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Memory Blocking in Schizophrenia Reflects Deficient Retrieval Control Mechanisms

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Abstract

Retrieval interference and orthographic processing were evaluated in schizophrenia, schizotypal personality disorder, and non-psychiatric control participants using a word fragment completion paradigm. Participants studied solutions and later completed corresponding fragments preceded by solutions, orthographically similar blocking words, or ampersands. Although schizophrenia patients completed fewest fragments, they showed equivalent repetition priming and blocking magnitude, supporting intact orthographic processing. Schizophrenia patients were more likely to commit intrusions in the blocking condition, whereas control participants displayed better mental control because they were more likely to withhold the response. These results suggest schizophrenia patients show abnormal functioning of control mechanisms responsible for selection and inhibition of competitors.

Keywords

schizophrenia; schizotypal personality disorder; word fragment completion; priming; retrieval control

1. Introduction

Verbal learning and memory impairments are prevalent in schizophrenia (SZ) and often exacerbated by impaired executive function (Ranganath et al., 2008; Touloupoulou and Murray, 2004). SZ patients perform more poorly under conditions that require the engagement of control processes, illustrated by increased intrusions, perseveration, and difficulty inhibiting distractors (Racsmany et al., 2008; Soriano et al., 2009a). However,

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implicit memory function (e.g., procedural and perceptual tasks) often remains intact (Soler et al., 2007).

Most studies of word learning and retrieval in schizophrenia have examined semantic processes (Doughty and Done, 2009). The word fragment completion (WFC) paradigm can inform the literature of orthographic processing in SZ because fragments constrict phonological possibilities and encourage dependency on orthographic information during retrieval. One example of orthographic interference in healthy adults is exposure to words that are orthographically similar to the fragment solution (ANALOGY) which reduces fragment completions (A_L__GY), increases attempts to offer the competitor as a solution (i.e., intrusions), and slows response times (RTs) due to target word and competitor competition (Landau and Leynes, 2006; Smith and Tindell, 1997). These blocking effects (BE) interfere with implicit memory, whereas repetition priming facilitates implicit memory (Healy et al., 2010).

Investigating the effects of blocked retrieval may improve understanding of dysfunctional cognitive mechanisms in the SZ spectrum and provide specific intervention targets. SZ patients have shown deficits in tasks investigating memory failure, including reduced inhibition in directed forgetting (Muller et al., 2005; Racsmany et al., 2008; Soriano et al., 2009b) and retrieval-induced forgetting (Soriano et al., 2009a). Blocking has not been investigated in SZ; however, patients might not show deficits because WFC is a perceptually-based task that does not rely on explicit memory (Soler et al., 2007) and evidence suggests that blocking effects represent interference in implicit memory (Healy et al., 2010; Lustig and Hasher, 2001; Rass et al., 2010).

The present study investigated blocking in SZ and schizotypal personality disorder (SPD). SPD shares a genetic diathesis, biological features, symptomatology, and cognitive impairment with SZ (Cadenhead et al., 1999), with a lesser degree of psychosocial impairment. Moreover, SPD has been associated with impaired episodic retrieval and cognitive inhibition (Cadenhead et al., 1999), but spared implicit verbal learning (Pedersen and Rist, 2001). We expected decreased baseline performance in SZ and SPD participants due to impaired explicit memory processes, but intact repetition priming since this depends on implicit processes. In addition, we predicted that abnormal inhibitory control mechanisms in SZ and SPD would produce increased use of highly activated but irrelevant responses as fragment solutions (i.e., intrusion errors).

2. Method

2.1. Participants

Schizophrenia or schizoaffective disorder (SZ) patients were recruited through outpatient units at community and state hospitals. SPD and control participants were recruited through newspaper advertisements. SZ diagnoses were determined using the Structured Clinical Interview for Axis-I disorders (SCID-I; First et al., 2001b), clinical observation, and medical chart review. SCID-II (First et al., 1997) and non-patient SCID-I (First et al., 2001a) interviews were used for diagnosis of SPD and screening of control participants. The Indiana University–Purdue University Indianapolis Human Subjects Review Committee approved the protocol, and all subjects gave written and verbal informed consent. Exclusion criteria for all participants included head trauma with loss of consciousness for greater than five minutes, history of seizures or electroconvulsive therapy, and neurological disorders.

2.2. Clinical and Neuropsychological Assessment

Table 1 describes participant demographic characteristics, symptom ratings, test performance, and medication status.

2.3. Materials

The stimuli were 120 sets that included a word fragment, fragment solution (i.e., a positive prime), and an orthographically similar word (i.e., a blocking word) taken from Leynes et al. (2008) (see also Rass and Leynes, 2007). Computer software randomly assigned the stimuli to each fragment type for each participant.

2.4. Procedure

Study procedures and dependent measures were similar to those used by Rass et al. (2010). During the encoding phase, participants read aloud the solutions to 120 test fragments, presented in a random order by the software. The computer advanced to the next word when the experimenter pressed a key indicating that the word was read. Figure 1 is a schematic of the events occurring on each WFC test trial. Participants attempted 120 fragments, of which 40 were preceded with blocking primes (blocking fragments hereafter), 40 with positive primes (positive fragments hereafter), and 40 with a series of ampersands (control fragments hereafter) presented in a random order. An experimenter recorded each participant's verbal response.

2.5. Dependent Measures

Correct completions refer to successful fragment solution. Omission errors happened when response time elapsed without a response. A blind rater examined all other responses to code for words that did not fit the fragment or non-word responses (other error) or intrusion errors (Rass et al., 2010 for details). To control for group baseline differences, errors were scaled to form a proportion of total error where the proportion of intrusion, omission, and other error summed to one.

3. Results

3.1. Clinical and Neuropsychological Measures

Table 1 displays one-way ANOVAs for group (3: SZ, SPD, Control) for SPQ dimensions and cognitive measures. Control participants had fewer schizotypal symptoms than both SPD and SZ participants. SZ patients showed a general deficit of cognitive function compared to control participants, whereas SPD participants did not differ from the control group.

3.2. WFC Performance

Table 2 displays the WFC dependent measures. Table 3 displays results from a mixed-model ANOVA with a between-subjects factor of Group (3) and within-subjects factor of Fragment (3: blocking, control, positive) used to assess accuracy and error (intrusion, omission, other) performance, with Fisher's LSD post-hoc testing. To determine whether groups (3) differed in priming and blocking, one-way ANOVAs analyzed the blocking effect (BE = proportion of blocked fragments – proportion of control fragments) and priming effect (PE = proportion of positive fragments – proportion of control fragments) measures.

3.2.1. Completed fragments—Fragment completion rates varied as a function of fragment type and group. Post-hoc comparisons revealed that exposure to blocking words decreased completion rates compared to control fragments ($F(1, 62)=59.74$), whereas exposure to positive primes increased completion rates compared to control fragments ($F(1, 62)=331.05$). Post-hoc testing revealed that control participants had greater accuracy than other groups. No BE or PE differences were found.

3.2.2. Fragment Errors—Intrusion, Omission, and Other errors were analyzed separately (Table 3). Intrusions varied as a function of fragment type with blocking fragments eliciting the most. The interaction reveals that SZ patients made more intrusion errors across all conditions than other groups, which was confirmed by the significant intrusion BE measure for SZ versus other groups (Table 3, Figure 2).

Omissions varied as a function of fragment type, with blocking fragments eliciting the most. The interaction revealed that SZ patients made fewer omissions across all conditions than other groups. The analysis of PE and BE measures revealed that blocking fragments evoked more omissions for control than SZ, whereas positive fragments produced fewer omissions for SZ versus other groups (Table 3, Figure 2).

Other errors varied as a function of fragment type, with control fragments eliciting the most. Post-hoc testing revealed that SZ patients made more errors than control participants.

4. Discussion

The WFC paradigm provided evidence for intact orthographic processing and a difference in the control of activated information among groups. After studying fragment solutions, participants solved corresponding fragments, preceded by a positive, control, or blocking probe. Repetition priming and blocked retrieval effects did not differ among groups, indicating intact orthographic processing and lexical priming in SZ and SPD. In contrast, a sensitivity to implicit memory interference was observed for SZ – but not SPD – patients because SZ patients exhibited more intrusion errors when primed with a blocking word. Although differences in visual acuity and processing speed may influence the behavioral differences for SZ patients, the stimulus presentation time was sufficient for detection (Moritz and Andresen, 2004). Moreover, we analyzed the relative error rates to eliminate the influence of recollection deficits on behavior.

While orthographic processing was intact, executive control was impaired in SZ. During blocking studies, fragments activate the target and competitor in (Healy et al., 2010; Leynes et al., 2008). Whereas healthy participants often control responding in blocking conditions by withholding a response, intrusion rates increase with age and with subthreshold prime presentation (Logan and Balota, 2003) suggesting that executive control processes govern WFC (Leynes et al., 2008). In the present study, the increase in intrusions for SZ patients is evidence that they suffer reduced lexical selection abilities that may result from abnormal prefrontal cortex functioning (Mecklinger, 2010). The frontal disinhibition hypothesis suggests a cognitive control deficit supported by disrupted inhibitory control, increased false alarms, and increased intrusion errors in frontal lobe lesion patients (Metzler and Parkin, 2000). Structural differences in the medial temporal lobe, including the hippocampus, the frontal lobes, including the prefrontal cortex, and the connection between them may drive the impaired lexical selection and increased intrusion rate in SZ patients during WFC (Boyer et al., 2007). Future studies should incorporate functional neuroimaging measures to determine the underlying neural correlates of retrieval control in clinical populations.

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Figure 1.

Schematic of the stimulus display during the fragment test. Each trial began with a fixation point that was followed by a probe, another fixation point, and then the fragment. Ten seconds were allotted for solving the fragment.

A. Intrusion Error

B. Omission Error

Figure 2.

Priming and Blocking Effects as a function of error type across groups: Schizophrenia (SZ), Schizotypal Personality Disorder (SPD), and non-psychiatric control. Priming tends to decrease the error rate relative to baseline performance, whereas blocking increases the error rate. A: Blocking fragments elicited more intrusions in the SZ group compared to the other groups. Priming fragments had no effect on intrusion error. B: Blocking fragments elicited fewer omission errors in the SZ group compared to the control group. Priming fragments elicited a greater decrease in omission errors for control and SPD groups compared to the SZ group. Error bars represent the standard error of the mean.

Table 1**Characteristics and Performance on Neuropsychological Measures**

	Control (N=33)	SPD (N=16)	SZ (N=14)	ANOVA
Sex (M : F)	13:20	12:4	7:7	$\chi^2=5.470, p = .065$
Age in Years (<i>S.D.</i>)	36.6 (12.2)	42.7 (9.7)	42.6 (9.9)	$F(2,60)=2.32, p > .10$
Years of Education	14.7 (1.8)	13.4 (2.1)	12.4 (1.6)	$F(2,60)=7.51, p < .01$ ¹
Age of Onset	–	–	19.6 (5.1)	
Illness Duration (years)	–	–	23 (10.6)	
PANSS				
Positive	–	–	17.3 (6.5)	
Negative	–	–	13.0 (4.4)	
General	–	–	30.5 (6.9)	
SPQ				
Cognitive-Perceptual	4.6 (5.6)	13.4 (10)	19.3 (10.1)	$F(2,60)=18.59, p < .01$ ²
Interpersonal	5.7 (4.8)	13.3 (8.4)	19.0 (9.0)	$F(2,60)=19.97, p < .01$ ^{2,3}
Disorganized	3.2 (3.6)	6.6 (3.6)	7.2 (4.0)	$F(2,60)=8.15, p < .01$ ²
WASI				
IQ Estimate	112.7 (14.3)	114.1 (12.5)	91.5 (11.9)	$F(2,57)=13.33, p < .001$ ⁴
Vocabulary	56.7 (11.7)	59.1 (8.6)	41.5 (7.9)	$F(2,57)=12.66, p < .001$ ⁴
Matrix Reasoning	57.6 (6.2)	56.9 (8.4)	48.2 (10.1)	$F(2,57)=7.19, p < .01$ ⁴
CERAD Delay	7.9 (1.5)	7.5 (2.2)	5.5 (3.2)	$F(2,56)=5.89, p < .01$ ⁴
CERAD Total	24.7 (2.7)	23.5 (3.3)	18.8 (5.6)	$F(2,56)=12.05, p < .001$ ⁴
Letter Fluency	14.9 (4.0)	15.6 (4.8)	11.7 (4.4)	$F(2,59)=3.56, p < .05$ ⁴
Digit Symbol	11.4 (2.6)	10.4 (3.5)	7.1 (2.9)	$F(2,57)=9.81, p < .001$ ⁴
Executive (Trails B-A)	26.8 (21.3)	31.1 (22.4)	92.5 (74.3)	$F(2,58)=13.59, p < .001$ ⁵
Medication Status				
Atypical antipsychotic	0	0	11	
Conventional antipsychotic	0	0	2	
Lithium	0	0	2	
Benzodiazepine	0	0	1	
Antidepressant	0	1	5	
Anticonvulsant	0	0	1	
Other psychoactive	0	0	6	

Note. SPD = schizotypal personality disorder; SZ = schizophrenia; C = control. Patients taking psychotropic medications typically used multiple medications. PANSS: Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987); SPQ: Schizotypal Personality Questionnaire (SPQ; Raine, 1991). WASI: Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999); CERAD (Consortium to Establish a Registry for Alzheimer's Disease) word list learning (Welsh et al., 1994); Digit-Symbol Coding subtest of the WAIS-III (Wechsler, 1997); Trails B-A: Trail-Making Test A - Test B time difference (RT_{Trails-B} – RT_{Trails-A}) (Reitan and Wolfson, 1993). Letter fluency was measured using the letter F for a one-minute interval. A patient taking more than one medication in a category (e.g., 2 antidepressants) was only counted once. Post hoc LSD ($p < .05$) analyses were performed on all significant ANOVAs:

¹ C > SZ, SPD;

²C < SPD, SZ;

³SZ > SPD;

⁴C, SPD > SZ;

⁵SZ > C, SPD.

Table 2

Proportion of responses for the Word Fragment Completion Paradigm

	Group		
	Control	SPD	SZ
<i>Fragment Type</i>	<i>Completions</i>		
Positive	.92 (.08)	.86 (.16)	.76 (.15)
Control	.65 (.12)	.54 (.18)	.48 (.11)
Blocked	.52 (.17)	.44 (.21)	.32 (.19)
BE	-.13 *	-.10 *	-.16 *
PE	.27 *	.31 *	.28 *
	<i>Intrusion Errors</i>		
Positive	.01 (.02)	.02 (.02)	.02 (.03)
Control	.02 (.03)	.05 (.05)	.06 (.04)
Blocked	.11 (.12)	.15 (.16)	.26 (.18)
	<i>Omission Errors</i>		
Positive	.05 (.05)	.06 (.06)	.07 (.07)
Control	.30 (.10)	.25 (.14)	.17 (.10)
Blocked	.38 (.13)	.29 (.18)	.13 (.10)
	<i>Other Errors</i>		
Positive	.02 (.03)	.04 (.04)	.07 (.03)
Control	.07 (.07)	.10 (.08)	.13 (.09)
Blocked	.05 (.04)	.05 (.04)	.08 (.06)

Note. The value in parentheses is the standard deviation. BE (blocking effects) = proportion of blocked fragments – proportion of control fragments. PE (priming effects) = proportion of positive fragments – proportion of control fragments.

An asterisk indicates that the BE or PE was significant.

Table 3

Group performance analysis for the Word Fragment Completion paradigm

Omnibus ANOVA: Group (3) × Fragment Type (3)				
Measure	Factor			
	Fragment	Fragment × Group	Group	
Accuracy	$F(1.53, 91.82) = 217.70^{***}$	–	$F(2,60) = 11.19^{***}$	
Intrusion Error	$F(1.10, 65.77) = 58.72^{***}$	$F(2.192, 65.767) = 3.82^*$	$F(2,60) = 7.17^*$	
Omission Error	$F(2,120) = 91.31^{***}$	$F(4,120) = 11.01^{***}$	$F(2,60) = 10.68^{***}$	
Other Error	$F(1.70,102.18) = 25.98^{***}$	–	$F(2,60) = 6.45^*$	
Follow-up LSD Analysis				
Factor	Measure			
	Accuracy	Intrusion Error	Omission Error	Other Error
Group	C > SPD [*] > SZ [*]	SZ > SPD [*] , C ^{**}	SZ < SPD [*] , C ^{**}	C < SZ ^{**}
Fragment	Pos > Con > Blo ^{***}	Pos, Con < Blo ^{***}	Pos < Con, Blo ^{**}	Con > Blo, Pos ^{**}
a-priori ANOVA: Group (3) × BE, PE				
Measure	BE	BE Post-hoc LSD	PE	PE Post-hoc LSD
Accuracy	–		–	
Intrusion Error	$F(2,60) = 3.73^*$	SZ > C [*] , SPD [*]	–	
Omission Error	$F(2,60) = 5.03^*$	C > SZ ^{**}	$F(2,60) = 7.66^{**}$	SZ < C ^{***} , SPD [*]
Other Error	–		–	

Note. SPD = schizotypal personality disorder, SZ = schizophrenia, C = control. Pos = Positive Fragment, Con = Control Fragment, Blo = Blocking Fragment. BE (blocking effects) = proportion of blocked fragments – proportion of control fragments. PE (priming effects) = proportion of positive fragments – proportion of control fragments. Geisser-Greenhouse correction for nonsphericity were used to correct degrees when appropriate.

*
 $p < 0.05$,

**
 $p < 0.01$,

 $p < 0.001$.