High delusional ideation is associated with false pictorial memory

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A B S T R A C T

Background and objectives: To assess the relationship between false memories and schizotypal experiences in healthy volunteers. Previous research has examined a number of schizotypal dimensions and experiences and found a variety of results. Our aim was to determine the specificity of these associations by giving participants a schizotypy measure which tapped positive, negative and disorganised dimensions (O-LIFE) and another which focused on delusional ideation (PDI).

Methods: A new memory task was used consisting of images of everyday items, separated into categories. At test participants were presented with pictures which had been seen in the study phase, related lures (additional items from the same categories but which were new) and new items which were not from these categories.

Results: Positive correlations were found between scores on the positive dimension of schizotypy/delusional ideation and proportion of false memories. Moreover, these participants also had a greater tendency to respond with the highest confidence old response, regardless of the status of the item. No significant correlations were found with the other dimensions of schizotypy.

Limitations: The confidence finding differs somewhat from previous research, which has found more confidence in memory errors and less confidence in correct responses in schizophrenia. It is unclear the reason(s) for this discrepancy.

Conclusions: Increased false memory is associated with the positive dimension of schizotypy and delusional ideation and not the disorganised or negative dimensions. Furthermore, our results suggest that those high in positive schizotypy/delusional ideation require less evidence before they are willing to call an item old.

1. Introduction

Many people think of memory as being like a collection of video clips that can be replayed when we need them, giving a fixed and robust narrative of the past. However, strong evidence exists to suggest that memory is not a reproductive system but is a constructive process, which involves piecing together elements of the experience that can be affected by expectations, beliefs and knowledge (Bartlett, 1932; Johnson, Hashtroudi, & Lindsay, 1993). Thus memory can be fallible; prone to distortion and error. A substantial literature demonstrates that individuals with schizophrenia have marked difficulties with remembering events from their personal past (Aleman, Hijman, de Haan, & Kahn, 1999; Danion, Rizzo, & Bruant, 1999; Gold, Randolph, Carpenter, Goldberg, & Weinberger, 1992). It is important to understand these memory deficits, as they are one of the strongest predictors of functional outcome (Green, 1996; Milev, Ho, Arndt & Anderson, 2005).

False memory describes memory for events that did not happen, and

it has received relatively less attention compared to veridical memory. The classic way of examining false memory in the lab has been to use a specialised paradigm called the Deese-Roediger-McDermott (DRM; Deese, 1959; revived by Roediger & McDermott, 1995). Here participants are presented with lists of words (e.g. tired, dream, bed, rest, awake, snooze, blanket etc.) all related to a non-studied critical lure (e.g. sleep). In a subsequent memory test, healthy volunteers frequently recall or recognise the critical lure, which was not presented, usually with high confidence (Roediger & McDermott, 1995; see also Gallo, 2010 for further discussion of the DRM paradigm). A number of studies have used this paradigm in people with schizophrenia, but results have been mixed. Some studies find no evidence for increased false memories in this group (e.g. Elvevåg, Fisher, Weickert, Weinberger, & Goldberg, 2004; Huron & Danion, 2002; Lee, Iao, & Lin, 2007, Exp 1; Moritz, Woodward, Cuttler, Whitman, & Watson, 2004; Paz-Alonso et al., 2013), whereas other studies have (e.g. Bhatt, Laws, & McKenna, 2010; Lee et al., 2007, Exp 2).

An alternative research strategy is to adopt a dimensional approach

to schizophrenia and measure schizotypy (Claridge, 1997; Johns & van Os, 2001). According to this view the symptoms of schizophrenia exist as a continuum of experiences in the general population, albeit perhaps fewer in quantity and/or in an attenuated form. When researchers have examined the link between schizotypy and false memory, as assessed by the DRM paradigm, a range of results have been found. Saunders, Randell, and Reed (2012) found that those participants high in the unusual experiences dimension of schizotypy (which maps on to positive experiences, such as hallucinations and delusions) and cognitive disorganisation had more false memories to the non-studied critical lure. However when Hodgetts, Hausmann, and Weis (2015) focused on the cognitive disorganisation dimension they failed to replicate this result with the critical lure, but did find increased recognition of new related items in participants high in this dimension (but only in those low in estradiol). In contrast, Dagnall and Parker (2009) failed to find any difference in false memories between high and low scorers on interpersonal and disorganised dimensions of schizotypy. They did, however, find that those participants who scored highly on a cognitive-perceptual dimension of schizotypy had *lower* false memory than the higher scorers.

Other researchers have focused on a specific symptom, in particular delusions. A continuum approach can also be adopted to these, just like schizotypy, in that many individuals within the general population may also experience anomalous beliefs and it is argued delusions reflect the extreme end of this scale (Peter, Joseph & Garety, 1999). Support for this suggestion comes from a study that compared deluded inpatients to participants from the general population. As would be anticipated the deluded patients scored significantly higher, but there was around 10% of the general population who scored above the mean of the deluded group on a measure of delusional ideation (PDI; Peters et al., 1999). Two studies have found that healthy volunteers who score highly on the Peters Delusional Inventory (PDI) have increased false memories on the DRM paradigm (Dehon, Bastin, & Larøi, 2008; Laws & Bhatt, 2005; but see also Corlett et al., 2009, who failed to find this relationship). A later study by Bhatt et al. (2010) found that individuals with schizophrenia who were experiencing delusions recalled more false memories than those with schizophrenia who were not delusional. Thus, there seems to be greater consistency in finding increased false memory rate when the more specific symptom of delusions or experience of delusional ideation is examined.

Furthermore, it has been suggested that examining confidence in the memory decision can complement the work completed with memory accuracy. Moritz and Woodward (2006) have suggested that overconfidence may play a role in the development and maintenance of some of the symptoms of schizophrenia, particularly delusions. They argue that false memory, where events are fabricated or distorted, may be important in accounting for some delusional themes that may develop. However they note that even if an individual has a large number of false memories these may not affect behaviour if the confidence in them is low i.e. they are tagged as fallible. The crucial factor is the person's overconfidence in these beliefs. Balzan (2016) gives the example of a person travelling on a bus who sees another passenger looking angrily at them. Even if this appraisal is incorrect it is unlikely to result in a strong cognitive or behavioural outcome. However if the individual assigns a high degree of confidence to this false perception it may elicit a strong conviction in a false belief (e.g. "I am under surveillance and my life is in danger"), which could lead to behavioural consequences and emotional distress. Thus overconfidence in false memories may also play a role in the genesis of delusions.

Not all researchers have examined the confidence of the memory judgement as well as memory accuracy in relation to delusions, but there are a few examples. Corlett et al. (2009) failed to find any relationships between DRM false memories and schizotypy scores or delusional ideation. However when they examined confidence they found that those participants with higher scores on the positive aspect of schizotypy were more confident in their false memories. Laws and Bhatt

(2005) did find a difference in the number of false memories between those with high and low scores on delusional ideation and also reported that those high in this dimension had greater confidence in their false memories. Similarly, Bhatt et al. (2010) also found effects of confidence in their study of patients with and without delusions. Interestingly, they found no difference between the two patient groups and controls on proportion of high confidence responses to false memories, but a higher number of high confidence new responses to old items i.e. misses, in the patients with delusions.

The aim of this study was to assess the relationship between accuracy and confidence of memories and schizotypal experiences in healthy volunteers. As outlined above a few studies have looked at this but a variety of results have been found. In light of this we wanted to determine the specificity of the relationships between false memories and dimensions of schizotypy and the more specific experience of delusional ideation. Only one other study, to our knowledge, has done this (Corlett et al., 2009) and they failed to find any relationships between any schizotypal experiences and false memory and did not report if there was an association between confidence in the false memory and delusional ideation. In this study participants will be given the O-LIFE (Mason, Claridge, & Jackson, 1995), a well-recognised measure of schizotypy, which has four dimensions: Unusual Experiences (positive schizotypal experiences), Cognitive Disorganisation (cognitive difficulties and social anxiety), Introvertive Anhedonia (negative schizotypal experiences) and Impulsive Nonconformity (reckless and antisocial tendencies; many researchers e.g. Pickering, 2004, have questioned the inclusion of this dimension as it does not resemble any feature of schizophrenia so it will not be considered in this study) and the PDI (Peters, Joseph, Day, & Garety, 2004). On the basis of work by Laws and colleagues (Bhatt et al., 2010; Laws & Bhatt, 2005) we anticipated finding a positive correlation between scores on the PDI and proportion of false memories. Furthermore, the same direction of association would be hypothesised between delusional ideation scores and confidence in memory errors. Given that the Unusual Experiences dimension indexes positive schizotypal experiences, including hallucinations and delusions, and there is a high degree of correlation between this dimension and the PDI (r = 0.65; Peters et al., 2004) we anticipated that the relationships stipulated with the PDI would also be found for the Unusual Experiences dimension of the O-LIFE. Given that there has been no consistent evidence of a relationship between disorganised or negative schizotypal experiences no statistically significant relationships were predicted between the Cognitive Disorganised or Introvertive Anhedonia dimensions and false memories.

Finally, it is noteworthy that within this research area there is a heavy reliance on the word DRM paradigm for eliciting false memories; all of the studies mentioned this far use this paradigm. One exception to this is Moritz, Woodward and Rodriguez-Raecke's (2006) study, which employed a visual variant of the paradigm. Here, participants viewed pictures of scenes e.g. a beach, with various prototypical items within them e.g. a sandcastle; at test critical lures were prototypical items not presented e.g. towel. Individuals with schizophrenia did not exhibit more false memories but were more confident in their errors. Critically, it is unknown whether the failure to find differences in the number of false memories is a result of the stimuli and paradigm used or because the group was not split according to whether they experienced delusions or not. Thus the final aim of this study was to use a new pictorial paradigm for examining the relationship between false memory and schizotypal experiences. The task developed was based upon Dennis, Bowman, and Vandekar (2012). In the study phase participants see a number of pictures from several categories e.g. chairs A, B and C. At test they see the same pictures again (chairs A, B and C), as well as additional pictures from the categories presented (related lures, chairs D, E and F) and new items which are not from these categories (unrelated lures, teddy bear). This is important to determine if the results found thus far are generalizable and not paradigm specific.

2. Method

2.1. Participants

Ninety-five undergraduate psychology students (83 females and 12 males) aged between 18 and 22 years old (M = 19.2 years, SD = 0.91 years) were tested. From a previous study which examined the correlation between number of false memories and PDI score a correlation of 0.48 was found (Bhatt et al., 2010). Using this effect size with an alpha level of 0.05 with 0.80 power a minimum sample of 29 participants is required. Participants received course credits for taking part in the study. The data from nine participants were excluded because these individuals had a corrected recognition score (proportion of hits – false alarms to new items) below 0.2. The final sample was of 86 participants (74 females). All participants provided informed consent and the study was approved by the departmental ethics committee.

2.2. Materials/apparatus

2.2.1. Questionnaires

The PDI (Peters et al., 2004) measures delusional ideation in the healthy population. It consists of 21 items that describe a range of unusual thoughts, such as: "Do you ever feel as if people are reading your mind?" Participants are asked to answer yes/no (yes = 1; no = 0). If they answer yes there are three sub-items related to distress, preoccupation and conviction which are each measured on a 5 point Likert scale (1–5, with 5 indicating a high level of distress, preoccupation or conviction). Together these scales capture the multidimensionality of delusions and total grand scores can range from 0 to 336. The PDI has high internal consistency and test-retest reliability, as well as good validity (see Peters et al., 2004 for more details). For this study the scores that we obtained were as follows: yes/no (M = 4.66, 0–18), distress (M = 12.63, 0–48), preoccupation (M = 11.03, 0–41), conviction (M = 13.31, 0–48) and grand total (M = 41.64, 0–140). The correlation between these different subscales is extremely high ranging from 0.94 to 0.98 in this study and so we only use the grand total measure in the Results section.

The Oxford Liverpool Inventory of Feelings and Experiences (O-LIFE; Mason et al., 1995) was used to assess schizotypy more globally to examine the specificity of the relationship with false memory. The dimensions relevant to schizotypy are: Unusual Experiences (perceptual aberrations, hallucinatory and delusional experiences and is akin to the positive symptoms of psychosis); Cognitive Disorganisation (social anxiety as well as difficulties with concentration and decision-making) and Introvertive Anhedonia (the inability to experience pleasure from typically enjoyable activities). The mean schizotypy scores, together with the range, obtained in our sample were as follows: Unusual Experiences (M = 5.99, 0–22), Cognitive Disorganisation (M = 12.31, 1–24) and Introvertive Anhedonia (M = 5.69, 0–16). The degree of correlation between the O-LIFE dimensions and the PDI grand total score in this study were as follows: Unusual Experiences [$\rho(84) = 0.73$, $p < 0.001$], Cognitive Disorganisation [$\rho(84) = 0.31$, $p < 0.01$], and Introvertive Anhedonia [$\rho(84) = 0.13$, $p > 0.05$].

2.2.2. False memory task

A computer-based false memory task was designed based upon the work by Dennis et al. (2012). Stimuli consisted of 600 colour images of everyday items, obtained from Google images and cropped and resized to approximately 225 × 225 pixels. Five-hundred images were of items from specific categories, with 10 examples of each category type. These categories includes items such as: cars, butterflies, skirts, fruit, trees and mirrors. In addition, there were 100 images that were of unrelated objects. During the study phase 250 images (5 from each category) were presented in a randomised order. In the test phase, these images were also presented (old items), together with the other 250 category items (related lures) and the 100 unrelated images (unrelated lures) in a random order. The old items and the related lures were counterbalanced across participants.

2.3. Procedure

The initial study phase was incidental. Participants saw the images in the centre of the screen, one at a time, and were asked to judge whether they thought they would be able to lift the object or not and indicate this with a keypress. Each study phase image was presented for 500 ms and then participants were given 2000 ms to make a response before a blank screen was displayed for 250 ms before the next trial. After the study phase participants were given 20 mins to complete the O-LIFE and the PDI. In the test phase participants saw all images, one at a time, and were required to make a 6 point old/new decision with confidence (1 = sure new, 2 = probably new, 3 = perhaps new, 4 = perhaps old, 5 = probably old, 6 = sure old). Each image was displayed until participants had made a response and then there was a blank screen for 250 ms before the next image. After every 100 trials there was an opportunity for participants to take a short break if they wanted.

3. Results

The proportion of responses that participants gave to each stimulus type is displayed in Table 1. The mean proportion of hits (an old response to an old item) was 0.57 (SD = 0.15), the proportion of false memories to the related lure was 0.34 (SD = 0.15) and false memories to the unrelated lure was 0.07 (SD = 0.09). As can be seen there was a greater proportion of old responses (collapsing confidence) to old items than to related lures [$t(85) = 18.76$, $p < 0.001$] or unrelated lures [$t(85) = 34.74$, $p < 0.001$], indicating participants' general ability to discriminate old from new items. Moreover, participants' overall false memory rate to unrelated lures was significantly less than to related lures [$t(85) = 23.68$, $p < 0.001$].

Spearman's correlations were calculated in the analyses outlined below due to some violations in the assumptions underlying parametric correlations for some variables. Levene's test for equality of variance was used when comparing two independent samples. If this assumption was found to be violated the degrees of freedom were reduced accordingly in that test.

3.1. PDI

Initially it was examined whether there was a relationship between the number of false memories and PDI scores. A positive relationship was found between this measure and false memories to the related lure [$\rho(84) = 0.22$, $p < 0.05$] and also to the unrelated lure [$\rho(84) = 0.25$, $p < 0.05$]. As some studies have used a different analysis approach

Table 1
Mean proportion of responses given to each category of items (and standard deviation in parenthesis).

	Sure new	Probably new	Perhaps new	Perhaps old	Probably old	Sure old
Old	0.14 (0.18)	0.14 (0.09)	0.16 (0.12)	0.17 (0.11)	0.22 (0.13)	0.18 (0.12)
Related lure	0.22 (0.22)	0.22 (0.12)	0.22 (0.16)	0.14 (0.09)	0.13 (0.12)	0.07 (0.09)
Unrelated lure	0.48 (0.28)	0.30 (0.18)	0.14 (0.15)	0.03 (0.04)	0.03 (0.07)	0.01 (0.02)

when assessing the link between PDI scores and false memory e.g. splitting the sample and comparing the groups, a median split was also performed (median = 31; although see McClelland, Lynch, Irwin, Spiller, & Fitzsimons, 2015, for issues with using a splitting approach). A significant difference was found between high and low scorers on the PDI on false memories to the related lure [0.38 versus 0.30; t (67.35) = 2.66, p = 0.01] and unrelated lure [0.10 versus 0.05; t (53.42) = 2.96, p = 0.005], with high scorers having more false memories.

Next it was examined if there was a relationship between PDI scores and confidence. For these analyses we examined the proportion of most confident responses (1 = sure new or 6 = sure old) to each of the item types. Initially confidence in memory errors was examined. There was no significant relationship between misses, where the participant is sure that an old item is new, and PDI score [$\rho(84) = 0.06$, p > 0.10]. In contrast, when looking at false alarm errors (false memory) there was a significant correlation between PDI scores and proportion of sure old responses to: related lure items [$\rho(84) = 0.27$, p < 0.05] and unrelated lures [$\rho(84) = 0.29$, p < 0.01].

We also examined participants' veridical memory. There was no significant correlation between PDI scores and hits i.e. saying old to an old item [$\rho(84) = 0.13$, p > 0.10]. There was no relationships with confidence in new responses to related lures [$\rho(84) = 0.01$, p > 0.10] or unrelated lures [$\rho(84) = -0.01$, p > 0.10]. There was a significant correlation between the proportion of sure old responses participants gave to old items and PDI scores [$\rho(84) = 0.23$, p < 0.05].

3.2. O-LIFE dimensions

A parallel set of analyses, as were conducted with the PDI scores, were also run with the O-LIFE dimensions of Unusual Experiences, Cognitive Disorganisation and Introvertive Anhedonia, these results can be seen in Table 2.

Significant correlations were found between the Unusual Experiences dimension of schizotypy and measures of confidence, which mirrored the pattern found with the PDI. There were significant associations between this dimension and proportion of sure old responses to: related lure items [$\rho(84) = 0.26$, p < 0.05], unrelated lures [$\rho(84) = 0.25$, p < 0.05] and old items [$\rho(84) = 0.26$, p < 0.05]. No significant correlations were found between Unusual Experiences and sure new responses to any item type (largest correlation = 0.15, smallest p value = 0.18). Finally, there were no significant correlations between the Cognitive Disorganisation or Introvertive Anhedonia dimensions of schizotypy and any confidence measures (largest correlation = 0.1, smallest p value = 0.35).

4. Discussion

The aim of the present study was to determine the specificity of the relationship between certain schizotypal experiences and false memories. Corroborating previous research (Bhatt et al., 2010; Dehon et al., 2008; Laws & Bhatt, 2005) a positive correlation was found between delusional ideation and false memory, such that those individuals high in delusional ideation had more false memories to both related and unrelated lures. In addition, there was a positive association between

Table 2
Spearman correlations between memory and schizotypy dimensions.

	False Memories to Related Lure	False Memories to Unrelated Lure	Hits
Unusual Experiences	.18[a]	.23*	.14
Cognitive Disorganisation	.03	.07	.05
Introvertive Anhedonia	.17	.16	.01

[a] = p < 0.1, * = p < 0.05.

delusional ideation scores and proportion of the most confident old rating to all three classes of item: old, related lures and unrelated lures. There were no significant relationships between PDI scores and the most confident new rating to any of the item types. Taken together the confidence results indicate that as delusional ideation scores increase so does the bias for giving highly confident old responses, but importantly this is regardless of the status of the item. These patterns of results were mirrored with the Unusual Experiences dimension of schizotypy, but there were no significant relationships between any of the variables highlighted above and Cognitive Disorganisation or Introvertive Anhedonia. Interestingly, there were no significant relationship between correct recognition of old items and any schizotypy dimension or experience. Thus the relationships between positive schizotypal experiences and PDI scores only extends to false memory and not veridical memory.

A secondary aim of this study was to determine if relationships between schizotypal experiences and false memory would be found if a new pictorial paradigm was used based upon Dennis et al. (2012). This differed somewhat from the traditional DRM paradigm because no critical item was omitted at study, instead participants had to differentiate between pictures from a category that they had seen in an incidental study phase and those they had not. The reason for examining this is because Moritz, Woodward, and Rodriguez-Raecke (2006) failed to find differences in number of false memories between schizophrenia patients and controls when using pictorial stimuli in a DRM paradigm. Also the wider memory literature would suggest that it is easier to discriminate old from new pictures compared to words (the picture superiority effect; Shepard, 1967), so less false alarms might be anticipated to pictures compared to words, and there have been some reports that the DRM effect is reduced if study items are presented visually rather than auditorily (e.g. Smith & Hunt, 1998, although see Smith, Hunt, & Gallagher, 2008 for how test format and order can affect this). The current study was successful in eliciting false memories, with around a third of responses to the related lure being that the items were old. In addition, the hypothesised relationships between false memory and the positive/delusional dimension of schizotypy were found. Thus the visual paradigm used by Moritz et al. (2006) does not appear to be the reason for their failure to find increased false memories in patients, instead it is likely to be related to the symptomatology of the patients.

Our work suggests that the critical dimension of schizotypy when examining false memory is the positive one and the experience of delusional ideation. This offers a useful way of thinking about and reconciling previous work in this area. Much of this work has tested individuals with schizophrenia and has not looked at symptom groups i.e. positive and negative or specific symptoms. For example, in Lee et al. (2007), Experiment 1, there was a failure to find more false memories to related words from the DRM paradigm between patients and controls. They also state "Patients in the present experiment were stable chronic patients; their positive symptoms were not as obvious as those presented in the acute stage but they exhibited chronic negative symptoms" (pg. 562). Thus in this particular study the patients tested did not have many positive/delusional symptoms and it seems possible that this might have led to the failure to find differences in false memory. In other studies it is difficult to determine if the characteristics of the patients may have had an effect as they are not described in sufficient detail to retrospectively assess this. For example, in the Moritz et al. (2006) paper outlined above, the patients were not split into delusional versus non-delusional groups. However the researchers did conduct an analysis to examine if there was any relationship between false memory variables and specific symptoms e.g. delusions, suspiciousness and hallucinations. No significant relationships were found but it is difficult to determine if this was due to low levels of these types of symptoms in this particular sample. An interesting question which arises from this discussion is about the nature of the relationship between delusions and false memory. If it is delusions in particular which are related to increased levels of false memory then it would be

anticipated that this link would be observed not just in the context of schizophrenia but also other disorders where delusions can be a symptom, such as: some forms of dementia, somatic illnesses and brain tumours/injury. This is a question which remains to be addressed.

Now that the link between positive/delusional symptoms and false memory has been established the next step in subsequent work is to understand the processes that lead to false memory and how these might be abnormal in these individuals. This was not addressed experimentally in this study but some possibilities are highlighted. A number of different theories have been proposed as to the processes that result in false memory e.g. activation-monitoring theory (Roediger & McDermott, 2000; Roediger, Watson, McDermott, & Gallo, 2001), fuzzy-trace theory (Brainerd, Reyna, & Kneer, 1995) and global matching models (Hintzman, 1988; Shiffrin & Steyvers, 1997). According to the activation-monitoring account (Gallo, 2010; Roediger & McDermott, 2000) the production of false memories is due to a combination of spreading activation and processes that determine the origin of information. When participants encounter an item during encoding this activation spreads to related representations and so the presented item, the related items and the encoding context become integrated in the memory trace. In the subsequent test phase false memories are produced because participants are unable to distinguish between items actually presented to them and those that have become activated via indirect association. Thus the spread in activation and/or the failure to attribute the memory to the correct source leads to increased false memories.

There is a large body of work which has examined spreading activation in schizophrenia using semantic priming tasks. The classic finding is that participants are quicker to respond when the prime and probe are related (e.g. cat-dog) compared to control conditions (e.g. car-dog). This priming effect is enhanced in individuals with schizophrenia, which suggests that they have an even quicker spread of activation compared to healthy volunteers. Moreover, when indirect priming is examined (e.g. using a prime, day, which is related to the probe, black, via a non-presented word, night) the priming effects are even greater which suggests that patients might have more widespread activation than controls (e.g. Spitzer, 1997; Moritz, Woodward, Kuppers, Lausen, & Schickel, 2003 and parallel findings in psychosis-prone individuals: Johnston, Rossell, & Gleeson, 2008). These results are generally found in patients with positive formal thought disorder e.g. loosening of associations and tangentially of speech. These reflect issues with the form of thinking; whereas delusions, which is the symptoms usually found in relation to elevated false memories, reflect a disorder in the content of thought. It is useful to note that in the current study a positive relationship was found between positive/delusional experiences and false memories to the unrelated lures. The spreading activation account can be used to explain false memory to the related lure but it is difficult to see how it would explain this relationship given the pictures are unrelated. This would suggest that another process must to operating as well as or instead of spreading activation. Thus in future research it would be informative to determine the link between spreading activation and false memories and to tease apart the pathways and relationships they have with delusions and thought disorder.

There is also a sizeable research field that has examined source monitoring in schizophrenia and found that they have substantial memory problems in determining the origin of information (e.g. Libby, Yonelinas, Ranganath, & Ragland, 2013). Moreover, researchers have also examined the type of decision which is important in a false memory paradigm: between whether an item has been presented or internally generated, known as reality monitoring (Johnson et al., 1993). This type of memory judgement is proposed to play a role in the pathogenesis of some of the positive symptoms of schizophrenia, such as hallucinations and delusions (Bentall, Baker, & Havers, 1991; Frith, 1992). A number of studies have found this deficit in people with schizophrenia (e.g. Brébion, Amador, Smith, Malaspina, Sharif, & Gorman, 2000; Brébion, Gorman, Amador, Malaspina, & Sharif, 2002;

Keefe, Arnold, Bayen, McEvoy, & Wilson, 2002; Vinogradov et al., 1997) and those scoring highly on schizotypy measures (e.g. Humpston, Linden, & Evans, 2017) and also that it tends to be associated with the positive symptoms of psychosis. Dehon et al. (2008) used a modified DRM task which involved an additional phase where participants were asked whether at study or test another word came to mind but they did not write it down because the experimenter had not produced it. This allowed them to get an index of activation and monitoring. Participants high in delusional ideation demonstrated more unsuccessful monitoring, but there was no relationship with activation. Thus further studies of this sort are required which can tease apart the processes contributing to false memory judgements and examine the relationships with positive symptoms and experiences.

In the current study participants high in positive experiences/delusional ideation showed a bias for giving highly confident responses across all item types. This only partially replicates previous research in this area. What has generally been found is that people with schizophrenia exhibit more confidence in their memory errors and also simultaneously can have less confidence in their correct responses (see review by Balzan, 2016). However although this result has been replicated on a number of occasions and has been demonstrated within the schizophrenia spectrum there are some caveats. Moritz et al. (2015) found that these confidence effects may only be found when participants feel competent with a given task or subjectively find the task easy. The false memory and confidence results from the current study correspond and suggest that individuals high in delusional ideation have a liberal response bias i.e. a general proclivity to respond old, which suggests that they require less evidence before they are willing to call an item old. This might reflect an impairment that extends beyond the memory domain as it converges with the jumping to conclusions literature. This is usually examined using a probabilistic reasoning task, such as the "beads task", and it is typically found that individuals with schizophrenia reach a decision on the basis of less evidence compared to healthy controls (Garety & Freeman, 2013). Interestingly, the jumping to conclusions bias has also been linked to delusions (Gawęda, Staszkiewick, & Balzan, 2017). There are now computational models which are attempting to unify deficits across multiple domains and how they might help to understand positive symptoms using a Bayesian framework (e.g. Fletcher & Frith, 2009) which offers much promise for the future.

Conflict of interest

Funding

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbtep.2018.09.005.

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