Schizophrenia Research xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Schizophrenia Research

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

Deficient single item maintenance following intact updating in schizophrenia

Tarra Combs [a,*], Jarett E. Roseberry [a], Leah H. Rubin [b,c], S. Kristian Hill [a]

[a] Department of Psychology, Rosalind Franklin University of Medicine and Science, United States
[b] Department of Psychiatry, University of Illinois at Chicago, United States
[c] Department of Neurology, Johns Hopkins School of Medicine, United States

ARTICLE INFO

Article history:
Received 14 January 2017
Received in revised form 13 September 2017
Accepted 14 September 2017
Available online xxxx

1. Introduction

Working memory is a core cognitive impairment in schizophrenia (Lee and Park, 2005; Silver et al., 2003), observed across modalities including visuospatial, auditory, and verbal working memory (Longenecker et al., 2010; Manglam et al., 2010; Park and Gooding, 2014). Baddeley proposed a working memory model in which a central executive controls how information is distributed and processed by lower level systems, the phonological loop and visuospatial sketchpad, which carry out auditory and visual information processing respectively (Baddeley, 1992; Baddeley, 2003). Subsequently, an episodic buffer was added, which integrates these two lower level systems. Successful working memory processing requires many sub-processes, including encoding, maintenance, manipulation, updating, and retrieval (Hill et al., 2010; Lee and Park, 2005). Beyond passive storage of task information, active operation is required for completion of working memory tasks (Miyake et al., 2000; ZhenZhu et al., 2008). Updating of working memory requires discarding of old information, reordering contents in memory, and/or adding new information (Carretti et al., 2010; ZhenZhu et al., 2008).

In schizophrenia, updating research yields inconsistent findings (Chan et al., 2006; Hahn et al., 2012; Levaux et al., 2009). Some discrepancies appear related to the variety of task methodologies. For example, patient and control performance is similar when visual items are paired with auditory cues and participants are given multiple choices when responding (Hahn et al., 2012). In contrast, patient impairments are well established on the N-Back task (Goldberg et al., 2003; Park and Gooding, 2014). In general, studies focusing on updating tend to utilize measures that assess updating in the context of other processing demands including maintenance, manipulation, problem solving, and retrieval.

When a distractor is present, patients perform worse than controls on working memory tasks. On a visual dot task with irrelevant spatial information, schizophrenia patients perform worse than controls (Cellard et al., 2007). Beyond external interference, simply accessing information may be sufficient to degrade the memory in schizophrenia patients (Hill et al., 2011). To further explore this notion, the present study limited to be remembered items to one, but required multiple comparisons. Should schizophrenia patients be susceptible to internal interference in working memory tasks, merely accessing stored information may be sufficient to disrupt performance.

Although there is some support for impaired updating in schizophrenia, this remains an understudied area, with inconsistent findings based on complex paradigms (Chan et al., 2006). The present study was designed to assess updating (the initial response) while limiting working memory load to one item and focusing on replacing this lone item, subsequent responses assess single item maintenance. In this manner, the present paradigm is thought to better isolate the cognitive processes of updating, which may be informative in understanding the nature of working memory dysfunction in schizophrenia.

2. Methods

2.1. Participants

Participants included 33 schizophrenia spectrum patients and 42 healthy volunteers with no psychiatric diagnosis based on the Structured Clinical Interview for DSM-IV. Patients were clinically stable with no acute symptomatology or medication change for one month prior to testing. All participants had normal range intelligence (Standard Score > 79). Exclusion criteria included substance abuse within the last six months, neurological disease, and head injury with loss of consciousness over 10 min. Patients were recruited from medication management clinics and research was introduced by clinic staff. Healthy participants were recruited from advertisements and a research registry. All participants provided written consent and the study was approved by the Institutional Review Boards at Rosalind Franklin University of Medicine and Science, University of Illinois at Chicago, and University of Chicago. There were no group differences for age, education, ethnicity, or estimated premorbid intelligence (Table 1).

* Corresponding author at: Rosalind Franklin University of Medicine and Science, Department of Psychology, 3333 Green Bay Rd., North Chicago, IL 60064, United States.
E-mail address: tarra.combs@my.rfums.org (T. Combs).

http://dx.doi.org/10.1016/j.schres.2017.09.019
0920-9964/

Table 1
Group demographic characteristics.

Demographics	Healthy comparison (CTL) n = 42	Schizophrenia (SZ) n = 33	Analysis F/x^2	df	p
Age (years)	40.53 (10.94)	41.39 (11.88)	0.11	1,73	0.74
Gender					
Male	42.9%	37.5%	2.27	1	0.13
Race					
African American	33.3%	63.6%	1.36	2	0.51
Caucasian	54.8%	21.2%			
Other	11.9%	15.9%			
Handedness					
Right	85.7%	84.8%	1.26	1	0.26
Education	13.21 (1.24)	13.83 (2.04)	2.63	1,73	0.11
WRAT-III: reading	96.10 (7.74)	98.12 (11.21)	0.86	1,73	0.36

WRAT-III: Wide Range Achievement Test: Third Edition

2.2. Updating/single item maintenance

Serial order processing (Hill et al., 2011) and updating paradigms (Roth et al., 2009) were adapted to develop a measure of updating that minimized other working memory demands. As illustrated in Fig. 1, participants were presented a target location and instructed to update to a new location periodically. Between updates, participants were presented one to seven spatial locations and asked to indicate if the item matched the target location. In this manner, working memory load was limited to a single item and the initial response assessed updating while subsequent responses assessed single item maintenance.

2.3. Statistical analysis

Mixed-effects regression modeling was conducted to examine the separate and interactive effects of diagnosis (schizophrenia vs. healthy controls) and maintenance processing on total accuracy (all items) and the degree to which accuracy varied by the number of responses between updates. This analysis was selected to handle the nesting of maintenance processing within individual. To reduce the number of potential comparisons and control the overall experimental error rate, responses were collapsed into blocks reflecting the amount of maintenance processing (Low: responses 2 and 3; Medium: responses 4 and 5; High: responses 6 and 7). Independent predictors included diagnosis, response blocks, and the two-way interactions.

3. Results

3.1. Updating task accuracy

Outliers (<2% of cases) skewed the distribution of updating accuracy. To normalize the data, outliers were Winsorized to three standard deviations from the mean (Field, 2013). Mixed-effects regression for updating accuracy revealed a significant group difference [$F(1, 219) = 4.56$, $p = 0.03$; $d = 0.50$], indicating that patients performed worse than controls. Mixed-effects regression modeling to examine accuracy across blocks and whether the pattern differed by diagnosis indicated a significant group by response block interaction [$F(3, 219) = 3.07$, $p = 0.03$, small effect]. This was clarified by evaluating groups separately across blocks (Fig. 2). Healthy controls showed a significant drop in accuracy between the initial response and subsequent blocks (Low: $B = -0.07$, $SE = 0.02$, $p = 0.0002$; Medium: $B = -0.12$, $SE = 0.02$, $p < 0.0001$; and High: $B = -0.11$, $SE = 0.02$, $p < 0.0001$). Patients also showed a significant drop after the initial response, but the magnitude of the decline was greater at each block (Low: $B = -0.13$, $SE = 0.02$, $p < 0.0001$; Medium: $B = -0.20$, $SE = 0.02$, $p < 0.0001$; and High: $B = -0.17$, $SE = 0.02$, $p < 0.0001$). While the groups did not differ on the initial response, indicating intact updating in patients, patients showed a greater drop than controls for maintenance items.

4. Discussion

In groups of demographically similar schizophrenia patients and healthy controls, no patient deficit was demonstrated for visuospatial updating. The present updating paradigm was designed to minimize other cognitive processes, such as manipulation, serial order processing, high maintenance loads, and retrieval, by limiting working memory load to one item and focusing on replacing this lone item (Roth and

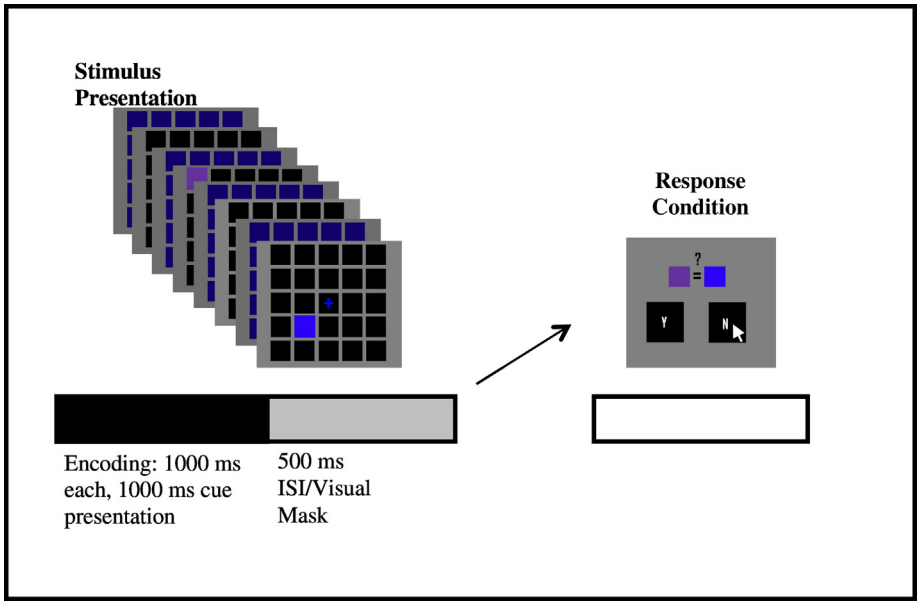

Fig. 1. The present study utilizes an updating paradigm that was adapted from Roth et al. (2009) and Hill et al. (2011) to explore updating relatively independent of other working memory components. Participants were instructed to remember the position of one target presented on a 5 × 5 grid. The center of the grid contained a fixation point that was never used as a target. Participants were cued to update the target stimulus when the fixation point changed color (remember the location of the next item). After updating, participants were instructed to indicate whether the new stimulus matched the target location previously presented. One to seven responses were made between each update.

Please cite this article as: Combs, T., et al., Deficient single item maintenance following intact updating in schizophrenia, Schizophr. Res. (2017), http://dx.doi.org/10.1016/j.schres.2017.09.019