Journal of Experimental Psychology: General

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Online First Publication, July 1, 2019. http://dx.doi.org/10.1037/xge0000645

American Psychological Association

Journal of Experimental Psychology: General

0096-3445/19/$12.00

http://dx.doi.org/10.1037/xge0000645

Differential Impairment of Positive and Negative Schizotypy in List-Method and Item-Method Directed Forgetting

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Schizophrenia is characterized by cognitive impairment and this impairment is expected to occur, albeit to a lesser degree, in people putatively at risk for schizophrenia. Two experiments assessed the relationship between directed forgetting (DF) and schizotypy, which is a multidimensional construct that reflects the expression of the underlying vulnerability for schizophrenia. Experiment 1 involved item-method DF and Experiment 2 involves list-method DF study. The schizotypy dimensions exhibited differential patterns of impairment across the 2 methods that suggest different underlying processes. Positive schizotypy showed impairment in item-method DF that was driven by reduced ability to forget forget-cued items, whereas performance on remember-cued items was unaffected in positive schizotypy. Despite the deficit in item-method DF, positive schizotypy participants showed preserved performance in list-method DF. The opposite pattern was found in negative schizotypy participants, who showed impairment in list-method DF, despite preserved performance in item-method DF. Negative schizotypy was previously associated with deficits in context processing and, consistent with context-change account of list-method DF, showed deficits in list-method DF task. Positive schizotypy is characterized by deficits in inhibitory control and, consistent with inhibitory account of item-method DF, showed deficits in item-method DF task. Collectively, these results (a) suggest that different DF methods involve different underlying mechanisms, (b) support the context-account of list-method DF and an inhibitory account of item-method DF, and (c) support the multidimensional model of schizotypy by showing differential impairment in positive and negative schizotypy across the 2 DF tasks.

Keywords: schizotypy, directed forgetting, inhibitory control, context processing

Supplemental materials: http://dx.doi.org/10.1037/xge0000645.supp

Everyday forgetting is an inevitable process that occurs largely outside of our conscious awareness or intentions; usually causing annoyance when it becomes apparent. Forgotten bills, misplaced keys, and missed birthdays uncomfortably remind us how frustrating it is to forget things. However, there are occasions when forgetting could be adaptive. For example, when checking out of hotel, we do not want to retain the number of the room where we stayed; purging that information out of mind helps declutter it. In this day of constantly needing to update passwords, it is functional to forget the old passwords. In extreme cases, such as when memories are traumatic, it can be dysfunctional to ruminate on them, and one may wish to reduce their accessibility. Thus, it is not always the case that remembering is the desired outcome, and forgetting is the flaw. Sometimes remembering is the undesired outcome, and forgetting is beneficial.

Memory control has been a topic of active investigation in cognitive research, and the directed forgetting (DF) procedure (Bjork, LaBerge, & Legrand, 1968) is a widely used laboratory paradigm for examining memory control. In DF studies, participants are presented items to learn for a memory test, some of which are subsequently cued to be remembered (R) or to be forgotten (F). In an *item-method* variant, F/R cues are delivered after each item, whereas in a *list-method* variant, the cues are delivered once after a whole set of items has been presented. Participants are told that F-items will not be tested, and they should attempt to forget them. At test, however, all items are evaluated regardless of memory instruction, and the typical outcomes reflect impaired memory for F-items compared with R-items, known as the DF effect. A variety of theoretical positions have been proposed to explain the item-method and list-method DF findings, and we expand on this discussion later. Furthermore, DF has been examined in a number of special populations including schizophrenia (for a review see Sahakyan, Delaney, Abushanab, & Foster, 2013), although it has never been examined in schizotypy.

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None of the data or narrative interpretations in the present manuscript have been previously disseminated in other manuscripts, conferences, listservs, websites, or academic social networks. This is original work that has not been published elsewhere. The authors are grateful to Elizabeth Digiulio, Michael Stucky, Fajir Al-Attar, and Ali Akhtar for assistance in data collection.

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The purpose of this investigation is to examine how individual differences in schizotypy affect item-method (Experiment 1) and list-method (Experiment 2) DF. Schizotypy is a multidimensional construct that reflects the expression of the underlying vulnerability for schizophrenia across a range of subclinical and clinical severity (Kwapil & Barrantes-Vidal, 2015; Lenzenweger, 2010). Schizotypy provides a useful construct for understanding the etiology and development of schizophrenia (Barrantes-Vidal, Grant, & Kwapil, 2015). The most commonly identified and studied dimensions are positive and negative schizotypy (Kwapil & Barrantes-Vidal, 2015). Positive schizotypy is characterized by odd beliefs, unusual perceptual experiences, and suspiciousness or paranoia, whereas negative schizotypy involves diminished functioning such as anhedonia, flattened affect, alogia, anergia, and avolition. Individuals with subclinical schizotypic symptoms and impairment are at heightened risk for developing schizophrenia-spectrum disorders (e.g., Kwapil, Gross, Silvia, & Barrantes-Vidal, 2013). More important, positive and negative schizotypy are associated with unique pattern of cognitive impairment that suggest different underlying mechanisms across schizotypy dimensions (e.g., Ettinger et al., 2015; Sahakyan & Kwapil, 2016, 2018b, 2019).

Cognitive Impairment in Schizophrenia and Schizotypy

Cognitive impairment is a hallmark of schizophrenia (e.g., Green & Nuechterlein, 1999; Harvey, 2013; Heinrichs & Zakzanis, 1998). Schizophrenia is associated with impairments in most, if not all, domains of cognition, typically with effect sizes on the order of medium to large effects (e.g., Schaefer, Giangrande, Weinberger, & Dickinson, 2013). Notably, cognitive impairment in schizophrenia is a robust predictor of disrupted functioning in patients with schizophrenia, in multiple domains including self-care; activities of daily living; and social, interpersonal, community, scholastic, and occupational functioning (e.g., Bowie & Harvey, 2006). However, the study of cognitive impairment in patients with schizophrenia is complicated by: (a) considerable individual differences in the range and severity of impairment, and (b) the fact that it is difficult to disentangle the extent to which cognitive impairment is a core feature or a consequence of the disorder. For example, performance of people with schizophrenia on cognitive tasks could be disrupted by the effects of medications or current symptoms (e.g., neglecting the task because of paranoid delusions about the examiner, attending to hallucinations, or diminished motivation). Thus, it can be difficult to determine the extent to which performance deficits on cognitive tasks are etiologically relevant to the disorder or simply represent sequelae of the disorder.

Schizotypy offers a promising approach for examining cognitive impairment in the schizophrenia spectrum given the continuity of subclinical or nondisordered schizotypy and full-blown schizophrenia. Furthermore, it allows for the assessment of cognitive performance relatively unaffected by the symptoms and consequences of disorder (for reviews, see Chun, Minor, & Cohen, 2013; Ettinger et al., 2015; Nelson, Seal, Pantelis, & Phillips, 2013; Steffens, Meyhöfer, Fassbender, Ettinger, & Kambeitz, 2018). However, effect sizes for cognitive impairment are expected to be considerably smaller in nonclinical schizotypy than in patients with schizophrenia-spectrum disorders (see also Steffens et al., 2018). Previous findings indicate that subclinical schizotypy is associated with schizophrenic-like cognitive impairment. Furthermore, positive and negative schizotypy are associated with unique patterns of cognitive deficits, highlighting the need to consider the multidimensional structure of schizotypy (Sahakyan & Kwapil, 2016, 2018a, 2018b, 2019), and suggesting different patterns of DF outcomes.

Item-Method DF

As mentioned previously, in an item-method DF study, the F/R cues are presented after each item, and the findings reflect robust memory impairment for F-items. The theoretical explanations focused on selective rehearsal of R-items (Basden, Basden, & Gargano, 1993; Bjork, 1970; Macleod, 1999), and/or inhibition of F-items (for a review, see Anderson & Hanslmayr, 2014). According to selective rehearsal, participants maintain an item in working memory until they receive the instruction. The F-cue leads participants to terminate rehearsal and remove the item from working memory, whereas the R-cue leads participants to encode that item more elaborately. Whereas the selective rehearsal account highlights the processes aimed at remembering the R-cued items, inhibition account highlights more active processes aimed at inhibiting F-cued items.

According to the inhibitory account, removal of items from working memory does not happen through passive decay but rather engages active, effortful processes aimed at terminating encoding of F-items (Fawcett & Taylor, 2008, 2010, 2012; Hauswald, Schulz, Iordanov, & Kissler, 2011; Ludowig et al., 2010; Nowicka, Marchewka, Jednoróg, Tacikowski, & Brechmann, 2011; Oberauer, 2018; Paz-Caballero, Menor, & Jiménez, 2004; Reber et al., 2002; Rizio & Dennis, 2013; Wylie, Foxe, & Taylor, 2008). Neural evidence consistently indicates that successful intentional forgetting recruits additional processes beyond those that are associated with passive forgetting, and the nature of these processes appear to be inhibitory in nature (for a review, see Anderson & Hanslmayr, 2014). Likewise, behavioral evidence also indicates that when participants perform a secondary task along with DF, RTs (reaction times) on the secondary task are slower during the execution of the F-cue, indicating that forgetting engages more cognitive load and is more effortful (e.g., Fawcett & Taylor, 2008, 2010, 2012).

Two studies examined item-method DF in schizophrenia patients (Müller, Ullsperger, Hammerstein, Sachweh, & Becker, 2005; Sonntag et al., 2003), producing inconsistent findings. Sonntag et al. (2003) reported similar magnitude of DF effect among patients and healthy controls. Although the authors did not find any significant relationship between DF and the positive/negative symptom dimensions of the disorder, they may have been underpowered to detect this relationship as they only included 21 patients, approximately half of whom were described as residual cases (not actively symptomatic). Müller et al. (2005) found a smaller DF effect in patients compared with controls, but they did not find any relationship between DF effect and symptom dimensions.

We are not aware of any DF studies using subclinical schizotypy participants. However, a task that appears close in spirit to item-method DF is known as *incidental learning task* in the clinical literature (Jones, Gray, & Hemsley, 1990), and the relationship between schizotypy and the incidental learning task was examined in two previous studies. Briefly, the task involves presenting 16 bisyllabic words on a computer screen, half of which begin with letter 'A,' whereas the remaining half of the words do not. Participants are told to learn the words that begin with letter 'A.' However, they are required to read the words aloud to make sure that non-A words are not simply ignored. After the encoding stage, participants are asked to recall all the words that begin with letter 'A' (intentional recall), and then to recall the words that do not begin with 'A' (incidental recall). The results across both studies revealed that intentional items were better recalled than "incidentally learned" items; however, higher positive schizotypy was associated with elevated recall of incidental items, but it did not affect the recall of intentional items (Burch, Hemsley, Corr, & Gwyer, 2006; Jones et al., 1990).

Although incidental learning task is not equivalent to item-method DF as participants are not explicitly told to forget anything, the finding that intentional recall exceeds incidental recall is similar to R-items being better recalled than F-items in item-method DF task. Importantly, incidentally learned items showed elevated recall in higher positive schizotypy suggesting a problem with "filtering" out less prioritized information. Thus, based on these findings, there are reasons to predict that item-method DF may be particularly difficult to perform for participants who score high on positive schizotypy. Specifically, we predict that higher positive schizotypy may be unrelated to R-items accuracy, but it may be positively associated with F-items accuracy in item-method DF task. As a result, we expect that higher positive schizotypy will show diminished item-method DF effect.

Experiment 1 examined this prediction. Instead of free recall, we used a recognition test to assess memory because item-method DF is robust both in recall and recognition, and recognition circumvents the concerns that may be raised with free recall test. For example, if R-items are recalled first in the retrieval sequence, F-items will suffer output interference making it appear that there is a DF effect, when in fact the pattern of recall may be mostly driven by output interference. This concern could be magnified if there are baseline differences in recall of remember items across schizotypy dimensions, which could exacerbate the magnitude of output interference on forget items. Recognition testing probes for R and F items randomly and bypasses output interference concern.

Experiment 1: Item-Method DF

Method

Participants. Based upon a power analysis, a minimum of 131 participants was needed to ensure power of .80 to detect a small effect size (f^2 = .08) for regression analyses with three predictors using two-tailed α of .05. Participants were 130 undergraduate students from University of Illinois at Urbana-Champaign (UIUC), who participated for course credit. Participants were recruited in two ways. Any participant in the pool was eligible to sign up for the study (this provided participants with a broad range of scores on the schizotypy dimensions). In addition, we oversampled participants who scored at least 1.5 *SD* above the mean on the Multidimensional Schizotypy Scale-Brief (MSS-B; Gross, Kwapil, Raulin, Silvia, & Barrantes-Vidal, 2018) positive or negative schizotypy subscales taken during a departmental prescreening. This oversampling or enrichment procedure has been successfully used before (e.g., Kwapil, Barrantes-Vidal, & Silvia, 2008) and was used to ensure adequate representation of participants with elevated scores on positive and negative dimensions. The sample consisted of 81 female and 49 male participants. Note that both Experiments 1 and 2 were approved by the UIUC Institutional Review Board and all participants in each study provided informed consent before taking part in the study.

Materials. The stimuli involved 72 English words selected from the MRC (Medical Research Council) linguistic database (Coltheart, 1981). They had an average word frequency of *M* = 62.01, *SD* = 8.14 (according to Kučera & Francis, 1967 norms), average word length of *M* = 4.76, *SD* = 0.76 letters, and average concreteness of *M* = 574.54, *SD* = 33.69 (in MRC database, concreteness values can range from 100 to 700, with *M* = 438, *SD* = 120). The words were split into two sets of 36 items, which served equally often as the target list (i.e., studied items) and the distractor list (e.g., unstudied items). The two sets were matched on frequency, word length, and concreteness. The 38-item MSS-B was used to assess positive and negative schizotypy dimensions. Consistent with the full-length Multidimensional Schizotypy Scale (Kwapil, Gross, Silvia, Raulin, & Barrantes-Vidal, 2018), the MSS-B scale has good psychometric properties (e.g., Gross, Kwapil, Raulin, et al., 2018; Kemp, Gross, & Kwapil, 2019) and validity for assessing schizotypy dimensions (e.g., Gross, Kwapil, Burgin, et al., 2018; Kemp, Gross, Barrantes-Vidal, & Kwapil, 2018). The MSS-B items were intermixed with 13-item Infrequency Scale (Chapman & Chapman, 1983), which was designed to identify invalid responders. Following Chapman and Chapman's recommendation, participants who endorse more than two infrequency items are excluded, although none of the participants in Experiment 1 warranted exclusion.

Procedure. Participants first completed the item-method DF task, followed by the schizotypy assessment. During the DF phase, they were presented 36 words one at a time on a computer screen for 2 s for each word. Each word was followed by R or F instructions, which were symbolized by an open blue circle for the R instruction (o), and an orange slashed-circle for the F instruction (ø). Before the study session, participants were familiarized with the symbols and their meaning, and they were told that after each word, they would see one of the two types of symbols, denoting whether a given word will be tested later or not. The symbols followed the words and remained on the screen for 2 s. Half of the studied items were followed by R, and the remaining half by F instruction, with each word being equally likely to be followed by either type of instruction. The order of R and F symbols was randomized with a constraint that no more than three symbols of the same type occurred in a row. After encoding, participants received an Old/New recognition test, which contained 36 studied items intermixed with 36 new items. Participants were told to press "Old" for any item they recognized from the experiment, regardless of whether it was followed by F or R instruction, and to press "New" for any item they did not recognize. Testing was self-paced, and the order of Old/New and R/F words was completely randomized for each participant during the test. After DF phase, participants completed the MSS-B.

Results

Descriptive statistics on the positive and negative schizotypy factor scores (based upon norms from 11,765 participants), and their correlation are provided in Table 1. The scores covered a broad range on each of the schizotypy dimensions, and the ranges were comparable with one another for positive and negative schizotypy. In the full sample, there was impaired accuracy (d') of the F-items ($M = 1.33$, $SD = .70$) compared with R-items ($M = 2.28$, $SD = .72$), confirming a significant item-method DF effect, $t(129) = 16.41$, $p < .001$, Cohen's $d_z = 1.44$.

To examine the magnitude of DF effect across schizotypy dimensions, we computed linear regression on the difference score between R and F items accuracy (d') (see Table 2). The positive and negative schizotypy factor scores were entered simultaneously at the first step, and the Positive × Negative Schizotypy interaction term was entered at the second step to examine the interaction over-and-above the main effects. Simple slopes analyses were computed to decompose significant interactions by examining the effect of one predictor at low (−1 *SD*), medium (0 *SD* or mean), and high (1 *SD*) levels of the other predictor. For all regression analyses, β coefficients, change in R^2, and effect sizes (f^2) are reported. Following Cohen (1992), f^2 values of .15 indicate medium effect sizes and .35 indicate large effect sizes.

The results indicate that the magnitude of DF effect was significantly reduced across increasing levels of positive schizotypy, consistent with the predictions. In contrast, DF effect was unaffected by negative schizotypy. The Positive × Negative Schizotypy interaction was significant. Simple slopes analysis indicated that positive schizotypy was significantly associated with the DF effect at low levels (−1 *SD*), $t(126) = -3.83$, $p < .001$, and the mean of negative schizotypy, $t(126) = -2.73$, $p < .01$, but not at high levels of negative schizotypy (1 *SD*), $t(126) = 0.15$, $p = .88$.

To evaluate the origin of diminished DF effect, we examined R and F item accuracy separately as a function of positive and negative schizotypy. Figure 1 summarizes R and F item accuracy as a function of positive schizotypy (left panel) and negative schizotypy (right panel). As the figure demonstrates, reduced DF in positive schizotypy was driven by increased recognition of F-items, whereas R-item recognition remained unaffected. In contrast, the magnitude of DF effect remained unaffected in negative schizotypy despite impaired recognition of both types of items across increasing negative schizotypy. These observations were confirmed by regression analyses. There was a significant positive relationship between F-item accuracy and positive schizotypy, but a negative relationship between F-item accuracy and negative schizotypy (the latter fell short of significance, $p = .056$). Regression analyses on R-item accuracy revealed no relationship between positive schizotypy, but a significant negative relationship between negative schizotypy and R-item accuracy. The Positive × Negative Schizotypy interaction significantly predicted R-item accuracy. Simple slopes analysis indicated that negative schizotypy was significantly associated with the remember item accuracy at low levels (−1 *SD*), $t(126) = -4.30$, $p < .001$, and the mean of positive schizotypy, $t(126) = -3.07$, $p < .01$, but not at high levels of positive schizotypy (1 *SD*), $t(126) = 0.72$, $p = .48$. Note that hit rates for forget and remember items, false alarms, and response bias (C) are presented in supplementary Table 1.

Discussion

The results of Experiment 1 indicate that the typical item-method DF effect is diminished or ameliorated in participants who score high on positive schizotypy, consistent with our predictions. The impairment appears to stem from diminished forgetting of F-cued items, rather than diminished memory for R-cued items. Thus, when the goal of the task was to forget some items, participants scoring higher on positive schizotypy showed a deficit in executing this goal. In contrast, participants who score high on negative schizotypy show the typical item-method DF effect, despite showing overall impairment in recognition memory for both types of items. The finding that R-item accuracy is unaffected in positive schizotypy, but it is impaired in negative schizotypy replicates our previous findings of similar patterns of impairment in recognition memory, without manipulating DF (Sahakyan & Kwapil, 2016). We found that negative, but not positive, schizotypy was associated with impairment in recognition accuracy (d'). The novel finding in the current experiment is that DF manipulation dissociated positive and negative dimensions of schizotypy—positive schizotypy ironically showed enhanced recognition of F-items, indicating a deficit in ability to execute the forgetting goal, whereas negative schizotypy was able to execute this goal, and showed intact DF effect. The differential pattern of impairment across two schizotypy dimensions suggests that control processes that are involved in downregulating memory of forget items, appear to be impaired in positive schizotypy, but not necessarily in negative schizotypy.

As mentioned previously, selective rehearsal of R-items and inhibition of F-items are two popular accounts of item-method DF (e.g., Anderson & Hanslmayr, 2014). The observed deficit in positive schizotypy is consistent with impaired inhibition of F-items; although it may also involve impaired source monitoring,

Table 1
Descriptive Statistics for Negative and Positive Schizotypy Factor Scores, and Their Correlation in Experiment 1 and Experiment 2

	Negative schizotypy		Positive schizotypy		Correlation between negative and positive schizotypy
Experiments	*M* (*SD*)	Range	*M* (*SD*)	Range	*r*
Experiment 1 ($N = 130$)	−.31 (.80)	−.76 to 3.49	.17 (1.16)	−.81 to 3.47	.13
Experiment 2 ($N = 260$)	.40 (1.21)	−1.07 to 4.17	.11 (1.04)	−1.36 to 4.84	.22

Note. Schizotypy was assessed with the Multidimensional Schizotypy Scale-Brief in Experiment 1. Values for the schizotypy subscales are normed based upon 11,765 participants. Schizotypy was assessed with the Wisconsin Schizotypy Scales-Brief in Experiment 2. Factor scores were derived based upon norms from 6,137 participants.

Table 2
Prediction of Item-Method Directed Forgetting by Negative Schizotypy, Positive Schizotypy, and Their Interaction in Experiment 1

	Step 1						Step 2			
	Negative schizotypy			Positive schizotypy			Negative × Positive interaction			
Measures	β	ΔR^2	f^2	β	ΔR^2	f^2	β	ΔR^2	f^2	Total R^2
DF effect (R-F)	−.04	.001	.00	−.24**	.059	.06	.26**	.050	.06	.113**
F item accuracy	−.17	.027	.03	.27**	.071	.08	.12	.011	.01	.099**
R item accuracy	−.20*	.037	.04	.04	.001	.00	.35***	.093	.11	.131***

Note. DF = directed forgetting; F = F-cued items; R = R-cued items. Each row represents a separate regression analysis predicting measures derived from recognition memory performance. Hierarchical regression was used to examine the unique prediction of memory performance by positive and negative schizotypy, and Positive × Negative Schizotypy interaction. For each predictor, the standardized regression coefficient (β), change in R^2, and effect size (f^2) are reported.
* $p < .05$. ** $p < .01$. *** $p < .001$.

which could contribute to problems with selective rehearsal of R-items. Studies examining memory for cues in item-method DF studies have generally found that participants remember which words were associated with F and R cues equally well (e.g., Bancroft, Hockley, & Farquhar, 2013; Thompson, Fawcett, & Taylor, 2011). However, if a particular population has deficits in source monitoring, F-items may be mistakenly confused with R-items and end up being rehearsed along with other R-items, producing a diminished item-method DF.

The literature does not provide a clear answer regarding source monitoring deficits in schizotypy. Some studies found that high positive schizotypy participants were more likely to misattribute self-generated events to external source (e.g., Aldebot, Weisman de Mamani, & Garcia, 2012; Humpston, Linden, & Evans, 2017; Peters, Smeets, Giesbrecht, Jelicic, & Merckelbach, 2007). In contrast, our own investigation revealed source monitoring deficits in negative schizotypy, but not positive schizotypy (Sahakyan & Kwapil, 2016), although the nature of source information in our study was temporal rather than internal/external. Mixed findings also emerge in research with patients with schizophrenia. Reality monitoring deficits that involve misattributing self-generated events to external sources characterize schizophrenia patients (Johns et al., 2001; Keefe, Arnold, Bayen, McEvoy, & Wilson, 2002; Vinogradov, Luks, Schulman, & Simpson, 2008), with some studies finding source monitoring deficits linked to positive symptoms (Brébion et al., 2000; Brébion, Gorman, Amador, Malaspina, & Sharif, 2002), whereas others finding the association with negative symptoms (Brébion et al., 2002; Moritz, Woodward, & Ruff, 2003). If the observed deficit in item-method DF in positive schizotypy was driven by confusion between which items to rehearse and which ones to stop rehearsing, then an assumption must be made that positive schizotypy involves difficulty remembering the source of R and F-items, whereas negative schizotypy does not. However, confusion between the two item types should not have disproportionately affected F-items without affecting R-items; one would expect remember items to suffer if they were not rehearsed

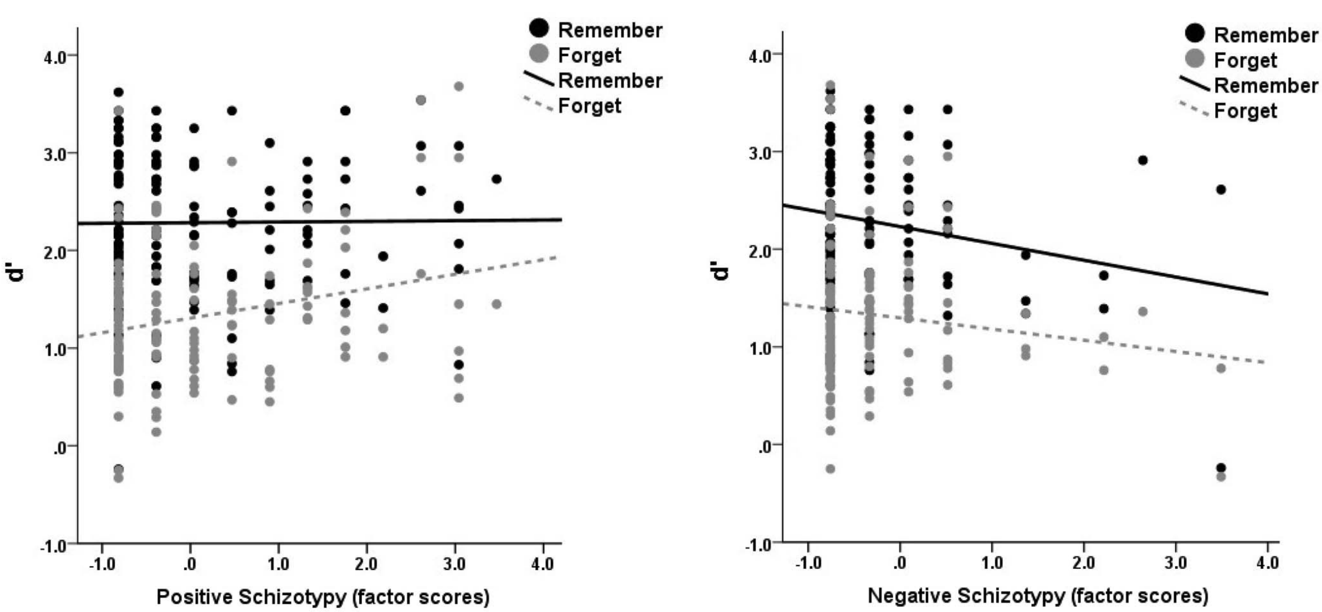

Figure 1. Recognition accuracy of remember (R) and forget (F) items in positive schizotypy (left panel) and negative schizotypy (right panel) in Experiment 1.

as often as they should have been because of confusion with F-items. The fact that reduced item-method DF in positive schizotypy was driven mainly by increased performance of F-items is more consistent with the impaired inhibition explanation. Indeed, deficits in inhibitory control and executive function are widely acknowledged both in schizophrenia and in positive schizotypy (e.g., Ettinger et al., 2015, 2018; Giakoumaki, 2012; Neill, Rossell, & Kordzadze, 2014; Stefaniak, Giot, Terrien, & Besche-Richard, 2015). Also, findings using an incidental learning task showed that positive schizotypy involved difficulty filtering “unwanted” items (Burch et al., 2006; Jones et al., 1990). Thus, the parsimonious explanation for the deficit in item-method DF appears to be impaired inhibition in positive schizotypy.

Experiment 2: List-Method DF

In Experiment 2, we evaluated the relation of schizotypy and list-method DF. List-method DF differs from item-method DF in that participants are instructed to forget an entire list after it has been encoded as opposed to individual items. In this variant of the task, participants study two lists and, after presentation of List 1, some participants receive an F-cue, whereas others receive an R-cue. Participants in the forget condition may be told that the list was presented in error, and they should attempt to forget to do better on the “real” list. Note, that participants could be warned to expect a forget instruction (i.e., the forget cue need not involve surprise/deception). Participants in the remember condition are told that List 1 included only half of the items and they should keep those in mind before studying the remainder half of items. Then all participants study List 2 and are subsequently tested on all items, including the ones they were told to forget. Two outcomes are associated with list-method procedure—List 1 impairment and List 2 enhancement in the forget condition compared with the remember condition lists.

Two widely held accounts of *list-method* DF involve the context-change account (Sahakyan & Kelley, 2002) and retrieval inhibition account (Anderson, 2005; Bjork, 1989; Geiselman, Bjork, & Fishman, 1983). According to retrieval inhibition, the F-cue triggers processes that inhibit List 1 items, impairing their recall during the test. Inhibited List 1 items reduce proactive interference on List 2 items, improving List 2 memory compared with the Remember group (e.g., Bjork & Bjork, 1996, 2003; Bjork, 1989; Geiselman et al., 1983).

An alternative interpretation is offered by the context-change account (Sahakyan & Kelley, 2002). Broadly, context refers to the “setting” in which items are encoded. It includes one’s thoughts, mood, and environment in which learning takes place. Importantly, free recall is initiated in the absence of externally provided cues, and participants must rely on context cues to search their memory. The dissimilarity between the cues used at retrieval and the cues present at encoding impairs recall (for a review, see Smith & Vela, 2001). According to context-change account, participants shift their mental context in response to F-instruction, distancing themselves from the context in which they encoded List 1 items. This impairs the ability of the F-group to reinstate List 1 context during test, because the context at test better matches List 2 than List 1, thereby producing DF impairment of List 1. DF enhancement of List 2 is attributed to reduced proactive interference in the F-group from having encoded the lists in two separate contexts[1] (for review, see Sahakyan et al., 2013).

Using a list-method DF task with schizophrenia patients, Racsmány et al. (2008) reported that patients were unable to perform DF, whereas Soriano, Jiménez, Román, and Bajo (2009) confirmed this deficit only in hallucinating patients; the nonhallucinating patients showed DF comparable with healthy controls. However, the lack of clarity in these findings may reflect the heterogeneity of the patient samples and the fact that the studies were not specifically designed to test hypotheses regarding positive and negative symptom dimensions. We are not aware of any studies using subclinical schizotypy participants with list-method DF.

If inhibitory processes are engaged in forgetting List 1 episode, one would expect to observe DF impairments in positive schizotypy, similar to those obtained in item-method DF in Experiment 1. However, if list-method DF is driven by context-change, then context account predicts that negative, but not positive schizotypy, should show impairment in list-method DF because negative schizotypy is associated with deficits in context processing, whereas positive schizotypy is not (Sahakyan & Kwapil, 2016, 2018b). More specifically, in previous investigations, negative schizotypy participants exhibited deficits on a number of context-related measures extracted from free recall and recognition performance. For example, high negative schizotypy participants were less likely to initiate recall with the first item in the list, suggesting impaired encoding or reinstatement of context under the assumption that the first item is more strongly associated with its episodic context than the ensuing items in the list as it defines the start of a new episode (e.g., Lehman & Malmberg, 2013). They also showed reduced temporal contiguity, which refers to a tendency to recall items nearby in the list to the just-recalled item during retrieval. Temporal contiguity is a robust phenomenon explained through a context mechanism—namely, recall of any item reinstates the context associated with that item, which is then used as a retrieval cue for other items (e.g., Howard & Kahana, 2002; Polyn, Norman, & Kahana, 2009; Sederberg, Howard, & Kahana, 2008). Reduced temporal contiguity in negative schizotypy participants suggests difficulty formulating and/or utilizing context to guide retrieval of other items. In addition, high negative schizotypy exhibited deficits in remembering the temporal context of items (Sahakyan & Kwapil, 2016), and made more cross-list intrusion errors in free recall consistent with impaired context processing. Finally, recall latency measures indicated difficulty delineating the relevant search set in memory based on context cues. Collectively, those findings indicated that high negative schizotypy is associated with deficits in binding and associating items with their episodic context during encoding, and/or difficulty with using context during retrieval. These findings are consistent with patient studies that reported impaired context processing in schizophrenia patients with negative symptoms (Barch, Carter, MacDonald, Braver, & Cohen, 2003; Gold et al., 2012; Javitt,

[1] Note that impaired List 1 and enhanced List 2 are not always observed together in list-method DF studies, and in response to dissociations, dual-factor accounts have been proposed, attributing List 1 impairment to context-change or inhibition, and attributing List 2 enhancement to a change in encoding strategy or a reset of encoding processes (Pastötter & Bäuml, 2010; Sahakyan & Delaney, 2003, 2005).

Rabinowicz, Silipo, & Dias, 2007; Niendam et al., 2014; Owoso et al., 2013; Richard, Carter, Cohen, & Cho, 2013), but not schizophrenia patients with positive symptoms (Barch et al., 2003; Cohen, Barch, Carter, & Servan-Schreiber, 1999; Gold et al., 2012; Javitt et al., 2007; MacDonald & Carter, 2003; Niendam et al., 2014; Owoso et al., 2013).

To summarize, retrieval inhibition and context-change account make different predictions regarding which dimension of schizotypy should be more impaired in list-method DF task. The inhibition account suggests that DF should be impaired in positive schizotypy akin to the impairment observed in item-method DF in Experiment 1. In contrast, context-change account predicts deficits in negative schizotypy, but not positive schizotypy, thus, differentiating the item-method and list-method of DF, and also differentiating positive and negative schizotypy.

Method

Participants. Based upon a power analysis, a minimum of 176 participants were needed to ensure power of .80 to detect a small effect size ($f^2 = .08$) for regression analyses with seven predictors using two-tailed α of .05. Participants were recruited from two sources. Lab participants were 90 UIUC undergraduates, who participated for course credit. Unlike in item-method DF, the F and R instructions are administered between-subjects in list-method DF study, and with 45 participants per group, we might not have a sufficient range of schizotypy scores to examine its relationship with list-method DF. Therefore, we also recruited participants from Amazon Mechanical Turk (MTurk). Past research from our lab indicates comparable list-method DF between the MTurk and lab samples (Akan & Sahakyan, 2018). To be eligible, MTurk participants had to be located in the United States, and to have a minimum of 95% Human Intelligence Task (HIT) Approval Ratio on MTurk. Research indicates that MTurk workers with ≥95% HIT approval ratio score higher on measures of attentiveness compared with participants with lower HIT approval rates (Peer, Vosgerau, & Acquisti, 2014). Participants were paid $1 for participation. Initially, 203 MTurk participants completed the study. However, we excluded 33 participants based on exclusion criteria that we had set a priori, including elevated infrequency scores, failure to report age, or age older than 65, given that previous research indicates that aging reduces DF effect (e.g., Sahakyan, Delaney, & Goodmon, 2008; Zacks, Radvansky, & Hasher, 1996). We also eliminated participants who indicated on the postexperimental questionnaires that, contrary to the F-instruction, they maintained F-cued words in mind because they expected to be tested. None of the participants in the lab sample met the exclusion criteria. Usable data were available from 131 participants in the F-group, and 129 in the R-group. None of the participants in Experiment 1 participated in Experiment 2.

Materials. A set of 32 unrelated English words was selected from the Toronto Noun Pool and randomly assigned to List 1 and List 2 for each participant, resulting in two lists of 16 words. Participants completed the Wisconsin Schizotypy Scales-Brief (WSS-B) that include brief versions of the Perceptual Aberration (Chapman, Chapman, & Raulin, 1978), Magical Ideation (Eckblad & Chapman, 1983), Physical Anhedonia (Chapman, Chapman, & Daut, 1976), and Revised Social Anhedonia (Eckblad, Chapman, Chapman, & Mishlove, 1982) Scales. The 60 WSS-B items were intermixed with the infrequency items used in Experiment 1. Previous studies support the reliability and validity of the WSS-B and indicate that two factors (positive and negative schizotypy) underlie the scales (Gross, Silvia, Barrantes-Vidal, & Kwapil, 2012, 2015). Each participant was assigned a positive factor score and a negative factor score, which were computed following formulae in Gross et al. (2015). The analogous WSS-B and MSS-B positive and negative schizotypy scales correlate highly with each other (>.77), indicating that they are tapping the same constructs.

Procedure. Participants first completed the DF task, followed by the WSS-B. In the DF phase, participants were randomly assigned to the forget or remember conditions. They were told that they were participating in a memory experiment in which they would be presented with two sets of words to learn for the subsequent test and that they should memorize those words by relying solely on their memory and without using any external aides, such as copying or taking pictures of the words during presentation. They were also forewarned that the experiment was about intentional forgetting of unwanted information and that the program will randomly determine whether they would be instructed to remember or forget List 1 after its presentation. It was further explained that they would only be tested on List 1 if they received an R-instruction, but not if they received a F-instruction. Participants were told that if they received the F-instruction, it was important to try to forget List 1 items as this would help them better remember the remaining items. However, because they would not know beforehand in which condition they were participating, they should put equal effort into learning List 1. Words were presented visually for 4 s, separated by 250 ms interstimulus interval. After presentation of 16 List 1 words, half of the participants were told to remember them for a subsequent test, whereas the remaining half was told to forget List 1 words. Next, List 2 words were presented, which all participants were instructed to remember. After a 60-s distractor task involving solving arithmetic problems that appeared on the screen, participants were given 90 s to recall each list by typing as many words as they could remember, including words they were earlier told to forget. To control for output interference, the order in which the two study lists were retrieved was counterbalanced, with half of the participants recalling List 1 first, followed by List 2, and the remaining participants recalling List 2 followed by List 1. After the memory test, participants completed a brief questionnaire that inquired about their encoding and forgetting strategies. After the DF phase, participants completed the WSS-B.

Results

Descriptive statistics on the positive and negative schizotypy factor scores (based upon norms from 6,137 participants), and their correlation are provided in Table 1. Note that the scores covered a broad range on each of the schizotypy dimensions, and the ranges were comparable for positive and negative schizotypy. In all reported analyses, we collapsed across recall order and source of participants because these variables neither produced main effects, nor interacted with variables of interest in the study.

A typical list-method DF effect is captured through a List (List 1 vs. List 2) × Instruction (F vs. R) interaction, which was significant in the current study, $F(1, 258) = 91.33$, $MSE = .025$, $p < .001$. Replicating prior research, List 1 recall was significantly impaired in the forget group (M = .26, SD = .20) compared with remember group (M = .39, SD = .22), $t(258) = 4.90$, $p < .001$, Cohen's d = .61, and List 2 recall was significantly enhanced in the forget group (M = .46, SD = .25) compared with remember group (M = .33, SD = .23), $t(258) = 4.64$, $p < .001$, Cohen's d = .54. Thus, both DF impairment and DF enhancement were observed, collectively constituting a DF effect.

To assess how positive and negative schizotypy affected list-method DF effect, we ran separate linear regressions on proportion List 1 recall (to assess DF impairment) and proportion List 2 recall (to assess DF enhancement). In each analyses, the instruction, positive, and negative schizotypy factor scores were entered simultaneously at the first step, the two-way interaction terms were entered at the second step to examine effects over-and-above the main effects (these included Instruction × Negative Schizotypy, Instruction × Positive Schizotypy, and Positive × Negative Schizotypy), with the three-way interaction term (Instruction × Negative Schizotypy × Positive Schizotypy) entered at the last step. The results are summarized in Figure 2 and Table 3.

In List 1 recall, after accounting for a significant main effect of instruction, there was a significant Instruction × Negative Schizotypy interaction (β = .20, p = .024), indicating that the magnitude of DF impairment was affected by negative schizotypy. Increasing levels of negative schizotypy were associated with significantly impaired recall in the R-group ($\beta = -.21$, p = .017), but not in the F-group (β = .05, p = .60). In contrast, there was no Instruction × Positive Schizotypy interaction (β = .01, p = .93), indicating that DF was unaffected by positive schizotypy. The top panel of Figure 2 shows differential impairment of DF across negative and positive schizotypy, with increasing levels of negative schizotypy leading to reduced DF, whereas increasing levels of positive schizotypy having no impact on DF. There was neither a Positive × Negative Schizotypy interaction ($\beta = -.07$, p = .27), nor a three-way interaction, ($\beta = -.17$, p = .16).

A similar pattern of findings was observed in List 2 recall (see Figure 2, bottom panel). Increasing levels of negative schizotypy were associated with significant impaired recall in the R-group ($\beta = -.21$, p = .015), but not in the F-group (β = .01, p = .93).

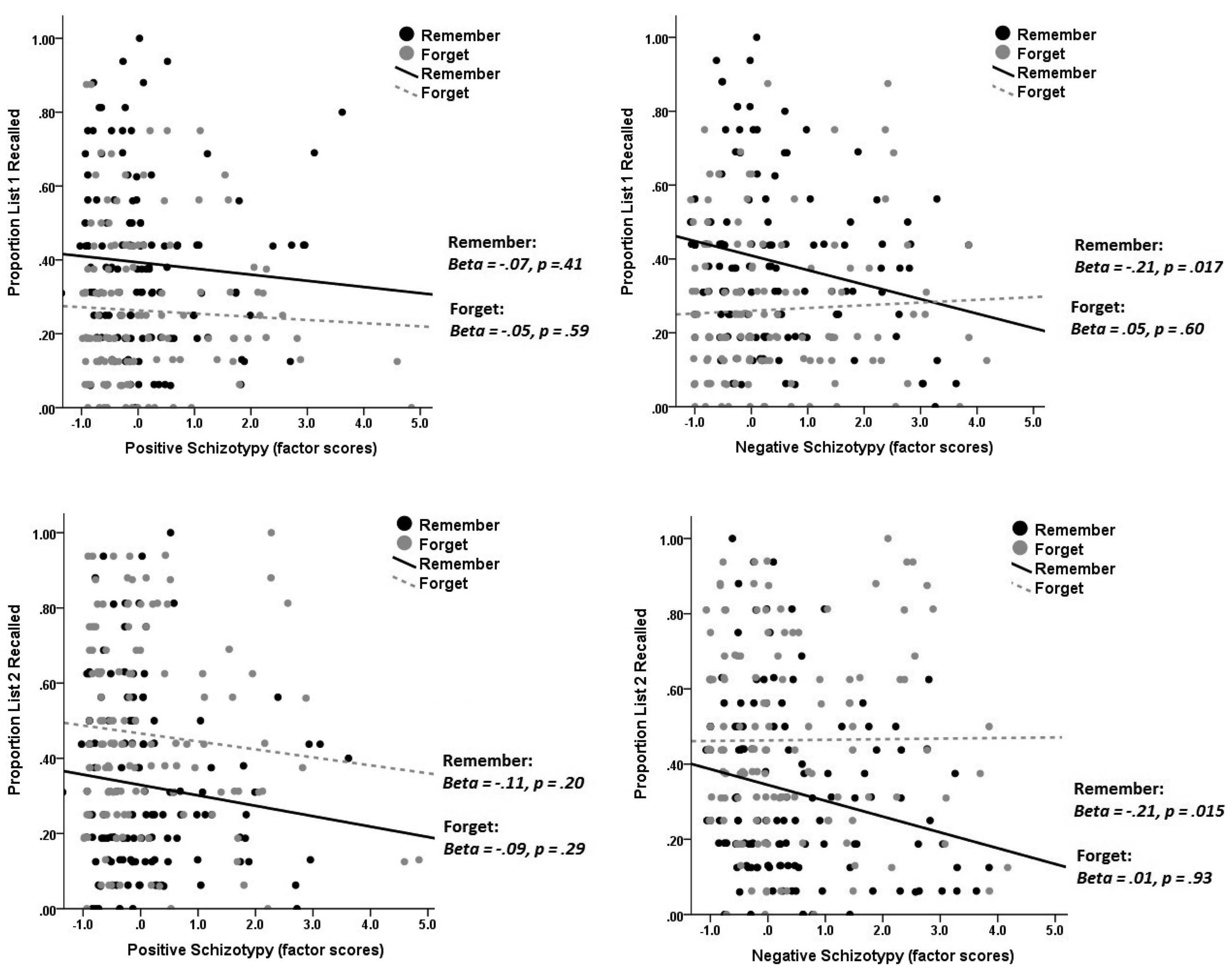

Figure 2. Proportion recall of List 1 (top panel) and List 2 (bottom panel) as a function of instruction in positive schizotypy (left panels) and negative schizotypy (right panels) in Experiment 2.

Table 3
Prediction of List 1 and 2 Recall by Instruction and Schizotypy in Experiment 2

	Step 1									Step 2									Step 3		
	Negative schizotypy			Positive schizotypy			Instruction (F/R)			Negative × Instruction interaction			Positive × Instruction interaction			Positive × Negative interaction			Three-way interaction		
Measures	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
List 1 recall	−.07	.005	.006	−.04	.002	.001	−.30***	.087	.095	.20*	.018	.020	.01	.000	.000	−.07	.004	.005	−.17	.007	.008
List 2 recall	−.07	.005	.005	−.08	.006	.007	.27***	.073	.080	.17	.012	.013	−.01	.000	.000	.01	.000	.000	−.14	.005	.006

Note. F = forget; R = remember. List 1 Recall R^2 total = .122***. List 2 Recall R^2 total = .107***. Each row represents a separate regression analysis predicting recall memory performance. Hierarchical regression was used to examine the unique prediction of memory performance by positive and negative schizotypy, the F/R instruction, and the interaction terms. For each predictor, the standardized regression coefficient (β), change in R^2, and effect size (f^2) are reported.
* $p < .05$. ** $p < .01$. *** $p < .001$.

In regression analyses, Instruction × Negative Schizotypy interaction fell short of significance (β = .17, p = .068). There was no Instruction × Positive Schizotypy interaction (β = −.01, p = .91), indicating that DF enhancement was unaffected by positive schizotypy. There was also neither a Positive × Negative Schizotypy interaction (β = .01, p = .85), nor a three-way interaction (β = −.14, p = .24).

Discussion

The results of Experiment 2 indicate that the list-method DF task is challenging for participants who score high on negative schizotypy. Negative schizotypy participants showed impaired recall of both lists in the R-group, fully replicating our previous findings (Sahakyan & Kwapil, 2016, 2018a, 2018b). Our previous assessment of recall dynamics suggested that negative schizotypy has deficits in context processing, which accounts for their free recall deficit (Sahakyan & Kwapil, 2018b). Thus, although recall deficits were observed in negative schizotypy after having studied two lists (i.e., R-group), those deficits emerged in the previous investigations even after a single list was encoded (e.g., Sahakyan & Kwapil, 2016, 2018a, 2018b, 2019). Therefore, it is unlikely that in this study recall suffered after studying two lists, but not after encoding a single list (as in List 2 in the F-group, which was supposed to be remembered, but did not show recall deficit across increasing negative schizotypy).

According to a recent meta-analyses by Steffens et al. (2018), both negative and positive schizotypy are associated with deficits in shifting (with greater effects associated with negative than positive schizotypy). In the meta-analysis, shifting was broadly defined in terms of flexible alternation of attention between different mental sets and was measured through tasks such as Wisconsin Card Sort, the Trail Making Test, and so forth (for details, see Steffens et al., 2018). Thus, one reasonable argument might be that high negative schizotypy participants had deficits in shifting between the contexts of the two lists in response to the F-cue, accounting for their deficits in list-method DF. Although this appears to be a plausible argument, the findings in positive schizotypy caution against it. That is, positive schizotypy was also associated with deficits in shifting in the meta-analysis, yet it was not associated with difficulty executing the list-method DF task in the current study. In addition, if high negative schizotypy participants simply did not shift their context, then the F-group should have resembled the R-group, and shown decreasing recall as a function of increasing negative schizotypy. That was clearly not the case in this study, as the typical inverse relationship between the negative schizotypy and recall was eliminated by the F-cue.

It is more likely that the deficits associated with context *encoding* are responsible for impaired list-method DF in negative schizotypy. In general, context processing deficits in negative schizotypy described previously (e.g., Sahakyan & Kwapil, 2018b) should lead to two outcomes: (a) free recall impairment in the R-group as noted in the current study, and importantly (b) in the F-group, context encoding deficit would ironically safeguard against list-method DF because since context is not properly encoded in the first place, then shifting the context should not hurt the items that are not associated with that context, thereby "protecting" against DF. A similar argument was raised to explain how poor encoding of context in low-working memory capacity participants (e.g., Sahakyan, Abushanab, Smith, & Gray, 2014) could be responsible for their deficit in list-method DF (e.g., Delaney & Sahakyan, 2007). Likewise, divided attention at encoding produces a deficit in context encoding (e.g., Sahakyan & Malmberg, 2018), and a deficit in list-method DF (e.g., Conway, Harries, Noyes, Racsmány, & Frankish, 2000). To summarize, poor encoding of context in negative schizotypy implies that receiving a test in a "different" context should ironically protect the items that were not associated with their previous context, and those items should not suffer from context-change.

If high negative schizotypy participants simply did not remember which list to maintain and which list to forget (i.e., deficit in source monitoring), then Experiment 2 findings are in stark contrast with Experiment 1, in which potential difficulty with source monitoring did not affect negative schizotypy in item-method DF task, but produced selective deficits in positive schizotypy. Thus, not knowing which list to maintain or discard is unlikely to account for the complex pattern of findings across both experiments.

Finally, in the meta-analyses of Steffens et al. (2018), there were no significant associations between schizotypy dimensions and inhibition (with the latter measured through tasks like Go/No-Go, Stop-signal, Stroop, etc.). Although the results were short of significance, the largest effects sizes in the meta-analyses were associated with deficits in positive schizotypy (Hedges $g = .15$), suggesting a possible trend. Therefore, if list-method DF involved some form of inhibition, those deficits should have been detected in positive schizotypy, not negative schizotypy, but this is not what we found in Experiment 2. At the same time, deficits in item-method DF found in Experiment 1are consistent with the inhibitory deficit trend detected in the meta-analysis.

Overall, positive and negative schizotypy showed differential pattern of impairment in list-method DF, with negative schizotypy participants showing deficits in list-method DF task, whereas positive schizotypy participants were capable of performing the task. The differential pattern of association between list-method DF and different dimensions of schizotypy supports the predictions of the context-change account.

General Discussion

In two experiments, we examined the relationship of multidimensional schizotypy with item-method DF (Experiment 1) and list-method DF (Experiment 2). The results showed that that the schizotypy dimensions were characterized by hypothesized, differential patterns of impairment across two DF methods. Negative schizotypy was associated with the typical pattern of DF on the item-method paradigm (albeit with reduced performance in both F-cued and R-cued items). Positive schizotypy, on the other hand, failed to show the expected item-method DF, an ability that is associated with engaging inhibitory control to suppress the unwanted information. The selective deficit in item-method DF observed in positive schizotypy was driven mainly by the lack of diminished performance on the F-cued items. In terms of list-method DF, negative schizotypy was associated with diminished recall of both lists in the R-group, replicating previous findings (e.g., Sahakyan & Kwapil, 2016, 2018a, 2018b). Importantly, the typical inverse relationship between negative schizotypy and recall was eliminated by the F-cue. The net outcome was that negative schizotypy had selective deficits in list-method DF, an ability associated with context processing and context change or shift. One candidate mechanisms that could account for the selective deficit in list-method DF in negative schizotypy is deficient encoding of contextual information. Namely, in the F-group, context encoding deficits would ironically safeguard against list-method DF because if context is not well-encoded in the first place, then context-change should not hurt the items that were not well-associated with that context, thereby "protecting" against DF.

If both DF methods were driven by some form of inhibition, one would expect positive schizotypy that is known for its deficits in inhibitory control to be affected similarly by both DF tasks. Our results across two experiments, however, produced divergent outcomes. Positive schizotypy showed selective deficits in item-method DF, despite preserved performance in list-method DF, whereas negative schizotypy showed selective deficits in list-method DF, despite preserved performance in item-method DF. Such findings indicate that list-method and item-method DF do not involve the same mechanism—be it inhibitory or rehearsal-based in nature. If both methods involved inhibition, the same dimension of schizotypy should have shown deficits in both tasks. If item and list-method DF arise from terminating rehearsal of F-cued items, again the same dimension of schizotypy should have shown deficits in both DF tasks. However, the results revealed dissociation between the two DF methods and two schizotypy dimensions, and the findings support the context-account of list-method DF and an inhibitory account of item-method DF.

Negative schizotypy was previously shown to have deficits in context processing (Sahakyan & Kwapil, 2016, 2018b), and consistent with context-change account of list-method DF, showed deficits in list-method DF task. Positive schizotypy is known for its deficits in inhibitory control (Ettinger et al., 2015, 2018; Giakoumaki, 2012; Neill et al., 2014; Stefaniak et al., 2015; see also Steffens et al., 2018), and consistently showed deficits in item-method DF task.

Note that we used two different schizotypy measures in our two experiments, the WSS-B and the MSS-B. However, both of the measures are closely comparable and they produce positive and negative schizotypy scores that have good-to-excellent psychometric properties and demonstrated validity for assessing these constructs (e.g., Gross, Kwapil, Burgin, et al., 2018; Gross et al., 2015). Furthermore, the analogous schizotypy factors on the MSS-B and WSS-B correlate highly ($r > .77$), indicating that they are tapping comparable constructs. It should be noted, however, that the mean negative schizotypy score was higher in Experiment 2, than in Experiment 1, whereas the mean positive schizotypy scores were comparable across studies (although participants in both studies scored across a wide range on both positive and negative schizotypy). As noted in Table 1, the standardized mean scores for negative schizotypy were $-.31$ in Experiment 1 (using the MSS-B) and .40 in Experiment 2 (using the WSS-B). However, the distributions of schizotypy scores are consistent with published findings by Gross et al. (2015) for the WSS-B and Gross et al. (2018) for the MSS-B. Given that the studies had comparable ranges of scores on the measures and the fact that the means for all four schizotypy measures fell within half of a *SD* of the normed means, this likely reflects normal variation within samples.

Schizophrenia and related disorders are characterized by marked impairment in cognitive performance across multiple domains.

However, understanding the relevance of this impairment to these disorders is problematic because of the heterogeneity of these conditions, the ubiquity of the deficits, and because of the difficulty of teasing apart impairments in cognitive processes that may be relevant to the etiology and development of such disorders from disruptions in performance that result from the consequences of these conditions. The present findings highlight several factors to consider. Schizophrenia-spectrum disorders are heterogeneous in terms of symptoms and course. Examining positive and negative schizotypy dimensions is essential for parsing this heterogeneity (and failure to do so risks obscuring relevant findings). Studying cognitive impairment in subclinical schizotypy offers a useful approach for identifying potentially etiologically relevant deficits without the confounds of medications, stigma, and symptom interference. Obviously, some participants with subclinical schizotypy may be experiencing mild or transient psychotic-like symptoms. However, these are the exceptions and such symptoms are likely less interfering than in patients with schizophrenia-spectrum disorders. The generalized performance deficits in patients with schizophrenia make it difficult to detect meaningful cognitive disruptions in these disorders. The finding that diminished item-method DF in positive schizotypy was because of enhanced performance on F-cued items is striking in that it is in opposition to such generalized performance deficits. Positive schizotypy was associated with diminished item-method DF, but this arose from their diminished ability to forget the F-cued words.

As noted, cognitive impairment is ubiquitous in schizophrenia-spectrum disorder. However, we need to move beyond simply identifying those patients with schizophrenia-spectrum disorders and subclinical schizotypy exhibit cognitive impairment to understanding the nature of these impairments and their underlying mechanisms. The present study, along with our recent findings (Sahakyan & Kwapil, 2016, 2018a, 2018b, 2019) have identified differential patterns of impairment in positive and negative schizotypy, and have linked them to particular processes and underlying mechanisms. Future studies should examine the extent to which these processes and resulting impairments are stable across time and are associated with elevated risk or protective factors regarding the development of symptoms and functional impairment, and transition into schizophrenia-spectrum disorders.

Context of the Research

The present study represents an integration of Professor Sahakyan's program of research examining DF and Professor Kwapil's program of research examining the development and expression of schizotypy as a multidimensional construct. Furthermore, it represents an extension of Professors Sahakayan and Kwapil's collaborative research examining memory performance and impairment in positive and negative schizotypy. The present investigation focused on several core issues of these programs of research: (a) Are positive and negative schizotypy associated with differential patterns of impairment in DF performance? (b) Do different DF methods involve different underlying mechanisms? (c) Do the pattern of deficits map onto our understanding of cognitive impairment in positive and negative schizotypy? Future studies will seek to build on these findings by further exploring the neural mechanisms underlying DF and their relationship to multidimensional schizotypy.

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Received January 11, 2019
Revision received May 21, 2019
Accepted May 23, 2019 ■