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The positive dimension of schizotypy is associated with self-report measures of autobiographical memory and future thinking but not experimenter-scored indices.

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Abstract

The ability to remember our past and to imagine the future are critical to our sense of self. Previous research has indicated that they are disrupted in schizophrenia. However, it is unclear i) whether this is found when examining experimenter-scored indices of content and/or participants' self-report of phenomenological characteristics, and ii) how these abilities might be related to symptoms. This study sought to address these questions by taking a dimensional approach and measuring positive and negative schizotypal experiences in healthy people (n = 90). Participants were given cue words. For some they remembered an event from the past and for others they generated an event in the future. No significant relationships were found with any aspect of schizotypy when participants' descriptions were scored by the experimenter according to a standardised episodic content measure. In contrast, several significant positive correlations were observed for past memory and future thinking when examining the positive dimension of schizotypy and participants' ratings, particularly to sensory characteristics of the experience and mental pre- or re-living. These results indicate enhanced subjective experiences of autobiographical memory and future thinking in those who report delusional and hallucinatory-like occurrences, which might be linked to mental imagery or metacognitive alterations.

Keywords: autobiographical memory, future thinking, schizotypy, positive symptoms, Autobiographical Interview, phenomenology.

Introduction

In our mind's eye we can project ourselves back to an episode in our personal past. We may remember the details of the event, such as the time and location it took place, and perhaps our thoughts and feelings at the time. This is known as autobiographical memory. Likewise, we can also project ourselves in the other direction, forwards, and construct a detailed representation of a specific episode in our personal future, known as episodic future thinking or imagining. According to the episodic simulation hypothesis (Schacter & Addis, 2007) remembering the past and imagining future events share several processes because creating future events requires the retrieval of autobiographical memories, elements of which are flexibly recombined to create a novel scenario. An important function of autobiographical memory is to develop and maintain our sense of self (Conway, 2005; McAdams, 2001; Prebble et al., 2013). We weave together the memories of specific events which have happened in our lives with knowledge of our personal characteristics to create an integrated and coherent life narrative. The sense of self also includes our aspirations for the future (Conway et al., 2019). This can be developed by imagining events that we anticipate happening in the future which would be meaningful and significant to our life story. Thus, memory for the past and future imaginings are inextricably linked to our sense of self.

Schizophrenia is a severe psychiatric disorder which affects around 1% of the population. A core feature of it is disturbances in the sense of self (Bleuler, 1950; Sass & Parnas, 2003). It is characterised by positive symptoms, such as hallucinations and delusions; negative symptoms, such as a lack of ability to experience pleasure and decreased initiation of goal-directed behaviour; and disorganised symptoms, which can be seen in speech, language and behaviour (Andreasen, 1994). Researchers have become increasingly interested in examining autobiographical memory and episodic future thinking within the schizophrenia spectrum because of the clear role of the self in both processes.

Most of the research in this area has examined the specificity of autobiographical memory in schizophrenia. One popular method to examine this involves giving participants a word cue or a time period, such as last year, and asking them to recall an event that happened at a specific time and place (e.g. Autobiographical Memory Test, Williams & Broadbent, 1986). Responses are then scored by the experimenter according to how specific they are i.e. the extent to which they are of a single event located at a particular time and place and lasting less than 24 hours. A wealth of research has demonstrated that individuals with a diagnosis of schizophrenia tend to have over general memories, whereby they recall extended or repeated events (Cuervo-Lombard et al., 2012; Danion

et al., 2005; Kaney et al., 1999; McLeod et al., 2006; Ricarte et al., 2014; for meta-analyses see Berna et al., 2016; Zhang et al., 2019). The same technique can also be used to examine episodic future thinking by asking the participant to imagine an event that could happen to them in the future, again at a specific time and place. The research findings mirror those on autobiographical memory: people with schizophrenia have over general future thinking (Chen et al., 2016; D'Argembeau et al., 2008; de Oliveira et al., 2009). Thus, there is robust evidence for over general memory and future thinking in schizophrenia.

A lesser studied feature is the content of the memory, that is, how detailed the narrative is. The experimenter can score various contextual details of the event, and this has been completed in numerous ways. McLeod et al. (2006) used the Autobiographical Memory Interview (Kopelman et al., 1990) to elicit memories over different time bands and scored these for the richness of the recollection. For all time periods, those with schizophrenia had less detailed memories than the controls. Similarly, Dassing et al. (2020) and Potheegadoo et al. (2014) coded the number of episodic details e.g. sensory, temporal, emotional and contextual (based on Levine et al., 2002), and found that those with schizophrenia described their autobiographical memories with significantly fewer details and these were more impoverished compared to a comparison group.

Other researchers have focused on experimenter-scored detail in future thinking. Raffard et al. (2010) used a procedure based upon Hassabis et al. (2007) where participants' narrations were scored according to four content categories: spatial references; distinct entities (e.g. objects, people and animals); sensory descriptions and thought/emotion/action. They found that people with a diagnosis of schizophrenia produced less spatial references and sensory descriptions than the control participants and this deficit seemed to be related to negative symptoms. Yang et al. (2018) also looked at future thinking only but used a different scoring scheme. This was loosely based upon Levine et al. (2002), where time/place, sensory aspects and thought/emotion details were scored on a 3-point scale. There was a significant decrement for thought/emotion details in the schizophrenia group. From the preceding studies, which have used experimenter ratings of the richness of the autobiographical memory or future thinking, there seems some evidence for an impairment. However, many of these studies have looked at one temporal direction and not the other, there are differences in the type of details the studies have examined and the ways in which they have been quantified.

Autobiographical memory and future thinking can also be assessed by the participant i.e. their subjective view on their experiences. There are various measures that can be used to examine this. A key aspect is the participant's ability to mentally time travel, either reliving the original event or pre-experiencing a hypothetical scenario in the future. Participants can also be asked about the vividness of their experiences, that is the clarity and salience of it. The phenomenological experience can also encompass the details of the event, such as sensory characteristics. Several meta-analyses and studies have found that individuals with schizophrenia, by their own report, were poorer at remembering the details of the event, had less vivid and more fragmented recollection and less sense of reliving the event compared to controls (Alle et al., 2020; Berna et al., 2016; Ricarte et al., 2017). Studies which have looked at future events also report a similar pattern of results. Individuals with schizophrenia have a reduced sense of presence or pre-experiencing (Raffard et al., 2010; Yang et al., 2018) and have a less vivid experience (Yang et al., 2018). Although interestingly Raffard et al. (2010) found within the schizophrenia group that those individuals with higher positive symptoms had an enhanced sense of presence in future events. Thus, there is consistent evidence that individuals with schizophrenia subjectively report that their phenomenological experiences of past memory and future imaginings are altered compared to healthy volunteers.

Some researchers have taken a dimensional approach to schizophrenia, believing that the psychosis phenotype is distributed along a continuum, whereby some of the same or similar symptoms that are seen in individuals with psychotic disorders can also be found in non-clinical populations (e.g. Claridge, 1997; Johns & Van Os, 2001; Raine, 2006; van Os, 2003). For example, hallucinatory experiences and delusional ideation can be experienced by a sizeable minority of the general population (McGrath et al., 2015; van Os et al., 2009). The assumption underlying this approach is that having these experiences is not inevitably associated with the presence of a clinical condition (Linscott & van Os, 2013). That is thought to be associated with a variety of factors, such as the characteristics of the experiences, including their frequency and intrusiveness; as well as personal factors, such as the individual's coping mechanisms and environmental risk factors (Johns & van Os, 2001; van Os et al., 2009). These subclinical psychotic experiences and traits, which do not reach diagnostic threshold, and are distributed through the general population are known by a variety of names, such as schizotypy or psychosis-proneness (see Grant et al., 2018 for a detailed consideration of the various models of schizotypy). Examining these experiences can provide a complementary way of looking at schizophrenia or psychotic experiences, which can be done without some of the confounds present when testing individuals with a clinical condition, such as medication and chronicity effects.

There are a few studies which have taken this approach by measuring psychotic-like experiences in the general population rather than clinical groups. Yang et al. (2018) found that college students who scored highly on social anhedonia generated impoverished thought/emotion details in future thinking using an experimenter-scored measure. In contrast, Winfield and Kamboj (2010) found using participant self-report measures, that healthy participants who scored higher on the positive dimension of schizotypy (e.g. experiencing hallucinatory or delusion-like experiences), reported greater olfactory/gustatory details (but not vision or audition) and sense of subjective time travel in both their autobiographical memories and their future imaginings than those individuals who scored lower on this scale. A recent study by Alle et al. (2023) looking at autobiographical memory using a variety of self-report measures in the general population found that hallucinatory-like experiences were associated with enhanced: olfactory details, intensity of emotion, personal importance of the event and the accessibility of it. There was very little evidence for relationships with negative psychosis-like experiences. These studies indicate different patterns of associations between schizotypy and autobiographical/future thinking, which might be due to whether they focus on the past or the future, the specific dimension of schizotypy (negative versus positive) and/or the use of an experimenter-scored or self-report measures.

The aim of this study was to systematically examine autobiographical memory and future thinking using both an objective measure of content as well as self-report measures to determine if there are relationships with schizotypy. This is the first study which will examine both objective and subjective measures of the same events in the same participants, meaning if any differences are found between these measures in their relationship to schizotypy this cannot be due to these other factors. Moreover, the same participants will also complete the past and future conditions. Given the ambiguity in the literature, both the positive and negative dimensions of schizotypy will be examined. Moreover, standardised measures will be used to examine these experiences. Participants will be given a cue word and asked to recollect an event from the past involving that word or to imagine an event in the future. These narrations will be scored by the experimenter according to the established criteria set out in the Autobiographical Interview (AI; Levine et al., 2002), which has been used extensively in healthy volunteers as well as a variety of patient groups (see <https://levinelab.weebly.com/ai-testing.html>). Of relevance for this study is the internal or episodic details which reflect qualities of the recollective experience. This comprises different subcategories, including event, perceptual, time, place and emotions/thought details, which allows for a more fine-grained assessment of which aspects of the content might be related to schizotypy.

No previous studies have examined these internal subcategories in relation to schizotypy. As previous studies which have found deficits in richness have been conducted on individuals with chronic schizophrenia, where there is a preponderance of negative symptoms, and based on the study by Yang et al. (2018), we hypothesised that there would be a negative relationship between the negative dimension of schizotypy and internal details for autobiographical memory and future thinking. It is unclear whether this will be found for all the internal subcategories or only some of them. We also examined the positive dimension of schizotypy in relation to internal details to determine if associations would be specific to the negative dimension.

This study will also examine participants' self-report of their memory and episodic future thinking. This will be done in two separate ways. First, in line with and building upon previous studies, we will administer to participants a comprehensive questionnaire (Assessment of the Phenomenology of Autobiographical Memory; Vannucci et al., 2020) on their subjective experiences after each narration. This measure includes most of the variables which have been examined previously (e.g. vividness, sense of reliving/pre-experiencing, coherence and personal relevance), but also other aspects which have not been investigated (e.g. detail in all sensory modalities and perspective). Therefore, this study aims to replicate and extend what has been found previously (e.g. Alle et al., 2023). Based upon the studies by Raffard et al. (2010), Winfield et al. (2010) and Alle et al. (2023) we anticipated positive relationships between the self-report measures of autobiographical memory and future thinking and the positive dimension of schizotypy. The negative dimension of schizotypy will also be examined to determine the specificity of the relationship.

The second way in which we will examine participants' subjective experience is by administering a trait-based measure, which asks about general experiences rather than after a specific event. There are several studies which have found that participant's phenomenological ratings are generally consistent across different cues (Rubin et al., 2003; 2004; 2021), which suggests that recollective quality might be a stable individual difference. If this is the case it would suggest that any relationships found between schizotypy and self-reported specific memories should also be found at the general dispositional level. There is only one previous study which has examined this. Alle et al. (2023) used the Autobiographical Recollection Test (Berntsen et al., 2019) which measures seven aspects of recollecting autobiographical memories: reliving, vividness, visual imagery, scene, coherence, life-story relevance and rehearsal. They found that the total score on this measure was associated with positive psychotic experiences and in particular hallucinatory-like experiences in the general population. In this study we will also administer a trait-based questionnaire. The Survey of

Autobiographical Memory (Palombo et al., 2013) measures different types of memory, including episodic, semantic, spatial and future thinking. Our aim was to determine if we could replicate the relationship found by Alle et al. (2023) with memory but also to see if it could be extended to the future thinking trait dimension. We hypothesised that there would be a positive correlation between the positive dimension of schizotypy and the episodic and future dimensions.

Method

Participants

A sample of 90 healthy undergraduate students (82 female; aged 18-41; mean age= 19.6) took part in the study. All participants were required to be fluent in English and confident in their ability to type written English. Written consent was obtained from all participants prior to testing. Participants received course credit for their time. This research was reviewed and approved by Cardiff University School of Psychology Ethics Committee. To determine the sample size, an a priori power calculation was completed for a correlation based upon two-tailed testing, a medium effect size (0.3), alpha of 0.05 and power of 0.8 which gave 84 participants.

Materials

Cue Word Paradigm

Participants completed an adapted version of the Galton-Crovitz cue word paradigm (Crovitz & Schiffman, 1974). Participants were presented with eight cue words (memorable meal, party, achievement, animals/pets, exam, day trip, shopping, birthday) one at a time, with 2 minutes to type their response. For half of the cue words participants remembered an event from the past and for the other half they generated an event in the future. Participants completed all cue words from one temporal direction before moving on to the other direction. The assignment of cues to each temporal direction was counterbalanced and so was the order in which participants encountered the past or future conditions.

Autobiographical Interview Scoring

Participants' written responses were scored according to the standardised procedure (see Levine et al., 2002 for more details). Responses were segmented into distinct sections to score for internal and external details. Internal details are those that are specific in time and place and relate directly to the main event described by the participant. These are the details which are of relevance to this

study. They were split into five subcategories: event, time, place, perceptual and emotion/thought details. Event details describe the activities, actions, people present and reactions of others. Time details encompass days, times, years or season information. Place is any information related to location, such as: towns, streets, countries, rooms or buildings. Perceptual details include those from any sensory modality i.e. olfaction, vision, taste, sound and touch. Finally, emotion/thought details relate to the mental state of the individual at the time of the event, such as thoughts, opinions, feelings and expectations. As has been completed in previous studies (Hodgetts et al., 2017; Irish et al., 2011) the dimensions of time and place were concatenated to create a spatiotemporal category. The score for each participant for each category was derived by summing across all four cues for each temporal direction. Scoring was completed by two raters (one blind to schizotypy scores) who double-scored all responses. Intra-class correlation analyses (two-way random model conducted in SPSS statistics 26) were conducted to evaluate the inter-rater consistency. All the categories displayed high levels of agreement (all $ps < .01$): internal: $r = .98$, event $r = .96$, time $r = .93$, place $r = .98$, perceptual $r = .98$, emotion/thought $r = .99$.

Assessment of the Phenomenology of Autobiographical Memory (APAM)

The APAM (Vannucci et al., 2020) is a newly developed comprehensive measure of the phenomenological characteristics of autobiographical memories which has 27 items most of which participants rate on a seven-point Likert scale. This measure has been shown to have excellent reliability (Vannucci et al., 2020). As this measure was used in the current study to measure participants' self-report of narrative characteristics for future thinking as well as autobiographical memory, we examined only those items which participants can answer for both temporal directions. We also examined the age of the event, giving participants several categories to use. All self-report questions are outlined in Table 1. As is recommended by the authors of this measure (Vannucci et al., 2020) means were calculated for each participant whereby the ratings for each characteristic were averaged across all four cues for each temporal direction.

Table 1 around here

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE)

The O-LIFE (Mason et al., 1995) was used to measure schizotypy. This scale was derived from factor analysis of fifteen existing psychosis-proneness scales in over 1000 participants (Claridge et al.,

1996). Although this scale has four orthogonal subdimensions: Unusual Experiences, Introvertive Anhedonia, Cognitive Disorganisation and Impulsive Non-conformity only the first two were examined for this study. These subdimensions were selected to provide continuity with the previous literature which has examined positive and negative symptoms and experiences of psychosis. The Unusual Experiences dimension (30 items) measures deviant perceptual experiences as well as magical thinking and is thought to be consistent with the positive symptoms of psychosis (e.g. Do you ever feel that your thoughts don't belong to you?; When in the dark do you often see shapes and forms even though there is nothing there?). The Introvertive Anhedonia scale (27 items) taps a loss of pleasure in activities that are usually enjoyed and avoidance of intimacy. This subdimension is consistent with the negative symptoms of psychosis (e.g. Are there very few things you have ever really enjoyed doing?; Have you often felt uncomfortable when your friends touch you?). Scores are calculated by totalling the number of items endorsed for each scale and includes reverse scored items. This questionnaire has high internal consistency and acceptable levels of skewness and kurtosis (Mason et al., 1995) as well as good test-retest reliability (Burch et al., 1998). Moreover, those with schizophrenia (Nettle, 2006) and at ultra-high risk for psychosis (Morrison et al., 2006) have higher scores on the Unusual Experiences and Introvertive Anhedonia scales compared to non-patients. For this study the mean Unusual Experiences score was 11.6, with a range of 0-27, and the mean score for Introvertive Anhedonia was 6.57 with a range of 0-17. The Unusual Experiences and Introvertive Anhedonia subscales were not significantly correlated ($\tau_b = 0.14$, $p = 0.07$).

The Survey of Autobiographical Memory (SAM)

The SAM is a self-report questionnaire where the participant is asked to rate their general memory ability rather than specific instances (Palombo et al., 2013). There are 26 items which are rated on a five-point Likert scale from strongly disagree to strongly agree. The SAM is divided into four subcategories, referring to a participant's self-reported ability for episodic (8 items), semantic (6 items), spatial (6 items) and future events (6 items). Of relevance to this study is the episodic scale which concerns memory for events occurring within a day, although participants need to rate their general ability to remember specific events rather than thinking of one event. The other scale used for this study was the future thinking scale. This asks participants to rate their general ability to imagine future events that are specific in time and place involving the participant. The scores for these scales were calculated using the original weighting protocol (provided by the authors). The scales used in this study have been found to have high internal consistency and they relate to self-reported vividness but there is only limited evidence for associations with autobiographical memory as assessed by the Autobiographical Interview (Setton et al., 2021). Although Sheldon et al. (2016)

found that individuals with highly superior autobiographical memory had higher scores on the episodic dimension. For this study the mean SAM episodic score was 98.5 (range = 76.5 - 137) and for SAM future 94.2 (range = 78-126).

Procedure

All participants were tested individually in an online Zoom session. After they had received information about the session and provided consent, they completed the questionnaires (SAM and O-LIFE) using Qualtrics. Following this the participants took part in the cue-word paradigm. The experimenter explained that participants would be presented with a series of cue words and that they were to use each word to either remember an event from the past or imagine an event in the future. It was clarified whether the past or future condition would take place first and that they would be notified before commencing the next temporal condition. Participants were asked to describe each event in as much detail as possible, refer to a specific place and time, and to choose an event lasting no longer than 24 hours. Before commencing the future condition, participants were instructed to imagine events that were both plausible and had not happened before. The experimenter presented each cue word on a card, which was presented to the camera, as well as stating it verbally as part of the standardised instructions. For each response participants needed to type their response and there was a two-minute time limit for each cue. If a participant stopped typing before the time limit, they were asked: "Are there any other specific details you can think of?". After the participant had completed their event description, they completed the questions outlined in Table 1 regarding the phenomenological characteristics of the event. Participants answered these questions after each event, with eight of them in total. Participants were fully debriefed at the end of the study. The experimenter and the participant were on the Zoom call for the entire study session (cameras could be turned off while completing the questionnaires at the start).

Results

Analyses were conducted using Jamovi (2023). The variables were initially checked to determine if they met the assumptions for conducting parametric correlations. As some of the variables violated normality, Kendall's Tau correlation coefficients are reported below. All correlations have been conducted two-tailed. As a high number of correlations were conducted with the APAM, which can increase the familywise error, we implemented a correction to help avoid false positives. The Benjamini-Hochberg (1995) correction was used with a false discovery rate of 0.05. We

supplemented the frequentist statistics by also including Bayes factor to indicate the strength of evidence in support of the alternative or null hypothesis, these are particularly important when interpreting null results (Dienes, 2014). The interpretation of Bayes factors is presented in Table 2.

Table 2 around here

Experimenter-scored autobiographical memory and future thinking measures

The associations between the positive (Unusual Experiences) and negative (Introvertive Anhedonia) dimensions of schizotypy were examined in relation to the categories derived from the Autobiographical Interview scoring. Internal describes the total episodic details and is comprised of the following categories: event, perceptual, spatiotemporal and emotion/thought. As can be seen from Table 3 there are no significant associations ($p < 0.05$) between either of the schizotypy dimensions and any of the experimenter-scored measures for past memory or future thinking. The Bayes Factors also indicate anecdotal or substantial evidence for the null hypothesis that there is no relationship between these variables.

Table 3 around here

Event-based self-report measures of autobiographical memory and future thinking

Relationships were also examined between the self-report questions derived from the APAM (Vannucci et al., 2020) and the schizotypy dimensions. As can be seen from the results in Table 4 there were significant positive relationships between the Unusual Experiences dimension and the sensory characteristics of past experience as well as the sense of reliving it generally and auditorily. These significant relationships were also found in the future thinking condition but there were several additionally significant correlations. Those high in the Unusual Experiences dimension seemed to have experiences when imagining their personal future which were more vivid, accessible, emotionally intense, self-distancing, personally relevant and experienced more as an observer. The Bayes Factors ranged from strong to decisive evidence for these relationships. There were no significant correlations between Introvertive Anhedonia and any of the self-report measures for autobiographical memory or future thinking.

Table 4 around here

Trait-based self-report measures of memory

Significant positive correlations were found between the Unusual Experiences dimension of schizotypy and the Episodic ($\tau_b = 0.17$, $p = 0.02$, $BF_{10} = 2.15$) and Future ($\tau_b = 0.27$, $p < 0.001$, $BF_{10} = 140.66$) subscales of the SAM, see Figure 1. There were no significant associations with the other sub-categories of the SAM (Spatial or Semantic, both $ps > 0.1$). Moreover, the Introverted Anhedonia scale was not associated with any of the dimensions ($ps > 0.1$)

Figure 1 around here

Discussion

For the first time we examined autobiographical memory and future thinking using experimenter-scored indices as well as self-report measures in relation to schizotypy. Contrary to our hypothesis, there were no significant relationships between the negative dimension of schizotypy (Introverted Anhedonia) and the experimenter-scored measures indexing the amount of episodic detail in the narrative. This was true for the overall internal category and all the subcategories: event, perceptual, spatiotemporal and emotion/thought, for past and future events. The Bayes Factors for these correlation coefficients were all in support of the null hypothesis, with most of them providing substantial support. In contrast, there was support for the hypothesis that there would be a positive association between the positive dimension of schizotypy (Unusual Experiences) and self-report measures of autobiographical memory and future thinking. A wide variety of subjective experiences were measured and while not all of them were significant, those higher in Unusual Experiences tended to rate the sensory details of the event more clearly and have a greater sense of mental time travel than those lower in this dimension. There were several additional subjective elements that were significant in the future thinking condition related to the personal importance of the event, emotional intensity, perspective and accessibility. The Bayes Factors for these significant relationships provided strong or very strong evidence (for touch, decisive evidence) for the existence of relationships between the Unusual Experiences dimension and self-report measures. Finally, we also examined a trait-based measure of participants' general memory experiences (The Survey of Autobiographical Memory, SAM, Palombo et al., 2013), to complement the event-based measures that we had used. We found support for our hypothesis that there would be a positive correlation between this measure, and the Episodic and Future dimensions, and Unusual Experiences. According to the Bayes Factors the evidence was decisive for the future dimension. Thus, there seemed to be agreement between the event- and trait- based measures in finding that those participants high in

the positive dimension of schizotypy self-report having enhanced memory and future thinking experiences.

The lack of relationship between schizotypy and the level of detail of participants' narratives, when they are scored using an established index (AI; Levine et al., 2003) by the experimenter, was surprising. Schizotypy is a construct with phenomenological similarity to schizophrenia and many studies have found parallel patterns of performance on a variety of cognitive tasks known to be impaired in schizophrenia (for reviews see Nelson et al., 2013 and Uttinger et al., 2015). Moreover, deficits have been found on episodic memory tasks (Sahakyan & Kwapil, 2016; 2018) and the study by Yang et al. (2018) demonstrated deficits in a future thinking task with the emotion/thought category. Thus, the absence of relationships does not appear to be due to schizotypy lacking validity as a dimensional correlate of schizophrenia generally. In these previous studies (Sahakyan & Kwapil, 2016; 2018; Yang et al., 2018) the scales that they used to examine the negative dimension of schizotypy focused on physical and social anhedonia, the same aspect as the current study. However, this experience is only one facet of negative symptomatology. This also includes blunted affect, alogia (reduction in the quantity of words spoken) and avolition (decreased goal-directed activity due to lack of motivation). Thus, it is possible that relationships might exist between these other types of negative experiences and a reduction in the detail of objectively scored autobiographical memory and future thinking. This would not have been found in the current study due to a focus on introverted anhedonia rather than a broader assessment of negative experiences. This is a potential area for future research. Furthermore, in the Yang et al. (2018) study they screened nearly 3000 participants and selected just over 1% of them to form the high schizotypy group. It is possible that deficits in experimenter-scored indices of autobiographical/future thinking may be very subtle and only observed at the extreme end of the schizotypy continuum.

Alternatively, it is possible that factors related to the administration and scoring of the AI might have contributed to the null result. The AI was designed to prompt as comprehensive as possible event descriptions from participants and the scoring includes a 'benefit of the doubt rule' whereby any detail that could reasonably be considered episodic should be scored as internal (Levine et al., 2002). While this rule was originally included to avoid false positives when classifying memory impairments, the liberal scoring system may have obscured the modest deficit which would be expected in healthy participants high in schizotypy. Moreover, our study used word cues as prompts for participants' narratives, which is in contrast to the original AI administration where participants are asked to recover memories from certain time windows e.g. childhood, early adulthood etc. These two

methods differ in their retrieval requirements. The cue word method is more of an associative bottom-up search process (Crovitz & Schiffman, 1974), whereas time windows are likely to require more of a strategic top-down search. Research indicates that giving people with schizophrenia more specific cues enhances the number and richness of detail of autobiographical memory (Potheegadoo et al., 2014). Furthermore, it is also likely that memories or future imaginings completed with the time window method will be of events that are more important, rehearsed and/or have greater significance to a person's identity (Glück & Bluck, 2007). Events elicited by the word cue method are also more likely to be from a more recent time period i.e. what comes to mind first (Janssen et al., 2005). Thus, there are characteristics of the word-cue paradigm which might make it less likely that relationships would be found with schizotypy; including it requiring less strategic search, generally eliciting less significant events and those which come to mind more readily. It would be a useful avenue for future research to examine comprehensively within schizophrenia and the spectrum how these different methods might affect the memories and future imaginings that participants generate.

In contrast, there were significant relationships between the Unusual Experiences dimension of schizotypy and several of the participant-rated indices of memory and future imaginings. For both the past and the future, participants high in the positive dimension of schizotypy rated the sensory experience, across several modalities as being heightened compared to those lower on this dimension. Moreover, these individuals had a greater sense of reliving or pre-experiencing the event as if it were happening now, perhaps due to the richness of the sensory information (Greenberg & Knowlton, 2014). This replicates the work of other researchers in schizotypy who have found positive relationships with gustatory (Winfield & Kamboj, 2010) and olfactory details (Alle et al., 2023; Winfield & Kamboj, 2010) as well as a subjective sense of time travel (Winfield & Kamboj, 2010). The present findings extend to other modalities including visual, auditory and tactile details as well as different modes of re-living and pre-living the event visually, auditory and sensorily.

It is possible that the higher subjective ratings on memory and future imaginings given by those with higher Unusual Experiences scores may be due to these individuals having enhanced mental imagery. This describes the representation and experience of sensory information without an external stimulus (Pearson et al., 2015). Importantly it is not restricted to just the visual domain but includes the other senses. The link between mental imagery and memory/future thinking has been supported by a variety of empirical findings. Individuals who lack the ability to generate visual images, a condition known as aphantasia, also report reduced imagery in other modalities and this is

related to less vivid and phenomenologically rich memory and imagining of future events (Dawes et al., 2020). Furthermore, there is cortical reactivation in relevant sensory areas when people recall an experience (Wheeler et al., 2000) and constructing future thinking has been proposed to rely on assimilating perceptual details previously experienced and reinstating them (Conti & Irish, 2021). Several studies have found that those in the schizophrenia spectrum, including those with a diagnosis of schizophrenia, their first-degree relatives and those high in schizotypy, have higher mental imagery vividness (Aleman et al., 2000; Mintz & Alpert, 1972; Oertel et al., 2009). Although, the evidence is mixed as to whether there is a direct link with positive symptoms, such as hallucinations (Oertel et al., 2009). It is likely that these types of symptoms arise from a combination of factors, including mental imagery differences as well as monitoring deficits which allow an individual to differentiate between internally generated experiences and externally derived i.e. reality monitoring (Vinogradov et al., 1997).

Participants with higher scores on the Unusual Experiences dimension also had elevated scores on the SAM questionnaire, which measures general memory ability. Thus, the results from this measure align with the event-based ones. On the SAM relationships were found with the Episodic and Future sub-dimensions, with a particularly strong relationship with Future. These findings might also be linked to enhanced mental imagery in those high in Unusual Experiences, which are driving these results. Armson et al. (2021) found that participants who had higher scores on the SAM (Episodic and Semantic dimensions) made more gaze fixations when recalling the episodic details of a museum style tour that they had taken a week earlier. This indicates greater visual exploration and suggests that people with higher scores on certain dimensions of the SAM may have a greater propensity to use visual imagery when they are remembering the past. Moreover, Clark and Maguire (2020) found that the Episodic and Future scales on the SAM predicted imagery ability on a scene construction task. These findings together with their own psychometric assessment of the SAM led Setton et al. (2021) to suggest that the different sub-dimensions of the SAM, rather than measuring different aspects of memory, might instead be capturing distinct facets of imagery. In this study stronger relationships were found with the Future dimension, which might be due to imagining future scenarios relying more heavily on mental imagery (Conti & Irish, 2021; Dawes et al., 2022).

One outstanding question with an imagery explanation is why we did not also observe higher scores on the experimenter-scored AI measures for these individuals. Given we did not see this it would suggest that the overt descriptions that these participants give of their past and future experiences do not align with their mental experiences when they complete the ratings. One explanation for this

finding might be because these tasks are tapping into different types of processes. Many researchers have suggested that there is a collection of processes supporting autobiographical and future thinking. For example, Andrews-Hanna and colleagues (2014, 2021) have suggested that we have a *mind's eye* which is focussed on the details of an event which is grounded in a specific spatio-temporal context and a *mind's mind* which is a more general and reflective system (see also Sheldon et al., 2019 who proposes perceptual and conceptual processes). These systems work in combination but depending on the circumstances one or other can take precedence. Tasks can require several different elements including the retrieval of specific details, integration of these elements into a coherent spatio-temporal context, reflections on our own and others' emotions and thoughts as well as how that event might fit into our life story. It is possible that the online response to the cue versus the ratings given afterwards might tap into these processes differently. For example, in the former of these there might be more weighting towards the specifics of the event whereas the ratings afterwards encourage a more holistic view of the episode with more reflection. Thus, our results might suggest that Unusual Experiences is associated with an enhancement of the reflective processes contributing to autobiographical and future thinking.

An alternative explanation might relate to disturbances in metacognition. This has been defined as "thinking about thinking" (Moritz & Lysaker, 2018). Impairments in metacognition have been found in schizophrenia (see meta-analysis by Davies & Greenwood, 2020) and several studies have demonstrated a link between schizotypy and poor metacognition using the Metacognitions Questionnaire (Barkus et al., 2010; Chan et al., 2015; Stirling et al., 2007). However, questionnaire-based measures of metacognition might be inadequate on their own as the accurate completion of these presupposes a high degree of introspective abilities. Therefore, some studies have examined task-based indices of metacognition indexed via trial-by-trial confidence ratings. For example, Evans et al. (2019) administered an episodic memory task and found that individuals high in the positive dimension of schizotypy had more false memories than those scoring lower on this dimension and a tendency to give highly confident responses across all item types. This indicates that they have a liberal response bias, whereby a participant needs less evidence before they are willing to designate an item as old. It might be that a similar response bias is in operation in the current study, whereby those high in Unusual Experiences are more likely to give higher phenomenological scores based upon less evidence. Further work is required to understand metacognitive abilities in schizotypy and to explain the objective-subjective disconnect frequently seen in schizotypy (Cohen et al., 2017).

An important question which needs to be addressed is why in this study examining schizotypy we found enhanced recollective and future thinking abilities, whereas research in individuals with schizophrenia tends to find that they have deficits in these areas. One possibility is that the studies which have tested people with a diagnosis are confounded by medication effects, as most of these individuals were receiving antipsychotic medication. Thus, the decrement in performance could be driven by medication rather than schizophrenia itself; and that is why we do not find this pattern of result in our healthy sample. The participants tested in the clinical studies tend to be stable outpatients who have had a diagnosis (generally > 10 years) and been medicated for a long time. The positive symptoms of psychosis are generally well-managed with antipsychotic medication, but treatment options are more limited for the negative symptoms (Correll & Schooler, 2020). Thus, in clinical studies the profile of symptoms seen is generally very low for positive symptoms and higher for negative. It is possible that the low levels of positive symptoms do not provide enough variability for any relationships to be found with memory and future thinking performance. Future clinical studies where individuals have higher levels of positive symptoms would be very useful.

In conclusion, in the current study no relationships were found between any aspects of schizotypy and objective measures of episodic content for memories and future imaginings scored by the experimenter. In contrast, when participants rated the phenomenological qualities of these experiences these tended to be enhanced in those high in the positive dimension of schizotypy. Future research is required to examine the mechanism(s) underlying these relationships and the difference in findings between clinical and non-clinical populations.

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Declaration of interest statement

The authors report there are no competing interests to declare.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Table 1. The items used from the Assessment of the Phenomenology of Autobiographical Memory (APAM; Vannucci et al., 2020) with their wording for the past conditions (future in italics) and the rating scale.

Item	Question and rating
Clarity	My memory/ <i>imagination</i> for this event is (1= dim; 7= sharp/clear)
Colour	My memory/ <i>imagination</i> for this event is (1= black and white; 7= entirely coloured)
Vividness	My memory/ <i>imagination</i> for this event is (1= vague; 7 = very vivid)
Vision	My memory/ <i>imagination</i> for this event involves visual detail (1 = little or none; 7 = a lot)
Audition	My memory/ <i>imagination</i> for this event involves sound (1 = little or none; 7 = a lot)
Olfaction	My memory/ <i>imagination</i> for this event involves smell (1 = little or none; 7 = a lot)
Touch	My memory/ <i>imagination</i> for this event involves touch (1 = little or none; 7 = a lot)
Taste	My memory/ <i>imagination</i> for this event involves taste (1 = little or none; 7 = a lot)
Reliving	As I remember the event, I feel as though I am reliving the original event <i>As I imagine the event, I feel as though I am there</i> (1= not at all; 7 = as clearly as if it were happening right now)
Auditory reliving	As I remember/ <i>imagine</i> the event, I can hear it in my mind (1= not at all; 7 = as clearly as if it were happening right now)
Visual reliving	As I remember/ <i>imagine</i> the event, I can see it in my mind (1= not at all; 7 = as clearly as if it were happening right now)
Spatial reliving	As I remember the event, I can recall the setting where it occurred <i>As I imagine the event, I can envision the setting where it will occur</i> (1= not at all; 7 = as clearly as if it were happening right now)
Formulation in words	As I remember/ <i>imagine</i> the event, it comes to me in words (1= completely disagree; 7= completely agree)

Coherence	As I remember/ <i>imagine</i> the event, it comes to me in words or in pictures as a coherent story or episode and not as an isolated fact, observation, or scene (1= completely disagree; 7= completely agree)
Accessibility	This memory/ <i>event</i> just sprang to my mind when I was shown the cue word (1= completely disagree; 7= completely agree)
Perspective, third person	I view this memory as if I was an observer to the experience <i>I view this event as if I am an observer to the experience</i> (1= completely disagree; 7= completely agree)
Emotional intensity	My feelings at the time of the event were intense <i>As I imagine the event, my feelings are intense</i> (1= not at all; 7 = a lot)
Self-distancing	I feel like the person in this memory/ <i>event</i> is a different person than who I am today (1= completely disagree; 7= completely agree)
Personal importance	This memory/ <i>event</i> is significant for my life because it imparts an important message for me or represents an anchor, critical juncture, or a turning point (1= completely disagree; 7= completely agree)
Age	Please date when the memory/ <i>event</i> happened/ <i>will happen</i> using the following categories: [1] within a week [2] within a month [3] within 6 months [4] within a year [5] 2-5 years [6] 6-10 years [7] 11-15 years [8] 16-30 years [9] 31-50 years [10] 50 years plus

Table 2. Interpretation of Bayes factors taken from Lee and Wagenmakers (2013)

BF10	Interpretation
>100	Extreme evidence for H1
30-100	Very strong evidence for H1
10-30	Strong evidence for H1
3-10	Moderate evidence for H1
1-3	Anecdotal evidence for H1
1	No evidence
0.33-1	Anecdotal evidence for H0
0.33-0.1	Moderate evidence for H0
0.1-0.03	Strong evidence for H0
0.03-0.01	Very strong evidence for H0
<0.01	Extreme evidence for H0

Table 3. Kendal’s tau coefficients and Bayes Factors between the dimensions of schizotypy and the experimenter-scored measures. Descriptive statistics for all participants are in the last column.

	Unusual Experiences		Introvertive Anhedonia		Mean (SD)
	τ_b	BF ₁₀	τ_b	BF ₁₀	
Past					
Internal	.02	0.15	-0.11	0.40	91.6 (27.7)
Event	.05	0.17	-.07	0.21	43.1 (12.7)
Perceptual	.01	0.14	-.02	0.15	5.76 (5.17)
Spatiotemporal	.02	0.14	-.12	0.57	19.0 (7.76)
Emotion/thought	-.06	0.19	.08	0.27	4.69 (3.64)
Future					
Internal	-.07	0.23	-.07	0.22	61.8 (20.5)
Event	-.07	0.22	-.04	0.16	37.3 (13.6)
Perceptual	.03	0.15	0	0.14	4.91 (5.11)
Spatiotemporal	-.14	0.92	-.06	0.19	15.0 (6.69)
Emotion/thought	-.01	0.14	-.06	0.19	4.6 (3.7)

Table 4. Kendal’s tau coefficients and Bayes Factors between the dimensions of schizotypy and the participant-scored measures. Descriptive statistics for all participants are in the last column.

	Unusual Experiences		Introvertive Anhedonia		Mean (SD)
	τ_b	BF ₁₀	τ_b	BF ₁₀	
Past					
Clarity	0.05	0.18	-0.06	0.21	5.42 (0.90)
Colour	0.07	0.21	-0.04	0.16	6.10 (0.89)
Vividness	0.09	0.28	-0.07	0.22	5.36 (0.97)
Vision	0.14	0.88	-0.14	0.93	5.80 (0.86)
Audition	0.22*	12.66	-0.11	0.42	4.04 (1.39)
Olfaction	0.26*	72.78	-0.10	0.36	2.67 (1.33)
Touch	0.31*	1411.51	-0.07	0.21	3.36 (1.46)
Taste	0.22*	11.58	-0.06	0.20	2.73 (1.25)
Reliving	0.25*	48.59	-0.05	0.17	4.66 (1.15)
Auditory reliving	0.21*	10.03	-0.16	1.64	3.89 (1.50)
Visual reliving	0.17	1.91	-0.10	0.34	5.51 (0.84)
Spatial reliving	0.03	0.15	-0.10	0.34	6.08 (0.76)
Formulation in words	-0.01	0.14	-0.11	0.42	3.66 (1.78)
Coherence	0.07	0.22	-0.06	0.18	4.94 (1.34)
Accessibility	0.15	1.33	-0.05	0.18	5.56 (1.10)
Perspective, third person	0.05	0.18	0.03	0.15	3.58 (1.54)
Emotional intensity	0.08	0.24	-0.17	1.88	4.54 (1.30)
Self-distancing	0.08	0.27	0	0.14	4.31 (1.32)
Personal importance	0.11	0.48	0.01	0.14	3.55 (1.36)
Age	0	0.14	0.02	0.14	4.35 (0.96)
Future					
Clarity	0.22*	14.31	-0.03	0.15	4.91 (1.10)
Colour	0.09	0.30	-0.08	0.27	5.73 (1.06)
Vividness	0.18*	2.59	-0.05	0.18	4.76 (1.13)
Vision	0.19*	5.10	-0.10	0.35	5.29 (1.04)

Audition	0.21*	11.29	-0.13	0.71	3.73 (1.37)
Olfaction	0.24*	31.76	-0.04	0.16	2.66 (1.37)
Touch	0.27*	126.22	-0.12	0.52	3.30 (1.52)
Taste	0.09	0.30	-0.17	2.51	2.71 (1.35)
Reliving	0.18*	3.55	-0.02	0.14	4.51 (1.17)
Auditory reliving	0.21*	11.34	-0.12	0.52	3.64 (1.33)
Visual reliving	0.23*	22.32	-0.12	0.51	5.31 (1.02)
Spatial reliving	0.10	0.34	-0.10	0.37	5.41 (0.98)
Formulation in words	0.07	0.23	-0.08	0.26	3.46 (1.62)
Coherence	0.14	0.93	-0.08	0.25	4.26 (1.24)
Accessibility	0.25*	47.18	-0.08	0.25	5.07 (1.20)
Perspective, third person	0.25*	44.38	0.10	0.39	3.81 (1.43)
Emotional intensity	0.23*	19.41	-0.09	0.30	3.98 (1.30)
Self-distancing	0.17*	2.20	0	0.14	3.20 (1.25)
Personal importance	0.25*	48.98	-0.02	0.14	3.62 (1.26)
Age	0.13	0.67	0.08	0.27	3.81 (1.17)

*Correlations which were significant after application of the Benjamini-Hochberg correction.

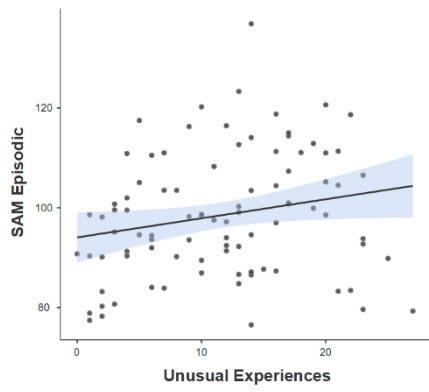
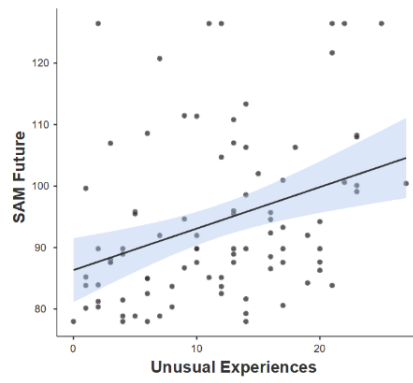
A**B**

Figure 1. Scatterplots of the correlation between Unusual Experiences scores and the SAM subscales of Episodic (Panel A) and Future (Panel B). Shaded areas represent the standard error.