest calibration scores revealed that at the end of the testing session, patients remained more overconfident than controls, but only marginally so, $t(35) = 1.92$, $p = .063$, $d = 0.63$, 95% CI [−0.03, 1.29].

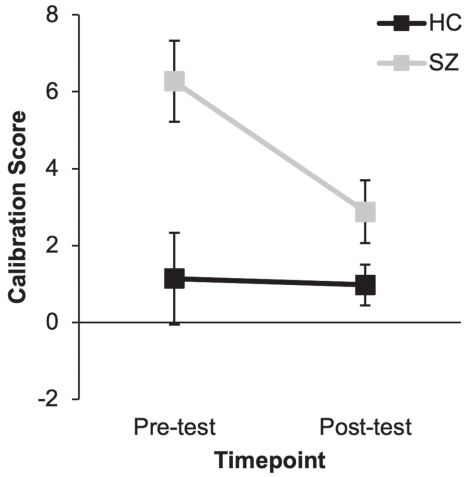
A 2 (group: patients, controls) × 2 (timepoint: pretest, posttest) ANOVA examining the change in participants' estimates of their recall ability revealed a main effect of group, $F(1, 35) = 5.84$, $p = .021$, $\eta_p^2 = .14$, a main effect of timepoint, $F(1, 35) = 5.32$, $p = .027$, $\eta_p^2 = .13$, and a Group × Timepoint interaction, $F(1, 35) = 4.37$, $p = .044$, $\eta_p^2 = .11$. In the patient group, experience with the value-directed remembering task resulted in a significant reduction in participants' estimates of their recall capacity from pre- to posttest, $t(18) = 3.33$, $p = .004$, $d = 0.76$, 95% CI [0.24, 1.27]. In the control group, which was relatively well calibrated at the beginning of the testing session, participants' estimates of their recall capacity did not change as a result of experience with the task, $t(17) = 0.14$, $p = .888$, $d = 0.03$, 95% CI [−0.43, 0.50].

Self-Reported Memory Selectivity

Participants' self-reported memory selectivity was coded based on their responses to the posttest questionnaire item that asked whether they did anything differently to learn the high-value words compared to the low-value words. Individuals categorized as insensitive to value claimed to have been indifferent to the values of the words, while individuals categorized as sensitive to value reported that they did something differently to learn high- versus low-value words. According to these self-reports, 55.0% of the patients and 77.8% of the controls were sensitive to value. The patient group and the control group did not differ significantly in the distribution of self-reported value sensitivity, $\chi^2(1) = 2.18$, $p = .139$, $V = .24$.

We next investigated how selectivity index varied based on group and self-reported value sensitivity. The results of this analysis are shown in Figure 4. A 2 (group: patients, controls) × 2 (sensitivity: insensitive, sensitive) ANOVA revealed a main effect of sensitivity, $F(1, 34) = 12.26$, $p = .001$, $\eta_p^2 = .27$, and a Group × Sensitivity interaction, $F(1, 34) = 11.76$, $p = .002$, $\eta_p^2 = .26$. In the control group, participants who reported being sensitive to value during encoding had significantly higher selectivity index scores than participants who reported being insensitive to value, $t(16) = 4.62$, $p < .001$, $d = 2.62$, 95% CI [1.17, 4.03]. In contrast, in the patient group, selectivity index scores did not differ according to self-reported value sensitivity, $t(18) = 0.06$, $p = .956$, $d = 0.03$, 95% CI [−0.86, 0.91].

Figure 3
Pre- and Posttest Calibration Scores



Note. Mean calibration scores for each group before and after completion of the value-directed remembering task. Error bars represent ±1 standard error. HC = healthy control; SZ = schizophrenia.

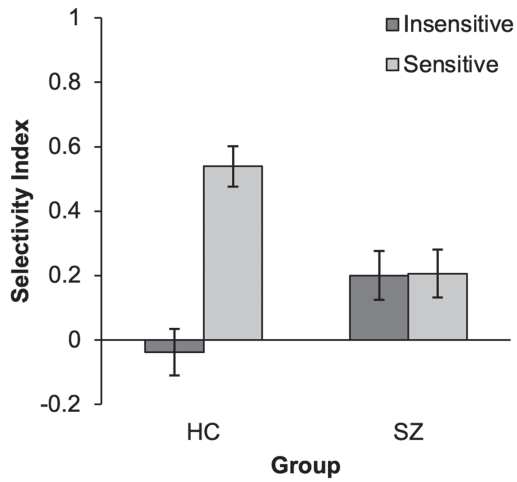
Discussion

In this study, we sought to evaluate performance of patients with first-episode schizophrenia on the value-directed remembering task. We found that these patients showed impairment not only in overall memory performance but also in the ability to use value to direct their memory. Specifically, during free recall tests, patients with schizophrenia recalled fewer words and exhibited lower memory selectivity than healthy controls. However, despite showing impairment relative to healthy controls, patients with schizophrenia did preferentially recall high-value words, indicating that the ability to use value to direct memory is present to some extent in this group. This pattern of overall memory impairment coupled with diminished memory selectivity is similar to findings obtained in patients with Alzheimer's disease (Castel et al., 2009; Wong et al., 2019) and differs from the pattern typically obtained in healthy older adults, where overall memory is impaired but memory selectivity is maintained (Castel et al., 2002, 2007, 2009; Castel, Humphreys, et al., 2011). The finding that patients with schizophrenia have some capacity to direct their memory to information that has been labeled as being of greater importance has clinical implications for cognitive training interventions; for example, training patients to use relative importance of to-be-remembered information more effectively when allocating their memory resources may assist them in compensating for overall memory deficits by helping ensure that important information is less likely to be forgotten. Given the relationship between memory and functional outcome measures in patients with schizophrenia (Green, 1996; Green et al., 2000), training that aims to give these patients greater ability to maximize their memory resources could have a positive impact on their social and occupational functioning.

On the recognition test, participants in the healthy control group correctly recognized a greater proportion of high-value than low-value items, whereas patients with schizophrenia showed no effect of value on recognition performance. Importantly, this analysis was limited to items that were not recalled during the prior free recall tests in order to avoid contamination of recognition data. Thus, although value did influence patients' free recall performance, it did not influence the recognition of items that were unable to be recalled. Consistent with prior work (Hennessee et al., 2017), the enhancement of recognition memory for high-value items in the healthy control group appeared to be due to greater levels of recollection-based "remembering" rather than familiarity-based "knowing." In contrast, patients with schizophrenia showed similar levels of "remembering" across low-value and high-value recognized items. These results suggest that while value appears to enhance recognition in healthy individuals by strengthening episodic detail, it does not appear to have this effect in patients with schizophrenia.

Figure 4

Selectivity as a Function of Self-Reported Value Sensitivity



Note. Mean selectivity index scores for each group as a function of self-reported sensitivity to value. Error bars represent ±1 standard error. HC = healthy control; SZ = schizophrenia.

Our results are consistent with findings of impaired episodic memory in patients with schizophrenia (Leavitt & Goldberg, 2009) and further suggest that value does not enhance episodic encoding in these patients as it does in healthy control participants. Patients with schizophrenia may not effectively engage in encoding that supports the binding of items to context that enables episodic retrieval.

In addition to investigating how value affected memory performance, we were also interested in investigating how participants' self-reports of memory capacity and memory selectivity aligned with their actual memory capacity and memory selectivity. We found that patients with schizophrenia were initially very overconfident in their memory capacity. Patients' posttest capacity estimates were substantially lower than their pretest capacity estimates, however, suggesting an intact ability to adjust memory capacity estimates based on task experience. Thus, while their initial miscalibration reflects metamemory impairment, patients' ability to adjust their capacity estimates reflects an area of preserved metamemory function. Our finding of initial miscalibration is in line with several studies that have indicated patients with schizophrenia are lacking insight into their neurocognitive status (Medalia & Lim, 2004; Medalia & Thysen, 2008; Medalia et al., 2008). The Cognitive Awareness Model (CAM; Agnew & Morris, 1998) was developed to account for heterogeneity in the lack of insight into memory deficits in patients with dementia. In this model, a comparator depending on executive function compares performance on the current task with knowledge about one's memory abilities in comparison with others. If a mismatch is detected, the personal knowledge base is updated. In the case of schizophrenia, patients did appear to update their knowledge base through experiencing performance on the task. However, it may be that these patients may not effectively consolidate these updates to long-term knowledge. Insight into neurocognitive impairment is of clinical interest because lack of insight may lead to less adherence to cognitive training programs. That the patients in our study were able to adjust their memory estimates suggests that a demonstration of misalignment between patients' estimates and their actual abilities could be incorporated into cognitive training.

With regard to self-reported memory selectivity, we found that, like healthy controls, a majority of patients in the schizophrenia group self-reported doing something different to learn the high-value words compared to the low-value words. However, in contrast to healthy controls, whose self-reported memory selectivity aligned with their actual memory selectivity, schizophrenia patients' self-reported memory selectivity was unrelated to their actual memory selectivity. In other words, patients with schizophrenia who reported being sensitive to value during encoding were no more selective than patients who reported being insensitive to value during encoding. These results differ from results obtained in a sample of patients with Alzheimer's disease, whose self-reported selectivity showed alignment with their actual selectivity on the value-directed remembering task (Wong et al., 2019). Instead, our results were similar to results obtained in a sample of patients with behavioral variant frontotemporal dementia, whose self-reported selectivity and actual selectivity were unrelated (Wong et al., 2019).

Our finding that patients with schizophrenia show impaired memory selectivity may reflect diminished recruitment of frontal lobe resources. Research in patients with frontal lobe damage has suggested that the frontal lobes play a vital role in metamemory (Shimamura, 1996). Alterations in prefrontal function are a well-known feature of schizophrenia (Carter et al., 1998; Perlstein et al., 2003; Snitz et al., 2005), and patients with schizophrenia show impairment on a variety of tasks known to rely on the frontal lobes (Barch & Ceaser, 2012; Orellana & Slachevsky, 2013). Additionally, the lack of value effects on recognition memory in patients in our study may reflect impaired hippocampal functioning. Prior work using the remember/know procedure during a recognition memory task indicated that recognized items given "remember" judgments selectively activated the hippocampus (Eldridge et al., 2000). To the extent that value effects in healthy controls' recognition memory appear to be supported by recollection-based "remembering," absence of value effects in the patient group may result from hippocampal dysfunction. Hippocampal dysfunction has been posited as one of the early neural abnormalities in the course of schizophrenia (Lieberman et al., 2018).

While collection of neuroimaging data was beyond the scope of this study, future studies would benefit from incorporation of such measures to test these hypotheses and to increase understanding of the neural underpinnings of value-directed remembering in patients with schizophrenia. A second potential direction for future research is investigation of whether the effects of value on memory could be increased by instructing patients with schizophrenia to use specific strategies to encode high-value items. While a majority of patients in our study reported doing something different to learn the high-value words compared to the low-value words, they may have used less effective strategies to learn the high-value items than participants in the healthy control group did. Prior work in patients with schizophrenia suggests they are less likely to use effective memory strategies spontaneously (Brébion et al., 1997; Iddon et al., 1998), but they are able to benefit from strategies that promote better memory performance when provided with them (Bonner-Jackson & Barch, 2011; Izaute et al., 2020; Ragland et al., 2003). Another potential direction for future research is investigation of whether patients with chronic schizophrenia would show a similar pattern of results to patients with first-episode schizophrenia. It is

possible that, based on their longer experience coping with a limited memory capacity, patients with chronic schizophrenia might know more about their memory limitations than first-episode patients and, as a result, might show greater memory selectivity.

The main limitation of the present study was the small sample size. While significant group deficits in memory selectivity emerged, we did not have adequate statistical power to explore individual differences or correlations between clinical features and memory selectivity, which are important future directions. In particular, it may be interesting for future research to focus on the effects of antipsychotic medication, positive symptoms, negative symptoms, and insight problems. Another significant limitation was the low reliability of the memory selectivity measure, likely due to the low number of observations (6) that contributed to this measure and the fact that participants likely increased their selectivity over the course of the task. Future research may achieve better reliability of this measure by giving participants more extensive practice with value-directed remembering.

The intended target population for this study was first-episode schizophrenia patients. We expect our results to generalize to first-episode schizophrenia patients that differ from our sample demographically. However, given the potential role of dopamine in supporting value-directed remembering (Knowlton & Castel, 2022), results may depend on participants' use of medications that act on the dopamine system. Direct replications of this study should use word lists that are similar in list length and verbal characteristics, with a similar presentation rate, and should take place in a distraction-free environment. We have no reason to believe that the results depend on other characteristics of the participants, materials, or context.

In conclusion, while the present study revealed substantial impairments in value-directed remembering and metamemory in patients with first-episode schizophrenia, we also observed that these patients were able to adjust their judgments of their memory capacity with experience. A better understanding of the metacognitive capabilities of patients with schizophrenia can improve our understanding of memory processes in this group and can potentially be applied to cognitive training interventions to improve cognitive functioning. Concomitant training aimed at improving both memory and metamemory has long been discussed in adult populations (Herzog, 1992), and training involving metamemory judgments has been used successfully to improve memory performance in healthy older adults (Youn et al., 2011). A similar approach may benefit patients with schizophrenia.

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(*Appendix follows*)

Appendix

Remember/Know Instructions

You will now see a series of words shown one at a time. Some of these are words that you saw earlier in this experiment, and some are words that you have not seen before in this experiment. For each word, you will indicate whether or not you saw it earlier in the experiment by marking it as "old" or "new."

When you see a word that you DID see earlier in this experiment, you should respond that it is an "old" word. When you see a word that you DID NOT see earlier in this experiment, you should respond that it is a "new" word. You should only choose "old" if you are at least fairly confident that you recognize the word from earlier. If you do not recognize the word from earlier or if you are unsure, you should choose "new."

For the words that you recognize as old, you will also make a judgment about whether you "remember" the word from earlier in the experiment or you just "know" on some other basis that you saw the word earlier in the experiment. Please pay attention to the following instructions to find out how to make the remember and know judgments.

You should make a "remember" judgment if you can consciously recollect what you experienced when you studied the word earlier. This may include aspects of the physical appearance of the item, of something that happened in the room, or of what you were thinking or doing at the time. You should make a "know" judgment if you recognize the item as being one that you studied, but you cannot consciously recollect what you experienced while studying it. In other words, choose "know" when you are fairly certain that you recognize the item, but it fails to evoke any specific conscious recollection of your experience learning that word.

Consider the following examples. If I asked you to remember eating breakfast this morning, you would likely be able to recollect where you were, what you ate, and what you were thinking about. You would thus give a "remember" response. However, in another situation, you may see someone on campus and know that you've met that person before, but you have no idea where and cannot remember anything else about him or her. In this situation, you would give a "know" response.

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