SCHIZOTYPY AND FLEXIBLE LEARNING: A PREREQUISITE FOR CREATIVITY?

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GENIUS AND MADNESS

The perceived relationship between creativity and mental health has had a long and colorful history (e.g., Brod, 1997; Eysenck, 1993; Folley and Park, 2005; Nettle, 2001; 2006). Formal and often more anecdotal research has tended to conclude that “genius” often carries with it the burden of “madness” (Bentall, 2003). Indeed, even a brief scan of the literature reveals a myriad of famous and highly successful authors, poets, mathematicians, and artists who reportedly lived in the shadow of mental illness, either within their family or directly. Authors such as Edgar Allen Poe, mathematicians including John Nash (Nasar, 1998) and Alan Turing (Hodges, 1992), composers like Beethoven (Mai, 2007), and Mozart (Lyon, in press), and others, such as Alexander Graham Bell (Carson, 2007), are all creative exemplars whose influential or even world-changing works seemingly came at the expense of their own emotional well-being.

CONVERGENT VERSUS DIVERGENT THINKING

However, amongst this varied group of imaginative individuals there is great diversity in type of creative output. One commonly investigated factor that has been used to explain these differences is that of “convergent” and “divergent” thinking styles (Andreasen and Powers, 1975; Keefe and Magaro, 1980; Nettle, 2006). A divergent thinking style is typically regarded as producing an advance in knowledge by finding novel associations between disparate concepts, and previously unrelated ideas. This cognitive style is usually regarded as flexible, unconstrained by convention, and serves as a generator of multiple novel ideas. Divergent thinking can be assessed in several ways; one typical measure is known as the alternate uses task where individuals must list as many uses for common household objects as possible (Guilford, 1967). Time is not a factor for the divergent thinker, and allowing the mind to wander unconstrained is key to the process. Successful creative outcomes can seemingly come from nowhere, Archimedes’ famous exclamation of “eureka” being one example of such success.

Convergent thinking, on the other hand, is seen to focus on pre-existing order, routine, and a narrow range of associations. Tasks involving convergent thinking often include arithmetic problems such as those found within the Wechsler intelligence scales (WAIS-III, Wechsler, 1997) and typically require use of logic. For example, “Linda had 8 yellow paper clips, 5 green paper clips, and 7 orange paper clips. She picked out one paper clip without looking. What was her chance of picking out a green paper clip?” (Wechsler).

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A convergent thinking style is often discouraged in students, with some teachers trying to promote a divergent thinking style, as it is oft regarded as the greater talent.

Whereas some might consider a convergent thinking style as the poor relation of divergent thinking, convergent thinking is in fact especially important within several creative domains, including mathematics and the hard sciences. Such subject areas tend to have had their greatest discoveries grounded in pure logic and reason, in topic areas with multiple boundary constraints, thus making them especially compatible with convergent thought processes.

**CREATIVE ABILITY AND MENTAL HEALTH**

An especially interesting aspect of recent research on cognitive style is the link between autism and autistic-like traits (i.e., Asperger’s syndrome) in those highly competent in applying convergent thinking methods. This cognitive style is sometimes described as systemizing, as it seems to be driven towards order and regularity (Baron-Cohen, Richler, Bisaraya, Gurunathan, & Wheelwright, 2003; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). However, despite the creative benefit that this cognitive ability may inspire, it is often found in association with poor social functioning and flattened affect—Dustin Hoffman’s portrayal as an autistic genius in the Rainman movie typifies this style of thinking at its extreme.

Individuals scoring highly on measures of convergent thinking tend to perform unsuccessfully on standard tests of creativity—those tests which try to capture the poorly specified, and seemingly “mystical,” thought processes associated with the divergent thinking style. However, high scores on standard tests of divergent thinking also tend to be predictive of scores on tests that measure susceptibility to psychosis (Fisher et al., 2004). Thus, much as convergent thinking and its creative output co-occurs with autistic-like traits, so that above average divergent thinking scores are also associated with a tendency towards (a quite different sort of) mental ill health.

In particular, those who are creatively gifted as measured by divergent thinking tests tend to be highly rated in schizotypy (Shulberg, 1988).

**ASSESSING VULNERABILITY TO SCHIZOPHRENIA: SCHIZOTYPAL PERSONALITY**

Schizotypy is the blanket term for a range of personality variables that can predict susceptibility to psychosis, and in particular, schizophrenia. Indeed, it has also been labeled psychosis-proneness (Claridge, 1985). Research on the topic has provided striking evidence to suggest that the symptoms of schizophrenia are merely at the extreme end of a continuum which ranges from healthy function, through eccentricity, to florid psychosis (e.g., Loughland & Williams, 1997; Nunn & Peters, 2001). However, there is abundant evidence that many people can have striking features of schizotypy, but never have any for-
mal mental health problems and do not tend to come into contact with psychiatric services (Nettle & Clegg, 2005). It is also important to stress that the schizotypal personality is multidimensional in nature, so that it is possible to exhibit certain personality traits consistent with schizophrenia without being psychotic.

There are inconsistencies in the literature regarding how many schizotypal dimensions there might be. All studies agree on two dimensions that map directly onto the clinical symptoms as displayed in those with schizophrenia. Firstly, a positive dimension, which is characterized by unusual experiences including visual and auditory hallucinations, together with magical thinking and perceptual aberrations (e.g., Schofield & Claridge, 2007).

There is also a negative dimension, which is described as introverted anhedonia, which includes social anxiety, an absence of close friends, and constricted affect (e.g., Schofield & Claridge, 2007).

A third factor of cognitive disorganization has more recently been seen as an additional, independent trait (whereas more traditionally it was considered to be part of the positive dimension). This factor is characterized by odd behavior and speech, purposelessness, and inattention (Raine, 1991).

A fourth factor of impulsive nonconformity is manifested in violent, self-abusive, and dangerous behaviors. However, this factor is most often seen to be consistent with sociopathy rather than schizophrenia, so is often not considered in studies of schizotypy which try to identify traits and behaviors which associate primarily with schizophrenia (Raine, 1991).

Thus, a three-factor model of schizotypy, inclusive of positive, negative, and cognitive disorganization factors, appears to capture the key dimensions of susceptibility to schizophrenia within the general population (Schofield & Claridge, 2007). Within this model, patients with schizophrenia score more highly than psychiatrically-normal individuals on each of the factors, with healthy relatives of such patients often displaying elevated levels in some, if not all, of the dimensions (Nettle & Clegg, 2005).

**THE PERSISTENCE OF SCHIZOPHRENIA**

Rather interestingly, recent research has focused on establishing why the heritable condition of schizophrenia remains persistent within the human population. Indeed, a genetic component to schizophrenia, and hence its prevalence within the gene pool (unbounded by culture), creates something of a paradox. Because schizophrenia is a chronic condition that ultimately reduces reproductive fitness, it would seem sensible to assume that the heritable traits associated with such a disorder would eventually cease to be passed on. This is, of course, not so, leading some researchers to suggest that there must be certain traits associated with schizophrenia that actually enhance fitness, and ultimately reproductive success (Nettle & Clegg, 2005). Such traits are likely to also be prevalent in relatives of people with schizophrenia; that is, those who would have elevated levels of schizotypy, but who would remain essentially healthy (Nettle & Clegg, 2006; Schofield & Claridge, 2007).
CREATIVITY, POSITIVE SCHIZOTYPY, AND MATING SUCCESS

In fact, several studies have found evidence to suggest that creativity might be the defining characteristic that has enabled the survival of schizophrenia-like traits within the population (Nettle, 2006; Nettle & Clegg, 2005). Thus, much like facial attractiveness or wealth, those deemed as creatively gifted are likely to have high levels of reproductive fitness. This success would not only ensure the survival of creative genius but, of course, would carry with it other schizotypal factors which may, given the correct circumstances, lead to psychopathology.

An especially interesting feature of the link between schizotypy and creativity is that elevations specifically in positive schizotypal traits (those mostly associated with magical thinking and unusual experiences) tend to strongly correlate with tests of creativity and divergent thinking (Nettle, 2006). Moreover, in poets, artists, mathematicians, psychiatric patients, and people from the general population, poets and artists were found to have scores within the positive domain that were as high as patients with schizophrenia. However, those highly creative individuals were differentiated from patients in terms of their negative scores. Whereas the psychiatric patients had very high negative scores, the psychiatrically-normal creative individuals had much lower scores on this factor (Nettle, 2006). Further, the mathematicians had positive scores lower than those provided by the general population. Their profiles were very different from both the psychiatric group and the poets and artists (Nettle, 2006).

Moreover, not only did writers and visual artists have higher positive (but not negative) scores than those in the general population, but they had a strikingly significant higher level of mating success (as defined by increased number of sexual partners) than those in the general population (Nettle & Clegg, 2005). Intriguingly, non-psychotic people rated with high negative scores (irrespective of positive score) not only had lower creativity scores than those from within the general population, but also had significantly fewer sexual partners (Nettle & Clegg, 2005).

Thus, the genetic basis of schizophrenia may be sustained in the general population through the reproductive effectiveness of those with the positive (and hence more creative) features of schizotypy (Nettle & Clegg, 2006; O’Reilly, Dunbar, & Bentall, 2001).

HEALTHY VERSUS UNHEALTHY SCHIZOTYPY

While it is clear that there are many advantages to the positive features of schizotypy, in terms of both creativity and reproductive success, there also appears to be substantial disadvantages to the negative features of schizotypy.

It appears that an increase in negative symptoms, namely, introvertive anhedonia, can be the critical indicator of poor mental health. Thus, although patients with schizophrenia are as highly rated in positive symptoms as healthy artists and poets, the elevated effects of negative symptoms in some patients can act to reduce the creative benefits that this might
bring. Indeed, non-psychotic individuals who have high negative schizotypy scores will be more at risk of developing several classes of mental health problems (Nettle, 2006; Nettle & Clegg, 2006; Schofield & Claridge, 2007).

Thus, it seems that in the absence of introvertive anhedonia, both high and very low positive scorers may yield creative successes. In the case of low scorers, a propensity to mathematical and scientific ability is the more likely route, whereas in high scorers, an affinity towards the written and visual arts is more common. However, both groups also tend to show vulnerabilities to clinical pathologies. The low positive group shows traits consistent with autism, and the high positive group exhibits traits consistent with schizophrenia (Nettle, 2006).

**CREATIVITY AND FLEXIBILITY: SCHIZOTYPY AND COGNITIVE FLEXIBILITY**

It has long been documented that people diagnosed with schizophrenia have specific deficits in cognitive flexibility (Koren et al., 1998; Pantelis et al., 1999; Van der Does & Van der Bosch, 1992). Traditionally, neuropsychological tests sensitive to frontal lobe functioning capture cognitive flexibility, of which there are two types (Dias, Robbins, & Roberts, 1996; Nelson, 1976).

**ATTENTIONAL SET-SHIFTING**

The first is known as set-shifting, which requires attentional inhibitory control. Impairments specifically to the lateral prefrontal cortex (an area consistently evidenced as a neural correlate of schizophrenia) impede this inhibitory control and thus the ability to set-shift (e.g., Nelson, 1976; Dias et al., 1996).

The Wisconsin Card Sorting Task (WCST; Nelson, 1976; see Figure 1) is the most common tool used to assess attentional set-shifting and requires individuals to sort cards dependent on differing “dimensional” rules. Participants have to logically deduce which rule the examiner has decided upon and must be able to “shift” this rule when the examiner decides to change it. In patients with schizophrenia, there is a tendency to persist in categorizing cards according to a previous dimensional rule, despite being told that a new rule has been introduced and categorization is now dependent on a different dimension (e.g., color rather than number; Grant & Berg, 1948; Pantelis et al., 1999). Such a failure in attentional set-shifting is known as perseveration and in the real world can cause many problems for people with schizophrenia.

Interestingly, failure on the WCST has been found to correlate with severity of negative but not positive symptoms of schizophrenia, and this has been paralleled with performance of people highly rated in the different dimensions of schizotypy (Tsakanikos & Reed, 2005).
REVERSAL LEARNING

The second type of cognitive flexibility (which again can be captured by certain neuropsychological assessment tools) is known as reversal learning, and is known to be related to functioning of the ventral prefrontal cortex. The ventral prefrontal cortex has received increasing attention in the literature on schizophrenia, mainly as it forms part of the limbic system and thus contributes substantially to the regulation of emotion. Modifications to this system, in particular the dopaminergic system have long been known to play a role in the development of schizophrenia, and indeed schizophrenia medication acts directly upon this system (Waltz & Gold, 2007).

Dias et al. (1996, 1997) created a novel paradigm in which it was shown that marmoset monkeys lesioned in ventral cortex were unable to flexibly respond to “changes in assignment of affective association” (1996, p.69). Dias’s experiment required monkeys to learn that response to one stimulus would provide a reward and that response to a second stimulus would not. After successful learning, the rewarding/non-rewarding stimuli were reversed. Results showed that, in contrast to tasks dependent on shifting attention between dimensions (e.g., 1a. Color = reward, 1b. Shape = irrelevant; 2a. Shape = reward, 2b. Color = irrelevant) the ability of which was preserved, when a stimulus-reward association was reversed within the same dimension (e.g., 1a. Blue = reward, 1b. Red = punishment; 2a. Blue = punishment, 2b. Red = reward), the ability to modify response to the originally rewarding stimulus was severely disrupted, leaving the monkeys incapable of inhibiting behavior which had previously been rewarding.

Thus, Dias et al. concluded that the ventral, and possibly medial, regions of prefrontal cortex underpinned the ability to modulate affective (and thus emotion-based) associations and that this was mediated by its relationship with the limbic system and, in particular, the dopaminergic system. Further, this type of cognitive flexibility dissociated with attentional set-shifting as mediated by lateral prefrontal cortex (Dias et al, 1996) and is known to be disrupted in people with schizophrenia.
We have only recently been able to investigate the issue of reversal learning in schizophrenia, but several studies have found impairments in reversal learning in patients with schizophrenia (e.g., Waltz & Gold, 2007). However, unlike studies which have investigated attentional set-shifting, many of these more recent studies have failed to establish whether there are differences in reversal learning dependent on positive versus negative symptoms.

One study that did investigate exactly this, however, used a novel modification to the widely used Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994; see Figure 2). This task has long been used to assess emotion-based decision making by essentially “playing off” low-risk, long-term cash rewards, against high-risk, long-term cash losses. The game is complex and ambiguous and requires that participants deploy affective learning strategies to guide card choices. People with schizophrenia tend to pass this reward-based decision-making game (Evans, Bowman, & Turnbull, 2005; Ritter, Meador-Woodruff, & Dalak, 2004; Shurman, Horan, & Nuechterlein, 2005; Wilder, Weinberger, & Goldberg, 1998), and this seems to be independent of underlying symptomatology (see Turnbull, Evans, Kemish, Park, & Bowman, 2006).

Thus, in the IGT, as in an attentional set-shifting game like the WCST, people with schizophrenia are capable of learning and performing well. However, as is often seen in the WCST, if rules regarding a previously learned strategy are changed, then often a catastrophic failure in performance occurs.

A MODIFIED IOWA GAMBLING TASK, REVERSAL LEARNING AND SCHIZOPHRENIA

Turnbull et al. (2006) adapted the IGT so that three reversal-learning phases would occur.
after the initial game had been played, that is, after rules regarding advantageous strategies had already been learned (see Figure 2). It was found that non-psychiatric control participants, and people with schizophrenia who were highly classified in positive symptoms, easily adapted to these reversals. However, participants rated highly in negative symptoms were unable to implement the new rules and thus were unable to negotiate the reversal learning phase of the game.

These data suggest that emotionally demanding tasks, such as IGT reversal learning, are selectively impaired in some patients with schizophrenia.

**REVERSAL LEARNING AND CREATIVITY?**

While much of the literature to date focuses on impairments in patients with schizophrenia, there are paradoxical signs in some studies of advantages in some domains. For example, during some of the reversal phases on the modified IGT, the patients with high positive symptoms were actually better at adapting to the reversals than were control participants; thus, demonstrating a possible improved flexibility with regard to reversal learning. This seems all the more striking given that the patients with schizophrenia examined in the Turnbull et al. (2006) study were all medicated, chronic in symptomatology, and living within residential accommodation.

This finding seems all the more interesting when framed within the context of creativity and psychopathology. Might it seem plausible that some of those people susceptible to psychosis-proneness and yet highly talented, might actually be more creative than the general population as a result of elevated ability for a possible precursor to creativity—namely, reversal learning (as assessed by emotion-related ventral prefrontal function)?

**AIMS**

Thus, the present study sought to investigate reversal learning on the modified Iowa Gambling Task in undergraduates highly rated in schizotypy. One might predict that schizotypal participants would learn the advantageous strategy while playing the original Iowa Gambling Task, given that this task can be performed normally even by those with diagnosed schizophrenia.

However, it might be predicted that those highly rated in negative traits (social anxiety, flattened affect) would perform poorly on the modified Iowa Gambling Task as a result of an inability to reverse previously learned associations. This finding would be relatively surprising, given that the schizotypals have no formal psychiatric history. Having poor performance on reversal learning in association with negative symptoms is a feature of schizophrenia.

Finally, there is the potentially paradoxical situation of those having strong positive traits of schizotypy (magical thinking, unusual beliefs) showing better than normal performance on the reversal learning component of the game.
METHOD

Participants

Four hundred and four undergraduate psychology students at Bangor University completed Raine’s Schizotypal Personality Questionnaire (SPQ; Raine, 1991) during class time. Of these students, 16 (8 female, overall mean age 22.8 years) formed the high schizotypy group, and 20 (16 female, overall mean age 21.85 years) comprised the low schizotypy group.

Measures and Design

The Schizotypal Personality Questionnaire (SPQ)

The SPQ is a well-known, thoroughly validated 74-question psychometric assessment tool designed to measure both the schizotypal personality as a whole, as well as the multidimensional nature of schizotypy (Raine, 1991). Each question requires a “yes/no” response with regard to personal experience with a particular occurrence.

The SPQ was developed based on the nine possible diagnostic criteria for schizotypy as documented in the Diagnostic and Statistical Manual (DSM-III-R; 1987). These nine features of schizotypy (inclusive of ideas of reference, excessive social anxiety, odd beliefs and magical thinking, unusual perceptual experiences, odd or eccentric behavior, no close friends, odd speech, constricted affect, and suspiciousness) can be measured either separately, overall, or categorized to reflect the dimensional nature of schizotypy—that is, positive, negative, and cognitive disorganization. Within the SPQ, confirmatory factor analysis has consistently provided evidence to support this three-factor model of schizotypy as represented in the questions presented in the SPQ.

Thus, those questions regarding ideas of reference, odd beliefs and magical thinking, unusual perceptual experiences, and suspiciousness can be summed to form the positive dimension. In total, 33 questions form this dimension, and questions such as: “Do you sometimes feel that things you see on the TV or read in newspapers have a special meaning for you?” and “Do you believe in telepathy (mind-reading)?” are representative of this factor. A “yes” response to any of these 33 questions represents an increase in positive schizotypy, therefore meaning that the highest possible positive schizotypy score is 33, and the lowest is 0.

Thirty-three questions comprise the negative schizotypal dimension, and these include the subscales of excessive social anxiety, no close friends, constricted affect, and suspiciousness. Such questions as, “I get very nervous when I have to make polite conversation,” and “I am mostly quiet when with other people,” comprise this negative dimension. A “yes” response to any of these 33 questions represents an elevation in negative schizotypy, with the highest score for negative schizotypy being 33, and the lowest being 0.

It should be noted that the eight suspiciousness questions from the SPQ (i.e., “I am sure I am being talked about behind my back.”) are represented in both the positive and nega-
tive dimensions of schizotypy, and thus, responses to these questions can be counted twice when categorizing participants based on dimensional classifications.

Sixteen questions regarding odd or eccentric behavior and odd speech form the third cognitive-disorganization dimension of schizotypy, and questions, such as “People sometimes comment on my unusual mannerisms and habits” and “I find it hard to communicate what I want to say to people” comprise this dimension. A “yes” response to these questions represents an elevated level of cognitive-disorganization, and thus the highest possible score for this dimension is 16, with 0 being the lowest.

As the SPQ hosts 74 questions in total, and a “yes” response represents an elevation in schizotypy, then it is possible to reach a highest possible score of 74 and a lowest possible score of 0 when measuring schizotypy as a whole (rather than by dimension).

The SPQ has been validated cross-culturally and its norms have been replicated with many samples of individuals. A sample of 103, 18- to 45-year-old American participants effectively represent these norms with a total SPQ mean score of 26.4 (SD 15.3), a positive dimension mean score of 11.1 (SD 7.4), a negative dimension mean score of 9.7 (SD 6.8) and a cognitive-disorganization mean score of 6.0 (SD 4.5; Raine, 1991). Also included in the questionnaire given out to students, were 73 questions from the Eysenck Personality Questionnaire (EPQ). These questions were included as “filler” questions in order to mask the nature of the SPQ questions. The EPQ questions are of a similar nature to the SPQ (e.g., “Have you ever taken the praise for something you knew someone else had really done?”), and require a yes/no response. On the questionnaire given out to students, questions from the SPQ were alternated with the EPQ, such that every odd question was an SPQ question. As a result, students answered 147 questions, but only the responses to the 74 SPQ questions were considered for further analysis.

SPQ participant selection
Elevated scores on any of the three SPQ dimensions reflect higher levels of schizotypy in that particular dimension. Further, an elevated overall SPQ score represents an elevation in schizotypy in general. In a deliberate attempt to dichotomize the sample of respondents and prevent the inclusion of false-positive cases, only those participants who scored an overall SPQ score greater than the 75th percentile were approached to form a high schizotypy group. In all, 16 participants formed this highly rated group. Not all participants within the group scored above the 75th percentile in each of the three schizotypal dimensions, but in order to gain a useable sample size, it was necessary to include those who were not at this criterion in each dimension. In fact, these participants provided us with the opportunity to further investigate the differences in behavioral performance of those very highly rated on one dimension but not others, while still investigating a sample that could overall be characterized as highly rated in schizotypy.

Further, a low schizotypy group consisted of 20 respondents who scored below the
median split on each of the three dimensions. This criterion was set so that the each group was as discrete as possible.

**The modified Iowa Gambling Task (mIGT)**

The modified Iowa Gambling Task (mIGT) was designed to specifically assess decision making and reversal learning within the context of affective, or rather, emotion-based processing (Turnbull, et al., 2006).

The spatial sequence of each deck of cards was the central component of this modified gambling task. The game comprised two phases as follows (see Figure 3).

**Phase 1:** The original gambling task, which involved 100 card selections from decks A, B, C, and D (Bechara et al., 1994) though administered in a computerized format (see Bowman et al., 2005). In this original phase, decks A and B were bad decks (consistent selection yielded a net loss) and decks C and D were good decks (consistent selection yielded a net gain). The original 100 card selections were kept as standard in order for participants to learn about the contingencies of the game.

**Phase 2:** The second phase of the game involved participants playing three consecutive gambling tasks, each identical in nature to Phase 1; two decks were advantageous and two were disadvantageous. However, in each of the three games within Phase 2, the rules about which decks were good and which were bad changed; thus three shift periods were created (shift period 1, shift period 2, and shift period 3).

A shift period was characterized by the changing of either contingency or frequency of punishment (or both) in each of the four decks of cards. In every shift period, the new schedule of reward and punishment had previously been characteristic of a different deck. In each phase of the game, no deck experienced the same schedule of reward and punishment more than once (see Table 1). For example in Shift Period 1, deck A assumed the characteristics of deck D from Phase 1, but deck D assumed the properties of deck C from Phase 1. So, in some instances, a deck that had previously been good remained good, and a deck which had been bad remained bad, however, the frequency of punishment always changed with each contingency shift. Thus, Phase 2 of the new IGT required an affective shift, thus representative of reversal learning, within the same dimension.
Table 1: Financial reward per card turn (pence) by deck and across Phase 1 and Phase 2 (Shift Period 1, 2, & 3) of the modified IGT. Frequency of punishment is indicated in parentheses; F=Frequent (5 punishments per 10 card turns), I=Infrequent (1 punishment per 10 card turns). Decks with the lesser reward per card turn (5p) are advantageous.

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In Phase 2, 40 card selections were required to be made within each shift period. It was theorized that if participants had learned successfully during the first 100 selections, then there would be a need to include enough trials to evidence the modification of such learning, but also enough to establish new contingency relationships.

Subjective experience ratings
After each block of 20 card selections, the game was interrupted briefly as participants completed subjective experience ratings (see Figure 3), where each deck was rated on a scale from 0 (very bad) to 10 (very good), dependent on how good or bad the participant felt it was (see Bowman et al., 2005, for further details).

Skin conductance recording (SCR)
SCR data was acquired via an MP1000 Workstation 16 channel (analog) digital data acquisition system (BIOPAC Systems, Inc., supplied by Linton Instrumentation, Norfolk, U.K.). Two disposable silver/silver chloride (AG-AGCL) snap electrodes (order number A10013-GSR, Linton Instrumentation, Norfolk, U.K.) measuring 1.5” x 1”, pre-gelled with wet, low ionic content, no chloride salt, electrically conductive ions, and backed by a latex-free adhesive strip were attached to the BIOPAC GSR 100C electrodermal activity amplifier module via two shielded electrode leads, measuring 1.9 mm in diameter (order number LEAD110S-W, Linton Instrumentation, Norfolk, U.K.).

AcqKnowledge III software for the MP1000 Workstation system was employed to analyze the data, and was run using Windows XP software. BIOPAC data acquisition, analysis systems, and amplifiers are issued with the guarantee that they are human safe, fully tested, and compliant with European and worldwide standards for medical safety.

PROCEDURE
All of those participants identified as being either above the 75th percentile or below the median split on the SPQ were approached via e-mail and asked to take part in a further experiment which would pay £10 for participation with the additional incentive of possibly winning more money during the task. The 36 participants that responded went on to complete the mIGT and each had skin conductance recordings measured during the task.
The mIGT participant instructions and SCR electrode attachment
Participants were seated opposite the computerized mIGT and were asked to read over the mIGT instructions presented on the screen in front of them (see Bowman et al., 2005, for further detail). On completion of this, a disposable AG-AGCl electrode was attached to both the index and ring finger of the non-dominant hand, with the electrode gel surface touching the underside of the finger. Disposable electrodes were utilized in this study in the interests of both convenience and hygiene. Once in place, participants were asked to rest this hand during the experiment and to use their dominant hand only when making card selections on the computer. Such steps were taken in order to eliminate the potential “artifact” SCRs generated by motor activity.

SCR recording
SCR activity was recorded continuously throughout the game as the IGT computer program automatically progressed between Phase 1 and each shifting period of Phase 2. There was a short break for revised instructions between shifting periods.

The SCR program registered each time a card selection was made, from which deck and what the outcome was (e.g., “Deck B, +10p, -£1.25”), as such the exact timing associated with the generation of a specific SCR was precisely recorded.

Intertrial interval
In order for the equipment to accurately record SCR generation, an intertrial interval between card selections was set at 6 seconds. During this time the decks of cards remained visible on the computer screen, but participants were unable to select from them. A verbal notice requested that participants, “Please wait,” immediately after the financial feedback information concerning the previous card selection had disappeared. At the end of the 6-second enforced delay period, this notice was exchanged with a new one requesting participants to “Pick a card” (after Bechara, Damasio, Damasio, & Lee, 1999).

RESULTS
Participant selection based on SPQ scores
Factorial and overall scores from the 404 respondents who completed the SPQ were investigated to confirm that our sample of individuals replicated the well-established cross-cultural norms typified by SPQ scores.

This was indeed the case, with our sample overall mean equaling 26.78 (SD 11.23) as compared to Raine’s (1991) sample overall mean of 26.4 (SD 15.3; see Figure 4). Factorial scores were also consistent with Raine’s reported norms (see Figure 4).

Participants were categorized with high schizotypy providing they had an overall mean SPQ score greater than the 75th percentile. This meant an overall SPQ score of 34 or above. Those participants with a score below the 50th percentile in each schizotypal factor were categorized with low schizotypy. This meant an overall score of 26.
Sixteen participants within the high schizotypy group and 20 participants from the low schizotypy group responded to a request for further participation in the study (see Figure 4). These groups were dichotomous in nature, with the high schizotypy group overall SPQ score equaling 40.94 (SE 1.63), which fell within the 80th percentile. Indeed, the overall mean score from those in the low schizotypy group equaled 16.25, and this fell below the 25th percentile (see Figure 4).

Group scores on the Schizotypal Personality Questionnaire (SPQ) by factor and overall

Figure 4: Overall and factorial mean SPQ scores for the initial sample of respondents and for each of the low and high schizotypy groups who went on to participate further in the experiment. Note, high scorers = high schizotypy group, low scorers = low schizotypy group. (Variance is represented as 1 standard error.)

**HIGH VERSUS LOW SCHIZOTYPY**

**INVESTIGATION 1: BEHAVIORAL PERFORMANCE**

As in Bechara et al. (1994), the 100 card selections from Phase 1 of the IGT (original 100 selections) were subdivided into five blocks: 1 – 20, 21 – 40, 41 – 60, 61 – 80, and 81 – 100. The net score for each block was calculated by subtracting the number of bad selections from the number of good selections: [(C+D) – (A+B)]. The 40 card selections from each shift period in Phase 2 of the IGT were analyzed in exactly the same manner: [(number of good selections) – (number of bad selections)], with the only difference being that there were two as opposed to five blocks in each of the shifting periods.

In each block, a net score below zero implied that participants were selecting disadvantageously, and a score above zero reflected advantageous choices.

**Phase 1**

During Phase 1 of the modified IGT there was not a marked difference in behavioral performance between the high schizotypy group (n=16) and the low schizotypy group (n=20; see Figure 5, Phase 1). The low schizotypy group began making advantageous choices from Block 2 onwards, with the high schizotypy group performing advantageous from Block 3 onwards. Indeed both groups learned to avoid the bad decks of cards following the typical learning curve seen in many other studies assessing performance in neurologically normal individuals.
A mixed ANOVA on the data found a main effect of block ($F(4,136)=12.3, p<.001$), but not a main effect of group ($F(1, 34)=.17, p=.68$). Interestingly, there was a borderline group by block interaction ($F(4,136)=2.4, p=.054$), probably explained by a significant between group difference during Block 1 ($t(34)=2.5, p=.02$) which interestingly suggests that the low schizotypy group was initially more tempted by the high risk decks.

**Phase 2**

The low schizotypy group made an increasing number of advantageous selections between Block 1 and 2 for each shift period of Phase 2. Further, in Shift Periods 2 and 3, participants within this group selected advantageously from Block 1 onwards and with increasing favor for the good decks with each new shifting period (see Figure 5).

However, the high schizotypy group, despite showing an increase in good selections within each shifting period, performed consistently less well than during 1 (see Figure 5). Further, this group did not demonstrate an improvement in performance with each new shifting period in the same way that the low schizotypy group did.

A mixed ANOVA found a main effect of block (collapsed across each of the three shifting periods: $F(3.8, 130.1)=6.82, p<.001$) and a main effect of group ($F(1,34)=6.15, p=.02$). There was, however, no interaction between block and group ($F(3.8, 130.1)=.8, p=.55$).

Post hoc independent samples t-tests revealed that the difference in number of good selections during Block 1 of Shifting Period 2 ($t(34)=4.0, p<.001$) and Block 1 of Shifting Period 3 ($t(34)=2.9, p=.007$) were most likely accountable for the significant difference in performance between groups.

**INVESTIGATION 2: INAPPROPRIATE SELECTIONS DURING THE SHIFTING PERIODS**

To further investigate the difficulties in shifting in the high schizotypy group, patterns of choices during Phase 2, in the context of preferences during Phase 1 were analyzed. In both the low and high schizotypy groups, participants showed normal levels of learning during Phase 1, such that decks C and D were perceived as advantageous. During the shifting periods the contingencies systematically alter. This offers an opportunity to inves-
tigate the extent to which the various groups had retained a strong preference for the decks that were originally advantageous (C and D), as opposed to those which acquired “good” characteristics during various periods of the shifting phase.

Mean card selections from decks that were previously good (C and D) were investigated. So, the were-good-now-bad decks were C (in Shifting Period 1), C and D (in Shifting Period 2), and D (in Shifting Period 3; see Figure 6). During Phase 1, a mixed-factor ANOVA revealed that there were no between group differences in number of bad cards selected across each of the five blocks. However, during Phase 2, a mixed-factor ANOVA found that the high schizotypy group did make more selections from decks which had previously been good but were now bad than did the low schizotypy group \( F(1, 34)=4.84, p=.04 \).

Figure 6: Mean “inappropriate selections” from were-good-now-bad decks across each of the three shifting periods for each group, following initial learning which demonstrated fewer bad choices across time during the original game in both groups (Phase 1).

INVESTIGATION 3: SUBJECTIVE EXPERIENCE

Subjective experience ratings were calculated as mean good deck ratings minus mean bad deck ratings. This format was applied to the subjective experience ratings within Phase 2 as well as Phase 1, with the only difference between the calculations being that there were two subjective rating periods during the shifting periods of Phase 2 as opposed to five within Phase 1.

Phase 1

Both the high and low schizotypy groups rated the good decks as better than the bad decks at the outset of the game (see Figure 7). This profile is remarkably similar to performance as reported during previous studies with undergraduates (Bowman et al., 2005).

Figure 7: Subjective experience of the modified IGT as represented by good minus bad deck ratings across each block of every 20 cards selected, for both Phase 1 and each shift period of Phase 2 and by group. (Variance is represented as one standard error.)
A mixed ANOVA revealed a main effect of block \( (F(2.97, 98.12)=5.65, p=.001) \), no main effect of group \( (F(1,33)=.002, p=.96) \), and no block by group interaction \( (F(2.97, 98.12)=1.07, p=.39) \).

**Phase 2**

Phase 2 yielded some interesting data. Despite the high schizotypy group’s selecting significantly fewer good cards during the shifting periods than the low schizotypy group, subjective experience ratings by the group were always in favor of the advantageous deck, and always higher than those provided by the low schizotypy group. Thus, the high schizotypy group rated the decks at odds with their behavioral performance. The low schizotypy group, on the other hand, provided ratings consistent with their behavioral performance (see Figure 7).

A mixed ANOVA found no main effect of block (when collapsed across each of the shifting periods; \( F(3.71, 122.37)=2.4, p=.06 \)) or group \( (F(1,33)=.62, p=.62) \), nor was there a block by group interaction \( (F(3.71, 122.37)=.04, p=.99) \).

**INVESTIGATION 4: PHYSIOLOGICAL CORRELATES**

**i) Anticipatory SCR analysis**

**Phase 1 and Phase 2**

Measuring physiological arousal in the time period immediately preceding a card selection assesses anticipatory responses. This time period always lasts for at least one second, and can last longer depending on how long it takes each participant to make a decision about which deck to select a card from. During Phase 1, anticipatory responses from decks with higher punishments (bad decks) are typically higher in magnitude than those with lower punishment (good decks) and are thought to represent an “advanced warning system” to warn the individual that an upcoming decision might be laden with risky consequences. During Phase 2, it has been shown that there is little difference between decks with regard to anticipatory responses (Bowman, unpublished thesis, 2004).

During Phase 1 it can be seen that, irrespective of group, physiological responses to the more punishing bad decks are slightly higher than those generated in response to card selection from the less punishing, or good decks (Figure 8).

Further, although the high schizotypy group demonstrated slightly lower anticipatory physiological responses, there were no significant differences between groups or by deck type (Figure 8).

Moreover, during Phase 2, the difference between arousal generated dependent on deck type (good versus bad) was less, and indeed there was less discrepancy between the low schizotypy and high schizotypy groups (see Figure 9), and again, there were no significant differences either by group, or by deck type.
ii) Consequence SCR analysis: Rewarding and punishing responses to card selections

Consequence SCRs are measured as overall amplitude of physiological arousal generated in the five-second period succeeding any given card choice. These SCRs can be measured after a rewarding card choice (5 pence on good decks and 10 pence on bad decks) or after a punishing card choice (any card selection which results in a loss of money). During Phase 1, SCRs generated in response to punishing consequences are typically higher in magnitude than those generated in response to a rewarding outcome. During Phase 2, consequence SCR magnitudes tend to be higher than those generated during Phase 1, irrespective of deck. It is presumed that this occurs as a result of participants paying closer attention to the changing contingencies, and that the monitoring of this shifting landscape assists the formation of new and adaptive rules (Bowman, unpublished thesis, 2004).

**Reward: Phase 1 and 2**

During Phase 1, independent of group, arousal in response to high reward (10 pence) was greater than arousal in response to low reward (5 pence).

Interestingly, during Phase 1 the high schizotypy group generated significantly lower SCR magnitudes in response to reward than did the low schizotypy group. This effect occurred irrespective of deck—that is, regardless of whether the reward was the lesser 5 pence or the greater 10 pence (t(20)=2.35, p=.03; t(20)=2.2, p=.04, respectively).

Further, both the effect of group and deck diminished during Phase 2, although SCR magnitudes were higher in general, as expected.

A mixed-factor ANOVA revealed a main effect of phase (F(1,20)=256, p<.001) and a borderline main effect of group (F(1,20)=4.3, p=.051), accounted for by the significantly higher SCRs generated by the low schizotypy group in response to reward (irrespective of deck) during Phase 1.

Figure 8: Mean anticipatory and consequence SCR magnitudes by deck and group for original 100 card selections of mIGT (Phase 1).

Figure 9: Mean anticipatory and consequence SCR magnitudes by deck and group collapsed across each of three shifting periods of mIGT (Phase 2).
**Punishment: Phase 1 and 2**

During Phase 1, punishment SCRs (irrespective of group), were only marginally higher than those generated in response to reward. Further, those generated in response to punishing consequences from the bad decks (loss of 25 pence to £1.15) were only slightly higher than those made in response to losses from the good decks (loss of 2 pence to 8 pence). There were no significant between group differences during Phase 1.

During Phase 2, SCRs were generally higher in response to punishment than those generated after money loss during Phase 1. A mixed-factor ANOVA revealed a main effect of phase ($F(1,20)=150.4$, $p<.001$) but no differences between groups or by deck (Figures 8 and 9).

**Overall**

Other than in response to reward during Phase 1, skin conductance profiles between groups were remarkably similar, especially during Phase 2, where behavioral differences between groups were found.

**HIGH NEGATIVE VERSUS HIGH POSITIVE SCHIZOTYPY**

*Investigating failure to shift:*

In order to investigate the possible differences in performance between negative and positive schizotypy, those participants from the high schizotypy sample who scored above the 75th percentile in any one of the three schizotypal dimensions (but with variable scores on the other two dimensions) were examined independently. Six participants from the high schizotypy group with scores above the 75th percentile on the positive factor, but with scores below the 75th percentile on the negative and cognitive disorganization factor formed a high positive group. Four participants from the high schizotypy group with scores above the 75th percentile on the negative factor, but with scores below the 75th percentile on the positive and cognitive disorganization factors formed a high negative group.

The samples examined in this investigation were small in number, and as a result no statistical analyses were run on these data.

**INVESTIGATION 5: BEHAVIORAL PERFORMANCE - PHASE 1 AND 2**

Figure 10 illustrates that those in the high positive group have intact behavioral performance across both phases of the mIGT, showing an increasing preference for advantageous cards despite contingency shifts.

In contrast, the high negative group shows a slow-but-eventual learning profile during Phase 1 of the game, and, despite an improvement within each block of the shifting periods, this group continues to select more disadvantageous cards throughout the shifting periods. This tendency does not improve over time, with the third reversal showing least improvement in performance (Figure 10).
Thus, individuals with high negative scores seemingly account for the shifting failures of the high schizotypy group overall.

**INVESTIGATION 6: SUBJECTIVE EXPERIENCE - PHASE 1 AND PHASE 2**

The high negative group was investigated further to identify if any other aspects of its performance during the mIGT was disrupted.

Figure 11 illustrates that subjectively, participants in the high negative group, across both phases of the mIGT, rated the good decks as better than the bad decks—despite showing behavioral selections quite to the contrary.

**INVESTIGATION 7: PHYSIOLOGICAL CORRELATES**

*High negative group*

The high negative group (Figure 12) showed an SCR profile consistent with other participants highly rated in schizotypy. In fact, those participants with high positive scores also showed less arousal in response to reward during Phase 1 (Figure 8) thus suggesting that this difference between high and low schizotypy groups is not accounted for by the high negative group, rather it seems to be consistent with high schizotypy in general.
Thus, the high negative group seemingly have intact subjective experience ratings along with a typical skin conductance profile while playing the mIGT. Despite this, these individuals behaviorally fail to learn new contingency relationships.

FLEXIBILITY IN HIGH POSITIVE, HIGH NEGATIVE, AND LOW SCHIZOTYPY

INVESTIGATION 8: IMPROVED SHIFTING PERFORMANCE IN HIGH POSITIVE SCHIZOTYPALS

It was predicted that the high positive group would be more flexible than either the high negative group or those with low schizotypy scores (<50th percentile). In order to assess this, a “shifting difference” was calculated for each of these three groups of participants. This score assessed the mean increase or decrease in advantageous selections between each block for each shifting period of Phase 2 of the mIGT. This score was then collapsed across shifting period to create a mean shifting difference score for each group of participants. A score above zero represents a positive shift in favor of good card selections across Phase 2 (Figure 13).

Intriguingly, both the high negative and the low schizotypy group had a shifting difference score in favor of good selections across each block during Phase 2 of the mIGT. However, the high positive group improved their within block performance by almost three times as much as the high negative and low schizotypy groups (Figure 13). This score seems to reflect a remarkable ability to quickly and consistently shift away from a less advantageous strategy in favor of a more advantageous strategy.
DISCUSSION

This paper set out to investigate whether psychiatrically-normal individuals, highly rated in schizotypy, would show performance akin to that shown by patients with schizophrenia, on a measure of emotion-mediated decision making that incorporates reward-based contingency shifts (the modified Iowa Gambling Task (mIGT), Turnbull et al., 2006).

The series of investigations yielded several interesting insights into the nature of schizotypy and, especially, revealed some aspects of the schizotypal personality variant. The findings suggest, on the one hand, a range of distinctive and potentially counterproductive deficits within some schizotypal individuals, akin to those seen in schizophrenia. On the other hand, and perhaps unexpectedly, it appears that some facets of schizotypy may enhance aspects of higher mental function, especially with regard to the formation of novel intellectual relationships.

HIGH SCHIZOTYPY, LOW SCHIZOTYPY, AND SCHIZOPHRENIA

We begin with results that bolster already reasonably well-established findings. As has been found in people with schizophrenia (Evans et al., 2005; Ritter et al., 2004; Shurman et al., 2005; Wilder et al., 1998), those highly rated in schizotypy were able to learn contingency relationships during the original 100 trials of the mIGT (Phase 1). That is, the formation of new rules, derived from emotionally-laden events in the world, was the same as for those who scored low in schizotypy.

However, once the affective associations learned during the original 100 card selections were altered, those individuals highly rated in schizotypy seemed unable to implement the new rules behaviorally. That is, they seemed drawn to persist in a preference for things that had previously been good in the world, but were now materially less rewarding. This is a maladaptive (but perhaps not entirely unexpected) strategy that, of course, might produce difficulties in the ability to operate in the world. Again, this finding was entirely consistent with performance displayed by people with schizophrenia (Turnbull et al., 2006).

An especially interesting aspect of this finding was that this failure by those highly rated in schizotypy was largely accounted for by a specific subset of individuals—those highly rated in the negative traits associated with schizotypy. That is, those individuals whose personality profile included social anxiety, constricted affect, lack of friends, and suspiciousness. This performance on the mIGT might well then represent a more formal measure of a worldview that fails to adapt to the complex and rapidly changing interpersonal landscape.

Disruptive effects of negative schizotypy

The finding that negative traits associated with schizotypy might account for failures on the mIGT is not especially surprising. It has long been known that people with high negative-schizophrenia symptoms make catastrophic failures on attentional set-shifting tasks (e.g.,
Nelson, 1976; Tsakanikos and Reed, 2005), such that their perseverative approach to problem solving (persisting with a strategy that is proving unproductive), creates substantial difficulties in the real world. In a reversal-learning task such as that assessed by the mIGT, powerful emotion-biased beliefs must be regularly updated for the task to be completed successfully. This is likely to require input from a complex series of brain structures, including prefrontal cortex and more emotionally-oriented (“limbic”) regions of the brain—areas that are known to be disrupted in schizophrenia (Benes, Davidson, & Bird, 1986; Guenther & Breitling, 1985; Golden, Graber, & Coffman, 1980; Andreasen, Nasrallah, Van Dunn, 1986; Weinberger, Berman, & Zee, 1986). Indeed, it is well established that anti-psychotic medication works by acting (in large part) on this system (Waltz & Gold, 2007).

One important aspect of the present study is, of course, that it investigates those who operate well in the world and, have no formal psychiatric history, yet still show schizotypal personality traits. Of course, schizophrenia and schizotypy have often been considered as having similar aetiological foundations (Claridge, 1985; Loughland & Williams, 1997). Nevertheless, it is remarkable that those highly rated in schizotypy are psychiatrically normal, but that the maladaptive features seen in both conditions represent evidence of their likely shared biological bases. Indeed, these results bear significantly on findings within the schizotypal literature which suggest that high negative scores on schizotypal personality measures are a significant indicator of poor mental health (Schofield and Claridge, 2007), which may additionally lead to a decline in mating success (Nettle & Clegg, 2006).

Intriguingly, individuals highly rated in negative traits who failed behaviorally on the mIGT, retained intact subjective experience, and also showed normal skin conductance responses. Thus, remarkably, it seems that this group of individuals ignore crucial information provided physiologically and cognitively, in favor of emotionally-biased sources, which in their case lack supporting evidence in the face of a changing environment. This finding might provide both clinically and theoretically important evidence, suggesting why this group is so resistant to change, and as such it warrants further investigation.

**Enhancing effects of positive schizotypy**

In contrast to those highly rated in the negative traits of schizotypy, those highly rated in positive traits (that is, magical thinking and unusual experiences), had a performance profile on the mIGT which was at least as good as those with low schizotypy traits, providing negative symptoms were low. Indeed, in many respects, this group substantially outperformed controls.

In particular, these individuals made substantially greater improvements during the shifting periods of the mIGT than either (predictably) those with high negative schizotypy or (remarkably) those with low schizotypy in general (those scoring below the 50th percentile on the SPQ). In fact, while they started with a relatively low baseline on the shifting periods (only slightly higher than those high in negative traits), they showed
remarkable levels of flexibility when required to adapt to a novel setting—learning up to three times more rapidly than other participants (see Figure 13). This enhanced ability to adapt to modified circumstances suggests impressive flexibility of emotion-biased learning systems in this subgroup. Indeed, we know that people in this group form a subset of healthy individuals who tend to be exceedingly creative and also show an increased tendency towards mating success (Nettle & Clegg, 2006; Schofield & Claridge, 2007).

The present study suggests that their enhanced flexibility in response to a changing environment may serve as a precursor for creative thought, and indeed may give rise to gifted thought processes that promote the discovery of novel associations between disparate concepts.

**CONCLUSION**

This series of investigations has cast light on some important paradoxes of the schizotypal personality. Firstly, we have shown that individuals with high negative schizotypal traits are unable to modify preexisting beliefs despite the punishing consequences of such unaltered behavior. These individuals, although non-psychotic, rather remarkably, perform in much the same way as people with schizophrenia. Secondly, we have found evidence for an increased ability towards flexibility in the modification of emotion-biased strategies in those individuals with high positive schizotypal traits. This finding offers the opportunity for us to understand why these individuals are so often creatively gifted.

**ACKNOWLEDGEMENTS**

We would like to thank the Philoctetes Center for funding this research.

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Commentary on “Schizotypy and Flexible Learning: A Prerequisite for Creativity?”

THE SEEKING SYSTEM AND THE FLOW OF CREATIVITY

JAAK PANKSEPP*

Caroline Bowman and Oliver Turnbull summarize a superlative set of studies highlighting how empirical measures of creativity are related to the personality trait of schizotypy. People with negative traits (flattened affect and social anxiety) exhibited constrained creative output, while those “enjoying” positive schizotypy (magical thinking and unusual perceptual experiences) exhibited elevated creativity—“increased flexibility of intuitive thinking.” These types of schizotypy correspond well to schizophrenic negative and positive symptomology, and as has been often noted, the sources of certain kinds of madness and creativity may have a common source. This is a terrific empirical demonstration of this classic idea.

Let me add further positive support for their argument, by focusing on a key brain system that may underlie such a confluence. A key brain mechanism may be the dopamine driven reward-SEEKING system—a general purpose brain network that is evolutionarily designed to seek out all the things mammals need to survive, from nuts to knowledge so to speak (Alcaro, Huber, & Panksepp, 2007; Ikemoto & Panksepp, 1999; Panksepp, 1998; Panksepp & Moskal, 2008). Not only does this system generate the instinctual urge to explore the environment, it rapidly coaxes the rest of the brain to learn and remember how to procure reward in the future. Once learning has occurred, it also energizes animals to return to places where they have found rewards in the past, although at that point behavior can become routine—habitual to the point where the SEEKING system needs to do little. Unless, of course, an individual wishes to make a variable and creative game out of life. This system is a general-purpose appetitive learning system. But in this role it can generate causal convictions about correlated life events, and thereby is ideally suited to generate adaptive creative solutions to life problems as well as delusions about the way the world is organized. After all, humans and other animals must seek to make causal sense out of correlated events, a process that often gets solidified in our dreams.

When operating at a normal high level of activity, the SEEKING urge constitutes a healthy reality-testing system that allows full-of-life creatures to have “aha” responses more rapidly than constitutionally less eager and more inhibited individuals. However, when the system is chronically overactive, it can also generate delusional connections and excessive

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insights about the world that are the hallmark of paranoid ideation. Indeed, when this dopamine charged system is chronically overdriven with psychostimulants such as amphetamine and cocaine, practically everyone becomes delusional and suspicious, but only after an initial period of increased “normal” mental activity, (Snyder, 1973). This indicates that the excessive “creative” potential for paranoid schizophrenia lurks in everyone. Hence it is no wonder that medicines that effectively reduce the positive symptoms of schizophrenia are all dopamine receptor blocking agents. Of course, these medicines do not feel good. They take away the sense of well-being and they also diminish creative energies by depleting dopamine well-being signals within the brain.

Although they do not focus on such possibilities, Bowman and Turnbull’s wonderful work may have illuminated a natural function of the SEEKING system—to increase creative engagement with the world. A variety of other lines of evidence also point in that direction. Here are just three:

The mesocortical dopamine system innervates the medial frontal lobes—executive structures that are essential for cognitive flexibility. Thus, one might expect that creative individuals have high levels of arousal in the frontal lobes. Indeed, PET cerebral blood flow measures have demonstrated just that (Carlsson, Wendt, & Risberg, 2000). Creative individuals tend to exhibit strong bilateral frontal arousal (often more on the right than left) during a divergent thinking task. In contrast, low creative individuals show less overall frontal arousal, often with a reversal of laterality. As noted by Bowman and Turnbull, it has long been known that people with frontal damage exhibit decreased creativity and the psychic deficits of schizophrenics with abundant negative symptoms may be due, in part, to dampened frontal lobe activity.

It has long been surmised that there is some kind of relationship between dreaming and creativity. Recently it has become clear that during dreaming the mesolimbic dopamine cells tend to exhibit more arousal, as indicated by increased bursting activity (Dahan et al., 2007), the type of firing pattern that is most effective in elevating forebrain dopamine release (Lena et al., 2005). Parenthetically, frontal lobe damage has long been known to reduce dreaming, which turns out to be dissociable from REM sleep (Solms, 2000).

Finally, if one probes for emotional personality traits with the Affective Neuroscience Personality Scale (ANPS) (Davis, Panksepp, & Normansell, 2003) one finds that high scores on the SEEKING dimension are strongly related to various measures of creativity, including figural, verbal, and numeric varieties (Reuter et al., 2005). Surprisingly, neither Eysenck’s psychoticism scale nor saliva testosterone was linked to any of those creativity measures. It would be most interesting to know if Bowman and Turnbull evaluated such emotional personality traits in their subjects. If not, might they still have access to the population of students they studied?

It is intellectually satisfying, at least for me, to see convergent evidence that the SEEKING system, which may easily be overactive in schizotypal individuals with positive symp-
toms, may contribute substantially to the normal mental flexibility we commonly call creativity. These findings offer a new window, consistent with other lines of evidence, that human creativity is based, in part, on demonstrable brain emotional systems. Considering that playfulness may be one of the main sources of human creativity, I am also gratified to note that our recent mapping of animal laughter (an indicator of playfulness) demonstrates intimate relationships to this same brain dopamine system (Burgdorf, Wood, Kroes, Moskal, & Panksepp, 2007). Although neuroscience has barely started to track down brain systems that mediate human creativity, the findings of Bowman and Turnbull can be taken as converging evidence that the brain systems that mediate human dreams, playfulness, and seeking urges, as well as milder varieties of human “madness,” are a major source of human creativity.

It is noteworthy that recent studies of frontal lobe activity in highly creative artists and scientists suggest specific regions of the brain where various forms of creativity incubate (Chávez-Eakle, Graff-Guerrero, García-Reyna, Vaugier, & Cruz-Fuentes, 2007). Indeed, these are brain regions in which excessive dopamine can provoke hallucinatory activity (Castner & Goldman-Rakic, 2003). Bowman and Turnbull’s work, taken in a broader neuropsychanalytic context, highlights a principle that is of great humanistic and psychiatric relevance.

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Commentary on “Schizotypy and Flexible Learning: A Prerequisite for Creativity?”

A DISCRETE IRONY OF THE SCHIZOTYPAL MIND

LOIS OPPENHEIM*

For some four or more decades, psychoanalytically-oriented critics of the literary and visual arts have sought to connect dynamically the study of creative output with the creator him- or herself. In fact, ever since Freud and later Kris applied psychoanalytic thinking to the interpretation of art—that is, well before criticism became truly interdisciplinary as it did in the 1960s and ’70s—the artist was put on the couch and the work was viewed as representative of something other than itself: i.e., the artist’s mental state, deemed pathological more often than not. Unfortunately, the result has been a not always entirely discrete disdain for applied psychoanalysis among those who believe it to be reductive. While it is true that the creative work is incomparable to the freely-associating patient, the only legitimate subject of psychoanalytic investigation, applied psychoanalysis, when focused on the creative effort, makes a most worthwhile contribution to our understanding of the mind and the workings of imagination.

What supports such investigation of creativity proper is precisely the kind of research done by Caroline Bowman and Oliver Turnbull who, in their important study of the relation between creativity—in the broadest sense of the term—and mental health, ask not what the creative endeavor (no matter the sphere) reveals of the inner life of the individual, but what might predispose one to being creative in the first place. More precisely, they inquire, and rather courageously at that, whether one particular personality type, schizotypy (defined as presenting with characteristics associated with schizophrenia without evidence of conversion to the illness as such) might harbor within it a flexibility of intuitive thought conducive to creative expression, problem solving, or adaptability.

Their study is significant for its intriguing if also somewhat surprising results, which need not be reiterated here. What I would emphasize, however, is that its significance is not only academic (i.e., theoretical or conjectural), contributing as it does to our understanding of what constitutes creativity and imaginative thinking, but practical as well. That is to say that there may be those who (mis)use the findings of this research to further the trajectory down an insufficiently scientific path of creativity-as-madness line of thought, but there should also now be those who respond to the invitation offered by this work to consider its application within the rehabilitative domain. In other words, to the extent that

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Bowman and Turnbull have shown a paradoxical flexibility with regard to intuitive thinking and looked at how this advantage might enhance creativity in the individual with schizotypal features, does an ethical imperative not ensue?

The authors of the study conclude “that individuals with high negative schizotypal traits are unable to modify pre-existing beliefs despite the punishing consequences of such unaltered behavior.” The question then becomes, what can be done to help such individuals compensate for this deficit? The authors also claim to “have found evidence for an increased ability towards flexibility in the modification of emotion-biased strategies in those individuals with high positive schizotypal traits.” Not only does this finding offer the prospect of greater understanding of why “these individuals are so often creatively gifted,” but the occasion to ask what can be done to capitalize on the paradoxical advantages of certain learning traits identified by the authors and shown to exist in those with the so-called positive features of the schizotypal personality. In fact, this work behooves us to ask how these individuals can be made to appreciate their own creative gifts and encouraged to make use of cognitive talents not previously identified as such. Furthermore, how these findings contribute to the early identification of high-risk individuals, those who in certain environmental circumstances (under certain kinds of stress, for instance) will convert from schizotypy to full-blown schizophrenia is a question that must be asked as well. In a word, the potential for the application of these findings must not be underestimated; indeed, it is what renders the work by Bowman and Turnbull invaluable.

That said, there are nonetheless a few issues I would raise with regard to the presentation of this important research. I would cite, for example, the need to pay more careful attention to the usage of certain terms: “autistic-like traits”; “introvertive anhedonia,” and “perseveration” come immediately to mind. The first is equated by Bowman and Turnbull with Asperger’s syndrome which, in fact, is on the autistic spectrum. It is not that those with Asperger’s syndrome are “autistic-like,” but that they have a milder form of autism; they are at the high-functioning end of the continuum of pervasive developmental disorders. It is true that PPD is merely an umbrella term owing much to our lack of knowledge and understanding of these disorders. (One sees, for instance, social withdrawal in depression, an affective disorder as opposed to the thought disorder that is schizophrenia or as opposed even to the schizotypal personality.) Finally, perseveration, as referred to here, is problematic in that is it is found as commonly, if not more commonly, in those with tem-
poral lobe epilepsy, of which no mention is made and whose symptoms may be related (eti-
ologically, i.e. genetically) to or even mistaken for schizophrenia.

I am also inclined to wonder about two other, very different matters: the reduction of
the measure of creative giftedness to divergent thinking as shown on testing and the con-
fusion surrounding the “positive” dimension of schizotypy. Regarding the first, how does
reversal learning, the “flexibility of emotion-based learning systems” relate to other meas-
ures of creativity and how, more to the point, is creativity itself defined? An assumption of
the meaning of “creativity” is made in this paper without any precise consideration of the
multiplicity of forms (cognitive, social, artistic, and other) it may take. Indeed, are we
meant to understand that this measure is the sole common denominator in all? Along the
same lines, the authors inquire as to the plausibility “that some of those people susceptible
to psychosis-proneness and yet highly talented might actually be more creative than the
general population as a result of an elevated ability for a possible precursor to creativity—
namely, reversal learning (as assessed by emotion-related ventral prefrontal function)?”
How is “highly talented” assessed? What are its parameters and does that apply to a single
or to multiple domains?

As concerns the positive dimension of schizotypy, “a three-factor model of schizotypy,
inclusive of positive, negative, and cognitive disorganization factors”, is adopted through-
out for the purposes of underscoring the relation of this personality type to schizophrenia.
Yet, confusion between positive and negative scores as related to symptoms is persistent.
And the distinction between positive dimension in schizotypy and schizophrenia is not
maintained. Whereas in the former it is identified with the traits of “magical thinking and
unusual experiences”, it is not made sufficiently clear that the positive dimension of schiz-
ophrenia is clearly delusional and/or hallucinatory. Moreover, that “those highly rated in
schizotypy are psychiatrically normal, but that the maladaptive features seen in both con-
ditions [schizotypy and schizophrenia] represent evidence of their likely shared biological
bases” is truly remarkable. But what is the measure of “normal”? The absence of DSM cri-
teria, lack of contact with the mental health system, or something else?

At the same time, however, the authors stress the multidimensional nature of the
schizotypal personality and they do so adding that “it is possible to exhibit certain person-
ality traits consistent with schizophrenia without being psychotic.” This is an exceedingly
important point, for not only can one display schizotypal personality traits without being
psychotic, but schizophrenia itself is now coming to be seen as so multidimensional as to
be recognized without psychosis in some instances as well. Moreover, the disorder is not a
static illness, but one that evolves over time. And therein lies a cultural consideration as
well: It is known to evolve in a significantly better direction (i.e., toward recovery) in third-
world countries, which may lend something more to the discussion of the “advantages” of
schizotypal traits on the creative front.

Bowman and Turnbull have done extraordinary work in an area sorely in need of
research. Despite the few reservations expressed above, it is clear that the age-old question of a link between madness and creativity (cognitive genius, aesthetic talent, and so on) will not be answered in any respectable manner without such experimentation. While the authors would be well-advised as they continue their pursuit of such answers (as one certainly hopes they will) to consult some of the most recent research on the etiology and evolution of schizophrenia in its connection with schizotypy, clearly this is an impressive beginning. They might want, for example, to look at new findings regarding glutamate, the neurotransmitter under closest scrutiny by the pharmaceutical industry at present, and norepinephrine (known, like dopamine, to be important for cognition) as they reference in the present paper the significance of the dopaminergic system. The very impressive work being done by Cheryl Corcoran and others at Columbia University and by Larry Davidson at Yale—work pertaining to the identification of “high risk” adolescents—would no doubt shed light on the discussion of schizotypy and creativity as well. For, indeed, the prodromal period of schizophrenia may be a prolonged period (inclusive of schizotypy) in which risk taking and other characteristics not infrequently identified with the creative personality may be observed. And the work of Brian Koehler and others on the psychosociobiological model—which shows that schizophrenia is not one but many illnesses that overlap—is highly recommended for further work in this area by the authors. That one speaks now of “schizophrenia spectrum disorders” (just as one does of autism) is due to the variation in both symptomology and etiological models, models that extend from the interplay between genetic vulnerability and psychosocial stress (with the concomitant neurobiological changes associated with the stress response) to abnormalities in neurodevelopmental processes and even to the use of cannabis. And this is significant in that creativity is often said to be lacking in the severely psychiatrically ill insofar as a coherent sense of self and mental function is thought necessary to the creative process while, at the same time, one thinks of the number of artists considered emotionally unstable as afflicted with profoundly destabilizing uni- or bipolar depression or other affective or cognitive disorders. In fact, dream memories, delusional thinking, and hallucinatory perceptions may facilitate creative expression, as we know from those who purposefully induce altered states of consciousness with the aim of enhancing imagination. Turnbull and Bowman have, in sum, opened many doors with their findings in this study, not least of which are those leading to the bolstering of creativity in the name of remediation, on the one hand, and to greater appreciation of the complex interaction between creative process and emotion-based learning, on the other.
Response from Oliver H. Turnbull and Caroline H. Bowman

DOPAMINE AND THE PLEASURE OF CREATIVITY

We would like to thank both Professor Panksepp and Professor Oppenheim for their insightful comments on our paper, including their interesting suggestions for future research, and their highlighting of links that we had not sufficiently emphasized in our paper. In response to their comments we offer a few observations.

EMPIRICISM

It has been fascinating to observe, over the last few decades, how psychology and especially neuroscience have come to investigate topics that had previously appeared to be “beyond” rational inquiry. Creativity has, for example, long been seen as an aspect of mental life that is open-ended and difficult to measure quantitatively. Investigating this topic also brings together ideas about the relationship between “madness” and creativity—ideas that have long had face validity (i.e., seem sensible) but have had limited experimental support.

These observations underpin Panksepp’s comments that our study is a “terrific empirical demonstration of [a] classic idea.” Of course, it is not easy to see how one might capture creative phenomena in a laboratory setting—and indeed Oppenheim rightly comments that creativity is multidimensional and difficult to specify, while at the same time admitting that these questions “will not be answered in any respectable manner without such experimentation.”

Modern neuroscience and psychology therefore face a huge challenge. Looking at a (joint) field entering a wonderfully productive phase, we have the opportunity to investigate a range of questions that had long been under-investigated—domains such as empathy, happiness, consciousness, and love. At first glance, these topics might well seem as potentially intractable to us as did, say, the problem of understanding chemical properties, and indeed chemical classification, in an era two centuries ago before the periodic table. At that time, chemistry had some traction on the problem of the way that materials interacted—but lacked the sense of “order-from-chaos” that was revealed by the discovery of Mendeleev’s systematic model. Now, as then, a scientific field progresses by collecting isolated nuggets of interesting data, in the reasonably secure hope that much greater clarity will be provided (hopefully in our lifetimes) by a grand unifying theory of the mind and its organic substrate. We need therefore to look upon this phase of neuropsychological development not as one of disorder, but rather as one in which the pace of learning is rapid, with the enticing prospect that we may live through an era in which our scientific discipline properly comes of age.
In this regard then, the work in our study remains exploratory. However, we are greatly assisted in these preliminary investigations by being able to build on the many remarkable links between the psychology and the neurobiology of creativity in its productive and its pathological forms. Here, an especially useful and unifying link has been centered around dopamine.

**DOPAMINE AND CREATIVITY**

Panksepp’s commentary fleshed out an aspect of the neuroscience of creativity, which our paper did not have the space to dwell upon: that is, the remarkable findings that link dopamine activity to creative thinking in its many variants.

The diversity of experience generated by variations in dopamine has one boundary in the stultifying absence of intentional thought that is observed in profound dopamine depletion disorders, such as *encephalitis lethargica* (as depicted so strikingly in Oliver Sacks's *Awakenings* book [Sacks, 1973/1982]). Sacks’s patients spent literally decades in a timeless state, an eventless stasis, which deprived them of all sense of history and happening. Isolated circumstances—fire alarms, dinner-gongs...might set them suddenly and startlingly alive for a minute...but such flashes in the depth of the darkness were rare. For the most part, patients lay motionless and speechless, and in some cases almost will-less and thoughtless, or with their thoughts and feelings unchangingly fixed... their minds remained perfectly clear and unclouded, but their whole beings, so to speak, were encysted or cocooned. (Sacks, 1973/ 1982, p. 22)

At the opposite end of the scale, dopamine enhancement clearly (as Panksepp points out) boosts exploratory activity and novelty seeking in many forms. There are few accounts of this as evocative as Freud’s:

Cocaine brings about an exhilaration and lasting euphoria which in no way differs from the normal euphoria of a normal person... You perceive an increase of self-control and possess more vitality and capacity for work... In other words you are simply normal, and it is soon hard to believe that you are under the influence of any drug... Long intensive mental or physical work is performed without any fatigue... This result is enjoyed without any of the unpleasant after effects that follow exhilaration brought about by alcohol. (Freud, 1885, pp.373-375)

However, whatever the temporary advantages to mental activation that dopamine enhancement might bring, it is also clear that chronic overactivity of this system appears to be as dysfunctional as does underactivation—leading as it does to (in Panksepp’s phrasing) “excessive insights,” “delusional connections,” and indeed “paranoid ideation.” This then, is the link between dopamine, psychological “energy,” and creative thought: that dopamine is essential for effective thought, and moreover that moderate amounts of dopamine enhancement may (if well managed) support increased levels of intellectual
work and perhaps even creativity. But, of course, there is a darker side to this influence—with genuine costs in terms of the ability to understand and appreciate reality.

Given that such brain chemistries can be experimentally manipulated, with all of the double blind and placebo controls that enhance scientific validity, we may anticipate an era in which the creative process can be investigated with a rigor that has not previously been possible.

**Positive Aspects of Dopamine**

One especially important aspect of Panksepp’s commentary is his emphasis on the question of normality in our growing understanding of the role of dopamine in mental life. As Panksepp (and our paper) points out, there has been a long-standing awareness of the role of dopamine-based systems in mental illness, especially in schizophrenia and bipolar mood disorder. This literature has always carried a heavy emphasis on pathology: stressing the failure of such patients to accurately perceive reality, their tendency to act in ineffective and self-defeating ways in everyday life, and, of course, the devastation that such disorders produce for the patient’s family and for the community.

This litany of negative features has (as our paper suggests) always been hard to square with the apparent evolutionary advantage which dopamine appears to bring—given that dopamine systems are present in similar design in all mammal species, and that dopamine-related disorders such as schizophrenia have not been selectively evolved out of the human gene pool, being present at roughly similar frequencies cross-culturally (Nettle & Clegg, 2006).

The answer is that such dopamine systems also support novel and flexible thinking, exemplified in phrases such as Panksepp’s that “playfulness may be one of the main sources of human creativity.” Thus, rather than focusing only on the pathology of such systems, we need to emphasize creativity as a “natural function” of this system. As a society, therefore, we are best advised to work with, rather than against these powerful creative forces, which provide great energy, but which appear also to have the potential to tip over into mental illness. Such “working with” has, of course, long been achieved in some societies where, for example, strikingly creative and potentially “delusional” processes can be accommodated within religion and/or shamanism, or indeed within the world or art.

**Creativity and Intellect**

We have one final class of observation. The commentaries also remind us that creativity is simultaneously an emotional and an intellectual act, on the cusp between raw feelings and higher cognitive processes. Thus, pleasurable emotions, when experienced alone and without engagement with the world, can be narcissistic and indeed solipsistic. This is, of course, the state repeatedly achieved in addictive disorders that gain the individual very little beyond immediate relief from the vagaries of life and certainly are of little gain to an addict’s family and to wider society.
In contrast, intellectual activity alone also has drawbacks. One might imagine, for example, a parody of the field of accounting, which is intellectually demanding but is reputed to be monotonous and sterile. Disciplines such as these produce, of course, financial gains for the individual and indeed for the community at large. But these gains are often achieved at the cost of personal happiness, because the intellectual work fails to chime with the forces that produce and sustain genuine pleasure.

Creativity, however, straddles the intellectual and emotional divide by producing activities which have sufficient novelty to engage the brain/emotion systems which reward novelty, while at the same time address the complexities of the external world and challenge the limits of cognitive systems. In this sense, then, creative acts recruit phylogenetically ancient brain systems (common to all mammals) that have always brought pleasure to our species but also recruit massively overdeveloped cortical systems which make human intellect unique. The creative state is, therefore, one that serves the needs of our species—in all its diversity—very well indeed.

REFERENCES

