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Dimensional approaches to experimental psychopathology of schizophrenia: shift learning and report of psychotic-like experiences in college students

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Abstract

Adopting a dimensional approach to experimental psychopathology, and taking into account inconsistencies in the previous literature, we examined whether reports of psychotic-like experiences in undergraduate students were associated with shift-learning deficits, akin to those seen in schizophrenia. The participants ($N = 72$) were tested on a new compound stimulus discrimination task before and after a target shift, and were administered a multi-dimensional schizotypy inventory (O-LIFE). Performance impairment following a target shift was associated with the negative (introvertive anhedonia) and the impulsive (impulsive non-conformity) dimension of schizotypy, but not with the positive (unusual experiences), nor the disorganised (cognitive disorganisation) dimension. None of the schizotypy measures were associated with performance on discrimination learning before the target shift. The obtained results are in line with past evidence that shift learning is associated with the severity of the negative symptomatology of schizophrenia. The possibility that psychotic-like features may

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contribute differentially to performance deficits across successive stages of learning is considered.

Keywords: Attentional set shifting; Concept learning; Negative schizotypy; Reversal shift learning; Rule learning; Social/interpersonal deficits; Stimulus discrimination

1. Introduction

Paradigms of learned inattention have been often used to investigate putative cognitive 'irregularities' and behavioural deficits in schizophrenia (see Crider, 1997; Oades & Sartory, 1997, for reviews). Typically, such paradigms study the influence of past associations on learning about new stimulus—response contingencies. For example, in shift learning paradigms (Amsel, 1992) the subjects initially learn that a certain stimulus (target discrimination) is the sole predictor of a significant event, such as reinforcement. In the next phase, the task requirement is shifted, as a previously irrelevant stimulus becomes the sole predictor of reinforcement (target shift). Shift learning has been found to be impaired in schizophrenic patients (Crider, 1997; Oades & Sartory, 1997), and has been linked to the neuropsychology of schizophrenia (Jentsch & Taylor, 2001).

The Wisconsin card sorting task (WCST), thought to be 'sensitive' to the function of the prefrontal cortex (see, Lezak, 1995; Reitan & Wolfson, 1994, for reviews), has been widely employed to assess attentional set shifting in schizophrenia. Interestingly, performance deficits on the WCST are reversible; such deficits can be modified through appropriate behavioural interventions, for example by employing training procedures based on learning principles (Goldman, Axelrod, & Tompkins, 1992; Kern, Wallace, Hellman, Womack, & Green, 1996). Impaired performance on the WCST has been associated with the severity of *negative* symptoms (i.e. symptoms referring to the *absence* of normal functions) but not with *positive* symptoms (i.e. symptoms involving the *presence* of abnormal experiences) such as hallucinations and delusions. Several investigations have reported an association between negative symptoms and performance on the WCST (e.g., Berman et al., 1997; Butler, Jenkins, Sprock, & Braff, 1992; Voruganti, Heslegrave, & Awad, 1997), although a number of studies have failed to provide evidence for such an association (Abbruzzese, Ferri, & Scarone, 1997; Collins, Remington, Coulter, & Birkett, 1997; Franke, Maier, Hain, & Klingler, 1992).

Performance on the WCST has been also found impaired in non-clinical participants who score highly on psychometric measures of psychosis-proneness, such as schizotypy (Daneluzzo, Bustini, Stratta, Casacchia, & Rossi, 1998; Gooding, Kwapil, & Tallent, 1999; Gooding, Tallent, & Hegyi, 2001; Laurent et al., 2001; Lenzenweger & Korfine, 1994; Poreh, Ross, & Whitman 1995; Raine, Sheard, Reynolds, & Lencz, 1992; Suhr, 1997; Suhr & Spitznagel, 2001; Tallent & Gooding, 1999). These data are in line with dimensional views of psychopathology (see Costello, 1994, for a review), and with evidence that self-report psychotic-like experiences in non-clinical participants can predict specific (and theoretically meaningful) patterns of performance, as assessed in various experimental paradigms (e.g., Merckelbach & van de Ven, 2001).

However, there is some inconsistent evidence in the WCST/schizotypy literature. According to some studies, impaired performance on the WCST has been exclusively associated either with 'negative' (Daneluzzo et al., 1998; Laurent et al., 2001; Raine et al., 1992; Suhr & Spitznagel, 2001) or with 'positive' schizotypy (Lenzenweger & Korfine, 1994; Poreh et al., 1995; Suhr, 1997), although in some studies performance on the WCST has been associated with both 'negative' and 'positive' schizotypy (Gooding et al., 1999, 2001; Tallent & Gooding, 1999). Given this inconsistency, it would be particularly informative to assess shift learning, as a function of different schizotypy dimensions, on a paradigm other than the WCST.

The WCST is a multi-faceted task; it seems to involve the interplay of domains such as spatial working memory, planning, abstract thinking, problem solving, and response inhibition (Lezak, 1995). Given that most of the above cognitive domains are likely to be impaired at some extent within the schizophrenia spectrum, the specificity of WCST as a measure of shift learning is limited. The WCST is made up of two sets of 64 different testing cards, containing all possible combination of colour (red, green, yellow or blue), shape (triangle, star, cross or circle), and number (1, 2, 3, or 4 coloured shapes). The participants are initially presented with a series of cards and they are asked to identify, through trial-and-error, a sorting principle/target stimulus. After a certain performance criterion is met, the target stimulus is shifted without warning. Following a rule shift, participants often get confused by the large number of different cards, having a difficulty in keeping in mind previous steps in order to identify the new rule (Barcelo & Knight, 2002).

It has been suggested (Lezak, 1995) that most participants would be able to identify the target rule, if the problem-solving character of this task was reduced. These controversial features of the WCST cast doubts on whether psychotic-like features in non-clinical participants are specifically associated with impaired performance on rule discrimination following a target shift. Such an uncertainty could be moderated if non-clinical participants were assessed on schizotypy measures, and were tested on a less complex paradigm of shift learning. One main problem with identifying specific cognitive deficits in schizophrenia relates to the heterogeneity of patient samples, as well as confounds such as floor effects due to generalised deficits, medication, poor motivation, and disruption caused by active psychotic symptomatology. Consequently, and in order to avoid such confounds, clinical research is often complemented through assessing non-clinical participants who show some sub-clinical features of schizophrenia, as assessed by psychometric measures of schizotypy.

The aim of the present investigation was to develop a less complex shift-learning paradigm[1] and assess shift learning as a function of different schizotypy dimensions.

[1]Although this *compound stimulus discrimination task* (CSDT) could be seen as a possible alternative to WCST in both clinical research and practice, such a development would require further validity studies with clinical populations and inclusion of additional similar tasks, which was beyond the aim of the present investigation. However, considering that card-shorting training in cognitive-behavioural therapies may have been over-emphasised, we do hope that other investigators will attempt to explore such a possibility.

Given past conflicting evidence, the present investigation examined whether shift learning would be associated with negative, positive or both negative and positive schizotypy.

2. Method

2.1. Design

The experimental task was designed to assess compound-stimulus discrimination, and subsequent target shift, in a within-participant experimental design. The task consisted of a computerised, rule-learning paradigm, in which participants had to identify a target compound stimulus through trial-and-error. The participants were simultaneously presented with three simple geometrical shapes (A, B and C), in three possible positions on the computer screen (1, 2, and 3). In phase I (discrimination), one shape was randomly defined as a target shape, and one position was randomly defined as target position. The combination between a target shape and target position was the to-be-found rule. In phase II (shift learning), the rule was shifted. One shape of the previously defined non-target shapes was assigned as target shape, and one position of the previously defined non-target positions was assigned as target position, creating a new rule. Table 1 presents a sample of four successive trials. The dependent measure was the number of correct responses, a traditional index of learning. Based on the principles of shift learning (Amsel, 1992), learning would be expected to be slower after the target shift (phase II) than during the initial target discrimination (phase I).

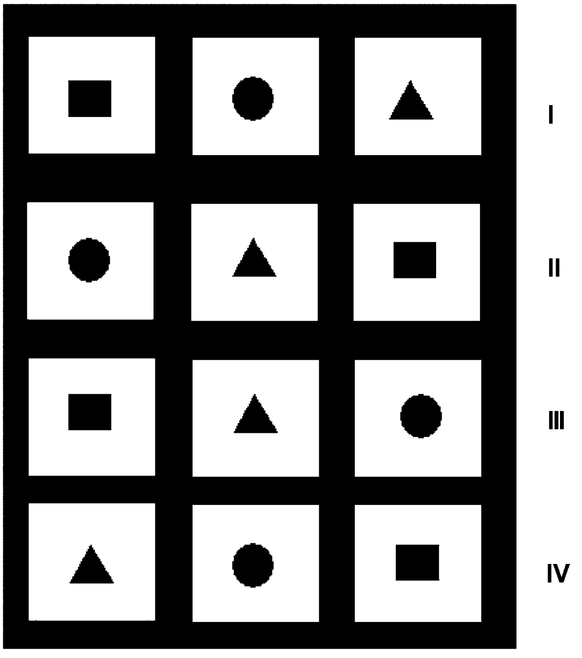
2.2. Participants

Seventy-two undergraduate students (28 males and 44 females), recruited from the UCL campus. The average age was 21.1 years, ranging from 18 to 28 years. The participants had normal or corrected-to-normal vision, and none of them admitted psychiatric or neurological history, learning disability or psychoactive medication use.

2.3. Stimuli and apparatus

Three geometrical shapes were used as component stimuli: a circle with diameter 4 cm (shape A), an isosceles triangle with side 4.5 (shape B), and a square with side 4 cm (shape C). In addition, three positions across the centre of a PC monitor were used as component stimuli: left (position 1), middle, (position 2) and right (position 3). Each shape was black, displayed on a white panel/position ($8.5 \times 8.5\,cm^2$) against a black background screen. The distance between each panel was 2.5 cm. The stimuli (Bitmap image files) were controlled by specially designed MS-DOS software, through which correct responses were also recorded.

Table 1
Sample of four successive trials



Component stimuli: shape A (circle), B (triangle) and C (square), position 1 (left), 2 (middle), and position 3 (right). The compound target stimulus C1 appeared in trials I and III (correct response: 'yes'), but not in trials II and IV (correct response: 'no').

2.4. Procedure

The participants were informed that were taking part in a computerised rule-learning task, and were seated in front of a PC in an individual cubicle. It was explained that they would be presented with three different shapes (A, B, and C), in three different positions (1, 2 and 3), and that they had to work out through the visual feedback (*correct* or *wrong*) what the rule was. On each trial, the stimuli were presented simultaneously. Two responses on the keyboard were possible, choosing either the *Y* (*yes*—the rule is present), or the *N* key (*no*—the rule is not present). Immediately after each response, the stimuli disappeared, and the appropriate feedback appeared on the screen. The rule for each set of trials was a random combination of a certain shape (for example, shape C) and a certain position (for example, position 1) creating a certain rule (i.e., the compound stimulus C1).

The participants received two sets of 18 trials. In the first set of 18 trials, (phase I / discrimination), they had to discover the target compound. In the second set of 18 trials (phase II /reversal), the rule was reversed. This change was announced to the participants. The current target compound was one of the previously non-target combinations, and the previously target compound became a non-target compound.

The shape/position combinations were counterbalanced across participants (Latin square). There was no time limit, and the target compound was present at the 50% of trials. No learning criterion was adopted (all the correct responses were recorded and subsequently analysed). Total number of correct responses was the dependent variable.

2.5. Schizotypy measures

O-LIFE. The Oxford–Liverpool Inventory for Feelings and Experiences consists of 159 items selected on the basis of factor-analytic studies of older scales assessing psychotic-like features in the general population (Mason, Claridge, & Jackson, 1995). Contributing to the experimental validity of this inventory, various studies have confirmed that high schizotypy scorers, as identified by the O-LIFE sub-scales, demonstrate cognitive deficits similar to those seen in schizophrenic patients (Burch, Steel, & Hemsley, 1998; Goodarzi, Wykes, & Hemsley, 2000; Gray, Fernandez, Williams, Ruddle, & Snowden, 2002; Tsakanikos & Reed, 2003). More specifically, it assesses the following dimensions:

Unusual experiences reflects the positive symptoms of psychosis, and consists of items assessing magical thinking, unusual perceptual aberrations, and hallucinatory experiences (e.g., *Are your thoughts sometimes so strong that you can almost hear them?*).

Cognitive disorganisation reflects the disorganised aspect of psychosis, and consists of items assessing difficulties with concentration and decision making, as well as social anxiety (e.g., *No matter how hard you try to concentrate do unrelated thoughts always creep into your mind?*).

Introvertive anhedonia reflects the negative aspects of psychosis, and consists of items assessing the lack of enjoyment from social contact, physical activities, coupled with aversion to emotional and physical intimacy (e.g., *Are people usually better off if they stay aloof from emotional involvements with people?*).

Impulsive non-conformity consists of items assessing aggressive, anti-social and impulsive behaviour (e.g., *Do* you *ever feel the urge to break or smash things*?).

3. Results and discussion

3.1. Schizotypy scores

Table 2 shows the means, standard deviations, and inter-correlations between the O-LIFE scales. The means, standard deviations, and the pattern of inter-correlations were comparable to these reported in the original study on the development of the scales (Mason et al., 1995), and to these reported in later studies (e.g., Tsakanikos & Reed, 2003). The inter-correlations between the O-LIFE scales suggest that most schizotypy symptoms are related to some extent (i.e. those with high positive symptoms also tend to have negative symptoms and high impulsivity). Inspection of Table 2 suggests that there were only small to moderate correlations. However, in order to control for this

Table 2
Means and standard deviations of the scales of the Oxford–Liverpool inventory of feeling and experiences (O-LIFE), and their inter-correlations

Schizotypy scale	Mean	SD	Range	1	2	3
1. Unusual experiences	8.77	5.62	25	—		
2. Cognitive disorganization	10.61	4.94	20	0.39**	—	
3. Introvertive anhedonia	3.61	3.41	15	0.27*	0.51**	—
4. Impulsive non-conformity	9.88	3.92	15	0.48**	0.14	−0.01

*$p<0.05$ (two-tailed).
**$p<0.01$ (two-tailed).

shared variance between the schizotypy measures regression analyses were subsequently (see 'compound stimulus discrimination and schizotypy scores') employed.

3.2. Compound stimulus discrimination

Fig. 1 presents performance (mean number of correct responses) as a function of learning phase (phase I—discrimination VS phase II—reversal), and block of trials (six-trial blocks). In phase I, performance appeared to increase gradually across the trials. In phase II, performance initially dropped when the rule was reversed (block 1), but then gradually increased across trials. The overall performance appeared lower in phase II than in phase I, especially in blocks 1 and 2.

These data were analysed by a 2×3 repeated-measures ANOVA, with 'learning phase' (phase I versus phase II) and 'block' of trials (1–3) as within-subject factors. The analysis revealed a significant effect of 'learning phase', $F_{(1,71)} = 5.26, p<0.05$, a significant effect of 'block', $F_{(2,142)} = 102.11$, $p<0.001$, and a significant interaction between 'learning phase' and 'block', $F_{(2,142)} = 5.16, p<0.01$. Follow-up t-tests (two-tailed) showed that the mean number of correct responses was significantly lower in block 1 of phase II than in block 1 of phase I, $t_{(71)} = 2.89$, and that the mean number of correct responses was significantly lower in block 2 of phase II than in block 2 of phase I, $t_{(71)} = 2.63$, both ps<0.05 following a bonferroni correction. There was no significant difference between block 3 of phase I and block 3 of phase II, $t<1$.

The above analyses confirmed that performance was significantly improved across trials for each learning phase separately. When the rule was reversed, the learning rate became significantly lower in phase II than in phase I. The results revealed that the reversal of the initial rule had a detrimental effect on learning rate during the phase II, especially during the early and middle stage (block 1 and 2) of this phase. Accuracy level was rapidly increased across blocks after few trials, suggesting that the discrimination procedure was a relatively simple task. During the initial discrimination, accuracy reached 63% after the first 6 trials, 78% after 12 trials, and 90% at the end of this phase (Fig. 1).[2]

[2]Similar results were obtained in a preliminary study that employed the same procedure in a different student sample ($N = 18$).

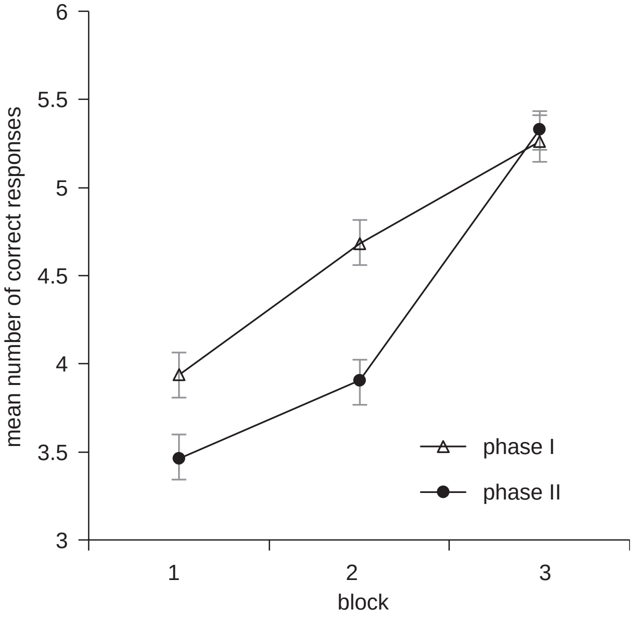


Fig. 1. Mean number of correct responses as a function of learning phase (phase I versus phase II) and block of trials (three, six-trial blocks).

3.3. Compound stimulus discrimination and schizotypy scores

To investigate whether scorers on different schizotypy measures could predict performance impairment on discrimination and shift learning, and to control for their inter-correlations, multiple regression analyses were performed. The number of correct responses was collapsed across trials for phase I, and phase II. In all subsequent analyses, the schizotypy scores were entered as predictor variables and the mean number of correct responses as the dependent variable.

For phase I (discrimination), the overall regression equation did not reach statistical significance, $F<1$, nor did any individual predictor, smallest $p>0.30$. For phase II (reversal), the regression equation was significant, $F_{(4,67)} = 5.29$, $p<0.001$, accounting for about 19% of the total variance (adjusted R^2). However, only the negative schizotypy ('introvertive anhedonia'), $\beta = -0.34$, $t = -2.75$, $p<0.01$, and the impulsive aspect of schizotypy ('impulsivity non-conformity'), $\beta = -0.26$, $t = -2.11$, $p<0.05$, were retained as significant predictors, any other $p>0.40$. The regression slopes for all the predictors were negative, indicating that an average increase in each of them was associated with a decrease in the dependent variable.

Given the obtained 'block' x 'learning phase' interaction (see analysis in 'compound stimulus discrimination'), regression analyses were then performed on each block separately for phase II (reversal). In block 1, the regression equation was significant, $F_{(4,67)} = 3.10$, $p<0.05$, accounting for about 10% of the variance (adjusted R^2), but only 'impulsivity non-conformity' made a significant contribution, $\beta = -0.30$, $t = -2.27$, $p < 0.05$, any other predictor, ps > 0.20. In block 2, the overall regression equation was significant, $F_{(4,67)} = 3.09$, $p < 0.05$, accounting for about 11% of the variance (adjusted R^2), but only 'introvertive anhedonia' made a significant independent contribution, $\beta = -0.33$, $t = -2.45$, $p < 0.05$, any other predictor, ps > 0.15. For block 3, the overall regression was not significant, $F < 1$, nor any individual predictor, ps > 0.20.

Overall, the above regression analyses revealed that schizotypy scores were associated with impaired performance during target shift, but not during the initial discrimination. Specifically, the impulsive aspect of schizotypy (impulsive non-conformity) was a significant predictor at the early stage of shift learning, while negative schizotypy (introvertive anhedonia) was a significant predictor of performance decrement at the middle stage of the same phase.

4. General discussion

The present investigation introduced a novel CSDT in order to assess shift learning. Performance impairment following a target shift was associated with specific dimensions of schizotypy. Performance impairment was associated with the negative (introvertive anhedonia) and the impulsive (impulsive non-conformity) dimension of schizotypy, but not with the positive (unusual experiences) nor with the disorganised (cognitive disorganisation) dimension. None of the schizotypy measures was associated with performance on discrimination learning before the target shift. These results are consistent with past evidence that shift learning, as assessed by the WCST, is primarily related to the severity of negative symptoms in schizophrenic patients (e.g., Berman et al., 1997; Butler et al., 1992; Voruganti et al., 1997), and negative schizotypy in non-clinical participants (Daneluzzo et al., 1998; Laurent et al., 2001; Raine et al., 1992; Suhr & Spitznagel, 2001).

The obtained pattern of results did not fully replicate past findings that shift learning, as assessed by the WCST, is associated with both negative and positive schizotypy (Gooding et al., 1999, 2001; Tallent & Gooding, 1999). A possible reason for this discrepancy could be due to fact that in the latter studies extreme schizotypy scorers were selected from a larger sample of non-clinical participants, and schizotypy was treated as a categorical variable.[3] In addition, these extreme scorers were tested on the WCST, a complex task that is likely to involve a number of different processes associated with both types of schizotypy. On the contrary, schizotypy was treated as a continuum variable in the present investigation, testing a

[3]We further selected 6 participants with the highest scores on positive schizotypy, 6 participants with the highest scores on negative schizotypy, and 6 controls (i.e. participants with low scores on all schizotypy measures) and we compared their performance in phase I and phase II. There were no significant differences between the 3 groups in phase I, $F < 1$. However, in phase II both positive and negative schizotypy scorers appeared to have lower performance than controls, $F(1,15) = 3.97$, $p < 0.05$. We take this as evidence that the extreme-scorers approach may obscure performance differences between two schizotypy groups.

single sample of undergraduate students on a less complex paradigm of shift learning. An alternative explanation for the partial discrepant findings between the present results and the previous Gooding et al. studies might be that in the latter studies participants scoring highly on positive schizotypy were perhaps also scoring highly on impulsive non-conformity. Taken together, these methodological differences may account for some inconsistencies in WCST/schizotypy literature, as highlighted in the introduction.

It could be argued that the association between negative schizotypy (introvertive anhedonia) and shift learning deficits might be due to lack of energy and depression that is often associated with anhedonia. However, lack of energy and/or depression would be expected to have an overall detrimental effect on both phase I (stimulus discrimination) and phase II (reversal shift), as the two phases were similar. Accuracy level in both phases was rapidly increased across blocks only after a few trials, suggesting that employed procedure was a relatively simple task. Furthermore, people with depression do not demonstrate performance deficits on shift learning tasks (see Elliott, McKenna, Robbins, & Sahakian, 1998).

One main argument for developing a new experimental procedure for assessing target/rule shift was that the WCST is a multi-factor task, which is that is likely to involve many different processes (e.g., spatial working memory, planning, abstract thinking, problem solving and response inhibition; Lezak, 1995), reducing the task's specificity as a measure of shift learning. It could be argued, however, that the present CSDT could involve similar confounding factors, such as problem solving and memory capacity. Although this is a plausible criticism, the main aim of the present investigation was to develop a less complex paradigm of shift learning, making less likely, albeit not completely excluding, even if this was ever possible, the potential involvement of other processes. In the CSDT, the stimuli were a combination of shape (triangle, circle or square) and position (left, middle or left). In contrast, each card-stimulus in the WCST constitutes a combination of shape (triangle, circle, star or cross), of colour (red, green, yellow or blue), and number (1, 2, 3, or 4 coloured shapes). Consequently, the CSDT is a comparatively less complex task than the WCST, and, therefore, less prone to possible confounds such as problem solving and memory capacity.

Shift learning is impaired in schizophrenia patients with preserved intellectual function, but not in patients with depression (Elliott et al., 1998), suggesting that such deficits are specific to schizophrenia rather than being the result of generalised deficits. Pantelis et al. (2004) propose that shift-learning deficits in schizophrenia represent a failure to generalise a previously learned rule, and an impaired ability to respond flexibly. Shift learning deficits are also associated with the duration of the psychotic illness (Pantelis et al., 2004), perhaps suggesting that the ability to learn that a previous irrelevant event can become subsequently relevant is a cognitive marker for the severity of schizophrenia symptoms. Correspondingly, duration of untreated psychosis is associated with impaired shift learning performance (Joyce et al., 2002). Given that such performance deficits can be reversed through appropriate cognitive-behavioural interventions (Goldman et al., 1992; Kern et al., 1996), a challenge for future research would be to examine whether reversal of shift-learning impairments could also improve clinical symptomatology.

In conclusion, the present investigation showed in a simple rule-learning paradigm that performance deficit after a single target shift was exclusively associated with the negative and impulsive dimension of schizotypy in a sample of undergraduate students. Furthermore, separate analyses on different block of trials during shift learning showed that performance deficit was initially (block1) associated with impulsivity, but later on (block 2) with negative schizotypy, a finding that could suggest that psychotic-like features contribute differentially to performance deficits across successive stages of learning. This latter possibility may well deserve further experimental attention. From the standpoint of therapy, detailed knowledge of learning deficits within the schizophrenia spectrum, as well as introduction of new experimental techniques assessing more specific aspects of performance, can contribute positively to the development of more effective behavioural interventions.

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