Negative schizotypy is associated with impaired episodic but not semantic coding in a conditional learning task

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Abstract

Context processing deficits associated with negative schizotypy may reflect variation in semantic and/or episodic declarative coding. Healthy volunteers (n = 166) were grouped on the basis of their introvertive anhedonia and unusual experiences scores on the Oxford and Liverpool Inventory of Feelings and Experiences (OLIFE). Discrimination learning was measured using a commodity-trading task that required participants to predict profit (+) and loss (-) outcomes based on pairs of commodities (e.g., Corn & Steel). Two forms of a biconditional discrimination were employed: (1) **fixed locations**; A → X+, A → Y-, B → X-, B → Y+ and (2) **variable locations**; A ↔ X+, A ↔ Y-, B ↔ X-, B ↔ Y+. With fixed locations (n = 84) stimuli A & B were always on the left, X & Y were always on right, in the variable locations condition (n=82) A, B, X, & Y occurred randomly in both left and right locations. Negative schizotypy reflected the expression of a cognitive phenotype that specifically impaired episodic (configural) representation formation in declarative memory. People with many negative schizotypal traits will struggle to learn appropriate responses when their choices are guided by multiple stimuli in inconsistent locations.

**Key words:** Episodic memory; semantic memory; schizotypal personality; biconditional discrimination

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Schizotypy traits are assumed to reflect liability for schizophrenia and other major mental illnesses (Grant, Green & Mason, 2018). Schizophrenia-like cognitive abnormalities in non-clinical high schizotypy samples have been widely studied partly because these groups provide an un-confounded analogue for schizophrenia in the search for cognitive endophenotypes (Haddon, et al., 2011; Haselgrove, & Evans, 2010), the relationship between schizotypy and cognition has developed into a field of enquiry in its own right (e.g., Gurvich et al., 2015) but the overlap between cognitive features associated with both schizotypy and schizophrenia has remained a dominant theme (Ettinger, et al., 2015). The focus in many analogue studies has been on positive and negative personality traits because these correspond with the most conspicuous (van Assche & Giersch, 2012) and incapacitating (Strauss, et al., 2013; Ventura, et al., 2009) aspects of psychosis. Negative symptoms have also been linked most strongly with both primary cognitive impairment (Nieuwenstein, Aleman & De Haan, 2001) and poor functional outcomes for patients (Carbon & Correll, 2014).

Memory deficits are consistently reported in schizophrenia (Schaefer, et al., 2013) and schizotypal personality disorder (Farmer, et al., 2000) and declarative memory (DM) is most robustly associated with schizophrenia (Stone & Hsi, 2011) deficits have also been observed in un-diagnosed relatives (Whyte, et al., 2005). Notably, impairment increases as a function of relatedness to patients (Faraone, et al., 2000). The specific character of DM impairment for schizophrenia samples and their close relatives is associated with poor representation formation rather than restricted DM capacity (Cirillo & Seidman, 2003). Also, imaging studies show abnormal activation in brain regions that support DM encoding rather than storage or retrieval (Pirnia, et al., 2015). These convergent lines of evidence suggest that DM dysfunction reflects the expression of heritable liability factors that can specifically impede representation formation in DM.

Declarative memory is measured using diverse procedures including the Wisconsin Card Sort task (Greenwood, et al., 2012), classic Stroop word-colour paradigm (van Assche & Giersch, 2012),

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the AX-CPT (Dias, et al., 2011), and biconditional discrimination learning (Haddon, et al., 2011). All of these tasks however have two important common features, they each require people to, (1) hold multiple representations active in memory, in order to, (2) select amongst otherwise ambiguous responses. Declarative memory (DM) is therefore differentiated from procedural memory because of the requirement for simultaneous engagement of multiple representations (Chen, Poldrack & Eichenbaum, 1997). This characterisation of DM is central to context processing accounts of schizophrenia and it has been argued that contexts can be encoded in different ways that each of these may have special significance for specific schizophrenia symptoms (Hemsley, 2005).

Declarative memory is not unitary but includes at least 2 sub-processes that serve semantic and episodic functions (Squire, 2004). Both semantic (Kiang, et al., 2012) and episodic (Wang, et al., 2010) impairment have been reported in schizophrenia. However these may reflect decreased global DM functioning (Minzenberg, et al., 2004), or, individual semantic (Goldberg, et al., 2014) versus episodic (Wang, et al., 2010) deficits. The current introduction will next present very brief characterisations of semantic and episodic memory and will then outline methods that should selectively engage each of these aspects of declarative memory.

**Semantic memory**

Semantic memory is complex with multiple modality- and category-specific networks (Martin, et al., 1996). Nevertheless, the functional significance of semantic memory lies in its capacity for the meaningful organisation of knowledge (Binder & Desai, 2011). Semantic memory allows objects to be categorised (e.g., cats versus dogs) on the basis of their properties. Importantly, semantic memory also allows people to know about the relationships between the stimuli that they hold knowledge about. Semantic memory permits people to know about the characteristics of cats and

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dogs (warm, furry, barking, & purring) and the antagonistic relationship between (relational semantic coding) these classes of animals (Kintsch, 2014).

Perhaps the simplest situation where relational semantic coding occurs is when one stimulus modulates the meaning of another. For instance, a dog may be placid except when it encounters a cat; the cat modulates the behavioural properties of the dog. Being able to encode modulatory relationships allows us to understand interactions between classes of objects, to make predictions regarding the result of interactions and enables selection of appropriate behavioural responses. It has been argued that this modulatory ability is compromised in schizophrenia (Cohen & Servan-Schreiber, 1992) and high schizotypy samples (Haddon, et al., 2011). Learning paradigms that imbue stimuli with modulatory functions have been extensively studied in conditional discrimination learning and there is evidence from nonhumans (Eichenbaum, 2004; Honey & Watt, 1998) and people (Baeyens, et al., 2004) that context and target stimuli are often represented in hierarchical/conjunctive representational structures (Bonardi, Bartle & Jennings, 2012; Holland, 2008).

**Episodic memory**

Episodic memory refers to a system that allows people to code, retain and retrieve their individual experiences across time (Tulving, 2002). The scope of experiences that require episodic coding is broad and could require almost infinite storage capacity. It has been argued therefore that processes that increase the efficiency of episodic memory are necessary (Shing, et al., 2010). One particular challenge for episodic memory relates to how multi-element stimuli can be represented most efficiently. According to configural accounts of learning, multiple stimulus inputs are integrated to form episodic representations (Pearce, 1987). There is recent evidence that similar integrative processes are disrupted in schizophrenia (Sanford, et al., 2014).

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In summary, semantic and episodic coding processes result in the formation of qualitatively distinct representational structures. It has been argued that the formation of one or other of these structures depends on how stimuli are presented to learners (Bonardi, Bartle & Jennings, 2012; Hemsley, 2005). Specifically, conditional discriminations that use fixed spatial or temporal parameters result in conjunctive representations whilst stimuli presented in variable locations promote configuration (Baeyens, et al., 2004). This dissociation is thought to arise because fixed locations permit sequential processing of stimuli, allowing segregation of contexts (processed first) from targets (processed second). When stimuli occur in inconsistent locations it is not possible for stimuli to be segregated and learners will rely upon configural episodic integration (Bonardi, Bartle & Jennings, 2012).

Brain imaging studies show that positive and negative symptoms of schizophrenia are associated with activation of separate brain regions during tests of DM (n-back task (Menon, et al., 2001)), similarly the behavioural neuroscience literature indicates that the formation of semantic and episodic representations depends upon separate neuroanatomical regions (see Gluck, Myers & Meeter, 2005 for an example). These lines of evidence together suggest that DM endophenotypes for positive and negative traits may be separable and could reflect impairment in different sub-systems within DM (Squire, 2004).

The arguments above are appealing because they suggest that manipulating one very simple parameter (stimulus locations) in a single task (biconditional discrimination) will selectively engage semantic or episodic sub-processes of DM and permit exploration of specific associations with

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schizotypy dimensions, see Table 1. Conditional learning impairment in healthy volunteers has been reported to be confined to people with high levels of negative schizotypy (Haddon et al., 2011). These observations are sadly confounded by concurrent presentation of a simple discrimination (so the deficit may be produced by excessive cognitive load, or, by the switching requirement of the task) further these observations do not resolve whether the deficit in high negative schizotypy resulted from impaired semantic or configural coding. One of the objectives of the current study was to examine conditional learning deficits in an unconfounded way and to provide a clearer picture of the specific nature of the context processing deficit associated with negative schizotypy in healthy volunteers.

**Aims and hypotheses**

**Positive schizotypy**

People diagnosed with schizophrenia show low levels of automatic organisation during the formation of stimulus-stimulus associations (within visual perceptual sets), this has been attributed to failure in top-down structural processes (van Assche, & Giersch, 2012). Perceptual disturbance is a prominent feature of positive symptoms in schizophrenia and within the logic of analogue studies it can be supposed that disruption to top-down structural processes may also underpin positive schizotypy because both will reflect the expression of a common endophenotype (impaired formation of top-down relational structures). Deficits during learning that rely upon top-down conjunctive structural coding of compound stimuli might therefore be anticipated in a high positive schizotypy group.

**Negative schizotypy**

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People diagnosed with schizophrenia show disrupted cortical activation during context-based episodic memory (Wang, et al., 2010) and negative symptoms of schizophrenia are particularly related to disrupted visual episodic memory (Palmer, et al., 2010). Complimentary findings using analogue methods show that negative schizotypy may also be associated with disrupted episodic configuration in conditional discrimination learning (Haddon, et al., 2014). Deficits in tasks that require configural episodic coding of complex visual stimuli are anticipated in a high negative schizotypy group.

The aim of the current study was to recruit a non-clinical sample and to utilise variability in their positive and negative schizotypy traits in order to explore separate associations with the operation of conjunctive (semantic) and configural (episodic) memory. The manipulation of interest was designed to engage either conjunctive (fixed locations) or configural (variable locations) representational systems during biconditional discrimination learning. Our purpose in doing this was to determine whether positive and negative schizotypy dimensions might be associated with different endophenotypes within DM.

Method

Design

Mixed factorial designs were used to compare biconditional discrimination learning over time for low vs high positive and negative schizotypy groups under conditions where the conditioned stimuli either remained in fixed, or, were presented randomly in left-right locations. The study employed a within subjects factor (time, 5 successive training blocks, ie. the rate of biconditional discrimination learning) and 2 between subjects factors; schizotypy dimension (negative vs positive), dimension status (low vs high). The design contrasted the rate at which low and high, positive and negative schizotypy groups learned under conditions of fixed or variable stimulus locations separately. Regression analysis was not chosen for 2 reasons. The first was because previous reports of

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Schizotypy double dissociation

Schizotypy-based conditional learning deficits have focused on rates of learning (Haddon et al., 2011), rather than on absolute deficits. More subtle rate of acquisition deficits would be obscured if learning over time were collapsed into a single dependent variable (reflecting overall performance) as would be required for multiple linear regression. Adoption of ANOVA modelling over regression also facilitated comparison of patterns of effects observed here with those reported previously.

Participants and schizotypy group allocation

The study was granted approval by a university ethics committee and the experiment was conducted during routine Psychology classes, participation was voluntary and sampling opportunistic. There were 166 participants (male = 49; female = 117), their average age was 21.7 years, the youngest participant was 19, the oldest was 56. The participants for the fixed (n = 84) and variable (n = 82) location versions of the task were recruited from successive annual cohorts. Year-cohort sampling did not confound administration of the two versions of the biconditional discrimination. Neither Introvertive anhedonia (Mean Fixed = 4.803, SD = 4.105; Mean Variable = 5.476, SD = 4.267: $F_{1,156} = 1.018; P = 0.315$) or Unusual experiences (Mean Fixed = 7.132, SD = 6.777; Mean Variable = 7.646, SD = 6.632: $F_{1,156} = 0.233; P = 0.630$) scores differed between the stimulus presentation conditions.

In order to increase the sensitivity of the analysis, learning data from participants who scored around the total sample mean ($\pm 2$) for Introvertive anhedonia or Unusual experiences were excluded from statistical analysis. This inclusion criterion was designed to reduce the degree of overlap between low and high groups and avoid Type II error. This general approach of segregating participants into Low and High groups based on a measure of central tendency (mean or median) has been used in previous studies with healthy volunteers (Haselgrove & Evans, 2010; Haddon, et al., 2011; 2014), our approach was designed to facilitate comparison of findings across studies but also to maximise the sensitivity and specificity of our approach.

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Materials

The Oxford and Liverpool Inventory of Feelings and Experiences (OLIFE: Mason, Claridge & Jackson, 1995) was used to measure schizotypy. The OLIFE was chosen because of good test-retest reliability (Burch, Steel & Hemsley, 1998) and because this measure has been used in many previous studies exploring associations between schizotypy personality and cognition. The approach of the current experiment was purposeful and so only data for 2 of the dimensions of the OLIFE were collected from participants (Introvertive anhedonia and Unusual experiences), items for the remaining dimensions were omitted from our materials.

The learning task was programmed using Visual Basic and required participants to imagine that they were working in a stock trading company with the goal of learning to predict profit and loss outcomes based on combinations of commodities. We developed this procedure to ensure unambiguous valence for trial outcomes, one is clearly positive (profit) and the second is clearly negative (loss). Previous studies have employed variants of the allergist paradigm in which one of the outcomes is somewhat ambiguous. With ambiguous outcomes participants are free to interpret valence and ‘no illness’ could be interpreted either as a positive event (ie. wellness) or as a neutral event (ie. life as usual). We chose therefore not to use the allergist paradigm but developed our own scenario where positive and negative outcomes could be equally likely and plausible. Four commodities (i.e. Nickel, Platinum, Corn & Rice) were randomly allocated for each participant to represent experimental stimuli (A, B, X, & Y), this controlled for pre-existing associations amongst

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the stimuli. Table 1 shows the combinations of stimuli and the trial outcomes employed for the fixed and variable locations conditions, the 4 trial types were presented once each, in random order, during 20 consecutive cycles of training trials, all participants received 80 training trials.

Procedure

The Experiment began with detailed task instructions on the computer screen. Participants were presented with 2 commodities on each trial (e.g. Nickel & Rice) and were required to provide a rating (by selecting a number on the computer keyboard) reflecting their confidence that the current trial would end with either profit or loss. The rating scale ranged from 1 (absolute confidence of loss) through 5 (uncertainty) to 9 (absolute confidence of profit). After entering their rating, participants were presented with immediate feedback. Feedback indicating profit was “The stocks MADE money” presented in green print and the feedback indicating loss was “The stocks LOST money” presented in red print. Outcomes were independent of participant responses. The commodities and outcome presented on each trial remained on screen until the participants initiated the next trial by pressing a next trial button on the computer screen using the mouse. Participants were not warned or briefed about the contingencies of the experiment. The layout of stimuli and rating scale have been presented elsewhere (Haselgrove & Evans, 2010).

Dependent variables and methods of analysis

Discrimination learning was measured using discrimination scores, these were calculated as the mean difference between confidence ratings on profit and loss trials. This was achieved by subtracting mean confidence ratings for loss trials ((BX + AY)/2) from mean ratings for profit trials ((AX + BY)/2) within each 4-trial cycle of training trials. To simplify data analysis and presentation, individual training cycle scores were pooled into 5 equally-sized training blocks that contained the
average discrimination score for 4 successive cycles (training cycles 1-4 were used to calculate block score 1, training cycles 5-8 were used to calculate block score 2 and so on. Discrimination scores could range between -8 and +8, higher scores indicated superior learning, zero represented chance performance and minus values showed performance that was opposed to the contingencies of the discrimination.

Results

The design of the study used 2 variants of the same discrimination procedure that we argued would rely on different forms of declarative memory. We argued that the fixed location form of the task should rely on hierarchical (semantic) stimulus-stimulus coding and that the variable location form of the task should rely on configural (episodic) coding. It is plausible that the 2 forms of the task may also have differed in terms of the cognitive load they placed on participants, the variable locations form of the task may simply have been more complex and therefore more difficult. So, the first analysis was designed to explore the possibility that task difficulty may have contributed to any differences observed between the 2 variants of the learning task. This analysis included all 166 participants and used a 2-Way mixed ANOVA to explore whether learning in the fixed and variable location forms of the task differed over successive blocks of trials. Discrimination scores were employed as the dependent variable over successive training blocks (Blocks 1-5) which served as a within subjects factor, stimulus presentation method served as a between subjects factor with 2 levels (fixed versus variable locations). There was a main effect of time $F_{4,565} = 72.11; P = 0.000$, indicating that participant discrimination scores increased over time and this effect did not interact with the stimulus presentation method $F_{4,656} = 1.399; P = 0.27$, suggesting that the 2 stimulus presentation methods produced learning at equivalent rates. This observation excludes the possibility that the 2 forms of stimulus presentation method varied in difficulty and consideration of this potential confound received no further consideration.
The next analysis was concerned with exploring whether schizotypy dimension status was related to learning rate in the fixed locations condition. All following analyses concentrated on the performance of participants who were retained after application of our exclusion criterion (those on either side of the mean score ±2 for each schizotypy dimension were excluded). Earlier we argued that participants would employ their semantic (hierarchical) declarative memory when solving the fixed location form of the task and so comparison of the performance of various schizotypy groups was a test to see if either positive or negative schizotypy traits were associated with variation in semantic declarative memory coding. Inspection of Figure 1 suggests no association between either negative or positive schizotypy status and learning with all groups learning the discrimination at roughly equivalent rates. This impression of the results was confirmed by a mixed 3-way ANOVA that included training blocks (1-5) as a within subjects factor and included the 2 schizotypy dimensions (Negative vs Positive) and schizotypy dimension status (Low vs High) as between subjects factors. Main effects of schizotypy status or interactions between either of the schizotypy dimensions and time would suggest associations between schizotypy and semantic declarative memory. There was a main effect of time $F_{4, 160} = 13.439; P = 0.000$ but no interactions involving schizotypy status and time (all $Fs < 1$) and no main effect of either negative or positive schizotypy status (both $Fs < 1$). Taken together, these results show that participants were able to learn the fixed locations form of the biconditional discrimination and learning was unaffected by either negative or positive schizotypy status. We conclude therefore that the various schizotypy groups were equivalent in their capacity to use semantic coding in the fixed locations condition.
The final analysis was concerned with exploring whether schizotypy dimension status was related to learning rate in the variable locations condition and again concentrated on the performance of participants who were retained for the main analysis after application of our exclusion criterion (those on either side of the mean score ±2 for each schizotypy dimension were excluded). Earlier we argued that participants would employ their episodic (configural) declarative memory when solving this form of the task and so comparison of the performance of various schizotypy groups on this form of the task was a test to see if either positive or negative schizotypy traits were associated with variation in episodic (configural) declarative coding. Inspection of Figure 2 suggests that there were indeed differences between the various negative and positive schizotypy groups. This impression of the results was examined more closely in a mixed 3-way ANOVA that included training blocks (1-5) as a within subjects factor and the 2 schizotypy dimensions (Negative vs Positive) and schizotypy dimension status (Low vs High) as between subjects factors. Again, main effects of schizotypy status or interactions between either of the schizotypy dimensions and time would suggest associations between schizotypy and semantic declarative memory. As with the analysis of the fixed locations, there was a main effect of time $F_{4, 172} = 20.20; P = 0.000$. Unlike the analysis with fixed locations, the analysis of the variable locations condition showed a significant interaction between Introvertive anhedonia status and time $F_{4, 172} = 2.47; P = 0.047$ and a main effect of Introvertive anhedonia status $F_{1, 43} = 4.71; P = 0.036$. There were no main effects or interactions involving the Unusual experiences dimension and discrimination learning. Post hoc analyses therefore focused on interactions involving the Introvertive anhedonia dimension, pairwise comparisons are presented following Bonferroni adjustment. The interaction between time and Introvertive anhedonia status was produced by a between subjects difference that was confined to

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the final 2 blocks of the training trials with mean differences in discrimination scores of 1.97 (P = .028) and 2.46 (P = .01) respectively, differences on the preceding 3 training blocks were not significant (lowest P = 0.28 on block 3). In summary, unusual experiences status was not associated with biconditional discrimination learning with conditioned stimuli in variable locations whilst HIGH Introvertive anhedonia status was associated with impaired performance, this impairment emerged over time and was confined to the later training blocks.

Discussion

The current study sought to manipulate the involvement of semantic-type and episodic-type stimulus-stimulus associations in a conditional learning task by presenting pairs of conditioned stimuli in either fixed or variable left/right locations in a conditional learning task. The current findings revealed a specific negative schizotypy based impairment in episodic (configural) declarative memory (Squire, 2004). Positive traits were unrelated to representation formation in conjunctive (semantic) and configural (episodic) coding. These findings are consistent with those previously reported by Haddon et al., (2011) but made a novel contribution by illuminating the nature of context processing impairment associated with negative schizotypy and challenge a substantial body

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of research that has characterised declarative memory as a unitary system (e.g., Krieger, et al., 2005) suggesting that specific patterns of impairment (see Figure 2) may have been obscured by previous unitary characterisations of DM. The pattern of impairment and a speculative theoretical interpretation of the current results are presented in Figure 3. We suppose, as argued previously by Bonardi, Bartell & Jennings (2012), that learners normally have access to both semantic and episodic coding and the selection of which is employed is dictated by the experimental stimulus-stimulus parameters. Fixed inter-stimulus parameters allow functional stimulus parsing and relationships are encoded hierarchically (semantically). When stimuli are presented in variable relative locations then parsing is less feasible and episodic (configural) processes are normally recruited. In this interpretative framework, our results suggest that people scoring high on negative schizotypy are relatively impaired in their ability to engage episodic declarative coding and may rely more on inflexible and inefficient semantic coding when episodic coding would increase memory efficiency.

As there were no associations between positive traits and either semantic or episodic performance in our conditional learning task, the following analysis will focus exclusively on negative traits and the likely impact of impaired episodicconfigural processing.

**Episodic configural impairment and negative traits**

Negative traits were related to impaired formation of episodic configural (Pearce, 1987) representations when stimuli were presented in variable locations. Varying stimulus locations would have prevented the formation of hierarchical associative structures and forced participants to use episodic configurations (Bonardi, Bartle & Jennings, 2012).

The main problem for participants to overcome when ‘solving’ a biconditional discrimination is the degree of generalisation between stimuli on occasions when they signal one outcome (AX+) versus occasions when they signal the alternate outcome (BX-), this problem extends to all of the individual stimuli in a biconditional discrimination. A process that can overcome primary

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generalisation is required and stimulus configuration is the dominant theoretical explanation for how this is achieved. According to configural theory, individual stimuli presented in compounds do not acquire association with outcomes directly, all of the stimuli instead become able to partially activate an episodic representation of the entire pattern of stimulation (Pearce, 1987). The variable location stimulus condition was designed to encourage reliance on episodic configuration by alternating stimulus locations and preventing segregation of context and target stimuli, thus preventing hierarchical learning (Bonardi, Bartle & Jennings, 2012). The intact performance of the high negative schizotypy group in the fixed locations condition indicated that their ability to form hierarchical semantic relations was unaffected, their relative inability to learn with variable locations suggested that they were impaired in their ability to form integrative configural representations in declarative memory.

Negative traits and symptoms describe cognitive and behavioural impoverishment that (in our analogue sample) reflected impaired learning in a situation that required integrative configural processing of complex stimuli (Haddon, et al., 2014). Failure in episodic configural integration diminished the efficiency with which the high negative schizotypy group were able to select responses when the spatial relationships between stimuli were dynamic and unpredictable. People with this form of episodic deficit would function adequately in situations where the relationships between stimuli are fixed, clear and predictable, they would be able to encode such stimulus relationships hierarchically and semantically. However, when these same people encounter more dynamic stimulus situations then they will struggle to select their responses appropriately because of their impaired episodic coding, under these circumstances learning would be more difficult and behaviour will become impoverished.

Conclusions, limits to observations and future directions

The ultimate aim of analogue studies is to refine understanding of basic cognitive processes in the development of schizophrenia. The current study has contributed to this end by dissecting

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the involvement of sub-processes in declarative memory and exploring separate associations with different (positive and negative) schizotypy dimensions.

One of the strengths of the current procedure was that we used a learning paradigm that required formation of arbitrary stimulus-stimulus relationships, the current observations were therefore free from pre-existing semantic networks which would have inevitably shown a degree of idiosyncrasy (Sumiyoshi, et al., 2005).

The analogue methods used here were characterised as a strength because they excluded clinical confounds that hinder interpretation of the cognitive performance of people diagnosed with schizophrenia (Haddon, et al., 2011; Haselgrove & Evans, 2010). The analogue nature of our sampling could also be characterised as a weakness. For example, the current findings may not generalise perfectly to the learning of people diagnosed with schizophrenia. Also, the materials used here (printed words) are not well suited to application with patient groups because they rely on language competence and people diagnosed with schizophrenia often show language difficulties (Doughty & Done, 2014; Kremen, et al., 2000). The current materials may therefore be of limited use for application with patient samples. We have recently developed visual materials with lower linguistic demand (multi-coloured discs) and plan to test the generality of our observations with patient groups using these new materials.

The current observations were based on the conditional learning of Psychology undergraduates recruited in a university. The sample was predominantly young, white and female and so the generality of our findings to the general population and more specifically to people diagnosed with schizophrenia (who are predominantly male) could be questioned. Our analysis shares these limitations with the many other schizotypy studies that have recruited from Psychology undergraduate populations. Our findings offer only a tentative suggestion that primary cognitive impairment (impaired episodic coding) associated here with negative schizotypy traits may also (by analogy) play an important role in the aetiology of negative symptoms of schizophrenia. Our

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findings need to be replicated in a more generalisable sample and our procedures could be informative about the precise nature of declarative memory impairment observed previously in unaffected first degree relatives of people with schizophrenia (Cirillo & Seidman, 2003).

The current experiment did not allow detailed characterisation of the cognitive impairment underpinning either of the schizotypy trait dimensions that were examined. It was clear for example that the high negative schizotypy group showed impaired learning under conditions that should normally promote episodic representations. However, this decrement could be interpreted in terms of a bias towards selecting alternate memory systems (see Figure 2) rather than as a deficit in the specific system that our procedures were supposed to be activating. This issue can be resolved by employing tests designed to examine the nature of associative structures formed during learning. Hierarchical associative structures have been examined using a variety of procedures in people (Baeyens, et al., 2004) and nonhumans (Honey & Watt, 1998) and there are also procedures for examining the formation of configural representations (George & Pearce, 2012). Whether decrements in learning reflect memory deficits or selection biases should be illuminated by application of the above learning procedures.

Negative symptoms of schizophrenia have been most strongly associated with primary cognitive impairment (Nieuwenstein, Aleman & De Haan, 2001), patients with untreated negative symptoms and cognitive impairment have poorer functional prognosis (Carbon & Carroll, 2014). Our findings suggest that cognitive impairment may be behaviourally silent for much of the time, when semantic processes are able to mask episodic impairment. However, when circumstances prevent people using their compensatory semantic systems, perhaps when they encounter chronic or severe acute stressors or when events co-occur in unpredictable fashion, then over-reliance on rigid semantic declarative memory may lead to inappropriate choices of actions, choices may seem irrational and this could potentially contribute to the cycle of psychotic illness. Although our study used healthy volunteers, in the logic of analogue studies, our findings are potentially informative.

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about primary cognitive impairment and how this might lead to psychotic decompensation in schizophrenia.

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Figure 1. Biconditional discrimination learning for LOW versus HIGH Introvertive anhedonia and Unusual experiences groups over successive training blocks in the fixed locations condition.
Figure 2. Biconditional discrimination learning for LOW versus HIGH Introvertive anhedonia and Unusual experiences groups over successive training blocks in the variable locations condition.
Figure 3. Diagrammatic representation of various schizotypy groups’ reliance on episodic versus semantic coding in declarative memory under fixed and variable stimulus-stimulus conditions.
<table>
<thead>
<tr>
<th>Fixed Locations</th>
<th>Variable locations</th>
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<tr>
<td>Stimulus combinations</td>
<td>Outcome</td>
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<td>A → X</td>
<td>Profit</td>
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<td>A → Y</td>
<td>Loss</td>
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<tr>
<td>B → X</td>
<td>Loss</td>
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<tr>
<td>B → Y</td>
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**Conjunctive representation**

**Configural representation**

Table 1 – Design: Stimuli A, B, X & Y were commodities (Nickel, Platinum, Corn & Rice), commodity pairs predicted trial outcomes.
### Table 2

<table>
<thead>
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<th>Fixed locations (n=84)</th>
<th>Variable locations (n=82)</th>
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<td>High</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Removed</td>
<td>25.0%</td>
</tr>
</tbody>
</table>

Table 2. Shows the numbers included and percentages of participants removed for analysis following application of the sensitivity-based inclusion criteria for Introvertive anhedonia or Unusual experiences.