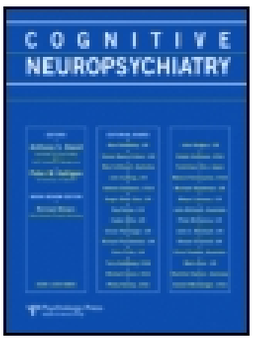

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Creative thinking in schizophrenia: The role of executive dysfunction and symptom severity

Anna Abraham PhD , Sabine Windmann , Peter McKenna & Onur Güntürkün

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Creative thinking in schizophrenia: The role of executive dysfunction and symptom severity

Anna Abraham

International Graduate School for Neuroscience, Ruhr University, and, Institute of Cognitive Neuroscience, Ruhr University Bochum, Germany

Sabine Windmann

School of Psychology, University of Plymouth, UK, and, Institute of Psychology, University of Frankfurt, Germany

Peter McKenna

Fulbourn Hospital, Cambridge, UK

Onur Güntürkün

Institute of Cognitive Neuroscience, Ruhr University Bochum, Germany

Introduction. This study examines the notion of enhanced creative thinking in schizophrenia and determines the mediating role of executive dysfunction and symptom severity in this relationship.
Method. Patients with chronic schizophrenia ($n = 28$) were assessed on varied facets of creative cognition and standard tests of executive control relative to matched healthy control participants ($n = 18$).
Results. Multivariate analyses revealed poorer performance by the patient group across almost all creative and executive function measures, except in the ability to be unconstrained by the influence of restrictive examples. Symptom-based contrasts using partial correlations revealed that differences were most extensive in the presence of thought disorder. Using hierarchical regression analyses, performance on the executive function tasks was found to play a mediatory role on specific aspects of creative cognition.
Conclusions. Results are at odds with the popular notion of enhanced creative thinking in schizophrenia, but elucidate complex interactions between executive control and certain facets of creative thinking. In particular, performance of the

Correspondence should be addressed to Anna Abraham, PhD, MPI for Human Cognitive and Brain Sciences, Department of Cognitive Neurology, Stephanstrasse 1a, 04103 Leipzig, Germany; e-mail: annaabr@gmail.com

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schizophrenia group on measures that tap creativity elements of fluency and relevance were either partially or fully mediated by their performance on the executive control tasks, but this was not true of measures of originality.

INTRODUCTION

Creativity is one of the most intriguing of all human abilities, but rarely the subject of concerted mainstream research given its seemingly elusive nature. J. P. Guilford (1956, 1967) provided much of the early impetus for the experimental study of creativity using a psychometric approach, and creative or divergent thought was held to be synonymous with the fluency, flexibility, and novelty of ideas. This model paved the way for the development of a number of tasks and test batteries that were devised to gauge creative or divergent thinking (e.g., Guilford, 1967; Torrance, 1974; Wallach & Kogan, 1965). Since then the study of creativity from different theoretical orientations has led to several conceptions of what creative thinking entails and, by extension, the espousal of a diverse array of variables that are equated with creative ability and expression. Central to any definition of creativity is the element of originality, which refers to the propensity to generate unique and unusual responses. Other pertinent dimensions include relevance, fluency, and flexibility of ideas.

The cognitive approach to understanding creativity is directed at examining the mental operations that underlie creative thought. Given the complex nature of creativity, it is evident that many different types of cognitive processes are involved in creative thinking. Within the Geneplore model of creative cognition (Finke, Ward, & Smith, 1992; Smith, Ward, & Finke, 1995), examining various normative cognitive processes under explicitly generative conditions is held to allow for a more thorough understanding of how creative thought can emerge in all its diversity. A number of such processes have been identified and several tasks have been developed to gauge them. These include conceptual expansion or the ability to go beyond the framework of established conceptual structures, creative imagery or the ability to create novel and usable combinations from a set of simple geometrical elements, the ability to surpass the constraining influence of recently activated knowledge, the proficiency in generating alternative uses for common objects, and insight in analytical problem solving.

The relationship between creativity and mental illness has been a persistent source of fascination to humankind for centuries despite the fact that this enchanting notion has not been empirically validated. The bulk of the support for this link derives from case studies (for reviews, see Lauronen et al., 2004; Waddell, 1998) where the incidence of mental illness

has been consistently reported to be elevated among eminent creative geniuses and individuals in creative professions (e.g., Andreasen, 1987; Jamison, 1989; Ludwig, 1995; Post, 1994; Wills, 2003). There is some contention, however, about which type of psychosis is related to superior creative ability. On balance, case report and case control studies tend to suggest a stronger association for mood disorders, whereas the few available experimental studies favour the link between creativity and schizophrenia (e.g., Glicksohn, Alon, Perlmutter, & Purisman, 2001; Jena & Ramachandra, 1995; Merten, 1995).

Famous historic personalities with schizophrenic symptoms, like Vincent van Gogh and John Nash, have long nourished the idea of a positive relationship between schizophrenia and creativity, particularly in the public eye. A few experimental studies have indeed supported this notion. For instance, Jena and Ramachandra (1995) demonstrated that schizophrenic subjects surpassed a matched healthy control group on the alternate uses task by inventing more unique and unusual uses for common objects. On another creativity task, a word association test, Merten (1995) found that schizophrenics were largely nonconformist in their free associative responses and overinclusive in their cognitive style as they generated uncommon or only remotely related associations to the cue words.

There is also evidence, however, that runs directly contrary to these claims (Eisenman, 1990; Richards, Kinney, Lunde, Benet, & Merzel, 1988). Andreasen and Powers (1975), for example, showed that schizophrenics exhibited underinclusive thinking on the Goldstein-Scheerer object sorting task in contrast to creative writers who were overinclusive in their conceptual styles. One line of reasoning that can be employed to explain such contradictory findings is the heterogeneity of the clinical samples across investigations. A lack of stringency in controlling for schizophrenic diagnostic subtypes or symptomatology, as was the case in much of the early research on schizophrenia, could perhaps account for the divergent pattern of results. Keefe and Magaro (1980), for instance, demonstrated symptom-based differences in performances such that nonparanoid schizophrenics performed better than paranoid schizophrenics and nonpsychiatric subjects on the alternate uses task.

In fact, Payne (1973) postulated that overinclusive thinking was associated specifically with formal thought disorder in schizophrenia, which is what makes the speech of such patients difficult to comprehend. Overinclusiveness was said to occur when the cognitive mechanism that allocates attention to only relevant information becomes unable to exclude irrelevant information. Overinclusiveness in conceptual thinking was defined as the inability to confine thinking to a given task at hand, which would in turn lead to concepts being less circumscribed in their boundaries. Closely and distantly related concepts could thus merge into one another.

One supposed cognitive marker of such an overinclusive thinking style is defocused attention. Defocused attention or a lack of attentional inhibition is widely held to play a formative role in overinclusive and creative thinking as such diffuse attentional control would lead to loosened associational thinking and result in the activation of more remote associations (Martindale, 1995). Highly creative individuals have been shown to demonstrate reduced attentional control in a number of studies (Dewing & Battye, 1971; Dykes & McGhie, 1976; Mendelsohn & Griswold, 1964; Toplyn & Maguire, 1991), as have schizophrenics (Baruch, Hemsley, & Gray, 1988; Beech, Powell, McWilliam, & Claridge, 1989; Dykes & McGhie, 1976).

In the case of schizophrenia, insufficiencies in attentional inhibition, as characterised by the inadequate inhibition or filtering out of irrelevant information and inefficient attentional control, can be related to a wider spectrum of cognitive impairments that are typical of schizophrenia. Schizophrenics show markedly impaired performance on many aspects of frontal lobe function that lead to deficient goal-directed behaviour as they demonstrate poor inhibitory control, defective working memory, and a perserveratory response style on set-shifting tasks (e.g., Curtis, Calkins, & Iacono, 2001; Liu, Tam, Xie, & Zhao, 2002; Park & Holzman, 1992), suggesting a fundamental deficit in executive functioning.

Symptom-based differences again have been implicated with regard to executive function deficits in schizophrenia. The symptom-based differences can be best expressed in terms of Liddle's (1987; Liddle & Barnes, 1990) three syndrome model of schizophrenia, which has been supported by factor-analytic studies (Kay, Opler, & Fiszbein, 1986; Mortimer, Lund, & McKenna, 1990). The symptoms are differentiated into three groups: positive symptoms or reality distortion syndrome (delusions and hallucinations), negative symptoms or psychomotor poverty syndrome (negative symptoms of poverty of speech, flat affect, and decreased spontaneous movement), and thought disorder or the disorganisation syndrome (thought disorder and inappropriate affect). It appears from neuropsychological tests of executive functions such as working memory, set-shifting, and inhibitory control that the negative/psychomotor poverty symptoms and thought disorder/disorganisation symptoms are most strongly associated with executive function impairments, whereas positive/reality distortion symptoms show little or no association (e.g., Lanser, Berger, Ellenbroek, Cools, & Zitman, 2002; Moritz et al., 2001; Pantelis et al., 2004; Park, Puschel, Sauter, Rentsch, & Hell, 2003). Furthermore, some limited evidence indicates that a high degree of positive/reality distortion symptom scores are mainly associated with verbal and semantic memory deficits (e.g., Bozikas, Kosmidis, Kioperlidou, & Karavatos, 2004; Mahurin, Velligan, & Miller, 1998).

In summary, schizophrenics are known to be markedly impaired on many cognitive domains that require effective goal-directed thinking and that these deficits are largely related to the degree of specific symptoms. The idea that schizophrenia could be accompanied by greater creative skills stems from the idea that loose associational thinking, which can result from insufficiencies in facets of executive function and goal-directed thinking, has been related to enhanced creative ability in other populations. This has been the rationale underlying many personality-based studies on creative or divergent thinking (e.g., Carson, Peterson, & Higgins, 2003; Woody & Claridge, 1977). A recent neurological study on frontal lobe patients, a population widely known to exhibit executive function impairments, were found to surpass a matched healthy control group on an insight problem-solving task but not on a control incremental problem-solving task (Reverberi, Toraldo, D'Agostini, & Skrap, 2005). Another recent study on adolescents with ADHD, a disorder characterised by inhibitory control deficits, revealed that the ADHD group relative to a healthy control group showed specific advantages in the creative process of overcoming constraints posed by interfering examples when trying to generate something new (Abraham, Windmann, Siefen, Daum, & Güntürkün, 2006).

This presents a paradox of sorts. Notwithstanding inconclusive empirical evidence, it is of course contentious to suggest that schizophrenics could possibly be generally more creative than average, especially after years of illness with recurring episodes and pharmacological treatment. Moreover, executive control and intact frontal lobe function seem to be required for some aspects of creative cognition, such as, for example, when it necessary to wilfully inhibit preactivated concepts to make a relevant response or to think flexibly so as to be able to generate many different ideas.

As creativity has many different facets, it may be possible that some of them require functional executive control but other would benefit from just the opposite case which would enable loose associational thinking. We therefore aim to draw a more differentiated picture than earlier investigations by examining: (a) the performance profile of schizophrenic patients across a range of different creative cognitive processes and, in doing so, tap into finer aspects of creative function than was the case in previous studies, (b) the mediating role of symptom severity, and (c) the potential mediatory effect by specific executive function factors on creative cognition. Apart from the differences between the groups, we endeavoured to clarify which facets of creative cognition are mediated in what manner by reduced executive control. Since it is established that executive functioning is disrupted in schizophrenia, this clinical population was assessed in order to understand how creative functions are affected as a consequence of deficits in executive control.

METHODS

Participants

Thirty-three patients were initially recruited for this study from Fulbourn Hospital in Cambridge, UK, under the guidance of the consultant psychiatrist (PM). After controlling for age and premorbid IQ scores, assessed using the National Adult Reading Test (NART; Nelson, 1982), the final clinical case group in this study (inclusion in the sample only with NART >90) consisted of 28 patients with schizophrenia (23 men) with a mean age of 43.07 ($SD = 9.91$) and a mean NART IQ value of 108.11 (range: 92–123). The group comprised of patients with chronic schizophrenia with a duration ranging from 7 to 30 years, who were at the upper end of the spectrum of presentations of chronic schizophrenia in terms of preserved intellectual function. The patients displayed ongoing negative and/or positive symptoms and were in a stable clinical condition during the time of testing. All but one of the patients lived outside hospital either in sheltered accommodation or independently with support. The remaining patient was undergoing rehabilitation in an inpatient unit. All the patients were unemployed, although one was doing a part-time degree course in computing (the field in which he had worked before he became ill). All the patients were taking medication at the time of testing, which was Clozapine in all cases.

The schedules for assessment of positive and negative symptoms (SAPS and SANS) of the Comprehensive Assessment of Symptoms and History (CASH; Andreasen, Flaum, & Arndt, 1992) were carried out for all the patients. The mean global ratings on a scale of 0–5 were 2.18 ($SD = 1.57$) for delusions, 2.5 ($SD = 1.31$) for hallucinations, 1.18 ($SD = 1.44$) for thought disorder, 2.25 ($SD = 1$) for affective flattening, 1.11 ($SD = 1.17$) for alogia, 2.39 ($SD = 1.03$) for avolition–apathy, and 2.14 ($SD = 1.01$) for anhedonia–asociality.

The control group was recruited from the local community and the initial sample included 21 healthy volunteers with no history of mental illness. After controlling for age and NART premorbid IQ scores, the final sample included 18 healthy adults (14 men) with a mean age of 39.11 ($SD = 12.54$) and a mean NART IQ value of 111.44 (range: 92–122). The schizophrenic and control groups were matched in terms of age, $t(44) = 1.19$, $p = .24$, and premorbid IQ, $t(44) = -1.17$, $p = .25$. All participants received payment of £4 per session (40 minutes) for their participation. In the case of the patients, only one session was carried out per day and no single experimental session lasted longer than 40 minutes. The number of sessions taken to complete all the tasks in the experiment was determined by the pace of the patient (average 3–4). Most control subjects completed all the tasks within two

lengthier sittings. This study was approved by the Cambridge Local Research Ethics Committee and all participants gave informed consent.

Materials and procedures

The experimental tasks used within the study included creative cognition tasks (conceptual expansion, creative imagery, constraints of examples, alternate uses, convergent problem solving) and executive function tasks (digit backward span, Hayling sentence completion test, Brixton spatial anticipation test, Stroop neuropsychological screening test). In all cases, scorers were blind to the hypothesis of the experiment and had no information about the participants.

Conceptual expansion. Conceptual expansion was assessed with the use of the Ward animal task (Ward, 1994). In this task, participants were required to imagine and draw animals that lived on another planet that were very different to those on Earth. The duration for the completion of the task was 5 minutes. Each drawing was subsequently coded in accordance with the procedures described by Ward (1994, Exp. 1; Abraham, Windmann, Daum, & Güntürkün, 2005) with the help of two independent scorers who had to note the presence or absence of the following features: bilateral symmetry of form, appendages (legs, arms, wings, tail), sense organs (eyes, mouth, nose, ears), atypical appendages, and atypical sense organs. A coding was deemed valid when both scorers were in agreement. In the occasional situation when both scorers were not in agreement (less than 2% of all observations), a third scorer was consulted and the majority result accepted.

The coded data yielded five elements of conceptual expansion: (a) bilateral asymmetry, (b) lack of appendages, (c) lack of sense organs, (d) unusual appendages, and (e) unusual sense organs. In the case of elements (b) and (c), when one or more of the four customary appendages or sense organs were present in a drawing it would qualify as a presence of an appendage or sense organ. Only a complete absence of all customary appendages and sense organs would be scored as lack of appendages or a lack of sense organs. The presence or absence of an element gave rise to a score of 1 or 0. The total expansion score for a drawing thus ranged from 0 to 5.

Creative imagery. In this task, the participant is required to assemble an object that falls into a predetermined category using three figures from an array of simple three-dimensional figures (see Abraham et al., 2006; Finke, 1990). Except for altering the form of the figures, the participants were allowed to vary the figures provided to them in any way with regard to size,

orientation, position, texture, and so on. The participants were required to put the figures together in a meaningful way so as to form a useful object from a certain category. There were a total of five trials in which the subjects were presented with the same combination of figures and categories across trials. In Trial 1, the figures were a sphere, a hook, and a tube for the category "furniture". In Trial 2, the figures were a cone, a flat square, and wheels for the category "tools and utensils". In Trial 3, the figures were a cylinder, a bracket, and a handle for the category "toys and games". In Trial 4, the figures were a half-sphere, a rectangular block, and a ring for the category "weapons". In the last trial, the figures were a cube, a wire, and a cross for the category "transportation".

The inventions were rated by two trained raters along two dimensions—originality (how unusual and unique the invention is) and practicality (how functionality and usable the invention is)—using a 5-point scale, and the average of their ratings were taken as the scores for the inventions. Each participant consequently obtained an average score of originality and practicality from the five inventions they generated across trials. The interrater correlation (Pearson's correlation coefficient) on the creative imagery task measures were highly significant: practicality scale, $+.71$ ($p < .0001$), and originality scale: $+.64$ ($p < .0001$).

Constraints of examples. In this task, subjects are asked to imagine that they were employed by a toy company that is in need of new ideas for toys. The subject's task was to imagine and draw a new and different toy of his or her own creative design within an allotted period of 5 minutes. Duplication of toys that currently exist or previously existed was not allowed. Prior to the drawing of the toys, the subject is exposed to exemplars of three examples of toys (taken from Smith, Ward, & Schumacher, 1993) that have three fundamental elements in common: the presence of a ball, the presence of high physical activity, and the presence of electronics. The subjects' drawings are thus assessed on the extent to which they include these three fundamental features of the examples. Two independent scorers noted whether the subjects' drawings contained any of these three elements. There was complete agreement between both scorers on all counts. The total score on this task ranged from 0 (none of the three common elements of the toy examples were present in the subject's drawing) to 3 (all three elements of the toy examples were present). The greater the constraining effect of the examples, the greater degree of similarity of the toy generated of the subject to that of the previously presented toy examples.

Alternate uses. In this task (based on Wallach & Kogan, 1965), participants are asked to generate as many uses as possible for three common objects: a newspaper, a shoe, and a brick. There was no time limit

for this task. The subjects' responses are assessed on the basis of two dimensions in line with the scoring procedures of Wallach and Kogan (1965): fluency, which is judged by the number of acceptable solutions generated for each object, and uniqueness, which is assessed by the infrequency or originality of the generated use. A use is scored as being unique only if one person in the whole sample has generated such a response. The total number of responses generated for each of the three objects was summed for every subject to obtain the total fluency score. The total number of unusual responses generated for each of the three objects was summed for each subject to obtain the uniqueness score.

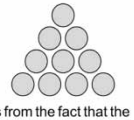
Convergent problem solving. Eight problems were employed in total, half of which were insight problems and the other half were incremental problems. In an effort to make the problems span a wide variety of subtypes, Weisberg's (1995) classification was employed in selecting problems which classifies four types of analytical problems: brain teasers or riddles, mathematical, geometrical, and manipulative. Correspondingly, one insight and one incremental problem for each of these problem types were selected (see Figure 1). A maximum of 4 minutes were allocated for the solving of each problem. If a subject gave wrong solutions to the problem within this period, they were given an explanation about why the solution was wrong and were allowed to continue working on the problem till the 4-minute period had elapsed. Each problem was scored with either a 1 for the successful solving of a problem or a 0 when the problem was unsolved. The total score on insight problem solving and incremental problem solving thus ranged from 0 to 4.

Digit backward span. The backward variant of the digit span task (from the WAIS-R; Wechsler, 1981) was used to assess verbal working memory. The participants were required to repeat a sequence of digits in the reverse order called aloud by the experimenter. Each subject's span was defined as the maximum sequence length at which a correct response was produced in at least one out of two trials.

Hayling sentence completion test. This test (Burgess & Shallice, 1997) consists of two sets of 15 sentences, each of which has the last word missing. The examiner reads aloud the sentences in the first set and the subjects are required to respond by simply providing a word that fits well at the end of the sentence as fast as possible. In the second set, the subject is required to complete the sentences by providing a word that is completely unrelated to the sentence as fast as possible. The scaled score of the number of inappropriate responses on this second set is taken as measure of response suppression failure.

Insight Problems

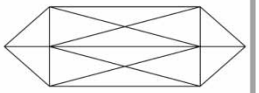
1. **Coin problem** (insight problem; brain teaser): A dealer in antique coins got an offer to buy a beautiful bronze coin. The coin had an emperor's head on one side and the date 544 B.C. stamped on the other side. The dealer examined the coin, but instead of buying it, he called the police to arrest the man. What made him realise that the coin was fake? (Adapted from Metcalfe, 1986). **Solution**: In 544 B.C. there was no knowledge of Jesus Christ as he was as yet unborn. A coin from that time thus could not be marked 'B.C'. Most initial false solutions concern whether the date matched the emperor ruling in 544 B.C., whether bronze was already discovered, etc.
2. **Egg problem** (insight problem; mathematical): Using only one 7-minute hourglass and one 11-minute hourglass, how will you be able to time the boiling of an egg for exactly 15 minutes? (Adapted from Sternberg & Davidson, 1982). **Solution:** Start both hourglasses at the same time. When the 7-minute hourglass runs out (and 4 minutes remain on the 11-minute hourglass), start boiling the egg. After the 4 minutes have elapsed, turn it over the 11-minute hourglass again to obtain a total time of 15 minutes. An egg is customarily put into a pot of water as soon as it commences to boil. To arrive at the correct solution, the fixedness to approach the problem using this strategy must be overcome.
3. **Triangle problem** (insight problem; geometrical): The triangle of coins in the picture provided here points to the top of the page. How can you make the triangle point to the bottom of the page by moving only three coins? (Adapted from Metcalfe, 1986). **Solution:** Coins to be moved are the ones on the bottom left, bottom right and the top. The difficulty in this task stems from the fact that the initial attempts in solving the problem are directed by moving the top three coins and rearranging them to form a downward pointing triangle. The correct solution requires a mental rotation.



4. **Candle problem** (insight problem; manipulation): The task is to link a candle to a cork wall. The problem is solved when the candle is linked to the wall, burns properly and does not drip wax on the cork wall, the wooden platform below or on the surrounding table, and without getting the cork wall burnt. Any of the materials provided (a candle, a matchbox, a few tacks) can be used in any way to complete the task. (Adapted from Duncker, 1945) **Solution:** The matchbox must be used as a candleholder and affixed it to the wall with the help of the tacks. The difficulty lies in thinking flexibly - that the matchbox can not only be used for its usual purpose but also in novel ways to solve the task.

Incremental Problems

1. **Card problem** (incremental problem; brain teaser): Three cards from an ordinary deck of playing cards are lying on a table, face down. The following information is known about the three cards: to the left of a queen there is a jack; to the left of a spade there is a diamond; to the right of the heart there is a king; to the right of the king there is a spade. Using this information, assign the proper suit to each picture card. (Adapted from Schooler, Ohlsson & Brooks, 1993). **Solution:** Queen of Hearts, King of Diamonds, Jack of Spades. This solution can be arrived at in a step-by-step manner after working through each of the conditions.
2. **Water jug problem** (incremental problem; mathematical): Given a source of unlimited water and four containers of different capacities - 99, 14, 25, and 11 litres obtain exactly 86 litres of water. (Adapted from Luchins, 1942) **Solution:** There are many possibilities to solve this problem, the easiest of which would be to use the 25-litre jar 3 times and the 11-litre jar once, (25 x 3) + 11 = 86. This solution is arrived progressively and in a stepwise manner.
3. **Trace problem** (incremental problem; geometrical): Without lifting your pencil from the paper, trace the figure that is provided below. This must be done under the condition that a line cannot be traced more than one time. (Adapted from Metcalfe & Wiebe, 1987) **Solution:** The starting point for the tracing has to be one of the extreme points on the left or right (the point at which an odd number of lines meet). This solution is arrived at progressively by trial-and-error.



4. **Tower of Hanoi** (incremental problem; manipulation): There are three poles with three differently sized discs on one of them. The objective of the task is to transport all the discs from the pole which is on the far left to the pole on the far right. The discs can only be moved in the following ways: move only one disc at a time, never place a larger disc on top of a smaller disc, and move only the topmost disc if more than two discs are on a pole. (Adapted from Metcalfe & Wiebe, 1987) **Solution:** A performance is judged correct when the problem is solved in 7 moves. This is possible only by adequate planning beforehand and requires overcoming the tendency in the first move to transport the smallest disc to the nearest pole.

Figure 1. The instructions and solutions to the insight and incremental analytical problems that were employed. Reprinted and adapted from *Journal of Research in Personality*, Z. Karimi, S. Windmann, O. Güntürkun, & A. Abraham, Insight problem solving in individuals with high versus low schizotypy, in press, Copyright (2006), with permission from Elsevier.

Brixton spatial anticipation test. This is a rule or concept attainment task (Burgess & Shallice, 1997) and the test consists of a 56-page stimulus booklet where each page shows the same array of 10 circles in two rows of five. On each page, one circle is coloured blue and the position of the blue circle varies from page to page. The subject is shown a page at a time and the task is to predict where the coloured circle will be on the next page by trying to infer a pattern or a "rule" based on what has been seen in previous pages. Errors result from either an inability to detect or follow a rule. The scaled score of number of errors made in this test is taken as measure of set-shifting capabilities.

Stroop Neuropsychological Screening Test. This test (Trennery, Crosson, DeBoe, & Leber, 1989) measures efficiency of attentional inhibition and includes three conditions and three forms per condition. The first condition is a control condition where the subject is required to read out a list of words (colour words printed in black ink) as fast as possible. In the second control condition, the subject is required to recognise and call aloud a list of colour patches (red, blue, green, and yellow) as fast as possible. In the third condition, the subject is presented with a list of colour words written in an incongruent colour ink (e.g., the word "RED" written in blue or the word "GREEN" written in yellow) and the subjects have to call aloud the ink colour that each word is written in as fast as possible. The time taken to finish each form is recorded with a stopwatch and the average time taken across the three forms is calculated for each condition.

RESULTS

The descriptive data of the schizophrenic and control groups across all the creative cognition and executive function variables including the summary of the findings based on comparisons between the groups are displayed in Table 1. Multivariate analyses were carried out to determine whether the performances of the schizophrenic and healthy control groups were significantly differentiable on any of the experimental variables.

With reference to the executive function measures, apart from the Hayling task on which no significant difference in performance was found between the groups, $F(1, 44) = 1.38$, $p = .25$, the schizophrenic group demonstrated significantly poorer performance than the control group on all the other executive control tasks: the digit backward span, $F(1, 44) = 9.61$, $p = .003$, the Brixton test, $F(1, 44) = -13.07$, $p = .001$, and showed prolonged reaction times (RT) across all three Stroop conditions: the word control condition RT, $F(1, 44) = 9.02$, $p = .004$, the colour control condition RT, $F(1, 44) = 9.53$, $p = .003$, and the colour/word interference condition RT,

TABLE 1
Descriptive data for the schizophrenia group and the healthy control group across all experimental variables and summarised findings of the performance differences between the groups after multivariate analysis

	Schizophrenia group		*Control group*		
	Mean	*(SD)*	*Mean*	*(SD)*	*p*
NART—Premorbid IQ	108.11	(9.88)	111.44	(8.61)	*ns*
Age	43.07	(9.91)	39.11	(12.54)	*ns*
Digits backward task	5.96	(2.36)	8.17	(2.33)	$<.01$
Brixton test: Error scaled score	4.39	(2.81)	7.06	(1.70)	$<.01$
Hayling test: Error scaled score	5.68	(1.87)	6.28	(1.36)	*ns*
Stroop: Words control condition	38.08	(11.02)	29.84	(4.53)	$<.01$
Stroop: Colours control condition	56.19	(13.74)	44.90	(8.91)	$<.01$
Stroop: Interference condition	95.78	(29.84)	77.28	(16.58)	$<.05$
Stroop: Interference—words	57.7	(26.73)	47.44	(14.78)	*ns*
Insight problem solving	0.79	(1.13)	1.94	(1.35)	$<.01$
Incremental problem solving	1.64	(0.95)	2.61	(1.14)	$<.01$
Constraints of examples	1.11	(0.80)	1.25	(0.86)	*ns*
Conceptual expansion	1.29	(1.36)	2.17	(1.38)	$<.05$
Alternate uses test: Fluency	9.21	(4.41)	18.44	(6.34)	$<.05$
Alternate uses test: Uniqueness	1.07	(1.61)	2.39	(2.25)	$<.001$
Practicality: Creative imagery	2.83	(0.61)	3.17	(0.61)	*ns*
Originality: Creative imagery	2.20	(0.57)	2.63	(0.81)	$<.05$

$F(1, 44) = 5.74$, $p = .021$. After the subtracting the Stroop interference condition RT from the word control condition RT, the differences between the groups were found to be nonsignificant, $F(1, 44) = 2.21$, $p = .15$.

On the creative cognition measures, the schizophrenic group were significantly poorer in performance on insight problem solving, $F(1, 44) = 9.03$, $p = .005$, incremental problem solving, $F(1, 44) = 9.88$, $p = .003$, the practicality imagery measure, $F(1, 44) = 5.37$, $p = .025$, the alternate uses uniqueness measure, $F(1, 44) = 4.85$, $p = .033$, and the alternate uses fluency measure, $F(1, 44) = 30.95$, $p < .001$. Although trends towards poorer performance were also found on the conceptual expansion task, $F(1, 44) = 3.81$, $p = .058$, and the originality imagery measure, $F(1, 44) = 3.25$, $p = .079$, no significant differences between the groups were found on the toy examples task, $F(1, 44) = -0.29$, $p = .6$.

To verify whether the main effects observed on the creative cognition variables as a function of experimental group were mediated by the performance on the executive control tasks on which significant main effects were also found, hierarchical multiple regression analyses were employed. In this procedure a first regression analysis is carried out in which a creative cognition variable is the dependent variable and the

executive function measures (digit backwards span, Brixton test, Hayling test, Stroop RT interference–word) are entered as independent variables. A second regression is then computed with the same dependent variable, whereas the experimental group (patient vs. control group) is also coded as an independent variable alongside the executive function variables. The difference in the *R*-square values between these two equations is then computed.

If the first regression analysis is significant but there is no significant difference between the *R*-square values of the two regression equations, then the differences between the schizophrenic and control groups on that particular creative cognition variable is fully mediated by the executive function variables. On the other hand, if the difference between the *R*-square values of the two regression equations is significant, the result signifies that performance on the executive function tasks only partially mediate the results on that creative cognition variable (if the regression 1 is significant), and that group status significantly explains individual differences in creative cognition even after executive control functions have been taken into account. This procedure was undertaken for each of the creative cognition variables, and results are presented in Table 2. The *p* value in the last column reflects the significance level of the difference in *R*-square values of regressions 1 and 2.

With regard to the measures of insight and incremental problem solving, results indicate significant Regression 1 but a nonsignificant difference between the first and the second regression equations. This signifies that schizophrenia had no further influence on these measures beyond what is explained by the executive control deficits. The same finding was true for the practicality–imagery measure. In contrast, in parallel to a significant Regression 1, the difference between the two regression equations was significant in the case of the alternate uses fluency measure, which indicates only a partial mediation effect of executive control on this task. On the alternate uses uniqueness measure, Regression 1 was nonsignificant but the difference between the two regression equations was significant, which implies that executive control deficits played no mediatory role on this variable. A similar pattern was found for the originality–imagery variable, but only at the level of a mild trend.

In order to determine whether the degree of severity of schizophrenic symptoms corresponded to changes in performance across the various experimental measures, a series of two-tailed partial correlations were carried out for each symptom type while controlling for the severity of the other symptom clusters. For the analyses of each of the negative symptom scores, the influence of hallucinations, delusions, and thought disorder were controlled for. In the analyses of the positive symptom variables, the variables that were controlled for included all four negative symptoms and

TABLE 2
Summary of results from the hierarchical multiple regression analyses

	F	*Sig.*	R^2	R^2 *difference*	*F difference*	*Sig. F difference*
Insight problems						
Regression 1	5.78	$p < .001$	.361			
Regression 2	5.07	$p < .001$	.388	.027	1.78	$p = .19$
Incremental problems						
Regression 1	5.01	$p = .001$	.328			
Regression 2	4.36	$p = .002$	.353	.025	1.152	$p = .225$
Conceptual expansion						
Regression 1	2.213	$p = .084$	.178			
Regression 2	2.291	$p = .064$	.223	.045	2.317	$p = .136$
Examples Task						
Regression 1	0.528	$p = .716$	.053			
Regression 2	0.422	$p = .83$	.054	.001	0.053	$p = .891$
Practicality–imagery						
Regression 1	2.683	$p = .045$	.130			
Regression 2	2.240	$p = .069$	.121	.011	0.579	$p = .451$
Originality–imagery						
Regression 1	0.386	$p = .817$	.036			
Regression 2	0.929	$p = .473$	.104	.068	3.024	$p = .09$
Alt. Uses: Fluency						
Regression 1	2.752	$p = .041$	.212			
Regression 2	7.077	$p < .001$	.469	.258	19.428	$p < .001$
Alt. Uses: Uniqueness						
Regression 1	0.380	$p = .822$	.036			
Regression 2	1.251	$p = .304$	.135	.099	4.601	$p = .038$

thought disorder. For the partial correlations for thought disorder, all the other symptoms were controlled for. The results of these analyses are presented in Table 3.

With regard to the significant results, the analyses revealed that the severity of hallucinations was positively correlated with the Hayling error score ($p = .013$), affective flattening was negatively correlated with the Brixton error score ($p = .025$) and positively correlated with the Stroop RT word condition ($p = .011$), and anhedonia-sociality was positively correlated with the Hayling error scaled score ($p = .009$). The presence of thought disorder corresponded with the largest number of performance differences. The severity of these symptoms was negatively correlated with performance on the digits backward span task ($p = .036$), the Brixton test ($p = .001$), the Hayling test ($p = .009$), Stroop RT interference ($p = .022$), Stroop RT interference–word ($p = .029$), insight problem solving ($p = .03$), and incre-

TABLE 3
Partial correlation analyses showing the degree of association between the severity of each schizophrenic symptom with performance across all the experimental variables after controlling for the influence of other symptom clusters

	Delusions	*Hallucinations*	*TD*	*Flat Affect*	*Alogia*	*Avolition*	*Anhedonia*
Digit backward span	.053	−.299	−.460*	−.380	−.340	−.120	−.061
Brixton test	.040	−.292	−.684**	−.456*	−.362	−.023	.089
Hayling test	.260	.521*	−.555**	.041	.186	.052	.524**
Stroop: RT word	−.098	−.254	.077	.511*	.341	−.026	−.093
Stroop: RT colour	−.170	.041	.494*	.391	.364	−.159	−.124
Stroop: RT interference	−.007	.310	.496*	.238	.373	−.220	−.188
RT interference–word	.028	.390	.476*	.065	.283	−.235	−.173
Insight problems	−.057	−.193	−.473*	−.256	−.252	.159	.042
Incremental problems	−.142	−.212	−.482*	−.171	−.099	.094	.138
Examples task	.361	.377	−.452*	−.022	.028	−.024	.356
Conceptual expansion	.209	.200	−.316	.111	.110	.276	.390
Alt. uses: Fluency	−.053	.104	−.079	.018	−.016	−.134	−.121
Alt. uses: Uniqueness	−.057	.230	.394	.120	.179	−.320	−.165
Practicality–imagery	.014	.186	−.400	.140	.095	.159	.217
Originality–imagery	−.273	−.233	−.160	.270	.125	.275	.103

*$p < .05$, **$p < .01$.

mental problem solving ($p = .027$). Interestingly, a significant negative correlation was also found between the severity of thought disorder and the tendency to be constrained by examples on the constraints of examples task ($p = .039$).

DISCUSSION

The multivariate analyses demonstrated that the schizophrenic group displayed poorer performance across the executive cognition tasks relative to the healthy control group except on the error scaled score of the Hayling sentence completion. This implies that although both groups appear to perform comparably on the executive function of response suppression, the schizophrenic group was poorer on working memory and set-shifting. With regard to the interference measure of the Stroop task, after controlling for general slowness in responding there was no significant difference between the groups on this measure of inhibitory control.

With regard to the creative cognition tasks, the analyses revealed that barring the constraints of examples task, the schizophrenics exhibited poorer performance across all the other tasks. In general then, relative to the control group the schizophrenic group were significantly less able to

solve insight and incremental analytical problems, invent unique uses or generate many uses for common objects, and devise objects in an imagery task that were functional and usable. They also showed a strong tendency to be less able to expand concepts and to be original when devising objects in an imagery task. The schizophrenic and healthy control group were, however, not differentiable in performance with regard to the effects of the constraining influence of examples when creating something new.

A series of hierarchical multiple regression analyses were carried out to determine if performance on the executive control variables had a mediating effect on the group based differences on the creative cognition tasks. The results indicated that the frontal variables did in fact positively mediate the performance differences between the schizophrenic and healthy control group on insight problem solving, incremental problem solving, and the practicality imagery measure. A partial positive mediation effect on the executive control variables was found on the alternate uses fluency measure, and no discernable mediation effects were apparent for rest of the creative cognition variables.

The results thus demonstrate that in contrast to the popular idea that poor executive function would be related to better performance on creative thinking tasks, the opposite was found to be true. The control group were not only found to perform better than the patients on almost all facets of executive and creative cognition, their better performance on select facets of creative cognition were also positively mediated by their superior performance on the executive function measures.

The severity of certain schizophrenic symptoms was also associated with poorer performance on the executive function and creative cognition measures. When controlling for other symptom clusters, the partial correlational analyses revealed that the severity of the negative schizophrenic symptoms were positively associated with poorer performance on some of the executive function measures but that the degree of thought disorder was significantly related to poorer performance on a wider variety of executive control tasks. One exception to this pattern of findings in the present analyses was in the Hayling task where there was no evidence for insufficiencies at the level of semantic response suppression in schizophrenia, which is in contrast to other studies (e.g., Waters, Badcock, Maybery, & Michie, 2003).

The results that were uncovered on the executive control tasks were in line with previous lines of research that have argued for a range of executive function deficits as typically seen in patients with schizophrenia such as defective working memory (e.g., Park & Holzman, 1992; Perlstein, Dixit, Carter, Noll, & Cohen, 2003) and poor set-shifting (e.g., Gold, Carpenter, Randolph, Goldberg, & Weinberger, 1997; van der Does & van der Bosch, 1992). Just as was found in the present study, there is also support for the

association of these varied cognitive deficits in schizophrenia with both negative (e.g., Lanser et al., 2002; Pantelis, Stuart, Nelson, Robbins, & Barnes, 2001; Park et al., 2003) and thought disorder (e.g., Brazo et al., 2002; Moritz et al., 2001; Pantelis et al., 2004) symptoms.

With reference to the creative cognition tasks, the schizophrenics were found to be significantly poorer than the controls on the creative cognition variable of insight in problem solving. The same pattern was also true for the incremental problems, which were employed as a control variable for the insight problems. Moreover, the symptom analyses revealed that a high degree of thought disorder was related to poorer performance on problem solving. The regression analyses also revealed that performance on the executive function tasks fully accounted for the significant group based performance differences that were found on these variables. This latter finding was also true for the practicality measure of creative imagery where the capacity to make functional and usable responses was examined.

These results suggest that in conditions that call for a prescribed goal to be reached for which operational working memory, set-shifting, and related processes are necessary, schizophrenics tend to display poor performance, and symptoms relating to thought disorder are particularly implicated in this respect. Patients with schizophrenia are thus impaired in the creative processes of insight in problem solving and practicality in creative imagery because good performance on these variables requires functional goal-directed thinking.

Performance on the executive function tasks were also found to partially mediate differences between the schizophrenic and control groups on the alternate uses fluency measure. The patients were unable to generate as many different uses for common objects as the control group. This pattern of verbal underproductivity, which is related to poor frontal lobe functioning, is one of the defining attributes of language deficits in schizophrenic function. Phonemic and semantic verbal fluency, as assessed by the capacity to generate words beginning with particular letters or belonging to particular categories, is reduced in schizophrenia (e.g., Kremen, Seidman, Faraone, & Tsuang, 2003), which ties in well with the present results.

No mediation effects were found on the remaining facets of creative cognition and, barring the examples task, there were no significant symptom-based differences in association with performance on these variables either. Only group-based differences were found, such that the schizophrenic group was significantly poorer in their performance on the alternate uses uniqueness measure and showed strong tendencies for poorer performance on the conceptual expansion task and the originality–imagery measure. There is an underlying commonality between these three measures. All assess the capacity to make original or unusual responses albeit in different generative situations with the alternate uses task being a verbal task while the other two are nonverbal tasks. The nonverbal measures also differ

from one another in that they necessitate differential levels of abstraction (Abraham et al., 2005).

The constraints of examples measure was the only creative cognition variable on which the schizophrenic and control groups performed comparably. Symptom analyses, however, revealed that the severity of thought disorder was associated with better performance on this task. This is interesting finding because a high degree of thought disorder was also associated with poorer performance across all the executive function measures. This may, however, be the very reason for the relative cognitive advantage of schizophrenic individuals on this task.

In the examples task, providing examples of novel toys with similar fundamental elements prior to allowing the subject to generate a novel toy results in the constraints being actively salient in this task. The examples interfere with the ability to generate a new toy as it is difficult to inhibit explicit recently activated information that is directly pertinent to the task at hand. Thought disorder is characterised by the tendency to be continually diverted from an intended direction and conceptual disorganisation in thinking (Payne, 1973). This kind of disorderly "digressive" thinking or the inability to stick to a logical train of thought because of involuntary access to irrelevant conceptual representations would more easily enable the activated conceptual restrictions posed by the constraints of examples task to be overridden.

A strong case thus emerges for poor creative faculties in chronic schizophrenia across most facets of creativity including originality, relevance, and fluency on the basis of the tasks used in the present study. It is particularly noteworthy that performance differences on the creativity measures that assessed the originality of generated responses were not linearly modulated by performance on the executive function tasks in comparison to the other creativity measures that tapped the propensity to make relevant or useful responses (practicality–imagery), generate many responses (alternate uses fluency), or employ effective strategies in service of a goal (insight and incremental problem solving). This implies that impairments at the level of executive function are accountable for deficits on select facets of creative cognition such as fluency and relevance, which require functional goal-directed thinking for optimal responses, but not in the case of originality.

These findings are not in line with most accounts that have argued for the role played by widened attentional control in allowing for loose associational thinking. Since inhibitory control systems are a key facet of executive function, their reduction should allow for loose associational thinking and could thereby result in ability to be more creative (e.g., Dykes & McGhie, 1976; Martindale, 1995; Mendelsohn & Griswold, 1964; Toplyn & Maguire, 1991). We offer the following suggestions to account for why the opposite association was found in the present study.

Personality studies on nonclinical populations have focused on traits of schizotypy that are nondysfunctional personality characteristics that correspond to diminished levels of psychotic symptoms in schizophrenia. Schizotypy has been associated with superior performance on creativity measures (e.g., Folley & Park, 2005; Karimi, Windmann, Güntürkün, & Abraham, 2006; Mohr, Graves, Gianotti, Pizzagalli, & Brugger, 2001) as well as poorer performance on executive control measures (e.g., Gooding, Kwapil, & Tallent, 1999; Park & McTigue, 1997). Some recent empirical evidence has also shown select advantages in creative cognition in relation to other psychiatric populations with established executive function impairments such as ADHD (Abraham et al., 2006), as well as in neurological populations such frontal lobe patients (Reverberi et al., 2005). Both these populations are known to have similar cognitive dysfunctions as is found in schizophrenia, albeit differing in the level of severity.

These findings suggest that poor executive functioning is advantageous in the ability to make a creative response, but only up to a point. Severely disrupted executive functioning is detrimental to creative performance, whereas milder levels of reduced function can be advantageous on some facets of creative cognition. So the relationship between executive and creative function is probably best expressed in terms of an inverted-U function with too much or two little executive control posing a hindrance to creative performance whereas intermediate degrees confer some degree of a cognitive advantage on select processes.

The higher prevalence of mental illness among individuals in creative professions has been taken in the past as a key indicator for the link between greater creative ability in bipolar disorder and schizophrenia, but it is also known that the creative geniuses of the past who were mentally ill tended to be at the lowest ebb of creative production when severely afflicted with psychosis. It could very well be the case that although the predisposition to develop psychosis may confer some form of enhanced creative potential that, other variables notwithstanding, could mature into greater creative ability, the manifestation of the illness thwarts this potential due to extensively disrupted perceptual and cognitive faculties. In fact there is evidence to suggest higher creative achievement (Karlsson, 2001) in families of mentally ill individuals and increased incidence of mental illness among siblings of highly creative people (Karlsson, 1999).

With reference to the finding that the executive function measures played a mediatory role on all facets of creative cognition except in the variables that tapped originality, it is possible that others facets of frontal lobe function need to be taken into consideration to obtain a more comprehensive understanding of the underlying phenomena. Factors related to executive control are inadequate to be the sole predictors of such complex cognition. Semantic cognitive processes such as semantic selection, which

reflects a different aspect of frontal lobe function, and semantic retrieval, for which the left temporal lobe is also implicated (Thompson-Schill, 2003), quite possibly play a selective mediatory role with regard to originality in creative cognition. To attribute an exclusive role for inhibitory executive factors in creativity appears to in fact impose artificial limitations in obtaining a true understanding of creative cognition.

What is novel about the present study is the fact that it is among the rare empirical studies that address the issue of creative function in schizophrenia and expands on this critical theme by examining different facets of creative thinking, which is vital given the multifaceted nature of creativity. By examining each of the creative cognition operations in parallel with the obtained results on the executive function tasks in the study, we attempted to attain a clearer understanding of the underlying mechanisms of complex cognitive function in schizophrenia and the workings of diverse creative mental operations. With the exception of response suppression in the Hayling test and the ability to be unconstrained by pertinent examples when generating something novel, the schizophrenic group exhibited poorer performance than the control group across all other creative cognition and executive function measures. However, only the relevance and fluency facets of creative cognition were found to be linearly mediated by performance on the executive function measures, which implies that these processes require functional goal-directed thinking.

The findings also indicate that it is inadequate to conceive of originality in creative thinking, or the ability to generate novel responses, purely with reference to inhibitory control and related facets of executive frontal lobe function, as it has been the case in the past. A reconceptualisation of the mechanisms underlying creative function thus seems necessary to allow for the integration of the findings in the present study. This would entail not only having to take into account other facets of complex cognition when exploring creativity, but also the differential influence of various cognitive variables on diverse aspects of creativity.

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