Individuals with high negative schizotypy learn conditional S-S relationships configurally, whilst individuals low on negative schizotypy learn them hierarchically

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Abstract

The study explored whether performance associated with high negative schizotypy result from impaired formation of hierarchical representations. Lower and higher negative schizotypy groups were created from normalised introvertive anhedonia scores from the O-LIFE scale. In Stage 1, a biconditional discrimination procedure was adopted (AX+,AY-,BX-,BY+). Letters specify commodities (rice, steel), either context (A,B), or target (X,Y). Compounds were followed by profit (+) or loss (–), which participants predicted. In Stage 2, participants learned a second biconditional discrimination (BP+,BQ-,XP-,XQ+). This functioned as a transfer of occasion-setting test, and as an associative revaluation of B (B was paired with P+ and not Q+). Generalisation between B and A was assessed with two compounds (AP+,AQ+) presented in a simple discrimination (AP+,AQ+,RS-,RT-) as a further test of hierarchical S-S structures. There were no differences in initial learning between lower and higher negative schizotpy groups. The lower negative schizotypy group showed transfer of occasion-setting, and acquired relational equivalence, between A and B; but the higher negative schizotypy group showed neither effect. These results indicate intact hierarchical learning in lower negative schizotypy, but a failure to form hierarchical S-S associations (plus reliance on configural learning) for those higher in negative schizotypy. These results provide a more precise characterisation of the context processing deficit in negative schizotypy.

Keywords: Biconditional discrimination; occasion-setting; hierarchical learning; negative schizotypy; configuration; schizophrenia; relational distinctiveness; relational equivalence.

Evidence suggests that learning deficits for individuals with high schizotypy levels may stem from a general context-processing deficit; that is, from an inability to use cues present during learning of simple associations to modulate performance (Cohen & Servan-Schreiber, 1992; Haddon et al., 2011). It is also thought that such an impairment in contextual control is associated with negative schizotypal characteristics (Haddon et al., 2011; 2014), but the nature of this contextual deficit is still unclear. Such contextual-processing problems may result from over-reliance on non-selective prediction error (Haselgrove & Evans, 2010), or extreme elemental processing in which each element on a complex cue to processed separately and not as a whole/compound (Haddon et al., 2014). Alternatively, those with high negative schizotypy may not encode hierarchical associations; that is, those associations between cues that signal when the relationship between other cues may hold. The current study aims to examine this issue using a bidirectional conditioning paradigm (biconditional discrimination), which allows exploration of several alternative theories regarding the impacts of high negative schizotypy on learning.

In a biconditional discrimination, individual conditional stimuli (CSs) do not predict the unconditional stimulus (US) reliably; instead, the US is predicted by combinations of CSs. For instance, stimulus X predicts the US when it occurs with stimulus A (AX+), but does not when it occurs with stimulus B (BX-). Conversely, stimulus Y predicts the US when presented with stimulus B (BY+), but not when presented with A (AY-). Biconditional learning, therefore, requires attention to all cues, on all trials, and the operation of a process that overcomes generalisation of A, B, X, and Y, between instances when they are, and are not, followed by the US.

----Table 1----

There are three plausible explanations regarding how learners ‘solve’ biconditional discriminations (Table 1). One view suggests that combinations of CSs may expose learners to patterns of stimulation unique to each type of learning trial ('trial-specific unique cues'; Rescorla, 1973; Table 1, top panel). The learner attends to the unique cues, rather than the stimuli from which they are derived. Representations of unique patterns of stimulation for the unique cues become associated with the US in the same fashion as they would in simple excitatory conditioning (Rescorla & Wagner, 1972). A second view postulates that the operation of episodic memory processes combines (or configures) all stimuli present on any learning trial, so that multiple CSs are represented as an integrated whole (Table 1, centre panel). These 'configural' representations form associations with the US (Pearce, 1987). A third view supposes that CS-representations enter into hierarchical associations with one another (Table 1, bottom panel). The representation of a contextual (occasion-setting) cue acts as a gate (or switch) that enhances an otherwise weak CS–US association (Bonardi et al., 2012; Holland, 1983; 2008). Hierarchical accounts suppose that contextual stimuli are processed differently from the target stimuli they disambiguate, as occasion-setting cues can become functionally distinct from simple CSs (Hardwick & Lipp, 2000). For instance, occasion-setters are better able to transfer their gating function to novel target stimuli than cues not treated as occasion-setters (Baeyens, et al., 2001; Holland, 1989).

Hierarchical learning has been demonstrated using discrimination paradigms such as transfer of occasion-setting following patterning-discrimination learning. The first stage of an occasion-setting transfer experiment involves positive-patterning discrimination (AX+,X-,B+); outcomes follow the target (X) only when X is preceded by an occasion setter (A), whilst B is trained as a simple exciter. Thus, A and B are matched for associative strength because both predict the outcome perfectly, but A differs from B because it serves an occasion-setting function with respect to X. The formation of a hierarchical relationship between A and X is demonstrated when A acquires superior discriminative control (relative to B) in a novel discrimination with new targets (AY+,Y-,BZ+,Z-). The hierarchical roles of stimuli in this learning are defined by the spatial and temporal relationships between stimuli, as well as by their functional roles, and failures to observe hierarchical associations occur when task parameters have not ensured consistent spatial or temporal separation of context and target stimuli (Bonardi et al., 2012).

Patterning-discrimination demonstrates a test for hierarchical context-processing, but the same argument can be applied to processes operating in more complex forms of discrimination learning. In a simple-patterning design, one context stimulus disambiguates a single target; but in a biconditional discrimination (AX+,AY-,BY+,BX-), two contexts (A & B) simultaneously disambiguate two targets (X & Y) in opposing ways. Haddon et al. (2011) reported higher negative schizotypy impaired acquisition of a biconditional discrimination, and argued that impaired acquisition could be explained in terms of context-processing deficits, possibly due to negative schizotypy diminishing the ability of the contextual cues to disambiguate target-outcome associations. However, Haddon et al. (2011) did not provide evidence that the discrimination was acquired hierarchically; participants may have employed a configural strategy (Pearce, 1987), and deficit may have been in forming such configural representations. Accurately characterising the nature of deficits associated with negative schizotypy is important as it allows clearer understanding of the underlying cognitive processes.

The current study examined context-processing in negative schizotypy, by testing for reduced deployment of hierarchical associations during acquisition of a biconditional discrimination. The focus was on negative schizotypy as contextual-learning deficits are specific to the introvertive anhedonia (negative) dimension of schizotypy (Haddon et al., 2011; 2014). One way to examine the adequacy of hierarchical accounts is to determine whether contextual and target stimuli acquire qualitatively distinct roles during biconditional discrimination learning. Such a test is equivalent to tests of transfer of occasion-setting used in nonhuman learning (Holland, 1989). Hierarchical representations can also be evaluated using acquired relational equivalence and distinctiveness of cues (Honey & Watt, 1998). If the context-processing account is correct, then transfer of occasion-setting and acquired relational distinctiveness must normally characterise human biconditional discrimination performance, and deficits in transfer of occasion-setting and/or acquired relational distinctiveness should be observed with high negative schizotypal traits. If those with high negative schizotypal traits show the same levels of transfer of occasion-setting and relational distinctiveness, then their ability to form hierarchical representations must be intact, and the context-processing account must be incorrect.

Method

Participants

Eighty-four undergraduate Psychology students (60 female, 24 male), with a mean age of 22 ($\pm$SD=5.4; range=19-56) years, were recruited initially during a regular practical workshop, and were fully debriefed about the design and purpose of the study after completion of the experiment. All were volunteers, not compensated for their participation, and native English speakers. G-Power suggested that, with a medium-effect size of .25 (Baeyens et al., 2001; Haddon et al., 2011), with $p < .05$, and 80% power, a mixed-model ANOVA modelling predicting within x between group interactions would need 24 participants.

Participants were assigned to one of two groups on the basis of their introvertive anhedonia sub-scale score from the Oxford and Liverpool Inventory of Feelings and Experiences (O-LIFE, Mason et al., 1995). This scale has 27 items, giving a score range of 0-27, and has reported internal reliability (Cronbach α) of .82 (Mason et al. 1995). Mason and Claridge (2006) reported the means, standard deviations, and 25^{th}, 50^{th}, and 75^{th}

percentile to be: females = 7.23±4.54; 2, 4, 7; and males = 8.59±4.77; 2, 5, 9. The means for the current sample was lower than this: females was 4.48 (±3.51; range=0-16); and for males it was 7.21 (±5.28; range=2-19). Although displaying somewhat lower scores than the norms reported by Mason, current participants were grouped in accordance with published age and gender norms for this trait (Mason & Claridge, 2006). Participants scoring in the second and third quartiles were assigned to the 'normal' functioning (Control) group (*n*=33), and those in the upper-most quartile were assigned to the Negative Schizotypy group (*n*=24). The lower scores in the current sample meant more participants than expected (32%) were in the bottom normed quartile. However, group assignment was not associated with gender, X^2=2.709, *p*=.258, and this factor was disregarded from subsequent analyses. Those in the bottom-most quartile (*n* = 27) were excluded as it is unclear whether low scores indicate a deviation from 'normal' function. The study was granted ethical approval by the Cardiff School of Health Sciences Research Ethics Committee.

Design

----Table 2----

The current Experiment had three Stages (Table 2). Stage 1 employed a biconditional discrimination (AX+,AY-,BX-,BY+) to replicate previous observations of impaired biconditional discrimination learning with negative schizotypy (Haddon et al., 2011). Stage 2 used another biconditional discrimination (BP+,BQ-,XP-,XQ+) designed as a test for transfer of occasion-setting. It used two novel stimuli (P & Q) as targets, and two stimuli (B & X) as contexts used previously in Stage 1. One of these cues (B) had served as a context stimulus in Stage 1, whilst the other (X) had served as a target stimulus. If, in Stage 1, participants processed A and B as context cues (occasion setters), and X and Y as target cues, then cue B should transfer its occasion-setting function more readily than X; that is, there would be superior acquisition of the portion of the biconditional discrimination mediated by B, relative to X, during the transfer test of Stage 2. If impaired biconditional discrimination learning in negative schizotypy results from a context-processing deficit (Haddon et al., 2011), then high negative schizotypy sample would be associated with a selective deficit in the magnitude of transfer of occasion-setting; that is, a reduction in difference between B and X in terms of their ability to acquire conditional discriminative control would be observed. Stage 3 provided an additional analysis of the associative structures involved in these tests. This test was based on methods employed with rats by Honey and Watt (1998; Experiment 2), and was designed as a test of acquired relational distinctiveness, based on the logic of backward sensory preconditioning (Ward-Robinson & Hall, 1996). Specifically, the presentation of P+ in compound AP+ should associatively activate a representation of B, due to Bs pairings with P+ in Stage 2 (BP+). However, because stimulus A was paired with the opposing set of associations, relative to B, in Stage 1 (AX+,AY-,BX-,BY+), then the associatively activated representation of B was expected to interfere (or compete with) the directly activated representation of A; if participants had represented the stimulus-stimulus associations in Stage 1 using hierarchical structures, a decrement in responding to AP+ was expected (relative to AQ+). Compounds RS- and RT- were included in the procedure of Stage 3 to keep conditions between the three stages of the experiment similar. These two compounds ensured that participants were still required to learn a discrimination (A+ vs R- (AP+,AQ+,RS-,RT-)), and that the trial-by-trial probability of the two outcomes was the same (50%) as in the previous two stages of the experiment.

The current method was somewhat simpler than that employed previously, but it was based on the same logic. In the Stage 1, participants were taught that context stimuli A and B were paired with opposing stimulus-outcome (S-O) associations involving target stimuli X and Y (AX+,BX-,AY-,BY+). In Stage 2, B was revalued through pairing B with a new set of

S-O associations (BP+,BQ-). The role of X switched from a target to a context, and XP-XQ+. Stage 3 tested whether the revaluation of B in Stage 2 had generalised to the other context stimulus from Stage 1 (A). This was achieved by presenting A in two novel compounds (AP+,AQ+). By virtue of the Stage 2, revaluation of B, the first of these S-O associations, was signalled by P (i.e. P+), whilst the other was not (i.e. Q+).

Materials

The Oxford and Liverpool Inventory of Feelings and Experiences (O-LIFE, Mason & Claridge, 1995) was used to measure schizotypal personality traits. The test has good test-retest reliability > .70 (Burch et al., 1998), published norms (Mason & Claridge, 2006), and has been used in many previous studies exploring associations between schizotypy and learning (Haselgrove & Evan, 2010; Haddon et al., 2011; 2014).

The experimental task was programmed using Visual Basic, and was a variant of the allergist paradigm (Haselgrove & Evans, 2010; Haddon et al., 2011; 2014). The task required participants to imagine that they were stockbrokers with the goal of determining which commodities predicted profit, and which predicted loss. Nine commodities (Nickel, Platinum, Corn, Rice, Beans, Carrot, Copper, Oats, and Potato) were randomly allocated to represent experimental stimuli (A, B, X, Y, P, Q, R, S, & T).

Table 2 shows the combinations of stimuli and the trial outcomes employed during the three Stages of the experiment. In Stage 1, two stimulus combinations, AX and BY, were paired with the profit outcome; whilst AY and BX were paired with loss. These four trial types were randomly presented once in 20 consecutive learning cycles. In Stage 2, stimulus combinations, BP and XQ, were paired with profit; whilst BQ and XP were paired with loss. These four trial types were randomly presented each in 10 consecutive learning cycles of trials. Stage 3 presented a further four novel stimulus compounds, and outcomes were arranged in accordance with a simple discrimination, AP and AQ, were paired with profit, while RS and RT were paired with loss. These four trial types were randomly presented once each in 10 consecutive learning cycles of trials.

In order to observe occasion-setting, context stimuli were always presented on the left of the screen, whilst target cues were presented on the right (Bonardi et al., 2012). Participants were not instructed about the spatial location of cues, but this context-left and target-right arrangement was chosen to exploit the natural tendency for English speakers to read from left to right, therefore, perceiving and processing the cues on the left first, so that these might act as contextual cues that would ‘set the occasion’ for processing of target cues to the right. Pairs of context and target stimuli were always presented simultaneously.

Procedure

Participants completed the experiment in a teaching laboratory with 32 Viglen desktop computers, each with a 19-inch flat screen monitor. Alternate computers were used, so that none of the participants sat directly next to one another to minimise distraction. Participants were tested in batches of 7-15 at a time. The schizotypy status of the students was not known to either the experimenter or participants at the time of test administration.

On each trial, of all Stages, of the experiment participants were presented with two commodities (e.g., Copper and Rice), and were required to provide a rating (by selecting a number on the computer keyboard) that reflected their confidence that each specific trial type predicted one of two possible outcomes. 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 feedback at the bottom of the screen indicating the actual outcome of the trial. The outcome indicating profit was: “*The stocks MADE money*”, presented in green print; and the outcome indicating loss was: “*The stocks LOST money*”, presented in red print. Outcomes were independent of participant responses, and were presented in accordance with the contingencies of the experiment (Table 2). 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 screen using the mouse. Participants were not warned or briefed about the contingencies of the task, and the three stages of the experiment commenced automatically and seamlessly.

Results

Discrimination performance was calculated as the mean difference between confidence ratings for Profit outcome trials minus the mean confidence ratings for Loss outcome trial ((AX + BY)/2) – ((AY + BX)/2). Scores ranged from +8 (perfect discrimination), through 0 (uncertainty), to -8 (perfectly incorrect responding).

----Figure 1----

Figure 1 presents the mean biconditional discrimination performance for Control and Negative schizotypy groups over the 20 training trial cycles of Stage 1. These data indicate no difference between Control and Negative Schizotypy groups. A two-way mixed-model ANOVA, with trial (training cycle 1-20) as the within-subjects factor, and group (Control vs. Negative Schizotypy) as the between-subjects factor (along with effect sizes and appropriate Bayes statistic) revealed a significant main effect of trial, $F(19,1045)=12.24$, $p<.001$, $\eta^2_p=.191$, $p(H_1|D)=.999$, but no main effect of group, $F(1,55)=1.28$, $p>.05$, $\eta^2_p=.023$, $p(H_0|D)=.999$, or interaction, $F(19,1045)=1.05$, $p>.05$, $\eta^2_p = 0.19$, $p(H_0|D)=.999$.

----Figure 2-----

A further analysis was conducted to contrast accuracy between the Control and Negative Schizotypy groups during acquisition of the biconditional discrimination. Discrimination performance was conducted on the probability of correct responses, and reflected the proportion of profit trials in which responding was higher than to any of the loss trials (i.e. AX+ > AY- **and** > BX-; BY+ > AY- **and** > BX-). In each cycle of trials, when ratings in profit trial were lower than both loss trials, a value of 0 was recorded (perfect inaccuracy); when ratings for profit trials were higher than only one loss trial, a value of 0.5 was recorded (chance); and, if ratings were higher in the profit trials than in both loss trials, a value of 1 was recorded (perfect accuracy). These accuracy scores indicated the proportion of time participants responded in accordance with the contingencies of the biconditonal discrimination. Figure 2 presents these data, and indicates both groups learnt the biconditional discrimination with equivalent accuracy. A mixed-model ANOVA (trial x group) revealed a significant main effect of trial, $F(19,1045)=8.73$, $p<.001$, $\eta^2_p=.137$, $p(H_1|D)=.999$, but no main effect of group, $F<1$, $\eta^2_p=.01$, $p(H_0|D)=.839$, or interaction, $F(19,1045)=1.16$, $p>.05$, $\eta^2_p=.021$, $p(H_0|D)=.999$.

Analysis of associative structures – Transfer of occasion-setting

The following analyses were designed to examine whether Control and Negative Schizotypy groups used hierarchical representational structures to solve the biconditional discrimination during Stage 1, and whether groups differed in their capacity to use contextual cues (occasion setters). If occasion-setting had been used in Stage 1, there would be superior acquisition of the portion of the biconditional discrimination mediated by B (because B was used as a context stimulus in both Stage 1 and Stage 2), relative to X (which was used as a target stimulus in Stage 1, but as a context in Stage 2), during the transfer test of Stage 2. Interpretation of Stage 2 performance is dependent upon the extent to which individuals had learned the contingencies of Stage 1 biconditonal discrimination. Inclusion of participants who had not acquired the discrimination would obscure transfer of occasion-setting. Consequently, participants were included only if their learning by the end of Stage 1 exceeded an inclusion criterion that reflected the accuracy of their performance. Accuracy was calculated over the final four cycles of training trials of Stage 1. The accuracy inclusion criterion was set at .75, as to attain this score (and above) participants must have been performing accurately in all components of the discrimination. The application of this inclusion criterion resulted in 17 participants from the Control, and 10 from the Negative Schizotypy, groups being excluded from all subsequent analysis. The exclusion of participants was not associated with group membership (p>.05).

----Figure 3----

Mean discriminative control exerted by B and by X during Stage 2 is separately presented for participants in the Control and Negative schizotypy groups in Figure 3. Discriminative control exerted by B was calculated using the mean difference in ratings between profit trials and loss trials containing B (BP minus BQ). Similarly, discriminative control exerted by X was calculated using the mean difference in ratings between profit and loss trials containing X (XQ minus XP). Figure 3 indicates that the Control group showed superior discriminative control by B relative to X in the early trials of the test, suggesting a transfer of occasion-setting effect. In contrast, the Negative Schizotypy group appeared to show superior discriminative control with X, rather than B, in the later trials.

A three-way mixed-model ANOVA (contextual cue (B vs X), time, and group) revealed no main effects of contextual cue, F<1, $p(H_0|D)$=.854, or group, F<1, $p(H_0|D)$=.878, but there was a significant contextual cue x group interaction, $F(1,28)$=5.94, p<.05, η^2_p=.175, $p(H_1|D)$=.969. There was no three-way interaction, F<1, $p(H_0|D)$=.999. Post hoc analysis found no between group differences, all ps > .05, but within-subjects pairwise comparisons showed that for the Control group learning with B as a context cue was superior to X (mean difference = 1.08, p<.05); i.e. a transfer of occasion-setting effect was observed. The

Negative Schizotypy group showed no difference in discriminative control for B relative to X (mean difference = .71, p>.05; i.e. there was no transfer of occasion-setting effect.

Analysis of associative structures – Acquired relational distinctiveness

----Figure 4----

Figure 4 presents the results of the acquired relational distinctiveness test in Stage 3. Confidence ratings for compounds AP and AQ started around uncertainty in the first cycle of trials for both Control and Negative schizotypy groups. No informative comparisons were expected for compounds RS- and RT-, because the CSs were all novel, and data from these learning trials were excluded from analysis. In the Control group, confidence ratings rose sharply for AP in the 2nd cycle of trials, and dropped to uncertainty in the 3rd cycle. The confidence of the Negative schizotypy group for AP and AQ did not appear to change over the three cycles of trials. A three-way ANOVA (contextual cue, trial, group) was used to analyse the confidence data for the first three training cycles of Stage 3, the remaining seven cycles of trials were discarded from analysis because the simple discrimination of Stage 3 was expected to obscure any subtle effects based on acquired relational distinctiveness. There was a significant three-way interaction, $F(2,56)=4.30$, p<.02, $\eta^2_p=.13$, $p(H_1|D)=.504$, all main effects and two-way interactions were nonsignificant (largest F value was main effect of time $F(2,56)=1.94$, $p=.15$, $\eta^2_p=.07$; in all other instances, $Fs<1$. Separate two-way ANOVAs (trial and stimulus) revealed that, for the Control group, there was no main effects of stimulus $F(1,15)=1.14$, $p>.05$, $\eta^2_p=.07$, $p(H_0|D)=.513$, or time $F(2,30)=2.36$, $p>.05$, $\eta^2_p=.14$, $p(H_0|D)=.521$, but an interaction, $F(2,30)=5.17$, $p<.02$, $\eta^2_p=.26$, $p(H_1|D)=.988$. Pairwise comparisons for AP vs. AQ in each of the three test cycles revealed no difference between AP and AQ, but confidence scores were higher for AP than AQ on the second cycle

(Mean difference = 2.75, p<.01). Two-way ANOVAs for the Negative Schizotypy group yielded no significant main effects of time or stimulus, and no interaction, Fs<1.

Discussion

The current study examined the context processing deficit account (Cohen Serben-Schreiber, 1992) of poor biconditional discrimination performance for negative schizotypy (Haddon et al, 2011) by testing for evidence of reduced deployment of hierarchical associations during the acquisition of a biconditional discrimination. This was achieved using transfer of occasion-setting (Holland, 1983), and acquired relational distinctiveness (Honey & Watt, 1998), tests. The Negative Schizotypy and Control groups' ability to learn a biconditional discrimination was indistinguishable from one another. However, while the Control group displayed transfer of occasion-setting, and acquired relational equivalence (Honey & Watt, 1998), the Negative Schizotypy group did not. This suggests the Control group formed hierarchical associative structures during biconditional discrimination learning, whilst the Negative Schizotypy group did not. It can be supposed that the Negative Schizotypy group must have learned about the values of commodity compounds by using one of two forms of configural structure, either unique cues (Rescorla, 1973), or encoding episodic configurations (Pearce, 1987), see Table 1.

The absence of both transfer of occasion-setting, and acquired relational equivalence, in the Negative Schizotypy group is consistent with the context-processing deficit account in schizophrenia and schizotypy (Cohen & Servan Schreiber, 1992; Haddon et al 2011). The current results make a novel contribution as they suggest this context-processing deficit is characterised by an inability to encode stimuli as contexts, rather than as a deficit in using contextual representations to mediate conflicting or ambiguous responses (Barch, et al., 2004; Haddon et al 2011). This observation may have important implications for the neurological locus of impairment in negative schizotypy. One issue regarding the transfer of occasion-setting observed here. In the design employed, which is standardly used, A and B are contexts, and X and Y are targets, in Stage 1; in Stage 2, B remains a context, but the role of X switches from target to context cue. Superior acquisition of the portion of biconditional mediated by B, relative to X, indicates transfer of the occasion setting function of B. This is what is disrupted in those with high levels of introverted anhedonia. However, it is possible that the switch in roles for X causes less efficient learning, meaning that it is not the maintenance of the role of B that causes the effect, but the switch in role for X. The current result do not necessarily allow this to be addressed, and may be usefully explored in future work.

The performance of the Control group in the test of acquired relational distinctiveness (Stage 3) was informative regarding how context stimuli (occasion setters) are represented in biconditional discriminations. Based on experiments reported by Honey and Watt (1998), it was anticipated that context cues would become functionally more dissimilar (relational distinctiveness) when they signalled opposing stimulus-outcome associations, as they do in a biconditional discrimination. The observation of acquired equivalence (not distinctiveness) was counter-intuitive, and at odds with previous observations with rats as participants. This finding suggests that humans with lower levels of negative schizotypal traits may represent context cues more similarly, by virtue of their contextual ‘function’, rather than their specific associative ‘meaning’. The idea that context cues can receive privileged higher-order processing, and that this alone can form the basis for generalisation between them, is a novel observation that provides additional support for hierarchical accounts of learning (Holland, 1989). In order to account for the counter-intuitive findings, it must be supposed that Control participants encoded both the higher order status of context stimuli A and B (due to the observed acquired relational equivalence and transfer of occasion-setting) along with the specific associations that these context stimuli acted upon (because they were able to learn the biconditional discrimination). The relational equivalence performance of the Control group in the acquired distinctiveness test indicated that functional equivalence between contexts was more able to control behaviour than acquired distinctiveness when these forms of representation competed with one another in the acquired distinctiveness test. However, it should be noted that these interpretations are based on the results from trial 2 only, which may mean the effect is somewhat transitory in nature.

The findings of the current experiment are inconsistent with work exploring learning deficits in negative schizotypy (Haddon et al., 2011). Haddon et al. (2011) reported a deficit in biconditional discrimination (AV+,AW-,BV-,BW+) learning with high negative schizotypy, whilst learning of a concurrently trained simple discrimination (CX+,CY-,DX+,DY-) was intact. That there was no deficit in biconditional discrimination learning was a failure to replicate these earlier findings, and may be explained by a number of procedural differences. Firstly, Haddon et al. (2011) used a median split method, whilst a quartile splits for the age- and gender-normed distribution of introvertive anhedonia was currently employed. It might be noted that the current study employed the published norms for the OLIFE (Mason et al., 1995), but obtained scores were a little lower than these, meaning the distribution of scores tended to be towards the lower normed quartile. The reasons for this are unclear, but this issue may be examined in future work. Secondly, Haddon et al. (2011) used food items as conditioned stimuli, and allergy versus no allergy as outcomes, whilst the current procedure used commodities as conditioned stimuli and profit versus loss as outcomes. Thirdly, biconditional and simple discriminations were employed concurrently by Haddon et al. (2011), and it is possible that learning of the simple discrimination may have interacted with learning of the biconditional discrimination, with the former potentially producing a decrement in the latter. The complex design of the Haddon et al. (2011), therefore, makes interpretation of the reported deficit very difficult.

Transfer of occasion-setting indicated that the Control group in the current study used hierarchical associative structures to 'solve' the biconditional discrimination. It was not possible to determine, directly, which form of associative structure was used by the Negative Schizotypy group, although it is possible that they employed either unique cues (Rescorla, 1973), or episodic configurations (Pearce, 1987). Further experimentation is required to address this issue, and one useful way to proceed might be to alter the parameters of the biconditional discrimination so that alternate strategies for learning cannot be employed.

The cognitive deficit underpinning biconditonal discrimination performance in negative schizotypy in the current study had two characteristics. Firstly, people with many negative schizotypal traits did not represent the contexts and targets hierarchically. Secondly, their ability to learn was not impaired relative to controls, suggesting the deployment of alternative configural associative structures (e.g., Pearce, 1987; Rescorla, 1973). By inference, negative symptoms of schizophrenia may be related to the same abnormality in encoding hierarchical associations.

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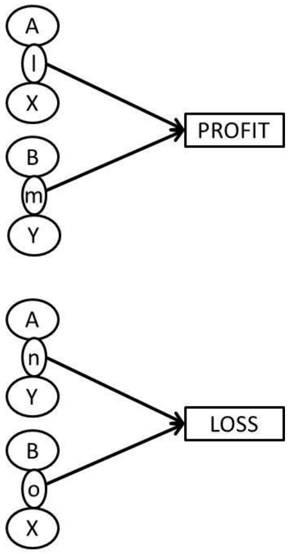
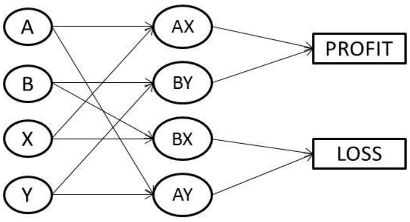
Table 1. Different associative structures that can account for biconditional discrimination learning.

Unique cues:



Configural learning:



Hierarchical learning:

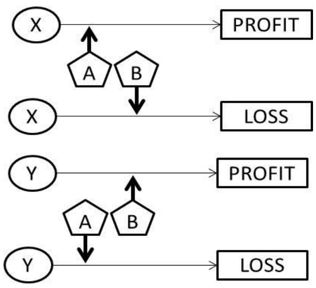


Table 2 – Design. Context stimuli were presented on the left of the screen, targets were presented on the right. Occasion setting was indicated by superior discriminative control by B rather than X in Stage 2. In Stage 3 acquired relational equivalence between A & B was indicated by higher confidence ratings for AP than AQ, acquired relational distinctiveness was indicated by higher scores for AQ than AP.

Stage 1 Biconditional discrimination			Stage 2 Occasion setting			Stage 3 Acquired relational generalisation		
Context	Target	Outcome	Context	Target	Outcome	Context	Target	Outcome
A	X Y	Profit Loss	B	P Q	Profit Loss	A	P Q	Profit Profit
B	X Y	Loss Profit	X	P Q	Loss Profit	R	S T	Loss Loss

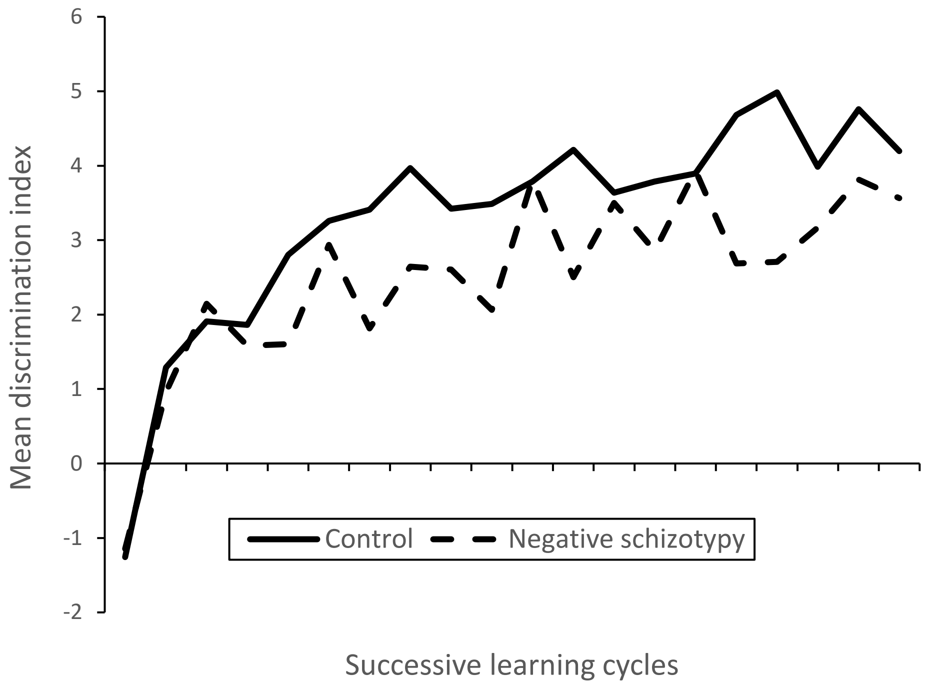


Figure 1. Mean discrimination index scores were calculated as the difference in confidence ratings between profit trials (AX+ & BY+) and loss trials (AY- & BX-) across 20 successive learning cycles of Stage 1 in Experiment 1 for the Control and Negative schizotypy groups.

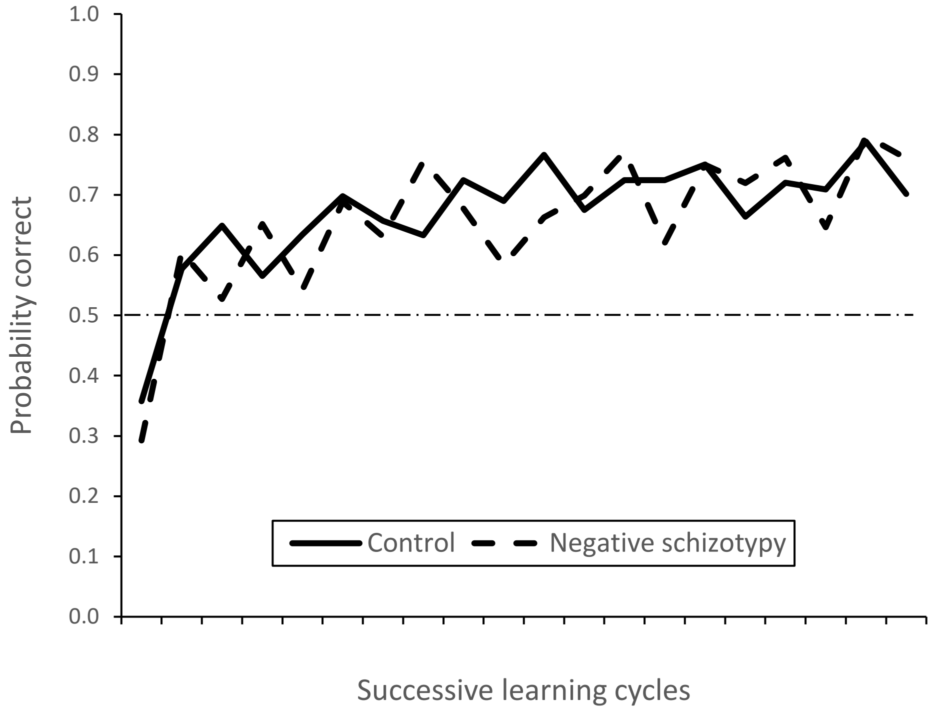


Figure 2. Mean accuracy of discrimination performance for the Control and Negative schizotypy groups in Stage 1 of Experiment 1. Accuracy reflects the proportion of the confidence ratings for profit trials (AX+ & BY+) that were higher than for both types of loss trials (BX- & AY-).

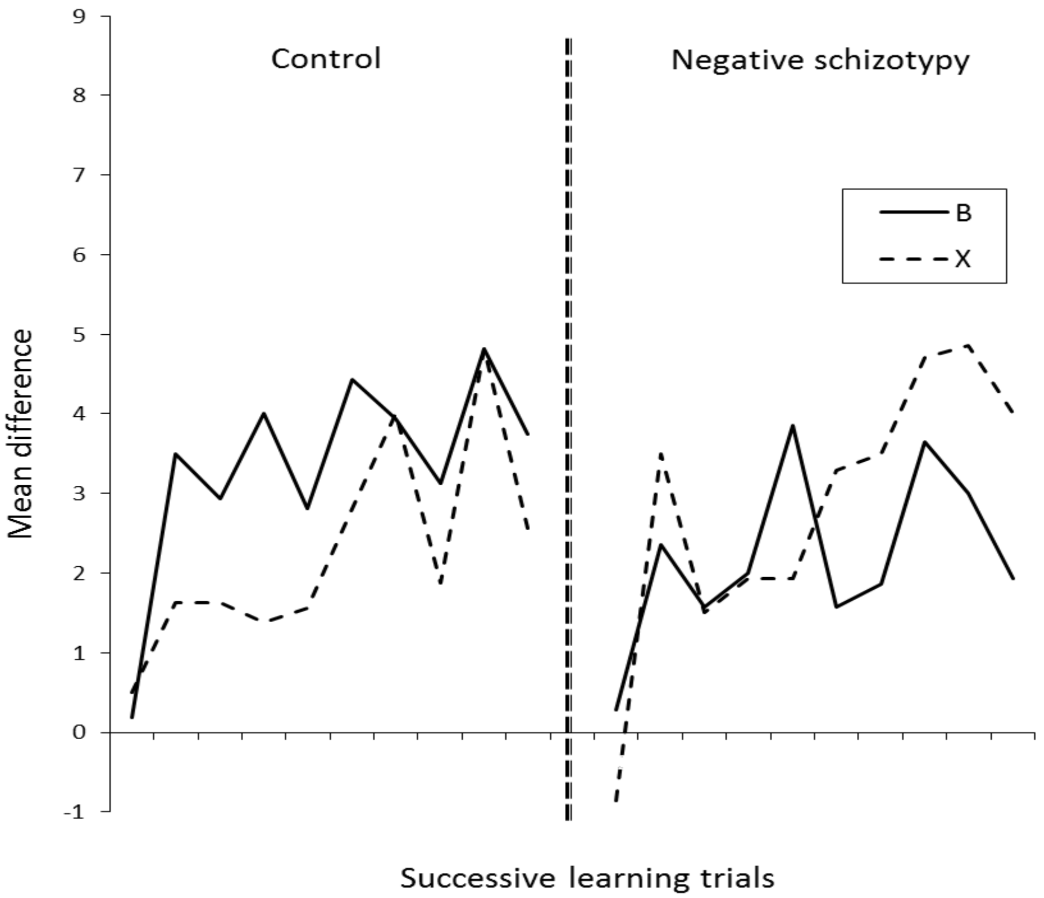


Figure 3. Mean discriminative control exerted by stimuli B & X across the 10 successive trial cycles of the transfer of occasion setting test (Stage 2). Discriminative control reflected the difference in confidence ratings between profit and loss trials including B (BP-BQ) versus X (XQ-XP).

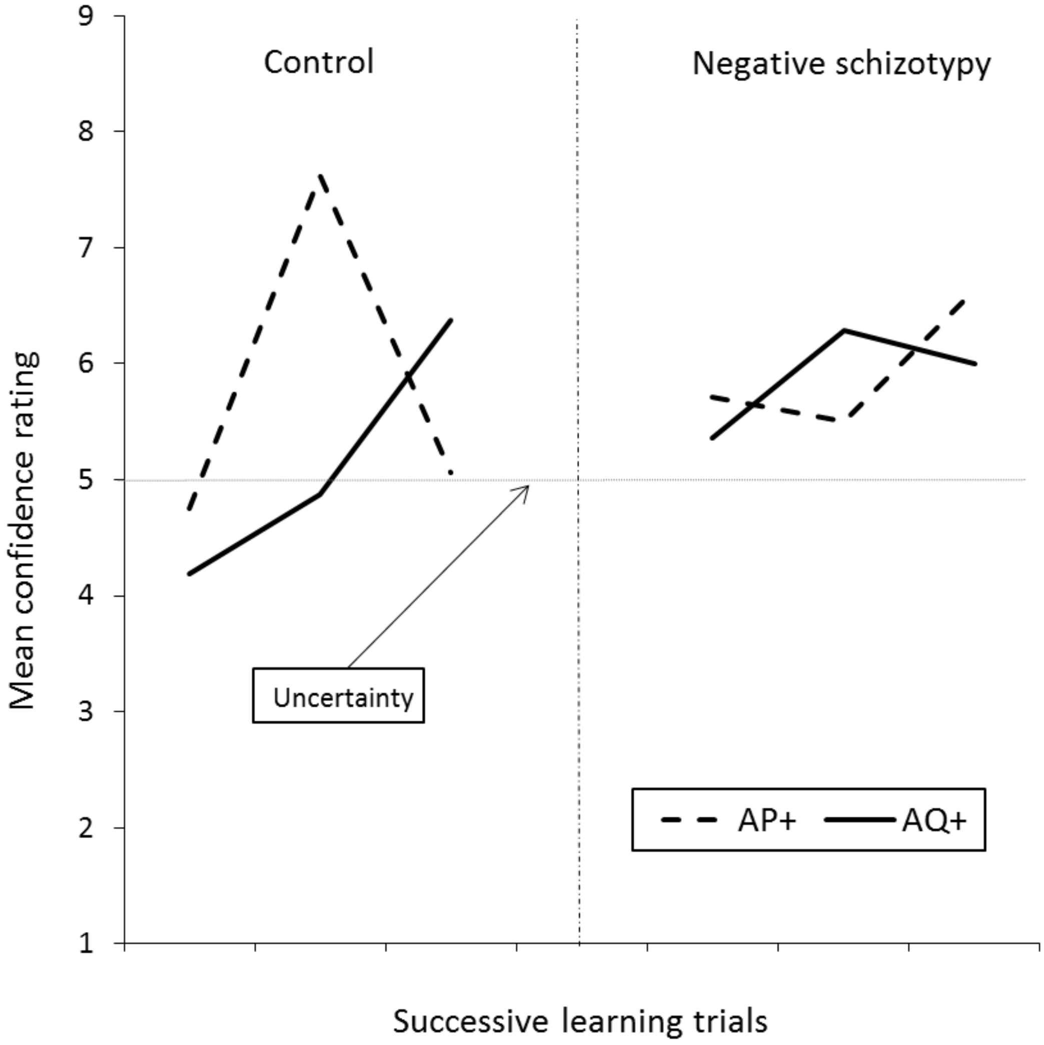


Figure 4. Mean confidence ratings for compounds AP and AQ in Stage 3 of Experiment 1. Higher ratings for AP indicate acquired relational equivalence, higher ratings for AQ indicate acquired distinctiveness.