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Episodic memory retrieval is impaired in negative schizotypy under fast response deadline

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ABSTRACT

Schizotypy offers a useful, multidimensional framework for understanding the development and expression of schizophrenia-spectrum psychopathology. Nonclinically ascertained young adults who endorse positive and negative schizotypy traits exhibit similar, albeit milder, versions of the symptoms and impairment seen in schizophrenia-spectrum disorders. Previous studies have demonstrated that negative, but not positive, schizotypy is associated with impairment in free-recall, recognition, and source memory. Furthermore, these deficits appear to result from context processing deficits in negative schizotypy. However, neither positive nor negative schizotypy were associated with variation in the set size effect. The present study further examined the association with set-size effect under fast and slow response deadlines across the schizotypy continuum. We replicated the finding that the set size effect was invariant across both positive and negative schizotypy dimensions. However, negative schizotypy was associated with poorer overall recall, and the negative schizotypy by response deadline interaction revealed that negative schizotypy was differentially impaired by the speeded responding in overall memory. Despite instructions to guess on the cued-recall task, negative schizotypy was associated with increased likelihood of omission errors (failing to produce a response), whereas positive schizotypy was associated with decreased omission errors. The findings provide further support for the multidimensional model of schizotypy and previous findings that negative schizotypy is associated with impaired retrieval, especially under fast response deadlines.

1. Introduction

Schizophrenia is a catastrophic mental disorder that affects approximately 1% of the population and is characterized by psychotic symptoms such as hallucinations, delusions, and formal thought disorder (Tandon et al., 2009). Current models suggest that schizophrenia is the most extreme manifestation of a continuum of clinical and subclinical symptoms and impairment referred to as schizotypy (Lenzenweger, 2010; Kwapil and Barrantes-Vidal, 2015). Schizotypy and schizophrenia are heterogeneous in terms of etiology, symptoms, and course, and this heterogeneity can be captured, at least in part, by a multidimensional structure. Although there is not universal agreement on the exact number and nature of these dimensions, consistent support has emerged for positive and negative schizotypy dimensions (e.g., American Psychiatric Association, 2013; Kwapil et al., 2008; Vollema and van den Bosch, 1995). The positive or psychotic-like dimension is characterized by disturbances in the content of thought (ranging from odd beliefs to full-blown delusions), unusual perceptual experiences (including illusions and hallucinations), and suspiciousness and paranoia. The negative or deficit dimension involves diminished experiences including alogia, anergia, avolition, anhedonia and affect. Although both of these symptom dimensions are associated with the development of schizophrenia-spectrum disorders (e.g., Kwapil et al., 2013), they are also associated with differential patterns of symptoms and impairment. Therefore, failure to consider the multidimensional structure of schizotypy and schizophrenia results in a lack of conceptual and empirical clarity.

Cognitive impairment is a hallmark of schizophrenia and related disorders (e.g., Green and Nuechterlein, 1999; Harvey, 2013; Heinrichs and Zakzanis, 1998). The limited evidence suggests there is continuity between the deficits observed in schizophrenia patients and the deficits observed in subclinical expressions of schizotypy (for reviews, see Chun et al., 2013; Ettinger et al., 2015; Nelson et al., 2013). In this paper, we focus primarily on episodic memory deficits, which have been reliably documented in schizophrenia (e.g., Dickinson et al., 2008; Gold et al., 1992; Mesholam-Gately et al., 2009; Ranganath et al., 2008). In contrast to the well-established findings in patients, there have been fewer studies examining long-term memory in schizotypy (e.g., Gooding and Braun, 2004; Sahakyan and Kwapil, 2016, 2018). Much of what we know about episodic memory

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impairments in schizotypy comes from research using clinical neurocognitive assessments that are more useful for documenting large effects in patients, as opposed to more subtle deficits expected to characterize subclinical schizotypy. Furthermore, clinical neurocognitive batteries may not allow for detailed assessment of the processes underlying memory impairment. Because memory performance is influenced by multiple processes, impairments may be seen in some but not other processes. For example, our previous research demonstrated deficits in free recall, recognition memory, and source memory in negative schizotypy, but not in positive schizotypy (Sahakyan and Kwapil, 2016, 2018). Furthermore, by decomposing free recall into more nuanced measures of performance, we traced these impairments to context processing deficits, which contribute to deficient search processes – namely, when searching memory, participants high in negative schizotypy search through more restricted search sets compared to positive schizotypy or control participants (Sahakyan and Kwapil, 2018). In contrast to these deficits in the aforementioned memory processes, we found no differences across positive and negative schizotypy and control participants in a cued-recall procedure, which assesses the influence of set-size of semantic networks on episodic memory.

Set-size effects are based on the notion that encoding a familiar word implicitly activates its related concepts (e.g., Anderson, 1983; Kintsch, 1988; Nelson et al., 1992), which affect memory despite not being consciously experienced. For example, words that have a large network of associates (i.e., they elicit many associates in free association) are less well remembered compared to words that have smaller network – known as the *set-size effect* (Nelson and Friedrich, 1980; Nelson et al., 1992, 1998). In the laboratory, set-size effects are examined by having participants study unrelated words (e.g., *decoration*), and during the test, presenting a meaningfully related (and previously unstudied) cue word (e.g., *cake*) to help retrieve the studied item. The negative effect of large set-sizes is attributed to interference from increasing number of competing associates that are activated in larger networks. In our previous research, we did not find any differences in the magnitude of the set-size effect across positive and negative schizotypy and control participants (Sahakyan and Kwapil, 2016).

The current study extends these findings in important ways. Our previous findings were based on an extreme-groups approach with relatively small sample sizes. Extreme group approaches can provide an expedient method for initially detecting effects. However, such designs tend to lose information and power (e.g., Preacher et al., 2005) and are not consistent with our view of schizotypy as a continuous construct. Thus, the purpose of the current study was to examine memory across continuous ranges of positive and negative schizotypy using a larger sample. We selected the set-size effect as the focus of interest given the limited research on this topic, and given that this was the only task from a set of five different measures of memory on which we did not find differences across positive and negative schizotypy dimensions. Importantly, the primary purpose for selecting the set-size task was not so much about the assessing the magnitude of set-size effect, per se, but because the effects of set-size are contingent on cued-recall method of testing memory – namely, participants are presented with a cue word, and have to search their memory for the correct word that goes along with that cue. This search process can be made more difficult by imposing a response deadline manipulation at retrieval, in which cues are shown for less time, requiring participants to respond more quickly. Speeded responding imposes greater demands on retrieval processes, which are already implicated in negative schizotypy as our previous work suggests. In a nutshell, a cued-recall task can be turned into a more direct retrieval-like task with speeded responding, allowing us to potentially observe the impairing effects in schizotypy under the fast response deadline conditions.

The novel manipulation of the current study involves requiring some participants to respond more quickly. The results from many recognition and cued-recall studies confirm that speeded responding hurts the retrieval process (Benjamin and Craik, 2001; Dosher, 1984; Gronlund and Ratcliff, 1989; Hintzman and Curran, 1994; Jacoby, 1991; McElree et al., 1999; Rotello and Heit, 1999). We therefore anticipated that the cued-recall procedure, which is the basis for examining the set-size effects, will be detrimentally affected by response deadline manipulation. Importantly, we anticipated that fast responding would differentiate negative and positive schizotypy because fast responding will impair retrieval processes – processes that have already been shown to be deficient in negative schizotypy (e.g., Sahakyan and Kwapil, 2016, 2018). Consistent with Sahakyan and Kwapil (2016), we did not expect to see that either positive or negative schizotypy would be associated with the set-size effect under slower responding. However, we did expect that that negative schizotypy would be differentially impacted by fast deadlines because of its impact on search and retrieval processes. Thus, we did not expect to see generalized impairment associated with negative schizotypy, but expected to find that memory performance in negative schizotypy is specifically disrupted by fast response demands.

2. Methods

2.1. Participants

Participants were 381 undergraduates who received course credit for taking part in the study. They completed the experiment in a classroom setting in groups of no more than 20 participants at a time. Thirty-three participants (9%) were omitted for invalid schizotypy protocols and were not included in the analyses. The results are based on the remaining sample of 348 participants.

2.2. Materials and procedure

The experiment began with the memory assessment. Participants then completed the Wisconsin Schizotypy Scales (WSS, also known as the Chapman Psychosis-Proneness Scales) that included the Perceptual Aberration (Chapman et al., 1978), Magical Ideation (Eckblad and Chapman, 1983), Physical Anhedonia (Chapman et al., 1976), and Revised Social Anhedonia (Eckblad et al., 1982) Scales. The 166 WSS items were intermixed with the 13-item Infrequency Scale (Chapman and Chapman, 1983), which was designed to identify invalid responders. Following Chapman and Chapman, participants who endorsed more than two infrequency items were omitted from further study. Previous studies support the reliability and validity of the WSS and indicate that two factors (positive and negative schizotypy) underlie the scales (Kwapil et al., 2008; Lewandowski et al., 2006). Factor scores were assigned based upon norms from 6137 college students (Kwapil et al., 2013).

The memory assessment involved showing participants 24 unrelated words on a computer screen at a rate of 3 s per item. Participants were instructed to learn the words for an upcoming memory test. At test, they were shown a meaningfully related cue word that did not appear on the study list, and were instructed to use it to help retrieve the related word from the study list (e.g., studying APARTMENT, and receiving BALCONY as a cue word). Participants were told that each cue was related only to one of the study words. They were encouraged to guess if they could not remember the related studied word.

The stimuli were the same as in Sahakyan and Kwapil's (2016) associative cuing tests. Specifically, 48 target words were split into two 24-item study lists (List A and B), and within each list, 12 words had a large set-size, whereas 12 words had a small set-size. Another set of 48 words served as test cues, with each cue being related only to a single target word. Within each list, the targets were unrelated to each other, and cues were unrelated to each other. Each participant received either List A or List B, but not both. For additional details about the stimuli, see Sahakyan and Kwapil (2016).

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The deadline manipulation involved varying between-subjects how long the cues were presented on the screen and thus, how long participants had to respond. For 172 participants, cues were presented at a rate of 15 s, whereas for remaining 176 participants the cues were presented for 8 s each. Note that participants were randomly assigned to the conditions.

We evaluated several dependent measures. Initially, we assessed the proportion of accurate recall for large set and small set items, as well as the difference between those two variables, which reflects the overall set-size effect. We also combined across the large and small set recall to gauge an estimate of overall memory. Finally, given that participants were encouraged to guess whenever they could not remember the studied item, we also assessed the errors they made. Omission errors occurred when a participant failed to give a response within the allocated deadline (despite the guessing instruction), whereas commission errors involved giving an incorrect response to the cue word. We assessed the recall and error measures across the schizotypy dimensions under the fast and slow response deadline conditions.

3. Results

The mean score for the positive schizotypy factor was −0.02 (SD = 0.93, range = −1.59 to 4.79), whereas the mean score for the negative schizotypy factor was 0.11 (SD = 0.96, range = −1.85 to 4.01). Thus both schizotypy dimensions had a wide and comparable range of scorers. The schizotypy factors correlated $r = 0.00$, $p = .95$. Given the expected positive skew in the schizotypy factor scores, the positive and negative schizotypy scores were transformed following Tabachnick and Fidell (2007) by computing the square root of the schizotypy score (after adding a constant to make the smallest value 1.0). Note that original and transformed values for each schizotypy factor correlated $r = 0.99$.

There was an overall set-size effect – recall of items from small sets was higher ($M = 0.54$, $SD = 0.19$) than items from large sets ($M = 0.45$, $SD = 0.20$), $t(347) = 9.69$, $p < .001$. The set-size effect was found both under the fast responding condition (small sets: $M = 0.48$, $SD = 0.19$; large sets: $M = 0.37$, $SD = 0.18$), $t(175) = 7.83$, $p < .001$, and the slow responding condition (small sets: $M = 0.60$, $SD = 0.18$; large sets: $M = 0.53$, $SD = 0.19$), $t(171) = 5.84$, $p < .001$.

In order to examine the association of the schizotypy dimensions with memory performance, a series of hierarchical linear regression analyses were computed (see Table 1). In each regression, positive and negative schizotypy were entered simultaneously at the first step, in order to examine the effect of each schizotypy dimension over-and-above the other dimension. Response deadline was entered at the second step. The two-way interactions (positive schizotypy × deadline, negative schizotypy × deadline, and positive schizotypy × negative schizotypy) were simultaneously entered at step 3, and the three-way interaction was entered at step 4. The standardized regression coefficient (β), change in R^2, and effect size (f^2) were reported for each variable. Following Cohen (1992), f^2 values of 0.02 are considered small effects, 0.15 are considered medium effects, and 0.35 are considered large effects. In order to calculate R^2 and f^2 for variables entered simultaneously, we reran the model with the variable of interest entered at a final step, over-and-above all the other variables already in the model.

As seen in Table 1, negative schizotypy was associated with impaired recall of items from small and large set sizes, impaired overall memory, and increased number of omission errors, but not commission errors. There was a significant negative schizotypy by deadline interaction for the prediction of small set sizes, large set sizes, and overall memory. Fig. 1 shows this interaction for overall memory, but the pattern was the same for small and large set size recall (not shown). As seen in Fig. 1, negative schizotypy was especially impacted by the demands of fast response deadline. In general, fast response deadline was associated with poorer overall memory performance, but this was especially pronounced for high levels of negative schizotypy.

Table 1
Prediction of memory performance by positive schizotypy, negative schizotypy, and response deadline.

Criterion	Step 1 df = 2, 345						Step 2 df = 1, 344			Step 3 df = 3, 341									Step 4 df = 1, 340			Total R^2
	Positive schizotypy			Negative schizotypy			Deadline			PosSz × deadline			NegSz × deadline			PosSz × NegSz			PosSz × NegSz × deadline			
	β	ΔR^2	f^2	β	ΔR^2	f^2	β	ΔR^2	f^2	β	ΔR^2	f^2	β	ΔR^2	f^2	β	ΔR^2	f^2	β	ΔR^2	f^2	
Small set recall	0.095	0.009	0.01	−0.130*	0.017	0.02	0.315***	0.099	**0.11**	−0.051	0.003	0.00	0.132**	0.017	0.02	−0.013	0.000	0.00	0.005	0.000	0.00	0.144***
Large set recall	0.064	0.004	0.00	−0.150**	0.022	0.02	0.393***	0.154	**0.19**	−0.047	0.002	0.00	0.100*	0.010	0.01	−0.015	0.000	0.00	−0.013	0.000	0.00	0.193***
Set size effect	0.033	0.001	0.00	0.027	0.001	0.00	−0.103	0.011	0.01	−0.004	0.000	0.00	0.034	0.001	0.00	0.003	0.000	0.00	0.020	0.000	0.00	0.014
Overall memory	0.088	0.008	0.01	−0.155**	0.024	0.03	0.392***	0.153	**0.19**	−0.054	0.003	0.00	0.128**	0.016	0.02	−0.016	0.000	0.00	−0.005	0.000	0.00	0.204***
Omission errors	−0.117*	0.014	0.01	0.154**	0.024	0.02	−0.242***	0.058	0.07	0.072	0.005	0.01	−0.080	0.006	0.01	−0.065	0.004	0.00	0.024	0.001	0.00	0.111***
Commission errors	0.005	0.000	0.00	−0.001	0.000	0.00	−0.112*	0.012	0.01	−0.034	0.001	0.00	0.001	0.000	0.00	0.024	0.001	0.00	−0.068	0.005	0.01	0.019

Note: medium effect sizes (f^2) in bold.
Each row represents a separate regression analysis predicting memory performance. Hierarchical regression was used to examine the unique prediction of memory performance by positive and negative schizotypy, response deadline, and the schizotypy × deadline interactions. For each predictor, the standardized regression coefficient (β), change in R-square, and effect size (f^2) are reported.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

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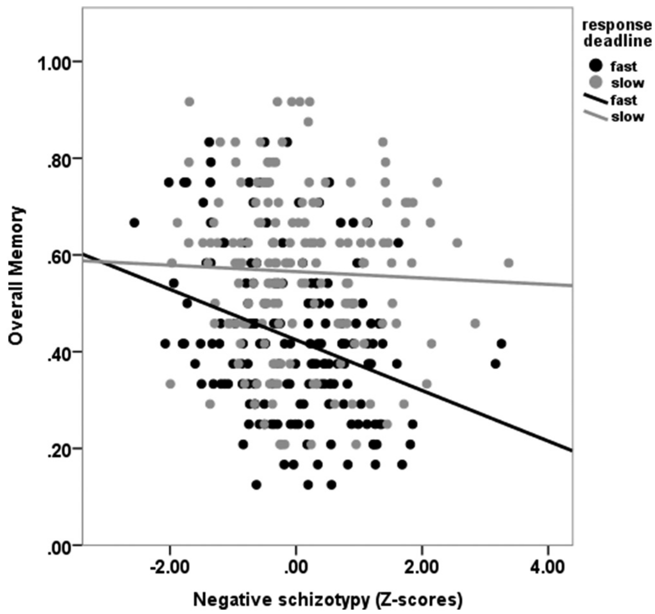

Fig. 1. Overall memory in negative schizotypy across fast and slow response deadline conditions.

As expected, positive schizotypy was not associated with impaired memory performance, in contrast to negative schizotypy. However, strikingly, positive schizotypy was associated with reduced omission errors, regardless of deadline. None of the positive schizotypy × deadline interactions, positive × negative schizotypy interactions, nor the three-way interactions were significant. Thus, omission errors differentiated between positive and negative schizotypy, with high negative schizotypy associated with more omission errors and high positive schizotypy associated with fewer omission errors.

Replicating our previous findings (Sahakyan and Kwapil, 2016), the set-size effect was invariant across positive and negative schizotypy dimensions, and it also did not interact with deadline. With the exception of several findings for deadline that were medium effect sizes, the remainder was small effects.

4. Discussion

The purpose of this study was to replicate and extend the findings reported by Sahakyan and Kwapil (2016; 2018) regarding episodic long-term memory deficits in psychometrically assessed schizotypy. Instead of the extreme-groups approach, we examined memory across continuous distributions of positive and negative schizotypy in a large sample. Furthermore, we selected the set-size task for several reasons. In previous research, we used five different ways of assessing memory, and set-size task was the only one where there were no deficits across negative or positive schizotypy dimensions when participants were selected to be extreme scorers on the respective dimensions. Thus, it was important to assess this potentially null effect in a larger sample. Importantly, the set-size task allowed replicating and extending two of the previously reported findings by introducing a speeded response manipulation.

Replicating our previous findings, the magnitude of the set-size effect (recall advantage of small set size items over large set size items) remained invariant across negative and positive schizotypy dimensions, and it also did not interact with deadline. Importantly, however, the speeded response manipulation differentiated the negative and the positive schizotypy dimensions. Namely, although faster responding impaired recall in general, this was particularly true of negative schizotypy. In contrast, positive schizotypy was not associated with impaired memory, regardless of slow or fast responding conditions. These findings confirm our predictions about the likely impact of speeded responding on negative schizotypy. Speeded responding adversely impacts the retrieval process, which as we have previously shown is impaired in negative schizotypy (Sahakyan and Kwapil, 2016, 2018). Our prior work suggests that when searching memory, the negative schizotypy participants search through more restricted search set. We suspect that the speeded responding further narrowed the search set, explaining why negative schizotypy was particularly impaired by the response deadline manipulation.

The positive and negative schizotypy dimensions were also differentiated by the errors made during the response phase. As noted, participants were encouraged to guess if they could not remember the studied word. There were no associations of positive and negative schizotypy with the number of commission errors made, which refer to providing an incorrect response to the cue word. In contrast, omission errors, which occur when participants failed to produce a response within the allocated deadline, showed the opposite pattern across positive and negative schizotypy. Namely, high negative schizotypy was associated with making more omission errors, whereas the opposite was true of high positive schizotypy, which was associated with fewer omission errors. These results together with accurate responses suggest that negative schizotypy is associated with impaired retrieval – they make fewer correct responses, and despite instructions to guess, they are more likely to be unable to make a response. This is consistent with the notion of searching through more restricted search set and failing to find a correct response. Note, that the fewer omission errors could also be driven by more conservative response bias in negative schizotypy in general. This supports the longstanding view that negative symptoms involve diminished cognitive functioning (Addington et al., 1991) and specifically, impairment in verbal learning and memory (O'Leary et al., 2000). Strikingly, the findings for positive schizotypy indicate that it was associated with decreased likelihood of making omission errors. Thus high positive schizotypy scorers were more likely to retrieve and make a response, even though they were not more accurate overall. This is consistent with suggestions that positive schizotypy is associated with increased spreading activation (e.g., Burch et al., 2006; Neill et al., 2014; Stefaniak et al., 2015), but it could also be explained by more general liberal response bias.

The present findings, in conjunction with the results from Sahakyan and Kwapil (2016; 2018) indicate that schizotypy is associated with schizophrenic-like cognitive impairment, but that it is essential to consider the multidimensional structure of schizotypy in order to identify and understand these deficits. Negative schizotypy, but not positive schizotypy, is characterized by deficits in free recall, recognition memory, and source memory. However, we have now demonstrated in both extreme-groups and continuous designs that neither positive nor negative schizotypy are associated with the set-size effect under typical time constraints. Nevertheless, we were able to experimentally produce impaired recall in negative schizotypy on this task by introducing a speeded responding manipulation.

Finally, it is important to set the present findings in the context of the larger literatures on cognition in schizophrenia and schizotypy. Cognitive impairment is ubiquitous in schizophrenia, with patients exhibiting a wide range of cognitive performance deficits, including deficits in multiple domains of memory performance, typically in the range of medium to large effect sizes (Heinrichs and Zakzanis, 1998). However, the reliable identification of cognitive impairment in nondisordered or subclinical schizotypy has proven more elusive to demonstrate (e.g., Kane et al., 2016). The recent meta-analysis by Chun et al. (2013) of cognitive performance in nondisordered schizotypy samples reported minimal effects for most cognitive domains. These findings suggest that some of the cognitive impairment in schizophrenia may represent consequences of the disorder, as opposed to reflecting premorbid deficits. Furthermore, it suggests that cognitive impairment may only occur in a small proportion of nondisordered schizotypes and in limited domains. Nevertheless, ample evidence indicates some degree of

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continuity of cognitive impairment across the schizotypy continuum (e.g., Ettinger et al., 2015), especially when the multidimensionality of schizotypy is considered. Furthermore, it may be that nondisordered schizotypes who exhibit cognitive deficits are at especially heightened risk for transitioning into schizophrenia-spectrum disorders (and this seems like a promising target for longitudinal study). In response to these concerns, Sahakyan and Kwapil (2018) advocated reconsidering the use of standard clinical neuropsychological batteries for assessing cognitive performance in schizotypy, as these measures are designed for patient populations and may not be sensitive enough to detect subtle cognitive impairment seen in nondisordered schizotypes. We also recommend examining schizotypy as a multidimensional construct to enhance precision for detecting small effect sizes, and recommend employing schizotypy measures that include the disorganized schizotypy dimension such as the Multidimensional Schizotypy Scale (Kwapil et al., 2018).

Conflict of interest

Neither author had a conflict of interest.

Contributors

Lili Sahakyan, Ph.D., designed the study, oversaw data collection, and was lead author of the manuscript. Thomas R. Kwapil, PhD, contributed to the data analyses and writing of the manuscript.

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