Relating Creative Cognition to Prefrontal Function

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October 2004

This dissertation is submitted for the degree of Doctor of Philosophy (PhD) at the International Graduate School of Neuroscience, Ruhr University Bochum, Germany.
Date of PhD Disputation: November 30\textsuperscript{th}, 2004

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Acknowledgements

I am deeply grateful to a number of people who have aided me in innumerable ways through the past three years of my PhD.

Professor Onur Güntürkün, my chief supervisor, who sanctioned these quirky ideas and allowed me abundant freedom in pursuing this ambitious project. Thank you very much for giving me this opportunity, for your support and readiness to experiment with new avenues, and for always being so approachable.

Professor Irene Daum, my second supervisor, who was involved from the inception of this project and organised the testing of the patients with schizophrenia at the University Clinic. Thank you for setting up that study and for your continual support.

Sabine Windmann, whose involvement with the project beginning from about a year ago gave it a much-needed boost. Thank you for your dedication, your enthusiasm and your honesty, and for being there for me when things were at a low ebb.

Till Schneider, Zohra Karimi, Meike Ramon and Mariam Aslan – my wonderful research assistants over the years who helped with the data collection and/or the scoring of the many experimental tasks. Thanks to all of you for being such diligent workers on the job and such fantastic people off the job.

I am also extremely grateful to the consultant/senior psychiatrists of the clinics in which the clinical studies were carried out for allowing me to assess their patients. The clinical study on the adolescents with attention-deficit/hyperactivity disorder and conduct disorder was carried out at the Westfälische Klinik für Kinder- und Jugendpsychiatrie und Psychotherapie in der Haard (Germany) with the help of PD Dr. med. Rainer G. Siefen.
Thanks also to all the doctors and nursing staff who helped with the recruitment of the patients.

The first schizophrenia study was carried out at the Westfälisches Zentrum für Psychiatrie und Psychotherapie, Bochum Universitätsklinik (Germany) with the aid of PD Dr. med. Wolfgang Vollmoeller. Thanks also to all the doctors and nursing staff who helped with the recruitment of the patients.

The second schizophrenia study was conducted at Fulbourn Hospital, Cambridge (UK), with the support of Dr. Peter McKenna. Many thanks also to the staff at the Mitchell Day Centre who were always friendly and helpful.

The project in its entirety was made possible with a fellowship granted by the International Graduate School of Neuroscience (IGSN). Thanks for providing me the opportunity.

Last but not least, I thank all the volunteers who took part in the experiments for their enthusiasm and involvement.
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Chapter 1

General Introduction

Creativity is undeniably among the most exalted and intriguing of all human abilities. Our species is unique in demonstrating remarkable feats of creativity everyday, as is most apparent in our flexible use of language during speech given that one rarely utters two sentences that are exactly the same. We are also able to continually construct novel ways of expressing ourselves and do so with considerable ease. Creative expression can be explored at many levels ranging from such kinds of everyday forms of creativity to outstanding modes of creativity as exhibited by geniuses in the arts and other creative professions. In defining what is meant by creativity or what variables are crucial for the assessment of creative ability, most accounts lay emphasis on the elements of “originality” and “relevance” as a product is judged to be creative in the extent that it is both original and applicable to a particular end.

Although a source of continual fascination, creativity is, however, rarely the focus of concerted mainstream research efforts. This is chiefly due to the immense complexity of the creativity construct itself, which has in turn resulted in a lack of unanimity in defining creativity and in developing methods to gauge creative ability. Although the subject warrants serious investigation, it is still regarded in many quarters as too vague a topic to be subjected to scientific scrutiny. Many endeavours have, nonetheless, been meticulously targeted at overcoming the obstacles posed by the scientific study of creativity and much headway has been made in understanding the nature of creativity at numerous levels.

1.1 Creativity – Theories and Perspectives

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. In conceptualising creativity, a number of factors have been highlighted as representing the crux of creativity. While Becker (1978) associated creativity with genius or intellectual giftedness, Ludwig (1995) noted that such evaluations of creativity are variably influenced by social and political contexts. Richards (1981) suggested that intelligence was essential but not sufficient for creativity, whereas Rothenburg (1990) held that ‘Janusian thinking’ or the ability to concurrently conceive of antitheses or opposites was central to creative thinking.

With respect to the influential theories of creativity, J. P. Guilford (1950, 1956, 1967) was among the earliest to experimentally investigate creativity under the psychometric approach where creative or divergent thought was held to be synonymous with the fluency, flexibility and novelty of ideas. Using this model as a base, a number of tasks and test batteries were devised to gauge and quantify creative ability or ‘divergent thinking’ (e.g. Wallach & Kogan, 1965; Guilford, 1967; Torrance, 1974). By defining a product to be creative in the extent that it is novel, useful and appropriate to a given situation, Amabile (1983, 1990), developed these ideas more comprehensively from a socio-psychological perspective and asserted the importance of the interaction of intrinsic motivation with creativity-relevant skills, such as a flexible cognitive style, and domain-relevant knowledge in the ability to be creative.

The investment theory of creativity of Sternberg and Lubart (1992, 1996, 1999) also employs such an integrative or ‘confluence’ approach in proposing that a range of conditions are essential for creativity such as analytical, practical and synthetic intellectual abilities, legislative and creative thinking styles, supportive and rewarding environments, in addition to knowledge, motivational and personality variables. Several personality traits like self-confidence, risk-taking, lack of compliance to social norms, independence of judgement and preference for complexity have been identified as typical of highly creative individuals (Drevdahl & Cattell, 1958; Barron & Harrington, 1981). With reference to motivational variables, the need for achievement (McClelland, Atkinson, Clark & Lowell, 1953) and intrinsic motivation (Gardner, 1993) are some of the variables that appear to be crucial in the capacity to be creative.

By relating greater levels of creativity with differential activity in the brain, Martindale (1999), in the pursuit to unravel the biological correlates of creativity, proposed that creative inspiration in highly creative individuals is accompanied by a state of defocused attention which can be brought about by lower levels of frontal lobe activation, reduced levels of
cortical arousal (Martindale & Hasenfus, 1978) or right-hemisphere dominant cortical activity (Martindale, Hines, Mitchell & Covello, 1984). Defocused attention, in his view, is a consequence of easier access to primary process cognition, which refers to thought processes that are characteristically free-associative, analogical, concrete and autistic. These processes typically arise during normal states of dreaming and reverie but are also found in abnormal states as in some forms of psychosis.

What can be gleaned from these brief glimpses into some prominent ideas and theories of creativity are the many complexities and challenges that arise depending on the adopted perspective and the key variables under study. Creativity can be examined at many conceptual levels - in terms of the person, the product, the process, the person-environment interactions and the brain (classification based in part on Simonton, 1988; Plucker & Renzulli, 1999). Given this complexity, any study of creativity necessitates the identification of not just the conceptual level of interest, but also specific constructs that are targeted within the level and the delineation of their parameters.

1.2 Creativity – Cognitive approach

The cognitive approach to understanding creativity is directed at examining the mental processes that underlie creative thought. Given the multifaceted nature of creativity, it is evident that many different types of cognitive operations are involved in creative thinking. This heterogeneity is strongly emphasised within the Geneplore model of creative cognition (Finke, Ward & Smith, 1992; Smith, Ward & Finke, 1995) where 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. By acknowledging that many different thought processes underlie creative thinking, this approach allows for the examination of several discrete mental operations that comprise different elements of creative cognition. A number of such cognitive processes have been identified and several tasks have been developed to gauge them. The processes of conceptual expansion, creative imagery, recently activated knowledge and insight problem solving are especially noteworthy within the framework of this treatise.
1.2.1 Creative Cognition: Conceptual Expansion

Conceptual expansion refers to the ability to broaden existing conceptual structures or loosen the confines of acquired concepts, a process that is especially vital in the formulation of novel ideas which is a core feature of creative thinking (Ward, 1994). This kind of process is tapped typically by experimental tasks that require the person to imagine an animal that lives on another planet which is different from Earth and what is assessed is how far the person’s drawing of an animal deviates from existing schemas of Earth animals in general, i.e., of having certain fundamental features like bilateral symmetry of form, presence of common appendages (like legs, arms, tails and wings), presence of common sense organs (like eyes, ears, mouth and nose), and so on. How ‘creative’ one is on this task is assessed by how well one can expand this concept. The better one is able to imagine an animal that does not have a bilaterally symmetrical form, that lacks the customary appendages and sense organs found on most Earth animals and, furthermore, has unusual features that are not found on most animals on Earth (like wheels instead of feet, or eyes at the end of long stalks), the greater one’s conceptual expansion. The usual pattern found in these drawings is that existing concepts of animals, in terms of their essential features, actively guide and pose considerable limitations on an individual’s ability to create a new type of animal. This tendency to draw on generic exemplars of animals even when explicitly instructed not to do so, is what is termed the path-of-least-resistance approach which is the most commonly employed strategy when faced with this kind of generative task (Ward, 1994; Ward, et al., 2000; Ward, Patterson & Sifonis, 2004). Tasks tapping other conceptual domains, including imaginary coins, fruits, tools and faces, have also been explored with regard to conceptual expansion (Bredart, Ward & Marczewski, 1998; Runbin & Kontis, 1983; Ward et al., 2002).

1.2.2 Creative Cognition: Creative Imagery

Drawing from historical and anecdotal accounts of the role of imagery in aiding insights, discoveries and artistic expression, creative imagery relates to the vividness of abstract imagination in generativity. The creative imagery task (Finke, 1990) explores how creativity can be fostered in generating innovative inventions under laboratory conditions. In this task the aim is to construct an object that falls into a predetermined category (e.g. transportation) using three randomly assigned simple 3-dimensional figures (e.g. a sphere, a cone and a cross). The invented object is then judged on two dimensions – originality, or how unusual the object is, and practicality, or how functional the object is – which are combined to give a total creative imagery score. Although the task allows much flexibility in combining and blending the elements to produce an object, it necessitates high levels of abstraction and
mental imagery as it does not relate directly to or tangibly draw from other kinds of familiar processes. When this task is made easier by having the subjects freely choose the figures or the categories in a trial, the resulting inventions are generally far less original than when the choice of elements is randomly determined by the experimenter (Finke, 1990). This implies that the inventions are judged to be more creative when conditions underlying the task are more restrictive and prevent a path-of-least-resistance strategy to be undertaken, just as in the previous case of the conceptual expansion task.

1.2.3 Creative Cognition: Insight versus Incremental Problem Solving

Wolfgang Köhler’s work (1924, 1969) on chimpanzees showing learning through ‘insight’, which was considered an alternative strategy to that of learning by trial-and-error, was the first experimental examination of the critical role of insight in certain kinds of problem solving. Ever since, efforts have been directed at understanding the precise function of insight in problem solving. This requires defining, at the outset, what constitutes an insightful problem (Weisberg, 1995) and how it differs from other analytical problems such as incremental problems. Problem solving within this framework involves convergent thinking, as opposed to divergent thinking, which implies that there is a definite solution for such problems and that the employed problem solving strategies are directed at obtaining this single correct solution. An analytical problem has a defined ‘means’ state, which refers to the conditions of the task at hand, and a specified ‘goal’ state, which is the objective of the problem or the solution that is to be reached. What makes problem solving strategies ‘incremental’ in an analytical problem is that the goal is reached in a stepwise or algorithmic manner. The problem solving process thus generally follows an incremental pattern. In contrast, solving an insight problem requires restructuring of the problem state or a vital change in the representation of the elements of the problem (Duncker, 1945; Ohlsson, 1984). Progression in problem solving process in the case of insight problems is therefore not incremental.

This idea of restructuring as the essence of the process of insight corresponds well to the Gestalt view of ‘productive’ thinking (Scheerer, 1963). As one’s knowledge and past experience could hinder the ability to solve problems by evoking mental sets or states of functional fixedness, productive thinking requires the ability to alter one’s perspective when faced which such a problem and to reformulate the problem at hand accordingly. Evidence in favour of the involvement of different cognitive operations while solving insight and incremental problems primarily stems from two sources. Directive and nondirective
verbalisation of strategies adopted during the problem solving process was found to thwart the solving of insight problems but had no effect on the solving of incremental problems (Schooler, Ohlsson & Brooks, 1993; Schooler & Melcher, 1995). As straightforward logical problem solving strategies are utilised during incremental problem solving, the verbalisation of these stepwise strategies should not interfere with the solving process itself. However, in insight problem solving, metacognitive processes rather than logical operations are adopted and having to verbalise these essentially unreportable processes would disrupt the solving process. Moreover, subjective predictors of performance in problem solving, like expectations of performance prior to solving and feelings of approaching the solution during the solving process, were relatively accurate in the case of non-insight and incremental problems but not so for the insight problems (Metcalfe, 1986a, 1986b; Metcalfe & Wiebe, 1987).

1.2.4 Creative Cognition: Recently Activated Knowledge in the Generation of Ideas

From the findings of the limitations of mental sets and fixations in the creative process of insight, some studies have looked at what kinds of situations induce fixations. Luchins (1945), for instance, was able to show that a mental set or *Einstellung* can be imposed by the repeated use of a particular strategy during mathematical problem solving. While this kind of mental set can be circumvented easily with a prior warning to the subject, other processes by which mental sets are brought about are less resistant to change. One such phenomenon is the effect of examples in the generation of new ideas. When subjects are asked to generate novel ideas for toys or animals after being exposed to exemplars of novel toys or animals by the experimenter, the ideas they produce tend to conform to the ideas in the examples (Smith, Ward & Schumacher, 1993; Marsh, Landau & Hicks, 1996). This is assessed by exposing the subject to the same fundamental features across all the exemplars. In the case of creative idea generation for toys, all the examples of toys shown to the subjects beforehand are similar in so far as they are all characterised by three common elements – the presence of a ball, the presence of electronics and the presence of a high degree of physical activity. The degree to which the ideas generated by the subjects incorporate these features from the exemplars is an indication of constraining effect of recently activated knowledge, in the form of examples, on creative idea generation.

1.2.5 Creative Cognition: Divergent Thinking -Alternate Uses Task

One of the more classically employed tasks in assessment of divergent thinking over the decades has been the Alternate Uses task which was introduced by Wallach and Kogan in 1965 with their investigations of creative potential in children. In this task, participants are
typically asked to generate as many uses as possible for common objects, like a newspaper or a shoe. A measure of the flexibility of the participant’s thought processes in this generative situation is assessed on the basis of the ‘Fluency’ and the ‘Uniqueness’ of the responses. Fluency is judged by the number of acceptable solutions generated for each object and Uniqueness is assessed by the infrequency or originality of the generated use. To take the example of a newspaper, using it to make paper hats is considered to be a less original or unique idea when compared to using a newspaper so that it can be torn into shreds when in a rage (Wallach & Kogan, 1965). Both the Fluency and Uniqueness measures are regarded as two discrete aspects of divergent thinking.

1.3 Knowledge and Creativity

In all of the creative cognitive operations outlined above, prior knowledge deriving from past experience plays a central role in the ability to create. How knowledge relates to creative thinking is, however, a rather ambiguous issue. In order to develop new and original ideas in any domain, a basic foundation of knowledge in the field is undoubtedly essential. What is contentious, however, is how much knowledge is necessary in order to be creative (Weisberg, 1999). The view adopted by most researchers is the ‘tension’ view where the relationship between knowledge and creativity is shaped like an inverted-U with intermediate levels of knowledge providing the best conditions for burgeoning potential while too little or too much knowledge hamper creativity. According to this perspective, copious amounts of knowledge can impede creativity as it often leads to inflexibility of ideas and the inability to break mental sets or established schemas of thought. The alternate ‘foundation’ view, however, argues for a straightforward positive correlation between knowledge and creativity by emphasising that extensive domain-specific knowledge is essential for creative ability. The capacity to generate original ideas, in this view, develops from a sound knowledge base and a clear understanding of prevailing ideas.

Another crucial issue that is seldom broached with regard to the role of knowledge in creative thinking concerns, not the magnitude of one’s knowledge store, but the pattern and degree of its influence. This can be better understood with reference to Eysenck’s (1993, 1995) theory where ‘overinclusive thinking’, or thought processes that are characterised by a wider conception of relevance than is conventional, is regarded as the cognitive style that forms the
cornerstone of creative ability. A task that is well suited to tap these kinds of overinclusive thought processes are word association tasks where the objective is to generate as many words as possible that are related to a prompt word provided by the experimenter. Overinclusive thinkers are likely to generate more unusual responses relative to underinclusive thinkers given that the influence of their knowledge base is broader and more diffuse. As their conception of what is relevant in a given situation is wider than usual, they have a larger realm of ideas to draw from when faced with such a task and consequently tend to produce more unusual, novel and unconventional responses.

The effect of knowledge or acquired associations and representations on various aspects of cognition has received abundant attention. From an information processing or cognitivist standpoint, it is synonymous with ‘top-down’ control on information processing, which refers to the influence of stored representations or knowledge and expectations that derive thereof in the interpretation of sensory information (Engel, Fries & Singer, 2001). This is in contrast to ‘bottom-up’ or stimulus-driven processing which involves the processing of stimuli progressively from sensory to abstract levels.

1.4 Top-Down Control on Information Processing

Apart from the cognitivist perspective of top-down control as expectation-driven processing, top-down accounts of sensorimotor processing can be examined at many other levels. From an anatomical standpoint, in a processing hierarchy which refers to a system of interconnected modules where higher-level areas in the brain contain relatively more abstract representations and are activated later than lower-level areas, top-down influences are synonymous with activity over feedback connections and bottom-up influences with feedforward links. Within a dynamicist framework, top-down influence refers to extensive dynamics, like those exerted by a network of neurons, that can influence local neuronal behaviour by recruiting the neurons to become part of the same neuronal assembly, for instance, through synchronised activity of lateral connections. The contextual modulation of perception where the ‘whole’ determines the perception of its ‘parts’ developed from the Gestalt approach is yet another conception of top-down influence on perception. What is apparent from all of these viewpoints is that they apply to different levels of description of a pervasive phenomenon and that they are not mutually exclusive (Engel et al., 2001).
Intelligent behaviour in daily life is guided by a fast and reliable cognitive system that select inputs that directly bear on the control of action by gauging the current stimulus situation with reference to relevant innate goals and motivational states. The rapid and consistent neural computations that are called for are possible only if the brain utilises top-down influences efficiently by matching expectations to environmental signals which in turn allows for predictions to be made about the impending stimulus situation. Several theories, including the adaptive resonance theory (Grossberg, 1999), the convergence zone model (Damasio, 1989) and the neuronal group selection model (Edelman, 1989) have been proposed to account for the operation of top-down mechanisms. In general, top-down factors have been characterised as intrinsic sources for the contextual modulation of neural processing (Engel et al., 2001). Functional imaging and electrophysiological studies have implicated the prefrontal cortex as the principal structure that underlies such top-down influences during information processing (Fuster, 1989; Desimone & Duncan, 1995; Frith & Dolan, 1997; Miller & Cohen, 2001).

1.5  The Prefrontal Cortex

The frontal lobes comprise the anterior half of the cerebral cortex within which the prefrontal cortex is the largest structure. The prefrontal cortex (PFC) is among the last regions in the brain to develop in terms of both phylogeny and ontogeny. In comparison to other species, it reaches maximum relative growth in humans accounting for almost one-third of the total neocortical surface (Brodmann, 1909/1994). It is also the region with the most prolonged postnatal development and full prefrontal maturation is only reached by late adolescence in humans. This tardy developmental process has been attributed to the slow maturation of the many complex cognitive functions that involve the prefrontal cortex (Fuster, 1997).

The prefrontal cortex is generally divided into three topographically segregated groups – the dorsolateral prefrontal cortex, the orbitofrontal cortex and the paralimbic regions which include the anterior cingulate and the mesial frontal cortex (Kaufer & Lewis, 1999). The prefrontal lobe is also the most highly interconnected of all neocortical regions as it receives afferent inputs from and reciprocates output efferents to almost all sensory neocortical and motor systems, the limbic system and several subcortical structures including the basal ganglia, the cerebellum and various brainstem nuclei via the thalamus (Passingham, 1993;
Goldman-Rakic, 1995). Of all the prefrontal areas, the lateral prefrontal cortex has the most extensive connectivity with sensory areas as it receives visual, auditory and somatosensory information from the occipital, parietal and temporal cortices. The dorsolateral prefrontal cortex has direct connections with many motor areas including the cerebellum, supplementary motor area, pre-supplementary motor area, cingulate, premotor cortex, superior colliculus and the frontal eye fields, many of which are directly connected with the primary motor cortex. Of particular note are the extensive interconnections between the prefrontal cortex and the basal ganglia as the caudate nucleus projects to mostly prefrontal areas. The orbital and medial prefrontal cortices are connected to limbic structures such as the hippocampus and related medial temporal lobe areas, as well as the amygdala and hypothalamus. Dense interconnections are also present between regions of the prefrontal cortex itself.

**Figure 1.1:** Schematic representation of some extrinsic and intrinsic connections of the prefrontal cortex. All connections except those with arrowheads are reciprocal. (Adapted from Miller & Cohen, 2001)

This rich interconnectivity with the rest of the brain, which is partly represented in the schematic diagram in Figure 1.1, allows for the prefrontal cortex to integrate vast amounts of
information from diverse sources and to facilitate complex behaviours. As it is the primary area involved in many aspects of higher-order cognition deriving from the representation and execution of actions, it has been labelled the ‘executive of the brain’ and the ‘organ of creativity’ (Fuster, 1999).

1.5.1 Prefrontal Cortex and Top-Down Control
Top-down control or the influence of previously formed representations on the processing of incoming information with reference to relevant goals is orchestrated by the prefrontal cortex. This control is exerted by assemblies of neurons in the prefrontal lobe that represent action goals and accordingly provide modulatory signals to the sensorimotor circuits that carry out the appropriate response selection (Miller, 2000; Miller & Cohen, 2001). These prefrontal cell assemblies carry high-level representations and moderate the direction of processing of new information coded by lower-level cell assemblies. In doing so, top-down influence mediates the activity of neural systems involved in several cognitive operations such as working memory, selective attention, goal definition, and action planning (Fuster, 1989; Desimone & Duncan, 1995; Kastner & Ungerleider, 2000; Miller, 2000; Miller & Cohen, 2001; Schall, 2001). These processes can be subsumed under the domain of ‘executive functions’ which refers to control processes involved in planning, problem-solving, decision-making, task management and purposive action (Shallice, 1982; Lezak, 1995; Eslinger, 1996; Smith & Jonides, 1999).

1.5.2 Prefrontal Cortex and Executive Functions
Welsh and Pennington (1988, pp. 201-202) defined executive functions

“… as the ability to maintain an appropriate problem solving set for attainment of a future goal … This set can involve one or more of the following: (a) an intention to inhibit a response or to defer it to a later more appropriate time, (b) a strategic plan of action sequences, and (c) a mental representation of the task including the relevant stimulus information encoded into memory and the desired future goal-state. In cognitive psychology, the concept of executive function is closely related to the notion of a limited-capacity central processing system.”

One primary executive function within this classification is that of ‘working memory’ which is the temporary online representation of task-relevant information in service of a goal (Baddeley, 1986; Goldman-Rakic, 1992). What is required in a working memory task is appropriate action selection through the dynamic process of constraint satisfaction which must be context specific and transient. The working system thus calls for continual symbiotic interaction between perceptual information and stored knowledge in view of relevant goals,
processing that is essentially executed by the prefrontal cortex. In the case of working memory, the lateral prefrontal cortex is especially critical.

In order to hold task-relevant information in mind for appropriate response selection, ‘inhibitory control’ or the ability to inhibit inappropriate representations and actions is vital. Interference sources can be external, stemming from sensory stimuli that appear in the context of the behavioural structure, or internal, arising from past experience and inborn tendencies. Distractors of either kind need to be actively suppressed as they can lead behaviour away from its goal. While early evidence pointed to the role of the ventral prefrontal cortex in inhibitory control (Mishkin, 1964; Fuster, 1989), others have attributed the mechanism of inhibiting prepotent response tendencies as a property of the prefrontal cortex as a whole (Roberts, Robbins & Weiskrantz, 1998).

A closely related concept to inhibitory control is that of ‘set-shifting’. On any task, a cognitive set or an intention to act on a stimulus in a particular way must be activated. In addition, the set must be maintained over a period of time until a new cognitive set is to be adopted. In line with changing task demands and representations, one’s cognitive set requires constant updating while information from old or incorrect sets needs to be inhibited. According to Shimamura (2000), the prefrontal cortex monitors and controls information processing via a dynamic filtering mechanism and rerouting is one aspect of executive control within this mechanism where adaptive responses to an ever-changing environment occurs by enabling shifts from one cognitive set or response tendency to another.

What can be gleaned from the function of the prefrontal cortex in the operation of diverse executive operations is that it is the central repository of high-order cognition in humans. Stuss (1987) outlined some critical components of prefrontal function which included the ability to shift from one concept to the other, to modify behaviour in accordance with new task demands, to synthesise and integrate isolated elements into a coherent whole, to manage multiple sources of information, and to make use of relevant acquired knowledge. Deficits at the level of prefrontal cortex, as found in patients with lesions of the frontal lobe, affects all of these abilities such that they demonstrate an inability to maintain attention, failure to initiate appropriate responses, impairments in planning and organising activity, insufficiencies in using feedback to modify behaviour, and a propensity for perseverative responses (Stuss & Benson, 1986).
Given its fundamental role in operation of a diverse array of complex mental operations and its wide and elaborate network with the rest of the brain, there is little doubt that the prefrontal lobe is crucial to what is perhaps the most complex of all aspects of human cognition – creative thinking.

1.5.3 Prefrontal Cortex and Creativity

In comparison to other aspects of cognition, there is a veritable dearth of focus on the neurobiology of creativity. The idea of prefrontal involvement in creative thinking has long been taken for granted, but the validation of these ideas are limited due to the fact that very few studies have addressed this issue. When tackling generative verbal tasks of differential complexity, the bilateral involvement of both prefrontal cortices (BA 8-11 and 45-47) was evident using positron emission tomography (PET) with more activation in BA 10, 11 and 45 as a function of greater complexity or higher creative load in the verbal task (Bekhtereva et al. 2000). These findings were replicated and extended in a polymethodological study using PET along with electroencephalography (EEG) (Bekhtereva et al., 2001).

Contrasting high and low creative groups on a short version of the alternate uses task relative to a control verbal fluency task, a regional cerebral blood flow (rCBF) paradigm was used by Carlsson, Wendt & Risberg (2000) to examine divergence in cortical activation as a function of creative ability. The two groups differed in both the amount of activation (increases or no differences for the high creative group relative to mainly decreases for the low creative group) and the pattern of activation (bilateral in the case of the high creative group and unilateral for the low creative group) in the anterior prefrontal, frontotemporal and superior frontal regions.

Examining differences in the complexity of EEG activity during convergent analytical thinking in comparison to divergent creative thinking, Mölle and his colleagues (1996) found evidence of comparable complexity over the frontal cortex during divergent thinking and a state of mental relaxation relative to reduced complexity during convergent thinking. Increased EEG complexity during mental relaxation was postulated to arise due to unfocused and loosened associational thinking which was reflected in the rearrangement of neuronal assemblies in a given network of mental representations and the consequent spread of activation to other neural assemblies that are seldom activated. Given the low associative strength of these cell assemblies within this newly activated network, the spread of excitation results in strong competition between them which in turn manifests as complicated EEG signals. The similarity of EEG complexity during mental relaxation and divergent thinking
was similarly held to be a expression of loosened attentional control during creative thinking, which corresponds to other evidence of an inverse correlation between attentional effort exerted during cognitive processing and EEG complexity over frontal areas (Elbert et al. 1992; Mölle et al., 1995).

Analysing EEG activity using a coherence analysis approach, where coherence refers to the linearity of the relationship between two signals in terms of frequency and phase, Petsche (1996) found more coherence increases between electrode activity over frontopolar and occipital sites during verbal, visual and musical creativity. In this approach, EEG activity during rest is compared with EEG activity during different creative thinking tasks and only significant differences are taken to reflect the temporal average of changes in the overall coherence pattern during a cognitive task. These results were regarded to be indicative of the greater involvement of long cortico-cortico fibre systems between frontal and posterior areas in the brain during creative thinking.

Another area that sheds light on the involvement of the brain in creative thinking, albeit more indirectly, is research on the processing of semantic information. Both prefrontal lobes play a central role in semantic processing in language with the activation of the left inferior prefrontal cortex when generating closely associated semantic items to a prime, and activation of the right middle and superior prefrontal cortices when generating unusual or more distantly associated items to a prime (Abdullaev & Posner, 1997; Seger et al., 2000). The right prefrontal cortex is thus involved in accessing and generating unusual associations between items of information, a process that is critical to creative cognition.

Further indirect evidence for the role of the prefrontal cortex in creativity derives from examining the modulating influence of affect on cognition. Induced positive mood states have been found to give rise to improvements in performance on creativity tasks (Isen, Daubman & Nowicki, 1987; Hirt et al., 1996; Phillips et al., 2002). Ashby, Isen and Turken (1999) have postulated that this effect is due to the fact that a positive mood state results in increased dopamine levels in the brain, most notably in the prefrontal cortex and the anterior cingulate, which leads to greater cognitive flexibility and, consequently, enhanced performance on certain cognitive tasks where increased flexibility would be advantageous. These ideas are supported by evidence that show increased prefrontal activity during happy mood states (Davidson et al, 1990; Baker, Frith & Dolan, 1997).
While the involvement of the prefrontal cortex in creative thinking is indisputable, what remains a mystery is the precise nature of this involvement as most studies addressing the issue employ a very general or unitary conception of creativity. The vast complexity of the creativity construct was expounded earlier in this chapter. Given the highly intricate nature of creative cognition, it is possible that various facets of creative thinking may be differentially modulated by the prefrontal cortex. By examining select populations characterised by altered prefrontal activity, the approach adopted in this treatise was directed at specifically addressing how certain creative cognitive processes may relate to select features of executive function.

1.6 A Comprehensive Approach:

Creative Cognition & Prefrontal Executive Function

How diverse aspects of creative thinking can be understood with reference to executive processing regulated by the prefrontal cortex was explored in the present treatise using three discrete lines of investigation. Within the first approach (Chapters 2 and 3), two separate studies were targeted at examining patients with schizophrenia, a clinical population with notable prefrontal irregularities and corresponding executive functions deficits, whose performance was contrasted to that of healthy controls.

Focusing on individual differences as a function of personality characteristics, two further studies were conducted within the second approach (Chapters 4 and 5) where healthy samples were differentiated based on the magnitude of select personality traits, that are associated with mild insufficiencies in executive function which was in turn predicted to give rise to differences in specific aspects of creative cognition.

The final approach (Chapter 6) included one study that compared the performances of children with Attention-Deficit/Hyperactivity Disorder (ADHD) and Conduct Disorder (CD) to a control group of healthy children. Both of these clinical populations have also been shown to have marked impairments in certain facets of prefrontal executive function but are distinguishable disease entities.

These three approaches taken together would allow for a clearer and more extensive understanding of the workings of creative cognition in terms of prefrontal executive function.
Chapter 2

Study 1: Schizophrenia

This chapter unfolds with an Introduction section that begins with what is known about the relationship between creativity and schizophrenia. How differential creative ability has been linked to defocused attention in schizophrenia will then be clarified and further explored in terms of its association to prefrontal function. The variety of executive deficits in schizophrenia will then be described and the Introduction concludes with the outline of hypotheses for Study 1 which derives from the neuropsychological profile of schizophrenia and how select aspects of atypical functioning may have a bearing on creative cognition. The Methods section outlines the experimental design for Study 1 and will be followed by the Results section where the obtained data will be subjected to statistical analyses. The results will be examined in detail in the Discussion section with reference to pertinent theories and findings in the established literature.

2.1 Introduction

Schizophrenia is a psychiatric diagnosis for a condition that is characterised by profound disruption and deterioration of cognitive, emotional and social functioning affecting perception, thought form, thought content, language, affect, and the sense of self. The many symptoms of this mental disorder include ‘positive’ symptoms like delusions, hallucinations, and thought disorder, and ‘negative’ or deficit symptoms like avolition, anhedonia, alogia, inattention and affective flattening (DSM IV; ICD 10). The Swiss psychiatrist Eugene Bleuler captured the essence of this disorder by coining the word ‘schizophrenia’ as a classificatory label for the condition in 1908 which derives from the Greek words schizo (split or divide) and phrenos (mind) and translates to denote a fragmented or shattered mind.
The idea of a fascinating association between schizophrenia or mental illness in general and creativity has existed since antiquity. The persistence of this ubiquitous notion is surprising given that there is extremely limited scientific evidence to support it as few experimental studies have been directed at demonstrating this purported link.

2.1.1 Creativity

Most of the backing for the relationship between creativity and psychosis has largely derived from case study approaches (for a review, see Waddell, 1998; Lauronen et al., 2004). The incidence of mental illness has been found to be elevated among eminent creative geniuses and individuals in creative professions (Andreasen, 1987; Jamison, 1989; Ludwig, 1992, 1994, 1995; Post, 1994, 1996; Wills, 2003). The frequency with which individuals of a particular creative profession are afflicted with a mental disorder has also been found to be variable. Artists, for instance, are far more likely to suffer from schizophrenia or bipolar disorder than scientists (Juda, 1949; Ludwig, 1992). There is also evidence to suggest greater scholastic ability (Isohanni et al., 1999) and creative achievement (Heston, 1966; Karlsson, 1983, 2001) in families of mentally ill individuals and increased incidence of mental illness among siblings of highly creative people (Karlsson, 1999). There is some contention however, about which type of psychosis is related to enhanced creative ability. While case report and case control studies tend to suggest that the association between creativity and mood disorders is greater than that of creativity and schizophrenia, experimental studies argue more strongly in favour of enhanced creative ability in the case of schizophrenia.

Ryabova and Mendelvich (2002), for instance, found that schizophrenics surpassed matched healthy controls on the Torrance Test of Verbal Creativity with differences between the groups occurring on the originality dimension but not the fluency or flexibility dimensions. On the Wallach and Kogan Alternate Uses task, schizophrenics have been found to generate more unique uses for common objects (Jena & Ramachandra, 1995). Schizophrenics, like artists exhibited better performances relative to healthy non-artist controls in aspects of syncretic cognition, such as vividness in imagery (Glicksohn et al., 2001). Using a word association test, Merten (1995) found that schizophrenics tended to be largely nonconformist in their free associative responses by generating uncommon or only remotely associated responses. This overinclusive style of thinking in schizophrenics was also found to be true in the case of higher-order association tasks (Bender, Vaitl & Schnattinger, 1985). However, these findings of enhanced creativity in schizophrenia are far from straightforward and opposing findings have also been reported (Eisenmann, 1990; Richards et al. 1988).
Andreasen and Powers (1975), for example, found that schizophrenics exhibited an underinclusive thinking style on the Goldstein-Scheerer Object Sorting Task whereas highly creative writers were overinclusive in their conceptual styles. The reason for these contradictory findings may be partly due to the polymorphous nature of the schizophrenia syndrome itself. When comparing paranoid with non-paranoid schizophrenics on the alternate uses task, Keefe and Magaro (1980) for instance, found that non-paranoid schizophrenics showed better performance in comparison to paranoid schizophrenics and psychiatric controls in the number of highly creative responses generated. A lack of stringency in controlling for differences between diagnostic subtypes of schizophrenia whilst sampling is one of the crucial reasons behind this varied pattern of results.

2.1.2 Defocused Attention

Yet another direction adopted in uncovering the cognitive markers of enhanced creative ability is by exploring discrepancies in other related aspects of perception and cognition. Defocused attention or a lack of attentional inhibition is widely held to play a formative role in creative thinking as defocused or diffuse attentional control would bring about loosened associational thinking and result in the activation of more remote associates than otherwise (Martindale, 1995). Highly creative individuals have been shown to demonstrate decreased attentional control in a number of studies (Mendelsohn & Griswold, 1964; Dewing & Battye, 1971; Dykes & McGhie, 1976; Toplyn & Maguire, 1991). While solving anagrams, for instance, subjects who were informed about the categories of the anagrams were less able to reach the solution due to the interference triggered by the information, but this pattern did not hold true for the highly creative subjects (Mendelsohn, 1976). With the premise that deductive reasoning requires the ability to attend to the current problem situation whereas creative thinking necessitates the added ability to access seemingly irrelevant information in the event that it may lead to insight, Ansburg and Hill (2003) found that performance on a remote associates creative task, and not a deductive task, predicted the ability to utilise concurrent peripheral cues.

In the case of schizophrenia, defocused attention, characterised by the inadequate inhibition or filtering out of irrelevant information and inefficient attentional control, appears to underlie the cognitive impairments associated with the disorder. Among the many paradigms used to investigate these phenomena, the effects of Negative Priming have been widely studied to assess inhibitory processes in selective attention. The negative priming effect refers to the response latencies towards a target, that in the immediately previous display or trial was a
distractor, in comparison to the reaction latencies to a target that is unrelated to the previous display (Tipper, 1985). What is typically observed is a tardiness in responding when the to-be-attended information in a trial is the same as the to-be-ignored or the to-be-inhibited information on a previous trial. Schizophrenic patients have been reported to show less inhibition or disinhibition on negative priming tasks such that they have faster response latencies on negative priming trials relative to controls (e.g. Beech et al., 1989; Park et al., 1996; MacQueen et al., 2003).

Latent inhibition (LI) is another paradigm used to examine inhibitory processes in attention and refers to tardiness in learning an association to a stimulus when the conditioned stimulus has been previously experienced without consequence (Lubow, 1989). This delay arises because the non-contingent preexposure to to-be-conditioned stimulus has already established the 'irrelevance' of the stimulus. The retarded acquisition of the new association is held to reflect the process of overcoming this learned irrelevance. Being unable to adequately ignore or filter out irrelevant stimuli would result in diminished latent inhibition, a finding which has been widely reported in schizophrenia (Baruch, Hemsley & Gray, 1988; Rascle et al., 2001; Cohen et al., 2004).

2.1.3 Prefrontal Function
These inhibitory attentional mechanisms fall into the same spectrum as that of prefrontal inhibitory control processes highlighted in Chapter 1. With respect to neuroanatomical abnormalities in schizophrenia, there is no single underlying pathology as a number of structures have been implicated and the current trend is to adopt more holistic approaches and focus on circuitry abnormalities. Among the more widely established findings of pathophysiology in schizophrenia are reduced prefrontal gray matter volume (e.g. Hirayasu et al., 2001), ventricular enlargement (e.g. Suddath et al., 1989), medial temporal, thalamic abnormalities (e.g. Andreasen, 1994), and pathology of the limbic system and basal ganglia (e.g. Bogerts, Meertz & Schonfeldt-Bausch, 1985; Torrey, 2002).

Functional abnormalities have also been widely reported among patients with schizophrenia where atypical patterns of activation across various cortical structures, and most notably the dorsolateral prefrontal cortex (DLPFC), have been observed. Early investigations paved the way for the hypofrontality hypothesis of schizophrenia as chronic patients did not exhibit the usual hyperfrontality or overactivity of the prefrontal areas during resting states (e.g. Ingvar & Franzén, 1974, Franzén & Ingvar, 1975). This finding of hypofrontality in schizophrenia is
still a matter of debate as many studies lent support to this claim (e.g. Buchsbaum et al., 1984; Wolkin et al., 1985) while others have countered it (e.g. Sheppard et al., 1983; Gur et al., 1987). These inconsistencies between reports have been attributed to many factors including the variable definition of a resting state, the unreliability of diagnostic tools to define samples, the heterogeneity of schizophrenia itself, methodological differences between studies and the lack of control over the confounding effects of antipsychotic medication (Fuster, 1997).

By correlating aspects of neuropsychological function, like performance on the Wisconsin Card Sorting Task (WCST), to activation in the cortex a much clearer picture has emerged about specific cortical abnormalities. The WCST (Grant & Berg, 1948; Milner, 1963) is among the most widely used tests to assess executive functioning. The prototypical WCST consists of a set of cards depicting geometric figures that vary along three dimensions – colour, number and form. The subject’s task is to sort the cards into separate piles based on one of these three dimensions. After some initial trial-and-error, the subject learns to sort the cards according to a particular rule or dimension based on the experimenter’s feedback of whether the sorting of a card into a given pile was correct or incorrect. Once the subject attains a criterion of ten correctly sorted cards however, the sorting rule is abruptly changed by the experimenter and the subject has to discover the new rule and sort the cards accordingly. Subjects exhibit errors of perseveration if they still revert to the old (and presently invalid rule) to sort the cards despite feedback to indicate that it is the wrong strategy.

Schizophrenics tend to make significantly more perseveratory errors on the WCST relative to controls which is indicative of the deficits in goal-directed behaviour in terms of impaired goal representation, poor interference control and inadequate set-shifting (Van der Does & Van der Bosch, 1992; Gold et al., 1997). Measuring rCBF of schizophrenics and controls while performing the WCST, Weinberger and his colleagues found an increase in the DLPFC of the controls but not in the schizophrenics (Berman, Zec & Weinberger 1986; Weinberger, Berman & Zec, 1986). More evidence for the critical role for DLPFC during the WCST derive from evidence from frontal patients with dorsolateral lesions who, as first shown by Milner (1963), also display inadequate performance on this task.

2.1.4 Other Executive Deficits
Similar deficits in prefrontal activation have also been reported across more specific frontal functions, like that of working memory. Park and Holzman (1992, Park, Holzman &
Goldman-Rakic, 1995), for instance, found that in contrast to bipolar patients and a normal control group, schizophrenic patients showed striking impairments in spatial working memory as gauged by oculomotor and haptic delayed-response tasks. In the standard delayed-response task, a monkey is seated in front of two identical food wells and observes food being placed in one well before both wells are hidden from view by a screen. The screen is removed after a delay period and the monkey is allowed to reach for the food. In order to do so successfully, the monkey has to retain information about the location of the food during the delay period. This is a classic paradigm to study working memory as it assesses how efficiently critical information has been held active in service of a goal. Schizophrenics have been consistently found to display deficits on this task with reduced activation of the DLPFC relative to controls (Perlstein et al., 2003).

Other tasks have also been employed to gauge working memory like the n-back task where subjects are typically presented with a sequence of stimuli, like letters, and are to respond when the stimulus currently display is the same one on the previous display (1-back task) or if it is identical to the display two trials before (2-back task), and so on. The further back the comparison stimulus is, the greater the working memory load. While schizophrenics have been consistently found to have impaired performance with greater memory load on the n-back task, but the activation pattern of the DLPFC during the task is not completely clear as some studies reported deficient activation while others report the contrary (Perlstein et al., 2001; Manoach et al., 2000). A recent study has found that the activation pattern seems to depend on how well the patients perform on the task, with high performers exhibiting increased and poor performers decreased activation of the DLPFC (Callicott et al., 2003).

Still more evidence for prefrontal deficits in schizophrenia have been reported from a wide range of tasks including saccadic disinhibition. In an antisaccade task, where a subject is to focus on a central point and a stimulus is presented in the periphery of the subject’s visual field, the objective is to make a saccade, not to the stimulus, but to the opposite direction of the stimulus. Schizophrenic patients show inadequate prefrontal activation and tend to make unwanted reflexive saccades on this task, which this is indicative of a defective inhibitory mechanism (Curtis, Calkins & Iacono, 2001; McDowell & Clementz, 2001). Schizophrenics also display a smooth pursuit eye movement abnormalities, as first discovered by Holzman and his colleagues (1974) where a pendulum is typically used as the target for pursuit eye tracking and the reaction of the viewer to the increase or decrease of both the oscillation frequency and the visual angle of pendulum is measured. Patients with schizophrenia showed
proportionally more velocity arrests, which are errors that occur when the eyes stop their movement when they should be tracking the target. This is a widely established finding and again, prefrontal dysfunction has been implicated (Park & Holzman, 1993; Snitz et al., 1999).

Apart from negative priming and inhibition of return which are also affected in schizophrenia, still more attentional executive impairments in schizophrenia are found in sustained and selective attention as mainly gauged by the Continuous Performance Test (CPT) and the Stroop Colour-Word Interference Test. In the CPT subjects are essentially required to respond to target stimuli in the presence of distractor stimuli continuously for a sustained period of time. Following the classic Stroop paradigm, subjects are presented with colour words (for example, the word RED) written in a different ink colour from the colour word (for example, the ink colour BLUE). The subjects are asked to report the ink colour of the word and not the word itself. Subjects are slower to identify the ink colour when it is incongruent to the colour word because reading is an extremely automated process and the active inhibition of a prepotent interfering response is called for. Schizophrenics show greater interference on the Stroop task and more sustained attention errors, both of which have been attributed to faulty processing in the prefrontal and anterior cingulate cortices (Cohen et al., 1998; McNeely et al., 2003).

More evidence for deficits in prefrontal function in schizophrenia come from studies on perceptual organization showing an over-reliance on bottom-up or stimulus-driven strategies in information processing on part of schizophrenics due to defective top-down processing. An early study by Bemporad (1967) illustrated this irregularity in schizophrenics with the use of a simple task where patients were presented with cards, each of which displayed a hazy image of a number that was composed of dots of varying sizes against a backdrop of dots of differing colours. When presented with the cards, the control patients reported the perception of the embedded number first and only later the dots. In doing so they revealed the customary dominant action of conceptually driven top-down processes on perception as they responded to the whole configuration of the number before responding to the elements from which the number was made up. The schizophrenics on the other hand, tended to instead perceive the isolated dots first before responding to the whole configuration, which was indicative of a lack of operational top-down processes.

Using another task where subjects were tachistoscopically presented with displays containing configurations of lines in varying complexity and were asked to report the number of lines
they perceived in the display, schizophrenics surpassed controls on more complex and disorderly displays which was indicative of a failure to adequately organise information during early processing (Schwartz-Place & Gilmore, 1980; Wells & Leventhal, 1984). These findings have been extended under other experimental designs (John & Hemsley, 1992; Keri et al., 1999) and more recently, Vianin and his colleagues (2002) assessed top-down processes during a gestalt recognition task using scalp recorded event-related potentials (ERP) and found that the schizophrenics demonstrated both poor task execution and reduced P300 amplitude, which is held to be an indicator of the brain’s response pattern in discriminating between potentially important or target stimuli and irrelevant non-target stimuli. This sub-optimal performance among schizophrenics was attributed to the failure in integrating stored information in prefrontal sites with novel incoming stimuli or deficient top-down control of information processing.

2.1.5 Aims of the Study

“...one of the cardinal, pathognomonic symptoms of schizophrenia is the loosening and disruption of associations in the thought process. The schizophrenic is clinically distinguished by his failure to construct logically coherent temporal configurations (gestalts) of thought – and consequently of speech and behavior.” (Fuster, 1997, pp. 203)

What is apparent so far is that schizophrenics are markedly impaired on many tasks of prefrontal function and show deficient goal-directed behaviour, poor inhibitory control, reduced set-shifting and perseveration. At the level of information processing, this is suggestive of a fundamental deficit at the level of top-down control, or the influence of goals, past experience and expectations on the processing of incoming stimuli. On the other hand, creative ability, a less widely studied aspect of prefrontal function, has been reported to be enhanced to some degree in schizophrenia. However, the findings from the creativity domain are problematic primarily because of the limitations of the early experimental studies of creativity in schizophrenia and the general insufficiencies of the case-study and case-control approaches.

It is also contentious to suggest that schizophrenics are more creative than average in terms of ability especially when they seem to be functionally uncreative as is evident by the inflexibility and rigidity of thought and behaviour. While the higher prevalence of mental illness among individuals in creative professions in contrast to individuals in uncreative professions has been taken as an key indicator for the link between greater creative ability in schizophrenia, it is also known that the creative geniuses of the past who were mental ill
tended to be at the lowest ebb of creative production when severely afflicted with the disorder. It may be the case that while the predisposition to develop schizophrenia may confer some form of enhanced creative potential that, other variables notwithstanding, could mature into greater creative ability, the development of severe mental illness would thwart this potential due to disrupted general neuropsychological functioning. This would be one way to integrate these diverse viewpoints. If some vestige of this potential still remains, it should be possible to gauge it by examining elementary cognitive processes that underlie creative thinking. Several such processes of creative cognition were outlined in Chapter 1 and for present purposes, the operations of conceptual expansion, creative imagery and problem solving are particularly pertinent.

In the case of Conceptual Expansion (Ward, 1994), as the key to expanding concepts is to move beyond what is already known about its specific conceptual structures, the influence of one’s knowledge and expectations that are derived from previous experience would have a considerable effect on this operation. A reduced influence of one’s knowledge could be advantageous to the process of conceptual expansion owing to the absence of the usual restraining effect posed by prior knowledge. Consider the following example. When asked to imagine an entirely novel type of fruit that should be unlike fruits that are found on Earth, existing knowledge of fruits and their properties limit one’s ability to imagine a new kind of fruit. It is surprisingly difficult to generate a unique fruit whose fundamental properties deviate substantially from those of common fruits like sweet taste, juiciness, having seeds or cores, having peels or rinds, etc. (Ward, et al., 2002). Given this, a reduced influence of one’s conceptual repertoire should have a beneficial effect on the ability to imagine a new type of fruit. In other words, the creative expansion of the ‘fruit’ concept would be abetted by less top-down influence on information processing.

With regard to the Creative Imagery task (Finke, 1990), the Originality component in this task, which measures how novel and unique the invented object is, would also be expected to benefit from reduced top-down processing in a same manner as in the conceptual expansion task. Although there is considerable pressure given the randomness of the task design in the assignment of figures and categories to create novel objects or inventions, the overriding tendency is to produce an invention that matches or is similar to familiar objects drawn from existing knowledge. Reduced top-down control should weaken this tendency to invent conventional objects and thus give rise to greater originality on such a task. The same would not hold true for the Practicality component as it relates to the functionality or usefulness of the object which is a fundamentally different element within this task.
In a similar vein, reduced top-down control should also be profitable in the case of the Insight problem solving tasks, which require active restructuring of a problem in order to solve it. As the ability to reorient the approach adopted during problem solving is easier with access to associations of wider than normal salience, less constraints as derived from diminished goal-directed processing and loosened associational thinking would be beneficial. On the other hand, reduced top-down control should be detrimental in solving incremental problems as a strong goal-directed analysis of the problem situation in a stepwise manner is essential for successful problem solving.

All of these predictions would be plausible in the case of schizophrenics who exhibit reduced top-down function.

2.2 Methods

Participants and Sample Description
The participants comprised of a clinical case group and a healthy control group. Patients with schizophrenia formed the clinical case group and were recruited with the guidance of one of the consultant psychiatrists (Dr. Wolfgang Vollmoeller) from a local Adult Psychiatry Clinic (Westfälisches Zentrum für Psychiatrie und Psychotherapie, Bochum Universitätsklinik, Germany). After controlling for IQ, the group comprised of 12 schizophrenics (5 women, 7 men) of which eight were diagnosed ‘schizophrenia: paranoid type’ (295.30 in the DSM-IV), one was diagnosed ‘schizophrenia: disorganised type’ (295.10), another was diagnosed ‘schizophrenia: catatonic type’ (295.20), and remaining two were diagnosed ‘schizophrenia: undifferentiated type’ (295.90). All except for one patient were taking atypical antipsychotic medication during the period of testing. Four were prescribed olanzapine (Zyprexa), three were prescribed risperdone (Risperdal), one was prescribed amisulpride (Solian) and risperdone, one was prescribed clozapine (Leponex) and risperdone, and one was prescribed quetiapine (Seroquel) and amisulpride. One patient was prescribed only antidepressant medication – clomipramine (Anafranil) and another was prescribed the antidepressant citalopram (Cipramil) along with clozapine. One patient from the sample was reported as having co-morbid depressive symptoms.

The mean age for the schizophrenic group was 39 years (minimum = 20; maximum = 58) which was comparable to the mean age 40 years (minimum = 19; maximum = 60) for the
control group, $t (26) = -0.267, p = .79$. The control group was recruited via newspaper advertisements and consisted of 16 adults (8 women, 8 men) who had no history of mental illness. They were matched to the clinical case groups based on age and IQ scores. To obtain an elementary measure of IQ, subjects were required to complete the Picture Completion task, which taps attention to fine detail, and the Similarities task, which provides a measure of concept formation, from the German WAIS-R (Dahl, 1986). Analyses using t-tests revealed no differences between the schizophrenic and control groups on the WAIS-R Picture Completion measure, $t (26) = -0.878, p = .39$, or on the WAIS-R Similarities measure, $t (26) = -0.685, p = .50$.

**Materials and Procedure**

Prior to participation, all participants were required to sign an informed consent form to indicate that they had been sufficiently briefed about the study and the tasks they would be required to undertake. Ethical permission to carry out this study with psychiatric patients was granted by the Ethical Commission of the Ruhr University Bochum. Individuals in control group received payment (EUR 15) for their participation.

The experimental tasks employed in this study were the convergent analytical problem-solving tasks, the conceptual expansion task, and the creative imagery task.

1. **Convergent problems**

   A total of eight problems were employed, half of which were insight problems and the other half were incremental problems. In an effort to make the insight and incremental tasks more comparable, Weisberg’s (1995) classification, was employed in selecting problems which could be classified into four types of analytical problems: brain teasers or riddles, mathematical, geometrical and manipulative. Correspondingly, there was one insight and one incremental problem for each of these problem types.

1. **Coin problem (INSIGHT; 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, 1986b)*
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. Card problem (INCREMENTAL; 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.
(adapted from Schooler, Ohlsson & Brooks, 1993)
a) To the left of a Queen there is a Jack
b) To the left of a Spade there is a Diamond
c) To the right of the Heart there is a King
d) To the right of the King there is a Spade
Using this information, assign the proper suit to each picture card.
Solution: Queen of Hearts, King of Diamonds, Jack of Spades. This solution can be arrived at in an algorithmic manner after working through each of the conditions.

3. Egg problem (INSIGHT; mathematical)
Using only a one 7-minute hourglass and a 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. Customarily, an egg is 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.

4. Water problem (INCREMENTAL; 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, \((25 \times 3) + 11 = 86\). This solution is arrived progressively and involves step-by-step analyses.
5. Triangle problem (INSIGHT; geometrical)
The triangle of coins in this picture 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, 1986b)

![Triangle of coins](image)

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.

6. Trace problem (INCREMENTAL; 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)

![Trace figure](image)

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 progressively at by trial-and-error and thus involves stepwise analyses.

7. Candle problem (INSIGHT; manipulative)
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 itself 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.

8. Tower of Hanoi (INCREMENTAL; manipulative)
There are three poles with three differently sized discs on one of them. 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 must be placed on the pole which is on the far right in the same order as seen on the pole which is on the far left – the largest disc must be the lowest disc on the pole and the smallest disc must be the topmost disc on the pole. The discs can also 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: This form of the Tower of Hanoi can be successfully completed using any number and sequence of movements.

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 simply scored with either a 1 for the successful solving of a problem or a 0 when the problem was unsolved. The total number of insightful and incremental problems solved thus ranged from 0-4. The total number of convergent problems solved ranged from 0-8.

II. Conceptual Expansion task
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 is wholly unlike Earth. The fact that the planet to be imagined was to be very different from Earth was strongly emphasised. Participants were asked to generate animals that were of two different species and were allowed a maximum of 5 minutes per drawing. The drawings were subsequently coded in accordance with the procedures described by Ward (1994, Experiment 1) with the help of two scorers who had to simply note the number of fundamental features common to animals found on Earth (Table 2.1). Both scorers were blind to the hypothesis of the experiment and had no information about the participants. A coding
was deemed valid when both scorers were in agreement. In the occasional situation when both
scorers were not in agreement, a third scorer was consulted and the majority result was
accepted. This data was then further processed by the experimenter by extracting 5 elements
from the coded data: bilateral asymmetry, lack of appendages, lack of sense organs, unusual
appendages and unusual sense organs (as shown in Table 2.1). Presence or absence of an
element gave rise to a score of 1 or 0 respectively. The total expansion score for each picture
thus ranged from 0-5. Statistical analyses on this task were carried out on by averaging the
scores obtained on both the drawings for each subject.

**Table 2.1:** Properties that are coded from the Conceptual Expansion task drawings

<table>
<thead>
<tr>
<th>No.</th>
<th>Property</th>
<th>Sub-Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bilateral Symmetry</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Appendages</td>
<td>a) Legs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Arms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Wings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Tails</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) Other Appendages (Unusual)</td>
</tr>
<tr>
<td>3.</td>
<td>Sense Organs</td>
<td>a) Eyes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Ears</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Nose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Mouth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) Other Sense Organs (Unusual)</td>
</tr>
</tbody>
</table>

**Note.** Adapted from ‘Structured imagination: The role of conceptual structure in
III. Creative Imagery task

In the creative imagery task (Finke, 1990), the participant is required to assemble an object that falls into a predetermined category using three figures from an array of simple 3-dimensional figures (see Table 2.2 for stimuli). 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. Following the procedure utilised by Finke (1990), the figures and the category were randomly assigned to each participant. As each participant was given six trials (3 minutes per trial), a maximum of 6 inventions per person were obtained. 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 five point scale and following a significant interrater correlation, the average of their ratings were taken as the scores for the inventions. Each participant consequently obtained an average score of practicality, originality and total creative imagery (practicality + originality) from the 6 inventions they generated across trials.

Table 2.2: Stimuli used in the Creative Imagery task

<table>
<thead>
<tr>
<th>Figures:</th>
<th>Categories:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphere</td>
<td>1) Furniture</td>
</tr>
<tr>
<td>Half-Sphere</td>
<td>2) Tools &amp; Utensils</td>
</tr>
<tr>
<td>Cub</td>
<td>3) Toys and Games</td>
</tr>
<tr>
<td>Cone</td>
<td>4) Weapons</td>
</tr>
<tr>
<td>Cylinder</td>
<td>5) Transportation</td>
</tr>
<tr>
<td>Wire</td>
<td>6) Personal Items</td>
</tr>
<tr>
<td>Tube</td>
<td></td>
</tr>
<tr>
<td>Flat Square</td>
<td>7) Appliances</td>
</tr>
<tr>
<td>Bracket</td>
<td></td>
</tr>
<tr>
<td>Rectangular Block</td>
<td></td>
</tr>
<tr>
<td>Hook</td>
<td></td>
</tr>
<tr>
<td>Wheels</td>
<td></td>
</tr>
<tr>
<td>Cross</td>
<td></td>
</tr>
<tr>
<td>Ring</td>
<td></td>
</tr>
<tr>
<td>Handle</td>
<td></td>
</tr>
</tbody>
</table>

Procedure

The whole array of tasks were administered within one session for the control subjects and two sessions with the patients (with as many breaks as the participant wanted). Each session began the completion of the WAIS-R subscales followed by the Conceptual Expansion task. The convergent problems were the next tasks to be undertaken and they were presented in the following order: Coin problem, Card problem, Water problem, Egg problem, Triangle problem, Trace problem, Tower of Hanoi problem, Candle problem. The Creative Imagery task was the final task in the experimental session. The interrater correlation (Pearson’s correlation coefficient) on the Creative Imagery task measures were highly significant: Practicality Scale, +0.73 \( (p < .0001) \), and Originality Scale: +0.59 \( (p < .001) \).

2.3 Results

Table 2.3 includes the means and the standard errors of the mean across all tasks for the schizophrenic and control groups. All analyses are carried out using 2-sided Chi-Square analyses, t-tests and ANOVAs.

**Table 2.3: Descriptive Data on all Experimental Variables in Study 1**

<table>
<thead>
<tr>
<th></th>
<th><strong>Schizophrenia Group</strong></th>
<th><strong>Control Group</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>Std Error</strong></td>
</tr>
<tr>
<td>WAIS - Picture Completion</td>
<td>101.50</td>
<td>3.806</td>
</tr>
<tr>
<td>WAIS - Similarities</td>
<td>110.33</td>
<td>2.356</td>
</tr>
<tr>
<td>Conceptual Expansion: Total</td>
<td>0.458</td>
<td>0.189</td>
</tr>
<tr>
<td>Conceptual Expansion-Asymmetry</td>
<td>0.083</td>
<td>0.056</td>
</tr>
<tr>
<td>Conceptual Expansion-Lack of appendages</td>
<td>0.042</td>
<td>0.042</td>
</tr>
<tr>
<td>Conceptual Expansion-Lack of sense organs</td>
<td>0.042</td>
<td>0.042</td>
</tr>
<tr>
<td>Conceptual Expansion-Unusual appendages</td>
<td>0.042</td>
<td>0.042</td>
</tr>
<tr>
<td>Conceptual Expansion-Unusual sense organs</td>
<td>0.250</td>
<td>0.115</td>
</tr>
<tr>
<td>Originality-Creative Imagery</td>
<td>2.120</td>
<td>0.137</td>
</tr>
<tr>
<td>Practicality-Creative Imagery</td>
<td>3.004</td>
<td>0.107</td>
</tr>
<tr>
<td>Total Solved: Insight problems</td>
<td>1.58</td>
<td>0.358</td>
</tr>
<tr>
<td>Total Solved: Incremental problems</td>
<td>1.58</td>
<td>0.313</td>
</tr>
<tr>
<td></td>
<td>Schizophrenia Group</td>
<td>Control Group</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Std Error</td>
</tr>
<tr>
<td>Total Solved: All convergent problems</td>
<td>3.17</td>
<td>0.588</td>
</tr>
<tr>
<td>Insight – Coin problem</td>
<td>0.58</td>
<td>0.149</td>
</tr>
<tr>
<td>Insight – Egg problem</td>
<td>0.42</td>
<td>0.149</td>
</tr>
<tr>
<td>Insight – Triangle problem</td>
<td>0.08</td>
<td>0.083</td>
</tr>
<tr>
<td>Insight – Candle problem</td>
<td>0.33</td>
<td>0.142</td>
</tr>
<tr>
<td>Incremental – Card problem</td>
<td>0.08</td>
<td>0.083</td>
</tr>
<tr>
<td>Incremental – Water problem</td>
<td>0.58</td>
<td>0.149</td>
</tr>
<tr>
<td>Incremental – Trace problem</td>
<td>0.33</td>
<td>0.142</td>
</tr>
<tr>
<td>Incremental – Tower of Hanoi problem</td>
<td>0.75</td>
<td>0.131</td>
</tr>
</tbody>
</table>

**Figure 2.1:** The mean and standard error of mean values for the schizophrenia group and the control group are contrasted for the Total Conceptual Expansion Score.

No differences resulted between the groups on any of the convergent tasks individually or on the total number of problems solved, the total insight score, $t (26) = 0.865, p = .395$, or the total incremental score, $t (26) = -0.818, p = .421$. Results on the conceptual expansion task were opposite to what was predicted in that the control group surpassed the schizophrenic group on the total expansion score, $t (26) = -2.912, p < .007$. This finding is demonstrated in
Figure 2.1 using error bars. Further analyses of differences between groups on the constituents of the total expansion score revealed significant differences on the Lack of Appendages measure, \( t (26) = -2.457, p < .021 \), the Unusual Appendages measure, \( t (26) = -2.444, p < .022 \), and the Lack of Sense Organs measure, \( t (26) = -2.150, p < .041 \).

There were no significant difference between the performances of both groups on the creative imagery task on either the originality dimension, \( t (26) = -1.076, p = .292 \), or the practicality dimension, \( t (26) = -0.627, p = .536 \).

2.4 Discussion

Given that schizophrenia is marked by reduced top-down control, as evidenced by diverse frontal executive deficits and perceptual grouping impairments in their cognitive functioning, the predictions made in the aims of the study were guided by the possibility that this degraded control could confer some advantage on tasks of creative cognition where a diminished influence of one’s conceptual structures would aid performance. Results obtained across three tasks of creative cognition, namely conceptual expansion, creative imagery and insight problem solving in comparison to incremental problem solving, were either contrary or inconclusive with regard to this hypothesis. While no significant differences resulted between the schizophrenic group and healthy control group on neither the originality nor the practicality measures of the creative imagery task or on the insight and incremental problem solving tasks, the schizophrenic group were found to show significantly poorer performance than the control group on the conceptual expansion task. The schizophrenics were far more likely than healthy individuals to draw animals that were like familiar Earth animals in terms of fundamental elements like bilateral symmetry, the presence of common sense organs and appendages, and the absence of unusual sense organs and appendages, and hence showed reduced conceptual expansion.

Although schizophrenics are known to have top-down deficits, and reduced top-down control would be expected to aid conceptual expansion, the opposite situation was found to be the case. The highly conventional and perseverative style of responding on part of the schizophrenics on this task suggests that reduced top-down processing, at least to the level of impairment found in schizophrenia, is disadvantageous for the process of conceptual
expansion. While it is possible that some degree of diminished top-down control may be beneficial in the operation of conceptual expansion, it appears that the level of reduced top-down control is too extensive in the case of schizophrenics. Disrupted or impaired top-down control thus does not seem to grant any advantageous pre-condition in conceptual expansion as even rudimentary levels of cognitive processing are affected. Whether milder forms of diminished or diffuse top-down control on information processing would be able to grant an advantage on the process of conceptual expansion remains an open question.

The lack of significant findings on the creative imagery task and the convergent problem solving tasks are more difficult to interpret. With regard to the creative imagery task, it is possible that aspects of the task situation itself were inadequate and led to some interference with the results. Although the task situation was adopted from that used by Finke (1990), feedback from the participants in the study indicated that two of the seven categories – ‘Personal Items’ and ‘Appliances’ – were difficult to comprehend. Many felt that these two categories were not well-defined in a concrete or precise manner unlike the other categories and that it was difficult to associate or classify more than a few objects with either of the categories. To circumvent this problem, only five categories were used in the creative imagery task in later studies.

It is also difficult to deduce anything of consequence from the results on the convergent insight and incremental problems. Following the original reduced top-down control premise, the schizophrenics were expected show better performance on the insight problems but poorer performance on the incremental problems relative to controls. However, no difference on either problem-type resulted between the groups which is somewhat puzzling given that the schizophrenics performed much worse than the control group on the conceptual expansion task which, at least superficially, seems to be a far less complex task than the convergent analytical reasoning problems. If the modified reduced (severely diminished to the point of impairment) versus diffuse (only slightly diminished) top-down hypothesis introduced earlier in the Discussion holds true, then the schizophrenics would also be expected to perform worse on both insight and incremental convergent tasks as impaired top-down control would bring about deficits in goal-directed behaviour. Intact working memory, set-shifting and inhibitory control executive functions would be necessary to adequately solve such analytic problems. If these results are to be accepted at face value, it would suggest that the schizophrenic and control groups cannot be differentiated on such complex tasks of problem solving. However, given the overwhelming weight of evidence that attests to the similarity between
schizophrenics and patients with lesions of frontal lobe such that both are drastically impaired on most tasks of frontal function, it is far more plausible that the results of this study were influenced by intervening factors that may be confounding the general picture.

2.4.1 Symptom-based Approaches
The heterogeneity of the schizophrenia syndrome is well-documented and differences that are present and evidently influence performance within groups of schizophrenics include the diagnostic categories of schizophrenia, exhibited symptoms, type of prescribed medication, amount of medication, and co-morbidity with other psychiatric disorders. Diagnostic categories based on the criteria of classification according to the DSM-IV and the ICD-10 are limiting in that not only are the categories subject to change over time, only a minority of schizophrenic patients perfectly fit into the textbook diagnostic categories. Due to concerns that the classification of schizophrenia according to diagnostic labels may be arbitrary (Frith, 1992), increasingly more research efforts use schizophrenic symptoms as a better gauge of differentiation within the disorder.

Contrasts based on the degree of symptoms have revealed that frontal neuropsychological impairments that are typical of schizophrenics are primarily associated with the negative symptoms of the disorder (e.g. Pantelis et al., 2004; Moritz et al., 2001). For a more thorough view on how creative cognition in schizophrenia is affected as a function of frontal lobe function then, any comparison would be incomplete without relating performance to the types of symptoms seen in schizophrenia. The relatively small sample size from the present study was an obstacle in this respect as a larger sample size is necessary when carrying out within-sample contrasts.

2.4.2 Overinclusive Thinking
A symptom-based approach has also been applied with regard to ‘overinclusive thinking’, a concept that was introduced in Chapter 1, which has a critical bearing on the predictions in the creative cognition tasks with reference to schizophrenic top-down function. Payne (1973) proposed that overinclusive thinking is associable with only select symptoms in schizophrenia and that both conceptual and perceptual overinclusiveness occur when the cognitive mechanism which allocates attention to only relevant information becomes unable to exclude irrelevant information. In his formulation, overinclusiveness was a characteristic feature of formal thought disorder in schizophrenia which he believed was the reason why it was difficult to comprehend their speech. While Payne was the first to test these assumptions
experimentally, the theoretical mould for these ideas was first put forward decades ahead of him by Cameron (1939, 1944). He described overinclusiveness in conceptual thinking as the inability to select, eliminate, and confine thinking to a given task at hand, which would in turn lead to concepts being less circumscribed in their boundaries. Closely or even distantly related concepts could thus merge into one another and as this eventuality would render the mental set of the patient to be different from that of a healthy individual, their speech would be too vague and unintelligible to follow clearly. This kind of incoherence in speech is a central feature of formal thought disorder in schizophrenia.

Overinclusive thinking was investigated using a number of cognitive tasks where subjects were required to give synonyms for words, or sort words or pictures into conceptual categories (Payne, 1973; Chapman & Chapman, 1973). Schizophrenics were found to be more overinclusive compared to healthy control groups but there were within group differences such that acute patients were found to be more overinclusive than chronic patients, whose performance was undifferentiable from normal individuals. Additionally, overinclusiveness was also found to be a typical of patients with mania, another psychiatric population that is characterised by formal thought disorder.

Additionally, indirect tests of overinclusive thinking in schizophrenia have been investigated using semantic priming paradigms which typically involve a lexical decision task requiring the recognition of words that are preceded or primed by either directly associated, indirectly associated, or non-associated words. In keeping with the associative network model of semantic priming, the spreading of semantic activation between associates dissipates with distance. There is evidence for the increased activation or disinhibition in the spreading of semantic associational activation in schizophrenic patients and more specifically, this was especially true of schizophrenics with thought disorder where semantic associations were found to spread further and faster to indirectly associated primes (Spitzer et al., 1993a; 1993b). More recently Moritz and his colleagues (2003) confirmed and extended these results by showing that thought disordered schizophrenics showed wider semantic activation than non-thought disordered patients and healthy individuals, and confounding variables, such as the length of illness, neuroleptic dosage and psychomotor slowness, did not affect priming.

Overinclusiveness in conceptual thinking can thus be understood within the framework of diminished top-down control as more loosely associated representations are likely to be activated as a consequence of a reduced influence of one’s existing conceptual structures. The
regular influence of one’s prior knowledge structures and expectations would result in the
activation of closely associated representations that are relevant to the task situation, the
decreased control of this influence in guiding action would aid wider associational thinking
and an overinclusive thinking style. What degree of diminished top-down control could give
rise to such overinclusiveness is still open to debate.

2.4.3 Future Directions

Established findings from neuropsychological tasks of executive function and the significant
finding on the conceptual expansion task in the present study appear to demonstrate that
schizophrenia is a condition marked by, not diffuse top-down functioning, but grossly reduced
and impaired top-down control of information processing. It is as yet unclear whether there is
reason enough to expect fundamental differences at the level of impaired as opposed to
diffuse top-down control within groups of patients with schizophrenia who are differentiated
in terms of type and degree of symptoms. The findings on overinclusive conceptual thinking
being associated primarily with schizophrenics with formal thought disorder suggests that it
may well be possible to apply separable hypotheses on related experimental variables as
incumbent upon symptom type and severity.

The studies highlighted in this section with reference to overinclusiveness in thinking serve to
illustrate why testing schizophrenics as a undifferentiated group can be severely limiting and
that only with symptom level analyses can one reach more assured conclusions with regard to
the nuances of cognitive function in schizophrenia. The present study was also limited in this
respect as a mixed sample of schizophrenics was assessed in comparison to controls and most
of the results were rendered inconclusive. A further study was carried out on a larger sample
of patients with schizophrenia who were contrasted on the basis of degree of symptoms so
that some of these issues concerning defective versus diffuse top-down control on information
processing could be clarified. This more comprehensive study is described in detail in the
following chapter.
Chapter 3

Study 2: Schizophrenia – Symptomatology Contrasts

This chapter commences with a description of the clinical picture of schizophrenia in terms of diverse symptomatology and symptom clusters in the Introduction section. Following a description of the dominant neurotransmitter theory that has been put forward to explain the manifestations of schizophrenia, the neuropsychological impairments in schizophrenia as a function of symptomatology is then explored. On the basis of these formulations, some postulations are proposed within the aims of the study concerning creative cognition in schizophrenia as contingent upon symptomatology. The outline of the experimental design for Study 2 is discussed next in the Methods section and in the Results section, the obtained data will be subject to comprehensive statistical analyses. The results will be examined in detail in the Discussion section with reference to pertinent theories and findings in the established literature.

3.1 Introduction

Whether schizophrenia should be regarded as one disease entity as opposed to a group of disorders remains a considerably polemic issue to date. This is because one of the most striking features of schizophrenia is its tremendous heterogeneity as reflected by the diversity in the behavioural symptoms, responses to medication, prognosis, and pathophysiology. Consistent patterns and trends have, nonetheless, been uncovered by selectively piecing together various findings that have emerged from investigations of schizophrenic subgroups differentiated on the basis of their symptomatology. The disparate neuropsychological profiles of schizophrenic subgroups are a critical issue when considering any of the relevant theories of schizophrenic function.
### 3.1.1 Symptoms in Schizophrenia: The Positive-Negative Dichotomy

The wide spectrum of symptoms in schizophrenia is classically categorised as positive, indicating the presence of behaviour defined as abnormal, or negative, indicating the absence of behaviour defined as normal (for an extensive review, see McKenna, 1994). Delusions, hallucinations and formal thought disorder belong to the positive constellation of symptoms. A *delusion* is defined as an absurd, fantastical, or extremely unlikely belief that is considered untrue as it does not correspond to the social, educational, or cultural background of the individual but is nevertheless held with fixed conviction and is persistent against any argument. The more common delusions are those of persecution, where the person believes that someone or something is trying to cause him harm, grandiosity, where the person believes that he has remarkable talents or uncommon influence or a divine purpose in life, and reference, where all kinds of neutral events are deemed specially significant for the person. In contrast, *hallucinations* refer to abnormal perceptions and by definition, a hallucination is a perception without an object that can accompany and influence real perceptions and are beyond voluntary control. Although they can occur in any sensory modality, auditory hallucinations, or hearing voices or sounds, are the most common form in schizophrenia. Disturbances in the structure, organization and coherence of thinking, as indicated by a loss of intelligibility of speech, are signs of *formal thought disorder*. Key features of thought disordered speech are derailment, which refers to the tendency to be continually sidetracked from a point while speaking, incoherence, which refers to incomprehensible speech, neologisms, which refers to the coining of novel words and phrases whose derivation is difficult to comprehend, and poverty of content of speech, which refers to speech that conveys little information despite being lengthy.

With regard to the negative symptoms associated within schizophrenia, *Affective Flattening* or blunting is the principal affective symptom. Also known as athymia, some of its critical features include inappropriate affect and affective unresponsiveness which primarily manifests in the form of unchanging facial expressions, a lack of expressive gestures, reduced spontaneous movements, and a lack of vocal inflections. *Alogia* is another negative symptom marked by poverty of speech, poverty of content of speech, and increased latency of response. Poor grooming and hygiene, a lack of persistence at work, and a lack of energy are the core characteristics of the *Avolition* negative symptom. A final central negative symptom is that of *Anhedonia* which refers to the inability to experience pleasure as mainly indicated by a loss of interest in recreation and sex and the inability to feel intimacy and form friendships.
This positive-negative dichotomy of symptoms in schizophrenia also has critical bearing on other differentiable aspects of schizophrenic function. With reference to the progression of the disorder, for instance, acute schizophrenia refers to the early stages of the illness that is marked by an attack of florid positive symptoms like delusions and hallucinations which tend to develop in conditions of poor rapport, suspiciousness and flat affect, followed by phases of improvement and then further exacerbations. In contrast, chronic schizophrenia, which is far more complicated in its presentation, is principally characterised by clear signs of deterioration in the form of negative symptoms like lack of volition, emotional indifference, flattening of affect and impoverished self-care, alongside only mild positive symptoms.

Aetiological differences between positive and negative symptoms have also been proposed (Crow, 1980) with negative symptoms being associated with structural brain abnormalities, such as enlargement of the lateral ventricles, and positive symptoms to an excess of the neurotransmitter dopamine in the brain. Added support for these ideas came from studies demonstrating that responses to drug treatment were determined by the type of psychotic symptoms present, with better response to neuroleptic treatment in the case of positive symptoms (e.g. Johnstone et al., 1988). In fact, early experimental intervention techniques using neuroleptic medication in schizophrenia paved the way for what still is the most influential model of pathogenesis in schizophrenia – the dopamine hypothesis.

3.1.2 The Dopamine Hypothesis

In the classical dopamine hypothesis of schizophrenia which emerged in the 1960s, excess subcortical dopamine was postulated to be associated with the positive symptoms of the disorder. Evidence for this claim stemmed from two sources. Sustained exposure to dopamine receptor agonists (specifically D2 receptors) like amphetamines induce psychotic-like positive symptoms (Connell, 1958) and all drugs with clear antipsychotic effects diminish the activity of dopamine in the brain to some degree, either by blocking the receptors for dopamine, or by altering the rate or amount of release of this chemical (for a review, Seeman, 1980). Recent studies in schizophrenics have used amphetamine challenge paradigms where brain scans are performed before and after amphetamine induction and the difference between the two scans reflects the amount of dopamine released after the challenge. Increased levels of dopamine transmission was demonstrated in schizophrenics relative to controls, which in turn was also found to produce an increase in positive symptoms (e.g. Laruelle et al., 1999). In a seminal paper investigating baseline occupancy of D2 receptors by dopamine, Abi-Dargham and her colleagues (2000) found that schizophrenics displayed greater availability of striatal D2
receptors after acute depletion of intrasynaptic dopamine relative to controls. In addition, patients with high synaptic levels of dopamine at baseline showed a greater improvement of positive symptoms after six weeks of antipsychotic treatment.

While the notion of hyperstimulation of D2 receptors in schizophrenia is in support of the classical dopamine hypothesis, the theory was severely wanting in many other respects, not least because it failed to account for the presence of negative symptoms. Following several reports linking negative symptoms in schizophrenia with diverse cognitive impairment (e.g. Pantelis et al., 2001), which was in turn associated with a dearth of cortical dopamine (e.g. Okubu, 1997), the dopamine hypothesis underwent critical reformulation (Davis et al., 1991). Deficits in prefrontal dopamine were thereafter held to underlie negative symptoms while excess striatal dopamine was equated with positive symptoms.

These ideas fit well with the pathophysiology of schizophrenia with regard to known structural abnormalities of the cortex (Lewis & Lieberman, 2000), where the D1 receptor is the most prominent of the dopamine receptor subtypes. The dorsolateral prefrontal cortex (DLPFC) of schizophrenic patients, in comparison to non-schizophrenic psychotic controls, showed twice the amount of normal levels of calcyon, a D1 dopamine receptor-interacting protein, but unchanged levels for two D2 dopamine receptor-interacting proteins, filamin-A and spinophilin (Koh et al., 2003). A recent functional imaging study using PET showed significantly elevated binding potential to a selective D1 receptor antagonist in the DLPFC in patients with schizophrenia compared to healthy individuals (Abi-Dargham et al., 2002). This high DLPFC D1 receptor up-regulation was negatively correlated with performance on the n-back working memory task suggesting that the up-regulation of D1 receptors represents a compensatory consequence of the dopamine deficit in the cortex. However, as this up-regulation is not functional, working memory performance remains sub-optimal due to the lack of stimulation by endogenous dopamine.

Another study using a different radiotracer revealed that reduced D1 receptor binding in the prefrontal cortex of schizophrenics, but not in the striatum, and that this reduction was related to the severity of the negative symptoms like emotional withdrawal and to impaired performance on an executive functioning test (Okubu et al., 1997). These two findings seems contradictory at first glance as the binding potential of two different radiotracers, while both associated with cognitive impairments, was increased in the former study and reduced in the latter study. However, a recent study of acute and subchronic dopamine depletion on the in
vivo binding of both these radiotracers in rats demonstrated that they were differentially affected by alterations in endogenous dopamine suggesting that binding of the tracers in the prefrontal cortices of schizophrenics patients may reflect changes in D1 receptors which are secondary to the sustained deficit in dopamine function (Guo et al., 2003).

Given that the dopaminergic system interacts with other neurotransmitter systems in the brain and cannot solely account for the pathological manifestations of the schizophrenia, other neurotransmitter theories, like that of glutamate and serotonin which regulate and are in turn regulated by dopamine, have also been proposed. Many contemporary research efforts aim to clarify the nature of these neurotransmitter interactions in terms of normal brain function and how it becomes dysfunctional in psychotic illness. With regard to the neuropsychology of schizophrenia though, the modified dopamine hypothesis is, as yet, the most widely investigated neurotransmitter theory and bears vital implications for the various cognitive impairments that are typical of schizophrenia.

3.1.3 Symptom Clusters and Neuropsychological Deficits

Investigating the neuropsychological correlates of schizophrenic symptom classes have revealed many discrepancies and these partly stem from the fact that the symptom clusters have been variably defined across studies. A number of comprehensive studies have examined correlations between ratings of negative and positive symptoms and the vast majority report no significant relationship between the two (e.g. Kay et al., 1986; Mortimer, Lund & McKenna, 1990). This implies that both types of symptoms can be found in any patient and this mixed symptomatic pattern is, as a matter of fact, the usual case in schizophrenia. Inter-correlations between negative symptoms have been found to be significant across many studies indicating a high degree of internal consistency within the negative assemblage of symptoms (e.g. Andreasen & Olsen, 1982; Kay et al., 1986). In the positive symptoms spectrum, delusions and hallucinations tend to correlate highly, but the findings are variable with regard to thought disorder (e.g. Andreasen & Olsen, 1982; Mortimer et al., 1990).

A series of factor-analytic studies of symptoms have demonstrated the consistent emergence of three factors: positive (delusions and hallucinations), negative, and what appears to be consistent with a separable thought disorder dimension (e.g. Mortimer et al., 1990; Arndt et al., 1991). Liddle (1987; Liddle & Barnes, 1990) has been at the forefront in promoting a three syndrome model of schizophrenia where the symptoms are discretely allocated into the psychomotor poverty syndrome (negative symptoms of poverty of speech, flat affect and
decreased spontaneous movement), the disorganisation syndrome (thought disorder and inappropriate affect), or the reality distortion syndrome (positive symptoms of delusions and hallucinations). Several independent studies have provided support for this threefold classification (e.g. Arndt et al., 1991; Sauer et al., 1991), which have also been differentiated in terms of neuropsychological function.

In neuropsychological tests of frontal lobe function, negative/psychomotor poverty symptoms and thought disorder/disorganization symptoms in schizophrenia have been widely associated with frontal lobe impairments while positive/reality distortion symptoms show little or no association. With reference to working memory in schizophrenia, deficits across paradigms, including the n-back task, digits backward span task, and delayed-matching-to-sample tasks using spatial and object stimuli, have been reported to be significantly associated with negative/psychomotor poverty symptoms (e.g. Park et al., 2003; Moritz et al., 2001; Gooding & Tallent, 2004; Pantelis et al., 2004). This specific link between negative/psychomotor poverty symptoms and working memory impairments in schizophrenia fits in well with the role of the DLPFC as underlying the pathophysiology of negative symptoms in schizophrenia and in the operation of working memory.

The association between symptoms clusters in schizophrenia and inhibitory control is less clear-cut, but the bulk of the evidence indicates that impaired inhibitory control or the inadequate suppression of inappropriate responses, as gauged by the Stroop colour word interference task, is associated with a greater degree of thought disorder/disorganisation symptoms (e.g. Woodward et al., 2003; Brazo et al., 2002; Moritz et al., 2001; Barch et al., 1999). Along with decreased perfusion in the right ventral prefrontal cortex, increased perfusion of the right anterior cingulate cortex, a site with maximal activation in association with the performance of the Stroop task in healthy individuals, has been found to be associated with the thought disorder/disorganisation schizophrenia syndrome (Liddle, 1994).

With regard to the frontal function of set-shifting, as chiefly assessed by the classic or modified Wisconsin Card Sorting Test (WCST or MCST) and the attentional set-shifting task (intra-dimensional versus extra-dimensional shifts), both negative/psychomotor poverty symptoms (e.g. Perry & Braff, 1998; Pantelis et al., 1999; Lanser et al., 2002) and thought disorder/disorganisation symptoms (e.g. Pantelis et al., 1999, 2004; Moritz et al., 2001; Brazo et al., 2002) have been associated with impaired set-shifting and cognitive inflexibility. Some imaging studies have reported reduced activation in prefrontal regions in schizophrenics.
during performance of the WCST (e.g. Parellada et al., 1994; Volz et al., 1997; Liu et al., 2002) which also has implications for both these symptom types.

While negative/psychomotor poverty and thought disorder/disorganisation symptoms have been associated with cognitive impairments, findings on positive/reality distortion symptoms are mixed and inconclusive with regard to frontal tasks. Some limited evidence indicated verbal and semantic memory deficits in association with positive symptom scores (e.g. Mahurin, Velligan & Miller, 1998; Bozikas et al., 2004) but correlations between positive symptom scores and performance on set-shifting, inhibitory control or working memory tasks tend to be mostly non-significant (e.g. Nieuwenstein, Aleman & de Haan, 2001; Moritz et al., 2001; Cameron et al., 2002).

3.1.4 Aims of the Study

The current study employs a batch of typical frontal neuropsychological tasks along with a set of creative cognition tasks and investigates the performance of patients with schizophrenia as a group relative to a healthy control group, in conjunction with within-group performance analyses where schizophrenic patients are contrasted based on the severity of symptom type. Given the discrepancies within schizophrenia on frontal lobe tasks as a function of symptom type, it is expected that differences on the creative cognition tasks will also show some divergence in association with symptom types.

While it is expected that schizophrenics, relative to healthy controls, should show poorer performance across all frontal tasks, symptom analyses should reveal that some symptom groups perform worse than other. More specifically, with regard to the negative symptoms cluster, worse performance is expected to be associated with the group on working memory and set-shifting tasks, whereas impaired performance on inhibitory control and set-shifting tasks are expected to vary as a function of degree of thought disorder. Other tasks of frontal function to measure response suppression (Hayling test), estimation (Cognitive Estimates Test) and short-term memory (Digit and Span Span) will also be employed and deficits on these tasks are predicted to be associated with the severity of global negative and thought disorder symptoms, but not positive symptoms.

With regard to the creative cognition tasks, the previous study on schizophrenia revealed inconclusive findings on the creative imagery and convergent problem solving tasks where there were no significant differences between the schizophrenic and healthy control groups.
The schizophrenic group however was significantly worse than the healthy control group on the conceptual expansion task. In the current study, the schizophrenic group is predicted to show poorer performance relative to the control group across all creative cognition tasks but probable differences are expected to arise at the level of symptoms. As impaired performance on the conceptual expansion task, for instance, was postulated to arise from a perseverative response tendency and defective top-down control, the degree of negative symptoms was expected to also be associated with worse performance on the conceptual expansion task and on an analogous creative cognition task, the recently activated knowledge task.

In a similar vein, a higher degree of negative symptoms is also expected to be linked to lower levels of originality on the creative imagery task. No differences are, however, expected on the practicality dimension of the task given that perseverative errors that are characteristic of the schizophrenic group would affect the capacity to be original, but not the capacity to make a functional invention on such a task. However, it is possible that positive and formal thought disorder symptoms would be associated with lower practicality scores in the creative imagery task, due to the presence of incoherent thoughts and aberrant perceptions. With reference to the convergent problems, as in the previous study, schizophrenics were expected to show impaired performance relative to controls on incremental problem solving. The expectations from insight problem solving are more complex. Given that it is plausible that increased set-shifting abilities would aid insight problem solving, a high degree of negative symptoms, and not positive symptoms, are expected to be related to worse insight problem solving.

On a final creative cognition task, the Alternate Uses task, while the uniqueness measure was not predicted to vary as a function of any one symptom type, the fluency measure was predicted to be negatively related to positive symptom scores. Positive symptoms were hypothesised to be less associable to global deficits in creative cognition than negative symptoms as they are not clearly associated with pervasive frontal deficits. In addition, given that altered prefrontal function could hypothetically be related to better performance on some creative cognition measures, a positive correlation between performance on the creative cognition tasks and schizophrenia was postulated to be only plausible in the case of positive symptoms, due to less impaired top-down control, and thought disorder symptoms, given that overinclusive conceptual thinking in schizophrenia has been primarily associated with this symptom subtype (Payne, 1973). Given that the presence of positive and negative symptoms vary considerably between patients and the difficulty in classifying patients as having predominantly positive versus predominantly negative symptoms, to address the manifold
interactions that could arise as a function of symptom clusters, combined between- and within-group analyses will be carried out where the schizophrenic sample will be partitioned into four subgroups based on the type and extent of symptomatology.

3.2 Methods

Sample Description, Materials and Procedure
The clinical case group in this study consisted of 31 patients with schizophrenia (5 women and 26 men, mean age 44.32), recruited from Fulbourn Hospital Cambridge, UK with the guidance of the consultant psychiatrist (Dr. Peter McKenna). The group was made up of patients with chronic schizophrenia with a duration ranging from seven years to over thirty years who were, however, at the upper end of the spectrum of presentations of chronic schizophrenia in terms of preserved intellectual function. The whole group showed 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 in-patient 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 2.1 for Delusions, 2.45 for Hallucinations, 1.19 for Thought Disorder, 2.36 for Affective Flattening, 1.16 for Alogia, 2.48 for Avolition-Apathy, 2.23 for Anhedonia-Asociality, and 2.26 for the Summary Score (the average of the global ratings).

The control group were recruited from the local community and included 15 healthy adults (3 women and 12 men, mean age 39.33) with no history of mental illness. The schizophrenic and control groups were matched in terms of age, $t(44) = 1.414, p > .1$, and pre-morbid IQ as estimated using the National Adult Reading Test (NART, Nelson, 1982), $t(44) = -1.65, p > .1$. All participants received payment for their participation in the amount of £4 per session (40 minutes). 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). The average number of sessions per patient was 4. Most control subjects completed all the tasks within 2 lengthy sittings. This study was approved by the Cambridge Local Research Ethics Committee and all subjects gave informed consent.

The experimental tasks used within the study were split into the creative cognition tasks and the frontal neuropsychological tasks. The following creative cognition tasks were employed.

Conceptual Expansion. (refer to Method section in Chapter 2, only one drawing instead of two).

Convergent problem solving. Insight and Incremental problems (refer to Method section in Chapter 2). Modifications were made to the Tower of Hanoi problem such that the participants were required to solve it using the least possible moves. A performance was thus judged correct only when the 3-ring Tower of Hanoi was solved in 7 moves.

Creative Imagery. (refer to Method section in Chapter 2 for stimuli). Alterations in this task for this study were the following. Only five categories were used instead of seven. Additionally, 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 the Sphere, Hook and Tube for the category ‘Furniture’. In trial 2, the figures were the Cone, Flat Square and Wheels for the category ‘Tools and Utensils’. In trial 3, the figures were the Cylinder, Bracket and Handle for the category ‘Toys and Games’. In trial 4, the figures were the Half-Sphere, Rectangular Block and Ring for the category ‘Weapons’. In the last trial, the figures were the Cube, Wire and Cross for the category ‘Transportation’. The interrater correlation (Pearson’s correlation coefficient) on the Creative Imagery task measures were highly significant: Practicality Scale, +0.71 ($p < .0001$), and Originality Scale: +0.64 ($p < .0001$).

Recently Activated Knowledge. In this task, subjects are asked to imagine that they are employed by a toy company that is in need of new ideas for toys. The subject’s task is 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) which have 3 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 (total score ranging from 0-3). 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 task* (based on Wallach & Kogan, 1965). In this task, 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 – 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. The total score for Fluency and Uniqueness is a sum of fluency and uniqueness scores obtained across all three objects.

The following tasks were employed to tap prefrontal function in this study.

*WAIS Picture Completion*. This is a task (from the WAIS-R, Wechsler, 1981) that taps attention to fine detail. Subjects are shown a series of drawings in which a key feature is missing. The subject is asked to simply report which feature is missing. The greater the score, the better the attention to detail.

*Digit Span*. The digits forward and digits backward tasks of the digit span (from the WAIS-R, Wechsler, 1981) were used to assess numerical span and verbal working memory respectively. The participants were required to repeat a sequence of digits in the order called aloud by the experimenter in the digits forward task (verbal span), and in reverse order in the digits backward task (verbal working memory). A subject’s digit span in both cases is defined as the maximum sequence length at which a correct response was produced in at least one out of two trials.

*Spatial Span*. The Corsi block-tapping task (Milner, 1971) was used to assess spatial short-term memory. Subjects are presented with a board comprising of nine 1½-inch cubes or blocks that are fastened in a random order to the surface of the board. By tapping the top surfaces of the blocks, the experimenter makes a tapping sequence. These sequences increase in complexity over time and the subject is required to reproduce these sequences. A subject’s spatial span is defined as the maximum sequence length at which they could produce a correct response in three out of five attempts.
Cognitive Estimates Test (Shallice & Evans, 1978). Participants required to give a reasonable estimate to ten questions about which they are unlikely to know the exact answer (e.g. What is the length of an average man’s spine?). The obtained error score reflects the degree to which the participants produced responses falling outside the range of estimates given by controls.

Hayling Sentence Completion Test (Burgess & Shallice, 1997). This test 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 number of errors on this set is taken as measures of response suppression (or degree to which the response is related to the sentence).

Brixton Spatial Anticipation Test (Burgess & Shallice, 1997). This is a rule or concept attainment task and the test consists of a 56-page stimulus booklet where each page shows the same array of ten 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 move 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 or random guessing behaviour.

Stroop Neuropsychological Screening Test (Trenerry et al., 1989). This test measures efficiency of attentional inhibition and includes three conditions and three forms per condition. Each form consists a list of 52 stimuli presented on an A4 size paper separated into three columns and subjects are required to recognise and call aloud the stimuli one after another from top to bottom column by column. 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 (rectangular blocks of colour) 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. In the second and third conditions, four colours are used in the stimuli: red, blue, green and yellow. Three forms of the Word condition are presented in the first, fourth and seventh trials, the
Colour Condition in the second, fifth and the eighth trials, the Colour/Word condition in the third, sixth and ninth trials. The time taken to finish each form is recorded with the help of a stopwatch and errors are noted across each trial. The measures include the average time taken and errors obtained across the three forms for each condition.

3.3 Results

To obtain a comprehensive picture of how the frontal and creative cognition variables are affected in schizophrenia, a series of between-groups and within-group analyses were carried out. The between-groups contrasts included a general level contrast between the full schizophrenic and control samples, a high IQ contrast using only high IQ (NART>100) schizophrenic (n=21) and control (n=14) subjects, a males-only contrast using only male schizophrenic (n=26) and control (n=13) subjects, and an age contrast using schizophrenic (n=17) and control subjects (n=14) aged 45 years or below. Table 3.1 shows the mean and standard error of mean values across all the variables for the general level contrast between the schizophrenic and control groups.

The general between-groups contrast revealed that on the frontal tasks the only test on which the schizophrenic and control groups performed comparably was the Hayling test, \( t(44) = -0.684, p = .50 \). Significant differences were found on the WAIS picture completion task, \( t(44) = -3.576, p < .001 \), the WAIS digit span task, \( t(44) = -3.308, p < .002 \), both the digits backward, \( t(44) = -3.099, p < .003 \), and the digits forward tasks, \( t(44) = -2.559, p < .014 \), the spatial span, \( t(44) = -2.954, p < .005 \), the cognitive estimates test, \( t(44) = 2.819, p < .007 \), the Brixton test, \( t(44) = -3.338, p < .002 \), and across all three Stroop conditions: the word control condition RT, \( t(43) = 2.715, p < .009 \), the colour control condition RT, \( t(43) = 2.62, p < .012 \), and the colour/word interference condition RT, \( t(43) = 1.785, p = .081 \), there were no significant differences between the groups on the errors obtained on the Stroop word control condition, \( t(43) = 1.276, p = .21 \), and the Stroop colour control condition, \( t(43) = 1.09, p = .28 \).

On the creative cognition tasks, barring the recently activated knowledge task, \( t(42) = -0.332, p = .74 \), and the practicality-imagery measure, \( t(44) = -1.58, p = .12 \), where the performances of the two groups were not differentiable, the schizophrenics showed significantly poorer
performance than the control group on all the other creative cognition measures: total conceptual expansion score, $t(44) = -2.099, p < .042$, originality-imagery measure, $t(44) = -2.066, p < .045$, insight problem solving, $t(44) = -3.486, p < .001$, incremental problem solving, $t(44) = -3.419, p < .001$, fluency-alternate uses task, $t(44) = -5.827, p < .0001$, and uniqueness-alternate uses task, $t(44) = -2.082, p < .043$.

**Table 3.1:** Descriptive data for the schizophrenia group and control group across all experimental variables in Study 2

<table>
<thead>
<tr>
<th>Schizophrenia Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NART -IQ</strong></td>
<td>105.903</td>
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<tr>
<td></td>
<td>2.085</td>
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<tr>
<td></td>
<td>111.33</td>
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<tr>
<td></td>
<td>1.9165</td>
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<tr>
<td><strong>WAIS Picture Completion</strong></td>
<td>13.5484</td>
</tr>
<tr>
<td></td>
<td>0.597</td>
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<tr>
<td></td>
<td>16.933</td>
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<tr>
<td></td>
<td>0.5646</td>
</tr>
<tr>
<td><strong>WAIS Digit Span</strong></td>
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<tr>
<td></td>
<td>0.693</td>
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<tr>
<td></td>
<td>16.8</td>
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<tr>
<td></td>
<td>0.9008</td>
</tr>
<tr>
<td><strong>Digits Forward</strong></td>
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<td>0.386</td>
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<tr>
<td></td>
<td>8.8</td>
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<tr>
<td></td>
<td>0.5273</td>
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<tr>
<td><strong>Digits Backward</strong></td>
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<td>0.429</td>
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<td></td>
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<td></td>
<td>0.4976</td>
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<td></td>
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<td><strong>Brixton test</strong></td>
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<td><strong>Hayling test: Error scaled score</strong></td>
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<td><strong>Cognitive Estimates Test</strong></td>
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<td></td>
<td>3.7333</td>
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<tr>
<td></td>
<td>0.8969</td>
</tr>
<tr>
<td><strong>Stroop: Word Control Condition</strong></td>
<td>38.7598</td>
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<tr>
<td></td>
<td>30.584</td>
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<td></td>
<td>1.1626</td>
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<td><strong>Stroop: Colour Control Condition</strong></td>
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<tr>
<td></td>
<td>2.442</td>
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<td></td>
<td>46.204</td>
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<td></td>
<td>2.3695</td>
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<td><strong>Stroop: Colour/Word Interference condition</strong></td>
<td>96.5455</td>
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<td>5.293</td>
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<tr>
<td></td>
<td>78.577</td>
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<td>4.5867</td>
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<td><strong>Stroop: Word Condition - No. of errors</strong></td>
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<td><strong>Total Expansion Score</strong></td>
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<td><strong>Recently Activated Knowledge</strong></td>
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<td>3.1533</td>
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<td><strong>Originality-Imagery</strong></td>
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<td></td>
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<td></td>
<td>0.1942</td>
</tr>
<tr>
<td><strong>Insight problems (total solved)</strong></td>
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<tr>
<td></td>
<td>0.197</td>
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<tr>
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<td>0.3237</td>
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<tr>
<td><strong>Incremental problems (total solved)</strong></td>
<td>1.58065</td>
</tr>
<tr>
<td></td>
<td>0.172</td>
</tr>
<tr>
<td></td>
<td>2.6667</td>
</tr>
<tr>
<td></td>
<td>0.2873</td>
</tr>
<tr>
<td><strong>Convergent problem solving</strong></td>
<td>2.32258</td>
</tr>
<tr>
<td></td>
<td>0.316</td>
</tr>
<tr>
<td></td>
<td>4.6667</td>
</tr>
<tr>
<td></td>
<td>0.5662</td>
</tr>
<tr>
<td><strong>Alternate Uses Task - Fluency</strong></td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>0.77</td>
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<tr>
<td></td>
<td>17.533</td>
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<tr>
<td></td>
<td>1.3831</td>
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<tr>
<td><strong>Alternate Uses Task - Uniqueness</strong></td>
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</tr>
<tr>
<td></td>
<td>0.278</td>
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<tr>
<td></td>
<td>2.1333</td>
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<tr>
<td></td>
<td>0.5333</td>
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</tbody>
</table>
### Table 3.2: Comparison between the schizophrenic and control groups across all the key experimental variables in Study 2

<table>
<thead>
<tr>
<th>Between-Groups Contrasts</th>
<th>General (all)</th>
<th>Age (45&amp;&lt;)</th>
<th>Males Only</th>
<th>High IQ (&gt;100)</th>
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<tr>
<td><strong>Frontal tasks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NART - IQ</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>WAIS-picture completion</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>WAIS-digit span</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Digits Backward</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>--</td>
</tr>
<tr>
<td>Digits Forward</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>--</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Cognitive Estimates Test</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Hayling test</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Brixton test</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Stroop (word) - RT</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Stroop (colour) - RT</td>
<td>+</td>
<td>$p&lt;.051$</td>
<td>--</td>
<td>$p&lt;.058$</td>
</tr>
<tr>
<td>Stroop (interference) - RT</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (word) - errors</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (colour) - errors</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (interference) - errors</td>
<td>$p&lt;.081$</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Creative cognition tasks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conceptual Expansion</td>
<td>+</td>
<td>--</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Recently Activated Knowledge</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Originality-Imagery</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>$p&lt;.082$</td>
</tr>
<tr>
<td>Practicality-Imagery</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Insight problem solving</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Incremental problem solving</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Alternate Uses: Fluency</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Alternate Uses: Uniqueness</td>
<td>+</td>
<td>$p&lt;.083$</td>
<td>++</td>
<td>--</td>
</tr>
</tbody>
</table>

**Key to the Symbols:**

Unless explicitly stated, the significant results indicate better performance by the control group in comparison to the schizophrenic group.

- -- no difference
- + $p < .05$
- ++ $p < .01$
- +++ $p < .001$

$p$ values of trends are indicated.
Employing other between-groups contrasts reveal a very similar profile, as displayed in Table 3.2, where the results from males-only, high IQ and age between-groups contrasts parallel that of the general level contrast very closely. The few resulting differences in the high IQ contrast were that the high IQ schizophrenic and control groups were no longer significantly differentiable on digits forward measure, $t(33) = -1.494, p = .15$, the uniqueness measure of the alternate uses test, $t(33) = -1.396, p = .17$, and on the Stroop colour/word interference condition RT, $t(33) = 1.148, p = .26$, and only at the level of a trend on the Stroop colour control condition RT, $t(33) = 1.962, p = .058$. Similar differences on the Stroop results were found in the males-only contrast where the schizophrenic and control groups were found to not differentiate on the Stroop colour/word interference condition RT, $t(36) = 1.337, p = .19$, and only at the level of a weak trend on the Stroop colour control condition RT, $t(36) = 1.734, p = .09$.

The age contrast revealed a similar picture on the Stroop results where the schizophrenic and control groups were found to not differentiate on the Stroop colour/word interference condition RT, $t(29) = 0.949, p = .32$, but showing a strong trend on the Stroop colour control condition RT, $t(29) = 2.035, p = .051$. The schizophrenic and control groups were also found to be comparable on the digits backward task, $t(29) = -1.598, p = .12$. With regard to the creative cognition tasks, no significant differences were found between the groups on the conceptual expansion task, $t(29) = -1.569, p = .13$ and only at the level of a trend on the uniqueness measure of the alternate uses task, $t(29) = -1.795, p = .08$.

A series of within-group contrasts were also carried out based on the median-split values of the CASH scores of the patients to assess if the degree of symptoms would influence the performance of the schizophrenic group. The symptomatology analyses included contrasts for delusions (low delusions 0-1: n=13, high delusions 2-5: n=18), hallucinations (low 0-2: n=15, high 3-5: n=16), thought disorder (low 0: n=16, high 1-5: n=15), flat affect (low 0-2: n=16, high 3-5: n=15), alogia (low 0-1: n=19, high 2-5: n=12), avolition (low 0-2: n=14, high 3-5: n=17), and anhedonia (low 0-2: n=13; high 3-5: n=18). As shown in Tables 3.3 and 3.4, for most part there were no significant differences in the performance of schizophrenics who were differentiated in terms of low versus high degree of positive and negative psychotic symptoms on the frontal or creative cognition tasks.
**Table 3.3:** Comparison of the positive symptomatology within-group contrasts for the schizophrenic group across all the key experimental variables in Study 2

<table>
<thead>
<tr>
<th>Frontal tasks</th>
<th>Delusions</th>
<th>Hallucinations</th>
<th>Thought Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAIS-picture completion</td>
<td>--</td>
<td>(p &lt; .079) (high &gt; low)</td>
<td>++</td>
</tr>
<tr>
<td>WAIS-digit span</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Digits Backward</td>
<td>--</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>Digits Forward</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>--</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>Cognitive Estimates Test</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Hayling test</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Brixton test</td>
<td>--</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>Stroop (word) – RT</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (colour) – RT</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Stroop (interference) – RT</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (word) – errors</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (colour) – errors</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (interference) – errors</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Creative cognition tasks</th>
<th>Delusions</th>
<th>Hallucinations</th>
<th>Thought Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Expansion</td>
<td>(p &lt; .057) (high &gt; low)</td>
<td>(p &lt; .085) (high &gt; low)</td>
<td>--</td>
</tr>
<tr>
<td>Recently Activated Knowledge</td>
<td>--</td>
<td>--</td>
<td>(p &lt; .058) (high &gt; low)</td>
</tr>
<tr>
<td>Originality-Imagery</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Practicality-Imagery</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Insight problem solving</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Incremental problem solving</td>
<td>--</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>Alternate Uses: Fluency</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Alternate Uses: Uniqueness</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Key to the Symbols:**
Unless explicitly stated, the significant results indicate better performance by the group with a lower degree of psychotic symptoms in comparison to group with a higher degree of symptoms.

- -- no difference
- + \(p < .05\)
- ++ \(p < .01\)
- +++ \(p < .001\)

\(p\) values of trends are indicated

*Frontal tasks* (within-group positive symptom analyses). Both the Hallucinations and the Delusions contrasts revealed no significant differences between the high and low
symptom schizophrenics on any frontal measure, except for a trend on the WAIS-picture completion task, in which the performance of the high-hallucinations group (mean: 14.56, SEM: 0.65) tended to be better than the low-hallucinations group (mean: 12.47, SEM: 0.97), $t(29) = -1.82, p = .079$. The Thought Disorder contrast, on the other hand, revealed many differences such that the low thought disorder group performed better than the high thought disorder group on the WAIS picture completion task, $t(29) = 2.777, p < .01$, the digits backward task, $t(29) = 3.323, p < .002$, the digit span task, $t(29) = 2.121, p < .043$, the spatial span task, $t(29) = 3.135, p < .004$, the Brixton task, $t(29) = 3.245, p < .003$, and the Stroop colour control condition RT, $t(29) = -2.104, p = .044$.

Creative cognition tasks (within-group positive symptoms analyses). On the conceptual expansion task, the high delusions group (mean: 1.61, SEM: 0.335) showed a strong tendency to better expand the animal concept compared to the low hallucinations group (mean: 0.692, SEM: 0.286), $t(29) = -1.982, p = .057$. A similar trend was found in the Hallucinations contrast as the high hallucinations group (mean: 1.625, SEM: 0.3) showed a tendency to better expand the animal concept compared to the low hallucinations group (mean: 0.8, SEM: 0.35), $t(29) = -1.781, p = .085$. The Thought Disorder contrast revealed that the low thought disorder group performed significantly better than the high thought disorder group on incremental problem solving, $t(29) = 2.652, p < .013$, but that the reverse pattern was true in the case of the recently activated knowledge task where there was a strong trend for the high thought disorder group (mean: 0.87, SEM: 0.21) to be less constrained by examples in their ability to generate an original toy than the low thought disorder group (mean: 1.4, SEM: 0.17), $t(28) = 1.974, p = .058$.

Frontal tasks (within-group negative symptom analyses). The negative symptom contrasts primarily revealed differences on the Stroop task for the Flat Affect and Alogia dimensions, the digits backward and Brixton tasks for the Avolition contrast and the WAIS-Picture completion task for the Anhedonia contrast. The Flat Affect contrasts revealed the low-flat affect group performed better than high-flat affect group significantly on the Stroop word control condition RT, $t(28) = -3.165, p < .004$, and the Stroop colour control condition, $t(28) = -2.487, p < .019$, and at the level of a trend on the Stroop interference condition, $t(28) = -1.869, p = .072$, and the Brixton test, $t(29) = 1.866, p = .072$. 

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### Table 3.4: Comparison of the negative symptomatology within-group contrasts for the schizophrenic group across all the key experimental variables in Study 2

<table>
<thead>
<tr>
<th></th>
<th>Flat Affect</th>
<th>Alogia</th>
<th>Avolition-Apathy</th>
<th>Anhedonia-Asociality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frontal tasks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAIS-picture completion</td>
<td>--&lt;br&gt;<strong>++</strong></td>
<td>--</td>
<td>--</td>
<td>+&lt;br&gt;<em>p &lt; 0.01</em></td>
</tr>
<tr>
<td>WAIS-digit span</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Digits Backward</td>
<td>--</td>
<td>--</td>
<td>++&lt;br&gt;<em>p &lt; 0.01</em></td>
<td>--</td>
</tr>
<tr>
<td>Digits Forward</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>--</td>
<td>--</td>
<td>--&lt;br&gt;<em>p &lt; 0.05</em></td>
<td>--&lt;br&gt;<em>p &lt; 0.01</em></td>
</tr>
<tr>
<td>Cognitive Estimates Test</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Hayling test</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Brixton test</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (word) - RT</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (colour) - RT</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
</tr>
<tr>
<td>Stroop (interference) - RT</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
</tr>
<tr>
<td>Stroop (word) - errors</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (colour) - errors</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stroop (interference) - errors</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Creative cognition tasks</strong></th>
<th>Flat Affect</th>
<th>Alogia</th>
<th>Avolition-Apathy</th>
<th>Anhedonia-Asociality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Expansion</td>
<td>--</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>Recently Activated Knowledge</td>
<td>--</td>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Originality-Imagery</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Practicality-Imagery</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Insight problem solving</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Incremental problem solving</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--&lt;br&gt;<em>p &lt; 0.05</em></td>
<td>--&lt;br&gt;<em>p &lt; 0.01</em></td>
</tr>
<tr>
<td>Alternate Uses: Fluency</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Alternate Uses: Uniqueness</td>
<td>--&lt;br&gt;<strong>+++</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Key to the Symbols:**
- Unless explicitly stated, the significant results indicate better performance by the group with a low degree of psychotic symptoms in comparison to group with a higher degree of symptoms.
- -- no difference
- + *p < 0.05*
- **++* p < 0.01*
- +++ *p < 0.001*
- *p values of trends are indicated

A similar pattern of results was found for the Alogia contrast with the low-alogia group performing better than the high-alogia group on the on the Stroop word control condition RT,
$t (28) = -2.54, p < .017$, and the Stroop interference condition, $t (28) = -2.439, p < .021$, and at the level of a strong trend on the Stroop colour control condition, $t (28) = -2.019, p = .053$. The low-avolition group were found to surpass the high-avolition group on the digits backward task, $t (29) = 2.202, p < .036$, and the Brixton task, $t (29) = 2.109, p < .044$, but only at the level of a trend on the spatial span task, $t (29) = 1.863, p = .073$. The low-anhedonia group were found to surpass the high-anhedonia group on the WAIS-picture completion task, $t (29) = 2.655, p < .013$, but only at the level of a trend on the digits backward, $t (29) = 1.818, p = .079$, and the spatial span tasks, $t (29) = 1.895, p = .068$.

Creative cognition tasks (within-group negative symptoms analyses). Apart from the alternate uses task where the low-avolition group performed better on both the fluency, $t (29) = 2.136, p < .041$, and uniqueness measures, $t (29) = 2.231, p < .034$, along with a trend for the low-anhedonia group to surpass the high-anhedonia group on incremental problem solving, $t (29) = 1.79, p = .084$, there were no other differences.

Combined between-groups and within-group analyses were carried out by creating combined positive and negative symptom groups by diving the patients based on a median split of the mean global ratings across the three positive symptom scales and the four negative symptoms scales. Four groups were thus created (see Table 3.5): a high positive-high negative symptoms group (hpos/hneg), a low positive-low negative symptoms group (lpos/lneg), a low positive-high negative symptoms group (lpos/hneg), and a high positive-low negative symptoms group (hpos/lneg).

**Table 3.5:** Classification of the schizophrenic patients into subgroups based on CASH symptom scores

<table>
<thead>
<tr>
<th></th>
<th>Low Positive (range 1-5)</th>
<th>High Positive (range 6-11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Negative (range 1-7)</td>
<td>n = 8</td>
<td>n = 6</td>
</tr>
<tr>
<td>Low Positive &amp; Low Negative (lpos/lneg)</td>
<td></td>
<td>High Positive &amp; Low Negative (hpos/lneg)</td>
</tr>
<tr>
<td>High Negative (range 8-15)</td>
<td>n = 7</td>
<td>n = 10</td>
</tr>
<tr>
<td>Low Positive &amp; High Negative (lpos/hneg)</td>
<td></td>
<td>High Positive &amp; High Negative (hpos/hneg)</td>
</tr>
</tbody>
</table>
Table 3.6: Descriptive data for the four schizophrenic symptom subgroups and the healthy control group across all the frontal and creative cognition variables.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>lpos/lneg</th>
<th>lpos/hneg</th>
<th>hpos/lneg</th>
<th>hpos/hneg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.E.M.</td>
<td>Mean</td>
<td>S.E.M.</td>
<td>Mean</td>
</tr>
<tr>
<td>WAIS Pic. Compl.</td>
<td>16.93</td>
<td>0.56</td>
<td>14.63</td>
<td>1.24</td>
<td>12.86</td>
</tr>
<tr>
<td>WAIS Digit Span</td>
<td>16.80</td>
<td>0.90</td>
<td>14.38</td>
<td>1.45</td>
<td>13.00</td>
</tr>
<tr>
<td>Digit Backward</td>
<td>8.00</td>
<td>0.50</td>
<td>7.25</td>
<td>0.49</td>
<td>5.86</td>
</tr>
<tr>
<td>Digit Forward</td>
<td>8.80</td>
<td>0.53</td>
<td>7.13</td>
<td>1.01</td>
<td>7.14</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>5.60</td>
<td>0.24</td>
<td>5.38</td>
<td>0.38</td>
<td>4.71</td>
</tr>
<tr>
<td>Cognitive Estimates Test</td>
<td>3.73</td>
<td>0.90</td>
<td>6.50</td>
<td>0.87</td>
<td>6.00</td>
</tr>
<tr>
<td>Hayling test</td>
<td>6.07</td>
<td>0.36</td>
<td>6.13</td>
<td>0.40</td>
<td>5.43</td>
</tr>
<tr>
<td>Brixton test</td>
<td>6.87</td>
<td>0.43</td>
<td>6.50</td>
<td>0.65</td>
<td>4.00</td>
</tr>
<tr>
<td>Stroop: Words RT</td>
<td>30.58</td>
<td>1.16</td>
<td>35.25</td>
<td>5.42</td>
<td>47.12</td>
</tr>
<tr>
<td>Stroop: Colours RT</td>
<td>46.20</td>
<td>2.37</td>
<td>50.94</td>
<td>6.07</td>
<td>61.00</td>
</tr>
<tr>
<td>Total Expansion Score</td>
<td>2.13</td>
<td>0.38</td>
<td>0.88</td>
<td>0.30</td>
<td>0.86</td>
</tr>
<tr>
<td>Recently activ. knowledge</td>
<td>1.21</td>
<td>0.19</td>
<td>1.00</td>
<td>0.19</td>
<td>1.14</td>
</tr>
<tr>
<td>Originality-Imagery</td>
<td>2.60</td>
<td>0.19</td>
<td>2.20</td>
<td>0.16</td>
<td>2.16</td>
</tr>
<tr>
<td>Practicality-Imagery</td>
<td>3.15</td>
<td>0.16</td>
<td>2.99</td>
<td>0.26</td>
<td>2.91</td>
</tr>
<tr>
<td>Insight problem solving</td>
<td>2.00</td>
<td>0.32</td>
<td>1.13</td>
<td>0.40</td>
<td>0.57</td>
</tr>
<tr>
<td>Incremental problem solving</td>
<td>2.67</td>
<td>0.29</td>
<td>2.13</td>
<td>0.35</td>
<td>2.00</td>
</tr>
<tr>
<td>Alternate Uses: Fluency</td>
<td>17.53</td>
<td>1.38</td>
<td>11.13</td>
<td>1.43</td>
<td>6.57</td>
</tr>
<tr>
<td>Alternate Uses: Uniqueness</td>
<td>2.13</td>
<td>0.53</td>
<td>0.88</td>
<td>0.52</td>
<td>0.43</td>
</tr>
</tbody>
</table>

As the sample size of some schizophrenic subgroups were too small to permit parametric test analyses, the Mann-Whitney U test, a non-parametric statistical significance test, was employed. The means and standard error of mean values for the four schizophrenic symptom subgroups and the healthy control group are provided in Table 3.6. Results from the combined between-and within-groups contrasts are given in Table 3.7 where the performance of the four schizophrenic subgroups was compared to that of the healthy control group (n=15). Except for a strong trend for worse performance on the cognitive estimates test, the lpos-lneg group was not found to be significantly different from the control group on any of the frontal tasks. However, the lpos-lneg group showed significantly worse performance on two creative cognition measures: the conceptual expansion task and fluency measure of the alternate uses task, along with a strong trend for a low uniqueness score on the alternate uses task.
Table 3.7: Combined between-groups and within-group contrasts across schizophrenic symptom subgroups and the control group

<table>
<thead>
<tr>
<th>Frontal tasks</th>
<th>Low Positive &amp; Low Negative</th>
<th>Low Positive &amp; High Negative</th>
<th>High Positive &amp; Low Negative</th>
<th>High Positive &amp; High Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAIS-picture completion</td>
<td>--</td>
<td>++</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>WAIS-digit span</td>
<td>--</td>
<td>+</td>
<td>--</td>
<td>+++</td>
</tr>
<tr>
<td>Digits Backward</td>
<td>--</td>
<td>+</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>Digits Forward</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>--</td>
<td>+</td>
<td>--</td>
<td>+++</td>
</tr>
<tr>
<td>Cognitive Estimates Test</td>
<td>$p &lt; .06$</td>
<td>--</td>
<td>--</td>
<td>+++</td>
</tr>
<tr>
<td>Hayling test</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Brixton test</td>
<td>--</td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Stroop (word) - RT</td>
<td>--</td>
<td>+++</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>Stroop (colour) - RT</td>
<td>--</td>
<td>++</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Stroop (interference) - RT</td>
<td>--</td>
<td>++</td>
<td>--</td>
<td>$p &lt; .069$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Creative cognition tasks</th>
<th>Low Positive &amp; Low Negative</th>
<th>Low Positive &amp; High Negative</th>
<th>High Positive &amp; Low Negative</th>
<th>High Positive &amp; High Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Expansion</td>
<td>+</td>
<td>+</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Recently Activated Knowledge</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Originality-Imagery</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Practicability-Imagery</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Insight problem solving</td>
<td>--</td>
<td>+</td>
<td>--</td>
<td>+++</td>
</tr>
<tr>
<td>Incremental problem solving</td>
<td>--</td>
<td>$p &lt; .064$</td>
<td>$p &lt; .051$</td>
<td>+++</td>
</tr>
<tr>
<td>Alternate Uses: Fluency</td>
<td>+</td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Alternate Uses: Uniqueness</td>
<td>$p &lt; .062$</td>
<td>+</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Key to the Symbols:**

Unless explicitly stated, the significant results indicate better performance by the control group in comparison to the 4 schizophrenic subgroups as depicted in Table 3.5.

-- no difference
+ $p < .05$
++ $p < .01$
+++ $p < .001$

$p$ values of trends are indicated.

This pattern of a lack of deficits across these complex tasks was also found in the hpos-lneg group, where the control group showed better performance only on the Brixton test and the fluency measure of the alternate uses task, and a trend for worse performance on the
incremental problem solving task. This picture, however, changes with the high negative groups. The lpos/hneg group was significantly worse than the control group on all the frontal measures barring the digits forward task, the cognitive estimates test and the Hayling test. On the creative cognition tasks, the lpos/hneg group performed worse on both the fluency and uniqueness measures of the alternate uses task, the conceptual expansion task and on insight problem solving and an accompanying trend for worse performance on the incremental problem solving task. The hpos/hneg group showed the most deficits compared to all the other schizophrenic groups relative to controls. Except for the Hayling test, the conceptual expansion task, the recently activated knowledge task and the originality-imagery measure, hpos/hneg group was significantly worse in comparison to the control group on all other frontal and creative cognition tasks and showed a trend for slower response time on the Stroop interference condition.

3.4 Discussion

A large selection of frontal neuropsychological tests and tasks of creative cognition were administered to a sample of chronic schizophrenic patients and a matched healthy control group. It was hypothesised that the schizophrenics as whole group would show worse performance across all the tasks relative to the healthy control group. The general between-groups analysis was confirmatory of these predictions on the frontal tasks except for the error scaled score of the Hayling sentence completion test where the performance of schizophrenics and healthy controls were not differentiable. This indicates that both groups were comparable on the frontal measure of response suppression. To assess whether there would be any change in this pattern of results when more stringent criteria were applied, three alternative between-groups analyses were carried out.

3.4.1 Findings: Between-Groups Analyses

Almost the same results from the general level contrast resulted except that the differences between the groups on the Stroop interference condition ceased to be significant when contrasting only participants under the age of 45 (age contrast), or only males, or only individuals with a NART-IQ of over 100 (high IQ contrast). This was a surprising result as it suggests that inhibitory control deficits in chronic schizophrenia are not found when more restrictions are applied in the sampling of schizophrenics as a case group. However, given the
weight of evidence in favour of a inhibitory deficit in schizophrenia, it is more likely that the current results indicate that the inhibitory deficit in schizophrenia may not be possible to gauge well when using a paper version of the Stroop interference task as opposed to computerised versions that employ more rigorous methodology. On the Stroop Word control condition, the schizophrenic group was found to be significantly slower across all the between-group analyses, indicating a general level of slowness in responding.

Additionally, the between-groups age contrast also revealed a lack of difference between the groups on the digits backward task indicating that working memory deficits seen in chronic schizophrenia are tied in with the effects of aging on cognition. The between-groups high IQ contrast revealed no differences between the schizophrenic and control groups on the digits forward task suggesting comparable short-term verbal memory span in the two groups. The short-term spatial span was, however, significantly lower in the schizophrenic group, a finding that was common to all the between-groups analyses.

With regard to the creative cognition tasks, the general level analyses revealed that barring the recently activated knowledge task and the practicality dimension of the creative imagery task, the schizophrenics showed worse performance relative to the control group across all the other tasks. The same pattern of findings also resulted from the males-only between groups contrast. The age contrast revealed no differences between the groups on the conceptual expansion task and the uniqueness dimension of the alternate uses task, which suggests that some facets of creative cognition function could be spared in younger schizophrenics. In a similar vein, the high IQ contrast also revealed that the schizophrenic and healthy control groups could not be differentiated on neither the uniqueness dimension of the alternate uses task nor the originality dimension of the creative imagery task. This implies that the significant role of IQ in creative cognitive processes varies as a function of the type of mental operation in question.

3.4.2 Findings: Within-Group Analyses

After establishing that the healthy group surpassed the schizophrenic group on almost all the frontal and creative cognition variables in question, within-group analyses were carried out to gauge if the performance of the schizophrenics would differ as a function of the degree of symptoms. The delusions and hallucinations contrasts within the schizophrenic group revealed no significant differences across all the tasks. A trend for the high-hallucinations groups to show better attention to detail on the WAIS-picture completion task than the low-
hallucinations group was found. Interestingly, on the conceptual expansion task, both the high-delusions and high-hallucinations groups showed a trend for better performance than the low-delusions and low-hallucinations groups. This relates to one of the possibilities outlined in the aims of the study for better performance on some creative cognitive measures being related to a higher degree of positive symptoms, which could arise as a function of diffuse, but not impaired, top-down control.

The within-group negative symptom contrasts revealed selective differences across tasks with each symptom type. The high- and low-flat affect groups were differentiated clearly only in terms of the reaction time on the two Stroop control conditions, while the high- and low-alogia group differentiated on the Stroop interference condition such that the high symptom groups recorded longer reaction times than the low symptom groups. The avolition-apathy symptoms revealed differences between the high and low groups on the digits backward working memory task, the Brixton spatial anticipation task and on both Alternate Uses measure with the high-avolition group showing poorer performance. The WAIS picture completion task was the only measure which revealed a difference between the high and low anhedonia groups with the low-anhedonia group demonstrating superior performance. These findings are consistent with the literature showing greater frontal impairments as a function of a higher degree of negative symptoms.

The thought disorder dimension was the one to reveal the most number of differences across tasks based on the high and low contrasts. The high-thought disorder group showed poorer performance than the low-thought disorder group across the WAIS-picture completion task, the digits backward task, the spatial span task, the Brixton task, and the incremental problem solving tasks. The most fascinating finding was the strong trend for the high thought disorder group to surpass the low thought disorder group on the recently activated knowledge task. The recently activated knowledge task was the only task, barring the Hayling test, on which the schizophrenic group was found to be comparable to the healthy control group across all contrasts so a trend for difference in this task between the high and low thought disorder groups is quite intriguing. As described in the aims of the study, the possibility that a greater degree of thought disorder symptoms could be related to better performance on select creative cognition measures was postulated to arise as a result of the defining feature of overinclusive thinking in formal thought disorder.
In summary then, the results on the frontal tasks are in line with specific predictions that were put forward in the aims of the study concerning which aspects of frontal neuropsychological function would relate to specific symptom clusters. In line with the hypotheses concerning set-shifting abilities, as assessed by the Brixton test, and the spatial span capacity, as assessed by the Corsi block tapping task, both the thought disorder (disorganisation) and the negative (psychomotor poverty) symptom constellations were associated with poorer performance. Poor working memory capacity was found to be related not just to negative symptoms, as was hypothesised, but also to the thought disorder dimension. Although inhibitory control was predicted to be related to the thought disorder dimension in schizophrenia, the results were mostly inconclusive. There was, however, limited evidence of an association between poor inhibitory control and negative symptoms.

3.4.3 Findings: Combined Between-Groups and Within-Group Analyses
As schizophrenics are characterised by a combination of negative and positive symptoms, to allow for more robust comparisons between differing schizophrenic symptom groups and the healthy control group, the schizophrenic group was divided into four subgroups based on the degree of their positive (including thought disorder) and negative symptoms. The general picture that emerged, as suggested by the results of the combined between- and within-group analyses as highlighted in Table 3.7, is that the number of significant differences between the schizophrenic and healthy control group on the frontal tasks increase dramatically with the presence of a high degree of negative symptoms. The only exception was in the case of the Stroop interference condition where significant differences were only found for the low positive/high negative group but only at the level of a trend in the high positive/high negative group in comparison to the healthy controls. The high positive/high negative group show the most pervasive frontal deficits followed by the low positive/high negative group. The results from the contrasts of both the low negative groups with the control group revealed only one significant difference on the Brixton spatial anticipation test in the high positive/low negative group and a trend for worse performance on cognitive estimates test on the part of the low positive/low negative group. This pattern of results is in support of the literature that associates a high degree of negative or psychomotor poverty symptoms with deficient frontal neuropsychological function.

With regard to the creative cognition tasks, the findings were less straightforward. All four schizophrenic groups performed worse than the control group on the fluency measure of the alternate uses task. In terms of overall performance, the high positive/high negative group
recorded the poorest performance and were significantly different from the control group on insight problem solving, incremental problem solving and practicality-imagery. Like the high positive/high negative group, the low positive/high negative group also showed poor performance on the insight problem solving tasks and a strong trend for worse performance on the incremental problem solving tasks. However, the low positive/high negative group and the low positive/low negative group performed worse on the uniqueness measure of the alternate uses test, a measure on which the generally more impaired high positive/high negative group was found to be no different from the control group. In a similar vein, the low positive/low negative and low positive/high negative groups showed worse performance on the conceptual expansion task, but this effect disappears in the high positive/high negative and high positive/low negative groups who show comparable performance to the healthy control group. This suggests that the usually less frontally impaired groups (lpos/lneg and lpos/hneg) perform worse on certain creative cognition measures than the most frontally impaired group (hpos/hneg). The fact this lack of impairments is associated with a high degree of positive symptomatology is partially in line with predictions made in the aims of the study.

So, in essence, the findings of this comprehensive study were that the schizophrenics relative to the healthy control group displayed poorer performance across all tasks, the presence of a high degree of negative symptoms was associated with worse performance across most tasks, and there was a strong trend for a high degree of positive and thought disorder symptoms to be associated with superior performance or at least comparable performance to that of the healthy control group on some creative cognition tasks.

3.4.4 Comparing the Conceptual Expansion and Recently Activated Knowledge Tasks
Unlike the frontal tasks where the results were mostly straightforward and easy to interpret, performances between and within groups on the creative cognition tasks revealed considerable variability depending on the type of task in question. On the conceptual expansion task, for instance, both the previous and the present study confirmed that the schizophrenics were markedly unable to expand on existing conceptual structures when compared to the healthy controls. However, on a seemingly parallel task, that of the recently activated knowledge, no differences between the groups resulted. Both tasks assess the degree to which subjects are constrained in their responses when explicitly instructed to create something new. The essential difference between the two tasks is the level at which constraints are held to operate. In the case of the conceptual expansion task, the constraints are imposed by the extent to which top-down factors such as one’s past experience and
existing knowledge in the form of conceptual structures of an ‘animal’ concept influence the ability to generate a novel kind of animal. By providing examples of toys with similar fundamental elements prior to allowing the subject to generate a novel toy, the constraints in the recently activated knowledge task are actively salient. The different pattern of performance between the schizophrenic and control groups across these two tasks indicate that the degree to which one expands concepts depends upon contextual factors, both in terms of the kind of context and the manner in which it is activated.

3.4.5 Contexts: Types and Influences
A number of researchers have addressed the critical issue of the modulatory role of the top-down factors of context on cognition. Hemsley (2003) has highlighted a number of distinctions that require clarification when addressing the issue of context due to the variety in the types of contextual input: temporal or spatial, tonic or phasic, inhibitory or facilitatory, and arising due to contextual priming or executive control. Although several findings have reported deficits in the processing of context in schizophrenia, it’s difficult to tease apart which specific aspects of context processing are blighted as both first-episode and chronic schizophrenics manifest deficits across a wide variety of tasks that tap context sensitivity like the WCST, the Stroop task, the Continuous Performance task, the anti-saccade task, and the n-back working memory task. Reduced context sensitivity in schizophrenia has also been reported across non-executive tasks such that they show reduced prepulse inhibition, inadequate use of context for phonemic disambiguation, reduced preattentive perceptual processing in terms of lower mismatch negativity ERP amplitudes, reduced effect of context in weight perception, and so on (for a review, see Phillips & Silverstein, 2003).

A more general classification of context effects was provided by Park et al. (2003) where three categories were isolated including perceptual contexts, which are pertinent to attentional tasks where the influence of target processing is assessed in terms of the relationship between a target and the context it is embedded in, and socioaffective contexts, which refer to the effect of the global affective state of the individual on contextual processing. The third category of cognitive contexts is the most relevant category with regard to the current study and it includes the contextual effects provided by stored representations in long-term memory which can be direct or indirect and explicit or implicit. An example of the workings of this kind of context would be in a semantic priming task where past experience and associations between stored representations would influence the readiness to respond on a lexical decision task. Another type of cognitive context is that provided by task-relevant information that is
activated during working memory. An example for the effects of this type of context is the AX-type Continuous Performance Task where the subject is required to respond to an X only if an A preceded it.

It may be possible to relate the creative cognition tasks of the conceptual expansion and recently activated knowledge within the framework of this classification. The type of context that is drawn upon while solving the conceptual expansion task is more long-term memory related when compared to the recently activated knowledge task where information relevant to the task at hand, in the form of the three toy examples, is activated at the time and dynamically influences the subject’s performance. The latter case, however, cannot be considered analogous to how task relevant information is pertinent to working memory where the task goals need to be actively maintained in order to reach a goal successfully. On the recently activated knowledge task, there is no prescribed goal to be reached and so an action cannot be deemed correct or incorrect. The information provided, although relevant to the task, is thus not overtly goal-related. Performance on this task would reveal how a currently activated induced context differentially affects individual performance.

Subtle variations with regard to the form of context then appear to have a significant bearing on whether the schizophrenics would show impairments or not and the results on these two tasks suggest that long-term memory related context effects, as gauged by the conceptual expansion ‘animal’ task, are impaired in schizophrenia whereas short-term memory related context effects, as in the case of the recently activated knowledge ‘toy’ task where the constraining effect of examples as assessed, are spared. That schizophrenic functioning was marked by a weakening of the influence of stored memories on current perception was an observation made early on by Hemsley (1987).

3.4.6 Contextual Modulation and Symptom Clusters

As introduced in the previous chapter, results from perceptual grouping tasks have allowed for much headway in the comprehension of contextual processing insufficiencies in schizophrenia. Diverse studies have reported impairments in perceptual gestalt organization in schizophrenia that cannot be explained by a generalised cognitive deficit as schizophrenics have been found to show better performance in situations where grouping would interfere with performance (e.g. Schwartz-Place & Gilmore, 1980; Silverstein et al., 1996a). However, perceptual grouping is not completely lost in schizophrenia as patients have been found to perform comparably to healthy controls when the grouping task involved stimuli with strong
configural properties or continuous contours (e.g. Knight & Silverstein, 1998), and it is only in the absence of strong cues that the schizophrenics show worse performance (e.g. Schwartz-Place & Gilmore, 1980; Silverstein et al., 1996a). This difference in performance of schizophrenics arising as a result of the difference between strong versus weak cues in the activation of context could readily be employed to explain the differential pattern of performance on the conceptual expansion and recently activated knowledge tasks in the current study. In the latter case, the activation of context is strong with the examples introduced just prior to the generation of a toy, while in the former case the activation of context is not as controlled or precise because of the absence of an explicit cue.

As highlighted several times in this chapter, contextual processing or top-down deficits as assessed by frontal executive function tasks on set-shifting, working memory or inhibitory control is associated with both negative symptoms and thought disorder symptoms. Contextual effects on perceptual grouping paradigms have, for most part, been shown to vary as a function of thought disorder or disorganisation symptom clusters in schizophrenia and such symptoms have been found to be the best predictor of performance on diverse perceptual organisation tasks. On a psychophysically well-controlled measure of contour integration, for instance, higher levels of disorganised symptoms in schizophrenics were related to the reduced capability to perceive closed contours (Silverstein et al., 2000). This pattern of findings has been reported from other context-sensitive tasks as well such as the Hooper Visual Organization test which provides an index of perceptual fragmentation (Lezak, 1995), and the degraded stimulus version of the Continuous Performance Test, which also requires functional perceptual grouping (Knight & Silverstein, 1998). How thought disorder or negative symptomatology interacts with the perceptual grouping abilities as a function of previously mentioned distinction of strong versus weak activation of contexts is, as yet, unknown.

### 3.4.7 Strong or Active Contexts versus Weak or Passive Contexts

Subtle differences across these two creative cognition tasks where found when contrasting the four schizophrenic subgroups with the healthy control group. Both the low positive (including thought disorder) symptom groups performed worse than the control group on the conceptual expansion task, but the two high positive symptom groups were found to be no different. This finding was backed by the within group analyses which showed that the high delusions and hallucinations groups showed a tendency to be better able to expand concepts compared to the low delusions and hallucinations groups. These results suggest that long-term memory related
context deficits associated with schizophrenic performance on this task are negated in the presence of high levels of positive symptoms. On the other hand, there was a strong tendency for the high thought disorder group in the within-group analyses to be less constrained by the examples in the recently activated knowledge task. To integrate these results with reference to the general picture poses some difficulties as there is very little to draw on from the current literature that allows for assured claims and only cautious proposals can be offered to clarify this pattern of performance.

Given that a strong or active context is induced in the recently activated knowledge task, it is plausible that the examples that are presented to induce a particular context would pose less constraints in the thought processes of schizophrenic patients with a high degree of thought disorder symptoms as their thinking is characterised by conceptual disorganisation and the tendency to be continually diverted from an intended direction. The application of inappropriate frames of reference to sensory input has been hypothesised to underlie some types of delusional beliefs which arise as a result of the disruption of relationship between long-term memory representations and stimulus input (Hemsley, 1994). Accordingly, in the case of conceptual expansion task, it is conceivable that impaired performance arising as a result of weak or passive long-term memory context activation is eliminated in the presence of high degree of positive symptoms which can in turn be related to the failure of a context to activate an appropriate schema by which processing can be guided.

3.4.8 Context: Alternate Uses Task

This rationale could also explain why the low positive symptom subgroups, regardless of the degree of negative symptoms, tended to show impaired performance relative to the healthy control group on the uniqueness measure of the alternate uses task but that this difference was not found when comparing both the high positive/low negative and high positive/high negative groups to the control group. This equivalence in performance from the high positive subgroups on the conceptual expansion task and the uniqueness measure of the alternate uses task argues strongly for a certain underlying similarity between the two tasks. The uniqueness measure of the alternate uses task, just as in the conceptual expansion task, taps the propensity to generate original, uncommon and innovative responses. An increased or more diffuse activation of long-term representations (weak or passive contextual factors) that are not entirely appropriate to the task at hand would result in less restrictive or overinclusive thinking. This could bring about the enhanced ability to generate unusual uses for common objects on the alternate uses task, a line of reasoning that can be employed to explain why the
high positive symptom subgroups performed comparably to the controls in contrast to the low positive symptom subgroups.

All four schizophrenic symptom subgroups demonstrated an impaired ability to generate many uses when compared to the control group as assessed by the fluency measure of the alternate uses task. This pattern of verbal underproductivity 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 (Kremen et al., 2003). The results on the alternate uses task fluency measure of the current study result tie in well with schizophrenic semantic fluency deficits which has been associated with the reduced lateralization of the frontal lobe in schizophrenia and a disorganized semantic system (e.g. Phillips et al., 2004; Weiss et al., 2004).

3.4.9  **Context: Convergent Problem Solving**

The pattern of performance of the groups on the convergent tasks of insight and incremental problem solving was strikingly similar to that of the frontal executive tasks. The low positive/low negative schizophrenic subgroup showed comparable performance to that of the healthy control group while the high positive/high negative subgroup showed marked impairments on both convergent problem types. In the same vein, the other high negative symptom group, low positive/high negative, was also significantly worse on the insight problems and showed worse performance at the level of a strong trend on the incremental problems. This suggests that in conditions that call for a prescribed goal to be reached, schizophrenics, in particular those with a high degree of negative symptoms, tend to display poor performance. Frontal executive function measures could serve as predictors in such types of convergent analytic reasoning tasks as the deficits seen among schizophrenics on both the convergent tasks and the frontal tasks can both be ascribed to impairments in goal-directed behaviour.

Curiously however, the high positive/low negative group, although showing a strong trend for worse performance on the incremental task, was comparable to the controls on the insight problems. As pointed out in the Introduction, the ability to solve insight analytical problems could be abetted by some degree of loosened associational thinking, a core feature of positive and thought disorder symptoms, as it enables more effortless restructuring of the problem situation. In the case of schizophrenics though, this loosened associational thinking style is far
too acute to be functional enough to grant any advantage that could lead to superior performance, but it may grant the capacity to perform in a comparable manner to that of the healthy control group when accompanied by adequate goal directed mental operations. This argument could be used to explain why the high positive/low negative group performed no differently in contrast to the healthy control group on insight problem solving even though they showed worse performance on incremental problem solving.

3.4.10 Context: Creative Imagery

The findings from the creative imagery task are more difficult to interpret. The between groups analyses between schizophrenics as a whole group and the healthy control subjects showed differences on the originality dimension but not on the practicality dimension. This pattern of results was predicted at the outset in the aims of the study. However, at the level of the combined between and within groups analyses using symptom subgroups, these differences were no longer found between the schizophrenic subgroups and the control group on the originality dimension. This was inconsistent with prior expectations because the predicted difference found at the level of the between groups contrast was expected to be related to greater degree of negative symptoms. A second hypothesis put forward in the aims of the study related higher levels of positive and thought disorder symptoms to lower practicality scores and this prediction was partially confirmed with the high positive/high negative subgroup performing significantly worse than the healthy control group on the practicality dimension of the creative imagery task but the other high positive subgroup (high positive/low negative) performed comparably to the control group. Although it is not possible to derive a conclusive deduction from this complicated pattern of results on the creative imagery task, this task of creative cognition still holds much promise in providing a tool by which differential schizophrenic function can be examined. Perhaps altering some of the parameters of the task, like increasing the number of trials per category or introducing more well-defined categories, may allow for more fine-grained differences to emerge.

A strong case then emerges for impaired, as opposed to only diffuse or mildly diminished top-down control, in schizophrenic function and this appears to be applicable whether top-down effects are conceived of as goal-directed control of information processing or, alternatively, as the influence of prior knowledge and the expectations that derive thereof on information processing. On tasks that require effective goal-directed thinking, the schizophrenics showed impairments in performance and the evidence indicates that this pattern was mainly found in the presence of high negative symptoms. In contrast, the positive and thought disorder
symptoms were associated with the reduced influence of stored knowledge and expectations, as manifested by loosened associational thinking and access to remote or wider association than customary. Schizophrenics with a high degree of such symptoms showed comparable performance to the healthy control group and were unimpaired on tasks which would be favoured by this kind of cognitive style. This divergence in performance based on differing symptom clusters within the schizophrenic group has considerable implications on the issue of context processing in schizophrenia as many theorists have tackled this issue from different conceptions of what comprises a context. The findings from current study could perhaps provide a common mould through which these theories can be allied.

3.4.11 Theoretical Formulations
The most influential model of context processing to date is that of Cohen and Servan-Schreiber (1992) who developed their theory from a connectionist or parallel distributed processing framework and emphasised the role of working memory. Within their model, context is defined as task relevant information that is supplied by events preceding the task itself, such as the task instructions, a specific previously presented stimulus, or the resulting information from the processing of a sequence of prior stimuli. An internal representation of such task-relevant contextual information must be actively maintained in order to mediate an appropriate behavioural response. While contextual information is relevant to the task at hand, it does not form part of the actual response and therefore relates, not to short-term memory, but to information stored in working memory, where task relevant information needs to be actively maintained in service of a goal.

A failure to maintain and update internal representations of task relevant contextual information or a lack of cognitive control was held to underlie the cognitive deficits that are widely associated with schizophrenia. Accordingly, a strong case for the fundamental role for the prefrontal cortex for the internal representation and the active maintenance and updating of context information in the face of interference also emerged. Drawing from observations that relating a vast number of cognitive impairments in schizophrenia to reduced activity of dopamine in the prefrontal lobe, Cohen and his colleagues developed a computational model of dopamine and prefrontal function. Their simulations revealed that dopamine acts by gating access to active representations in the prefrontal cortex to allow for flexible updating an interference control and that this action was mediated by phasic changes in dopamine activity (Braver, Barch & Cohen, 1999). As schizophrenics exhibit down-regulation of dopamine in the prefrontal cortex, there is an abnormal gating of dopamine into the prefrontal cortex which
would cause a reduction in the functional focus of cortical neuronal network activity and the subsequent inability to produce appropriate responses. This would exhibit as an incapacity to maintain and update mental representations of pertinent contextual information. As impaired cognitive control within the conception of this model specifically relates to working memory and executive control deficits, it is particularly pertinent to the realm of the cognitive manifestations of negative symptoms in schizophrenia.

This account was in contrast to an earlier rival theoretical model that argued for the importance of concurrent context on perception that was held to depend on long-term memory representations (e.g. Gray et al., 1991; Hemsley et al., 1993). This theory was put forward to account for the positive symptoms (including thought disorder) of acute schizophrenia. A disturbance in the normal projection of limbic system input via the subiculum to the nucleus accumbens in the basal ganglia was held to bring about the positive symptoms of schizophrenia. This was in turn related to the subcortical hyperactivity of dopamine (specifically D2), which in accordance with the dopamine hypothesis, is associated with the expression of positive schizophrenic symptoms. In cognitive terms, this excess dopamine subcortically leads to ‘over-attention’ or the broadening of selective attention and consequently impaired associational learning. Positive symptoms were found to be associated with impaired performance on attentional paradigms assessing mainly latent inhibition and Kamin-blocking effects. This theory incorporated Frith’s view (1987) which claimed that schizophrenics show a weakened capability to monitor willed intentions, with that of Hemsley (1987) who postulated that schizophrenia is marked by the diminished influence of stored memories of past regularities on the processing on current input. This incapacity to proficiently monitor thoughts and actions was linked to insufficiencies of septo-hippocampal system, which according to Gray (1982) is responsible for such a monitoring function in the brain, and its interactions with the striatal motor programming systems.

The latest comprehensive theoretical model that has been proposed to explain select facets of schizophrenic function combines the ideas of both these approaches when defining the domain of context. By expressly associating deficits in ‘cognitive coordination’ to thought disorder symptoms in schizophrenia, Phillips and Silverstein (2003) argue for the critical role of underactivity in NMDA glutamate receptor channels in schizophrenic pathophysiology. Central to their conception of context is its role in cognitive coordination which determines the salience and timing of a particular neuronal response while leaving the essential meaning of the response itself unchanged. A context then is not identified in terms of a particular type
of knowledge but as a certain class of effects that affect the transmission of neural signals encoding for primary input without becoming a part of their meaning. So it allows for the incorporation of both the working memory and the long-term memory conceptions of context. In general terms, two major classes of the glutamatergic system are believed to underlie to this distinction between primary and contextual input. AMPA and kainate glutamate receptors are charged with the primary input drive as they open whenever glutamate binds to them. Contextual effects, though, are believed to be mediated by NMDA-receptors as the effect of direct excitatory input could be modulated via its voltage dependent properties which could in turn aid coordination by amplifying activity that is appropriate and suppressing activity that is inappropriate through inhibitory interneurons. In line with this, a recent study on pigeons revealed that a blockade of prefrontal NMDA receptors selectively affected the executive function of response selection, which taps the capacity to select appropriate responses in accordance with the conditions of a given task, while sparing the capacity for the maintenance of stimulus information in a working memory paradigm (Lissek & Güntürkün, 2004).

At the level of the locus of cortical control, cognitive coordination is believed to subserved by widely distributed local interactions within and between regions as well as by top-down strategic control. So prefrontally mediated goal directed control, pre-attentive organisational signals and local motor control are all implicated. This receives additional backing from the fact that NMDA receptors are widely distributed across all cortical regions and are particularly dense in the hippocampus, the basal ganglia and the prefrontal cortex, areas that have been prominently implicated in schizophrenic function in terms of structural or functional abnormalities.

As impairments in cognitive coordination, evidenced by deficits in pre-attentive sensory gating, selective attention, working memory and long-term memory, are most prominent among schizophrenic patients with thought disorder or disorganisation symptoms, the NMDA hypoactivity model of Phillips and Silverstein was put forward to characterise schizophrenia that is primarily marked by thought disorder. Direct evidence for the same comes from studies that show impaired perceptual grouping in schizophrenia (Knight & Silverstein, 1998), poor sensorimotor gating (Perry, Geyer & Braff, 1999), inadequate context sensitivity in language perception (Kuperberg, McGuire & David, 1998), impaired context sensitivity in language production (Spitzer et al., 1994), deficits in working memory (Cohen et al., 1999), and disordered semantic systems (Goldberg et al., 1998). Additionally, the glutamate hypothesis of schizophrenia that was proposed in recognition of the effects of NMDA antagonists like
phencyclidine (PCP) in producing behavioural symptoms akin to that of schizophrenic cognitive disorganization and thought disorder, which also lends support to the model (e.g. Javitt & Zukin, 1991; Abi-Saab et al., 1998).

3.4.12 Summary

The findings of the present study relate in part to all three of the above-mentioned theoretical formulations. A greater degree of negative symptoms, with or without the presence of a high degree of thought disorder and positive symptoms, were associated with worse performance across all goal-directed tasks which fits in well with predictions from the defective working memory approach of Cohen and his colleagues (1992, 1999). Positive and thought disorder symptoms in the absence of a high degree of negative symptoms were not associated with impaired goal-directed thinking. On some tasks of creative cognition which could be hypothetically abetted by overinclusive or loosened associational thinking and the activation of remote schemas, a higher degree of positive and thought disorder symptoms, even in the presence of a high degree of negative symptoms, was associated with unimpaired performance while a low degree of positive symptoms was accompanied by poorer performance. Although conclusions that emerge from an outcome of lack of significant differences is not powerful enough to allow for assured claims, it may be stated that the results obtained from the high combined positive and thought disorder symptom groups essentially correspond to the ‘over-attention’ account of Gray and Hemsley (1991, 1993) of the functional profile of positive schizophrenic symptoms.

In the case of only thought disorder symptoms, it is more difficult to reach firm conclusions with reference to the theoretical models as positive and thought symptoms were combined to obtain a total positive symptom score in order classify the patients into the schizophrenic subgroups analyses. Although no clear conclusions can be reached about specifically thought disorder functioning with reference to healthy individuals, the within groups contrasts on thought disorder, where patients with and without thought disorder were compared, would allow for at least limited inferences with regard to proposed theory. The schizophrenics with thought disorder were markedly more impaired on all the goal-directed tasks of frontal function and on incremental problem solving when compared to those without thought disorder. In addition, they were either unimpaired or showed a strong tendency for better performance on the creative cognition tasks where wider associational thinking and the activation of remote or even irrelevant contextual representations would abet performance.
Both of these patterns of performance as a function of thought disorder would be in line with the NMDA hypoactivity model of Phillips and Silverstein.

The broad findings resulting from this current study have in turn generated a number of ideas for the improvement and extension of the current paradigm that would be valuable in order to arrive at a more comprehensive understanding of creative cognition as a function of prefrontal function in schizophrenia. The present study was carried out on chronic schizophrenic patients as they show considerably more homogeneity in their general level of functioning in comparison to acute patients. How the pattern of performance of first-episode schizophrenics, medicated and unmedicated, would differ from those of chronic patients on the creative cognition tasks would reveal much about the finer effects of contextual processing on cognition. Although first-episode patients generally display better neuropsychological functioning than chronic patients, it is far more difficult to recruit a homogenous well-controlled acute schizophrenic sample of patients for study. A larger sample size would ideally enable more thorough symptom-based contrasts and longitudinal studies would allow for the examination of the effects of age and maturation of schizophrenic pathology on creative cognitive function. The wider implications of schizophrenic function can be addressed by exploring other disorders from the schizophrenia spectrum and by investigating healthy individuals who demonstrate a predisposition for developing schizophrenia, like first degree relatives of schizophrenics who exhibit a vulnerability for neuropsychological insufficiencies and structural brain abnormalities like schizophrenics (e.g. Johnstone, Lawrie & Cosway, 2002), or individuals characterised by a high degree of psychotic personality traits.
Chapter 4

Study 3: Psychoticism

This chapter unfolds with an Introduction section that begins with an outline of the Psychoticism construct and its relation to psychoses. An overview of studies associating enhanced creative ability as a function of the extent of psychoticism will follow. A brief focus on altered cognitive functioning in psychoticism, its relation to top-down control and the aims of the current study will mark the end of the Introduction. The Methods section outlines the experimental design for Study 3 and the obtained data will be subject to statistical analyses in the Results section. The findings will be interpreted in detail in the Discussion section with reference to pertinent theories and findings within the established literature.

4.1 Introduction

Investigations on clinical populations are enfeebled by a variety of shortcomings that prevail even after applying the most stringent controls. The more commonly recognized limitations stem from the inability to adequately account for diverse influences on a patient’s ability to act and react in an experimental situation that are brought about by various factors, including the types of medication prescribed to deal with the illness, the period of onset of the illness, and the duration of illness. The reliability of DSM-IV and ICD-10 psychiatric diagnoses is also a debatable issue in this light as diagnoses, especially in case of patients with schizophrenia, are subject to considerable amendment over time. Different psychiatrists have also been noted to apply different diagnostic labels to the same patients and several researchers argue against the use of diagnostic manual criteria in selecting and classifying patients in an investigation and instead favour a symptom-based approach.
One strategy that has been widely adopted to circumvent these problems in research is founded upon the continuity-based approach. This stems from the fact that a categorical differentiation of normalcy from psychosis, in that the psychoses are viewed as being qualitatively different from normality, is erroneous as it suggests that there is an exact point at which the normal and abnormal can be distinguished. More realistically, normalcy and psychosis seem to form two ends of a hypothetical continuum and the extent to which psychotic personality traits are found in the healthy population vary considerably (Claridge, 1985). One can thus apply and test hypotheses, albeit only limitedly, of expected differences between psychotic and healthy populations by contrasting groups of healthy individuals who are differentiated in terms of high and low degrees of psychotic personality characteristics. This approach has many advantages as it avoids the problems that plague clinical research and additionally serves to supplement patient data and in the long run, may even help to characterise a potential high-risk or psychosis-prone population.

4.1.1 Psychoticism: The Construct

Hans J. Eysenck first outlined his model of ‘Psychoticism’ (P) in 1952 as the third major dimension of personality which was orthogonal to the first two dimensions – Neuroticism (N) and Extraversion (E). It was an offshoot of the Einheitspsychose view which dominated in the 19th century where the major functional psychoses, manic-depressive psychosis and schizophrenia, were believed to be linked by an underlying commonality (for a review, see Berrios, 1995). Kraepelin was the first to differentiate the two as unrelated disease entities in 1897 and this bifurcation has stuck ever since. The validity of this distinction is, however, somewhat dubious (for a review, see Eysenck, 1992). Kraepelin (1920) himself noted early on that his diagnostic criteria could not be satisfactorily employed for a large proportion of patients. This was found to be the case in an innovative study that used discriminant function analysis to obtain maximum separation between groups of 146 schizophrenics and 146 affective patients and revealed a trimodal, as opposed to a Kraepelinian bimodal, distribution with the major peak in the centre indicating that the number of ‘schizo-affective’ cases are far greater than that of either disorder alone (Kendall & Gourlay, 1970).

More evidence that weakens the Kraepelinian approach to psychoses comes from studies on modifications to diagnoses over time. Kendall (1974), for example, followed up 1913 patients four years after their original diagnosis and while 69% of depressive illness, 75% of schizophrenia and 35% of personality disorder diagnoses remained unchanged, there was a 10.9% change from schizophrenia to depressive illness, 7.4% from depressive illness to
schizophrenia, 17% change from mania to schizophrenia and 2.3% change from mania to schizophrenia. Studies on genetic predisposition towards developing psychoses have shown that children of parents with affective disorder have a higher likelihood of developing both affective psychoses and schizophrenia than normal (e.g. Rosenthal, 1970). Co-morbidity risks in 1587 first-degree relatives of manics, schizophrenics, depressives and controls found that schizophrenia in first-degree relatives of controls was 0.8%, in schizophrenics was over five times as high, in depressives over twice as high and in manics over three times as high (Tsuang, Winokur & Crowe, 1980). Bipolar affective disorder was more common in relatives of schizophrenics than depressives, a pattern that was much less so in the case of unipolar depression. None of the above findings would be expected given a purist Kraepelinian disease classification of schizophrenia and manic-depressive psychosis.

In line with these ideas, Eysenck’s theory of psychoticism (1992; 1995) assumes that there is some degree of continuity among the functional psychoses which can extend to less serious disorders, like some personality disorders, and to normal behaviour.

**Figure 4.1:** Schematic representation of Eysenck’s continuity theory: Psychoticism as a personality variable $P_A$ (adapted from Eysenck, 1992).

The Psychoticism Scale (P-Scale) of the Eysenck Personality Questionnaire (EPQ) was developed as a measure of psychoticism in normal or healthy individuals (Eysenck & Eysenck, 1976; 1991). Following a diathesis-stress model (Gottesman & Shields, 1972),
where a genetic diathesis is a prerequisite for the development of psychoses, functional psychoses according to the Eysenckian continuity model (see Figure 4.1), is hypothesised to occur under conditions of environmental stress with a probability of \( P_A \), which is a monotonic function of psychoticism. Figure 4.1 shows that psychosis and normality form end points of the continuum and that there is no categorical differentiation between different types of psychoses. On the basis of this theory, there are a number of inter-correlating personality traits that form a higher-order psychoticism factor, as schematically represented in Figure 4.2.

**Figure 4.2:** Personality traits characteristic of high psychoticism (adapted from Eysenck, 1992).

Evidence for this continuity approach was found using the method of criterion-analysis (Eysenck, 1952, 1992), where a criterion (psychosis-normality) is used to characterise a model which could either show continuity or discontinuity. By selecting a theoretical concept that postulates a significant difference between schizophrenics and healthy individuals and following the construction of a test of the concept in question (T) and provided the validity of the test, i.e., in its ability to differentiate the schizophrenics from the normal group, if a hypothesis of a P continuum is correct then P and T should correlate significantly within the normal group and possibly also within the psychotic group, notwithstanding the confounding factors outlined earlier. The proportionality of schizophrenia versus normal T scores should be found in within-group comparisons of high-P versus low-P scoring normals and high-P versus low-P scoring psychotics. Therefore, if the continuity approach is valid, then on a given test T, schizophrenics : normals = high P : low P. Evidence for the continuity theory of
psychoticism stems from diverse sources including the prevalence of hallucinations (e.g. Slade, 1976; Launay & Slade, 1981), eye-tracking dysfunction (e.g. Lipton et al., 1983; Iacono & Lykken, 1979), word association responses (e.g. Kent & Rosanoff, 1910; Ward & McConaghy, 1991) and defective inhibitory control (e.g. Baruch, Hemsley & Gray, 1988; Lubow et al., 1992).

4.1.2 Psychoticism and Creativity

Eysenck (1993, 1995) was the first to expound a model of creative thinking with reference to personality theory and postulated that ‘overinclusive thinking’, or thought processes that are characterised by a wider conception of relevance than conventional, is the cognitive style that forms the cornerstone of creative ability. In contrast to the more standard views of creativity where originality and relevance of ideas generated are viewed as two separable dimensions of creative thinking, Eysenck derived the concept of originality from the concept of relevance. The extent of unusualness of responses on a word association task best captures the workings of an overinclusive thinking style, where a broader conception of relevance would allow access to a larger sample of ideas than is customarily retrieved during the search process. The likelihood of producing unusual or novel ideas during such a generative task given an overinclusive thinking style is far greater than normal. Eysenck (1993, 1995) went on to postulate that this cognitive style is typical of individuals of a high psychoticism personality disposition type.

Several studies have equated greater degrees of creative ability with higher levels of psychoticism as indicated by performance on various measures of creative ability and divergent thinking (Merten & Fischer, 1999; Rawlings et al., 1998; Rawlings & Toogood, 1997; Stavridou & Furnham, 1996; Rawlings et al., 1995; Eysenck, 1994; Eysenck & Furnham, 1993; Merten; 1993; Woody & Claridge, 1977). While some mixed and contrary findings to this pattern of results have been brought to light (e.g. Kwiatkowski, Vartanian & Martindale, 1996; Kline & Cooper, 1986), on balance, the evidence argues in favour of an association between creative ability and psychoticism. Using the Wallach and Kogan (1965) divergent thinking tasks, Woody & Claridge (1977) were among the first to demonstrate that high psychoticism was strongly related to enhanced creativity. The same was found to be the case when using other divergent measures like the word association task where Merten (1993), for instance, found that individuals with high P-scale scores were far more likely to produce unique responses than those with low P-scale scores. Greater preference for complexity were also reported in high-P individuals in a music preference study by Rawlings
and his colleagues (1995) where high-P group displayed a stronger preference for more complex dissonant triad chords (augmented, diminished and atonal) over consonant triads (major and minor) relative to the low-P group.

Positive correlations between the incidence of psychoticism personality characteristics in highly creative populations like artists, scientists and musicians have also been reported (Booker, Fearn & Francis, 2001; Rushton; 1990; Wills, 1984 Götz & Götz, 1979a, 1979b). The Götz and Götz studies, for example, found that, in comparison to non-artists, visual artists obtained higher scores on the P-scale, and furthermore, that a greater degree of success within a sample of artists was associated with higher levels of psychoticism. Similar results were found in a large group of professional musicians, where Wills (1984) found that elevated levels of both psychoticism and neuroticism appeared to characterised the sample under study.

4.1.3 Psychoticism and Prefrontal Function

Psychoticism has also been associated with altered functioning on various prefrontal functions indicating a propensity for diffuse or less constrained top-down control as evidenced by reduced negative priming and subtle insufficiencies in sustained attention (Stavridou & Furnham, 1996; Obiols, García-Domingo, de Trinchería & Doménech, 1993). Stavridou and Furnham (1996), for instance, examined psychoticism in relation to both creative thinking and cognitive inhibition in a negative priming task and found that in addition to high-P scorers producing more unique responses on divergent thinking tasks in comparison to the low-P scorers, they also demonstrated reduced negative priming. The effect that task-irrelevant stimuli have on the processing of information can be tapped in a Stroop experimental paradigm with a manipulation for negative priming which, as mentioned earlier, refers to the typical slowness in responding when the to-be-attended information in a trial is the same as the to-be-ignored information on a previous trial. The negative priming effect was found to be diminished in the case of the high-P scorers relative to the low-P scorers.

Reduced negative priming can be explained in terms of differential top-down influence on information processing. The effect of top-down processes can be likened to the action of a spotlight. When trying to ignore a distractor, one’s focus is centred on the task at hand by keeping the task goals in mind. With diffuse, as opposed to regular, top-down influence, the spotlight of this focus is broader so as to include more irrelevant information. As a result, the distractor item is more easily accessed when it becomes the target item as it is not adequately inhibited and remains within the purview of one’s attentional stream.
More evidence in favour of altered prefrontal function in psychoticism, just as is seen in schizophrenia, comes from studies on the related construct of schizotypy. Schizotypy, which will be explored in detail in Chapter 5, is a more widely investigated construct within this domain. It also stems from a continuity approach of normalcy and psychosis but specifically represents the continuum of the schizophrenia spectrum of disorders, in contrast to the Eysenckian Einheitpsychose conception. Altered prefrontal or top-down function in high schizotypy groups has been reported in the form of reduced negative priming (e.g. Moritz, Mass & Junk, 1998), impairments on sustained attention tasks (e.g. Obiols et al., 1993), working memory (e.g. Park & McTigue, 1997) and disturbances in eye tracking in antisaccade tasks (e.g. O’Driscoll, Lenzenweger & Holzman, 1998).

4.1.4 Aims of the Study

Diffuse top-down control may similarly also support Eysenck’s conception of overinclusive thinking style, which is supposed to be characteristic of high psychoticism individuals. If the focus of the spotlight is narrow, the influence of expectation and prior activation are relatively concentrated on selected representations. In the case of atypical diffuse top-down control, the spotlight is broader so more loosely associated and more widely distributed representations are co-activated, although perhaps with less intensity. To take the example of the conceptual expansion task, the key to expanding a concept is to move beyond what is already known about its specific conceptual structures. As the influence of one’s knowledge and expectations would pose a hindrance to one’s ability to this perform this operation, diffuse top-down influence would be profitable to the process of conceptual expansion owing to the diminished influence of the usual restraining effect posed by one’s conceptual repertoire.

With regard to the creative imagery task, the originality component in this task, which measures how novel and unique the invented object is, would also be expected to benefit from broadened top-down processing in a similar manner as the conceptual expansion task. Although there is considerable pressure given the randomness of the task design in the assignment of figures and categories to create novel objects or inventions, the overriding tendency is to produce an invention that matches or is similar to familiar objects drawn from existing knowledge. Diminished top-down control should weaken this tendency to invent conventional objects and thus give rise to greater originality on such a task. The same would not hold true for the practicality component as it relates to the functionality or usefulness of the object which is a fundamentally different element within this task.
Similarly on the convergent thinking measures, while both psychoticism groups are expected to perform comparably on the incremental problems, greater levels of psychoticism are expected to be associated with better performance on insight problems as diffuse top-down control would facilitate the restructuring of the problem situation during solution finding. Although the converse could be expected of the incremental problems where reduced top-down influence would be detrimental as an inability to keep focused as a result of extremely loosened associational thinking would disrupt goal-directed stepwise analyses of a problem, psychoticism is expected to be accompanied by only mildly diffuse, as opposed to extremely reduced and therefore impaired, top-down processing which is less likely to severely disrupt performance on this type of task.

The present study addressed the issue of what specific types of creative cognitive processes relate to psychoticism and whether this fits within the mould of Eysenck’s view of creativity. By contrasting individuals based on the magnitude of psychoticism, greater levels of psychoticism was expected to be related to enhanced performance on insight convergent problems, greater conceptual expansion, and higher levels of originality on the creative imagery task.

### 4.2 Methods

**Participants**

This study was originally carried out on two separate populations – university students (n = 44) and schooled adults with no university training (n = 36). As the results from both populations were comparable on the conceptual expansion and creative imagery measures, the data from both samples were pooled. The comparisons on the insight and incremental convergent problems were only carried out on the non-university sample. The university sample were not tested on the convergent tasks as the university-trained sample were expected to have more highly developed analytical reasoning skills than those without and this would render both the university and non-university groups incomparable on these measures. All analyses and results presented from the convergent tasks were derived only from the non-university adult sample. A total of 80 individuals, 29 men (mean age: 31) and 51 women (mean age: 30) were thus recruited for this study and received payment for their participation.
**Sample Description, Materials and Procedure**

The participants were instructed to first complete the German version of the revised Eysenck Personality Questionnaire – Short Form (Eysenck & Eysenck, 1991; Ruch, 1999) and scores obtained on the Psychoticism Scale (P-scale) were taken as a measure of psychoticism. The sample was divided into 2 groups for the analyses using a median-split division. As the median P-scale score for the group was 3 (mean = 3.41), participants with a P-scale score of 0-3 formed the Low-Psychoticism or low-P group (n = 45) and participants with a P-scale score of 4 and above formed the High-Psychoticism or high-P group (n = 35).

To obtain an elementary measure of IQ, subjects were required to complete the Picture Completion task, which taps attention to fine detail, and the Similarities task, which provides a measure of concept formation, from the German WAIS-R (Dahl, 1986). Analyses using t-tests revealed no differences between the high-P and low-P groups on either of the WAIS-R sub-measures. Additionally, P-scale scores did not correlate significantly with either of these WAIS-R scales.

The experimental tasks used in the present study have been described in detail in the previous chapter: the Conceptual Expansion task, the Creative Imagery task, and the Insight and Incremental problems (refer to the Method section in Chapter 2). The whole array of tasks were administered within one session for all subjects. Each session began the completion of the WAIS-R subscales and the EPQ-R followed by the Conceptual Expansion task. The convergent problems were the next tasks to be undertaken and they were presented in the following order: Coin problem, Card problem, Water problem, Egg problem, Triangle problem, Trace problem, Tower of Hanoi problem, Candle problem. The Creative Imagery task was the final task in the experimental session. The scoring procedures of the tasks were also done in the same manner as in the previous study. The interrater correlations (Pearson’s correlation coefficient) on the Creative Imagery task measures were significant: Practicality Scale, +0.37 (p<0.001), and Originality Scale: +0.25 (p<0.001).

### 4.3 Results

Table 4.1 includes the mean and standard error of mean values across all experimental variables for both the psychoticism groups. Preliminary analyses were carried out at the outset
to gauge if any sex differences were present across the variables under study. Apart from a strong trend for women to score higher than males on the EPQ Neuroticism Scale, \( t(78) = -1.960, p < .054 \), a pattern consistent with previous research findings, there were no significant results. When contrasting the four scales of the EPQ-R, the psychoticism scale, the extraversion scale, the neuroticism scale and the lie scale (which taps the propensity to make socially desirable responses on the scale), a highly significant negative correlation was present between the Psychoticism Scale and the Lie Scale, revealing that lower the psychoticism score, higher the lie scale score (\( r = -0.342, p < .003 \)). As a check, all the analyses presented below were repeated after excluding participants with very high lie scale scores (excluding L > 6, remaining N = 74). As the results obtained were virtually the same as the ones outlined below, the values presented here are those obtained from the whole sample (n = 80).

**Table 4.1:** Descriptive Data for the low and high psychoticism groups across all the Experimental Variables in Study 3

<table>
<thead>
<tr>
<th></th>
<th>Low Psychoticism</th>
<th>High Psychoticism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std Error</td>
</tr>
<tr>
<td>WAIS - Picture Completion</td>
<td>109.7</td>
<td>1.278</td>
</tr>
<tr>
<td>WAIS - Similarities</td>
<td>113.4</td>
<td>0.92</td>
</tr>
<tr>
<td>Conceptual Expansion: Total</td>
<td>1.567</td>
<td>0.161</td>
</tr>
<tr>
<td>Conceptual Expansion-Asymmetry</td>
<td>0.200</td>
<td>0.043</td>
</tr>
<tr>
<td>Conceptual Expansion-Lack of appendages</td>
<td>0.322</td>
<td>0.051</td>
</tr>
<tr>
<td>Conceptual Expansion-Lack of sense organs</td>
<td>0.167</td>
<td>0.042</td>
</tr>
<tr>
<td>Conceptual Expansion-Unusual appendages</td>
<td>0.456</td>
<td>0.055</td>
</tr>
<tr>
<td>Conceptual Expansion-Unusual sense organs</td>
<td>0.422</td>
<td>0.057</td>
</tr>
<tr>
<td>Originality-Creative Imagery</td>
<td>2.524</td>
<td>0.071</td>
</tr>
<tr>
<td>Practicality-Creative Imagery</td>
<td>2.965</td>
<td>0.079</td>
</tr>
<tr>
<td>Total Solved: Insight problems (n=36)</td>
<td>1.762</td>
<td>0.300</td>
</tr>
<tr>
<td>Total Solved: Incremental problems (n=36)</td>
<td>2.143</td>
<td>0.221</td>
</tr>
<tr>
<td>Insight – Coin problem</td>
<td>0.571</td>
<td>0.111</td>
</tr>
<tr>
<td>Insight – Egg problem</td>
<td>0.429</td>
<td>0.111</td>
</tr>
<tr>
<td>Insight – Triangle problem</td>
<td>0.286</td>
<td>0.101</td>
</tr>
<tr>
<td>Insight – Candle problem</td>
<td>0.476</td>
<td>0.112</td>
</tr>
<tr>
<td>Incremental – Card problem</td>
<td>0.190</td>
<td>0.088</td>
</tr>
<tr>
<td>Incremental – Water problem</td>
<td>0.619</td>
<td>0.109</td>
</tr>
<tr>
<td>Incremental – Trace problem</td>
<td>0.619</td>
<td>0.109</td>
</tr>
<tr>
<td>Incremental – Tower of Hanoi problem</td>
<td>0.714</td>
<td>0.101</td>
</tr>
</tbody>
</table>
Using t-tests to contrast the performances of the low-P and high-P group, significant differences were found between the psychoticism groups on the conceptual expansion task such that the low-P group obtained significantly lower total expansion scores relative to the high-P group, $t(78) = -2.346$, $p < .022$. Figure 4.3 illustrates this significant difference between the groups on the total conceptual expansion score by contrasting the standard error of mean values of each group. In verifying whether these differences would be present in all the elements of the conceptual expansion score, analyses revealed highly significant differences between the low-P and high-P group on the following components - bilateral asymmetry, $t(78) = -2.942$, $p < .004$; lack of appendages, $t(78) = -2.699$, $p < .009$; and lack of sense organs, $t(78) = -2.650$, $p < .01$. The absence of significant differences on the unusual appendages, $t(78) = -0.335$, $p = .739$, and unusual sense organs measures, $t(78) = -0.075$, $p = .941$, may be due to the fact that it is considerably easier to expand the ‘animal’ concept as assessed in this study by replacing regular properties of Earth animals with unusual ones (for instance, wheels as an appendage instead of feet), rather than by excluding them entirely (for instance, absence of eyes or other visual apparatus).

**Figure 4.3:** The mean and standard error of mean values for the low and high psychoticism groups are contrasted on the total conceptual expansion score
When contrasting the low- and high-P groups on the two measures of the creative imagery task, the high-P group were found to surpass the low-P group on the originality-imagery measure, $t(78) = -1.993, p < .05$. No differences were found between the groups on the practicality-imagery score, $t(78) = -0.386, p = .70$. Figure 4.4 contrasts the differences between the psychoticism groups on the originality-imagery dimension of the creative imagery task. With regard to the convergent problem solving tasks, analyses of the performances of the low-P and high-P groups revealed no significant differences for the sum of correctly solved insight problems, $t(34) = -0.217, p = .83$ or for the sum of correctly solved incremental problems, $t(34) = -0.983, p = .33$.

**Figure 4.4:** The mean and standard error of mean values for the low and high psychoticism groups are contrasted on the originality-imagery score

The degree of interaction between psychoticism and these creative cognition variables were also analysed using a bivariate correlation analysis (Pearson’s correlation coefficient). A low but significant positive correlation was found between the total conceptual expansion score and psychoticism, $r = 0.285, p < .01$, suggesting that higher the psychoticism score, greater the conceptual expansion. A scatterplot showing this relationship is presented in Figure 4.5. While no significant relationship was found between psychoticism and the practicality-imagery measure, there was a strong trend to suggest a positive relationship between
psychoticism and the originality-imagery score, $r = 0.218$, $p < .052$. As a caveat it is important to note that given the small size of the correlation coefficient, there is a possibility that positive results were inflated due to the large number of computations. Bearing that in mind, the correlations need to interpreted cautiously.

Figure 4.4: A scatterplot demonstrating the significant positive correlation between the total expansion score and the psychoticism score

No significant correlation resulted between sum of solved insight or incremental problems and psychoticism. The correlations between the two imagery measures and the conceptual expansion score were non-significant although there was a trend for a positive correlation between the conceptual expansion score and the originality imagery score ($r = 0.192$, $p < .089$). There was a positive correlation between the sum of solved insight and the sum of solved incremental scores, $r = 0.342$, $p < .041$. The sum of solved insight problems was also found to have a significant positive correlation with the originality-imagery score, $r = 0.378$, $p < .023$, as well as the total conceptual expansion score, $r = 0.392$, $p < .018$. The sum of solved incremental problems also correlated significantly with total conceptual expansion score, $r = 0.473$, $p < .004$.

Interestingly, the creative imagery variables were found to also correlate highly with the two IQ subscale variables from the WAIS-R. Significant positive correlations were found between
the originality-imagery score and both the WAIS-Picture completion measure ($r = 0.372, p < 0.001$) and the WAIS-Similarities measure ($r = 0.224, p < 0.046$). The practicality-imagery score correlated significantly only with the WAIS-Picture Completion measure ($r = 0.263, p < 0.018$). However, no significant correlations were found between WAIS measures and the total conceptual expansion score. With regard to convergent problem solving, there was a significant correlation between both WAIS measures and insight problem solving: WAIS-Picture completion measure ($r = 0.583, p < 0.0001$) and the WAIS-Similarities measure ($r = 0.469, p < 0.004$), but not with incremental problem solving.

4.4 Discussion

The present study contrasted healthy individuals who differed from one another in the level of psychoticism traits on three tasks of creative cognition: conceptual expansion, creative imagery and convergent (insight and incremental) problem solving with the premise that the high psychoticism individuals would surpass their low psychoticism counterparts on the variables in which overinclusive thinking would grant an advantage. The results obtained were mostly confirmatory of these predictions. With regard to convergent insight and incremental problem solving, it was predicted that the high psychoticism group would perform better than the low psychoticism group on the insight problems but that the groups would perform comparably on the incremental problems. The psychoticism groups were, however, found to not differ significantly on either convergent problem type indicating that the groups were not differentiable on convergent problem solving. This is in line with some early evidence where no significant relationship was found between convergent thinking abilities, as assessed by the Nufferno tests of inductive reasoning, and the degree of psychoticism (Woody & Claridge, 1977).

4.4.1 Findings: Conceptual Expansion and Creative Imagery

On the conceptual expansion task, in line with predictions, the high psychoticism group was better able to generate animals that are not prototypically similar to familiar animals. This was accomplished by altering fundamental features or elements of the ‘animal’ concept like creating bilaterally asymmetrical forms and excluding limbs and sensory organs typical of most Earth animals. Likewise, on the creative imagery task, the high psychoticism group was found to surpass the low psychoticism group in the ability to generate inventions that are
original, unique or uncommon in an explicitly generative situation that requires a high level of abstract imagery. Both groups were not significantly different from one another with regard to the practicality dimension of the creative imagery task, however, as they generated inventions that were comparable insofar as they were functional and utilizable.

The positive correlation between psychoticism and both creative imagery and conceptual expansion tasks along with the trend for a positive correlation between performance on the conceptual expansion task and scores on the originality dimension of the imagery task appear to indicate that there is an underlying commonality between the two processes in that they both tap the tendency to produce original, unusual or statistically low responses. However, the fact that the trend for a correlation is relatively low may also be suggestive of the inherent differences between the two creative cognitive processes with regard to their intrinsic complexities as they both tap originality yet necessitate differential levels of abstraction during execution. The imagery task lays more restrictions on the creative process as both the elements and the purpose of the creative invention are predefined by the experimenter. Solving the imagery task therefore requires more goal-directed thinking relative to the conceptual expansion task where subjects are allowed substantially greater mental liberty during the execution of the task.

The relationship between performance on the conceptual expansion task and the creative imagery task relative to the two WAIS IQ subscales, the picture completion task and the similarities task, seems to bolster this argument. While performance on the conceptual expansion task did not correlate with performance either of these IQ subscales, the contrary was true of the imagery task. Performance on both WAIS subscales correlated highly with performance on the originality and practicality components of the creative imagery task. This may be indicative of the intrinsic complexity of creative imagery task where vividness of mental imagery and imagination are tapped and the level of intellectual abilities may be vital in terms of the degree to which this ability can operate.

In line with Eysenck’s theory of overinclusive thinking in creativity then, the results indicate that the capacity to produce original or unusual on some creative cognition tasks appears to be enhanced as a function of psychoticism. This is directly supportive of Eysenck’s notion of overinclusive thinking as a fundamental cognitive style in high psychoticism individuals as originality in these processes of conceptual expansion and originality in creative imagery would derive from a wider conception of relevance. The increased capacity to restructure
problem situations so that insightful solutions can be reached more effortlessly, does not, however, seem to be facilitated by psychoticism.

4.4.2 Diffuse Top-down Control and Defocused Attention

These results are also in line with existing literature that link greater levels of psychoticism with enhanced creative ability or divergent thinking (e.g. Merten & Fischer, 1999; Rawlings et al., 1998; Eysenck, 1994; Woody & Claridge, 1997; Götz & Götz, 1979a, 1979b). With regard to psychoticism traits, the EPQ psychoticism scale was developed to measure, among other things, nonconformist tendencies (Eysenck & Eysenck, 1976), which are highly relevant in the ability to be creative as it allows for a greater degree of intellectual flexibility and fluency to ideas. There is experimental evidence to indicate that creativity is positive correlated with preference for novelty (Houston & Mednick, 1963) and with a need for stimulation (Farley, 1985). These related traits in the capacity to develop novel, unusual and original ideas, have also been found to be positively correlated with psychoticism as assessed by novelty-seeking and impulsivity scales (e.g. Zuckerman et al., 1993). The present findings were predicted in light of diffuse top-down control and its effects on differing aspects of cognition in high psychoticism individuals. Diffuse top-down control would aid performance on the conceptual expansion task and the originality measure of the creative imagery task given that a less concentrated yet broader influence of one’s knowledge and expectations would allow for a wider conception of relevance and, consequently, the ability to generate more original responses.

As described in the previous study, impairments at the level of top-down control in schizophrenia, as shown in studies by Silverstein and his colleagues (1996a,1998) in the inability of schizophrenics to use top-down factors in differentiating relevant from irrelevant factors and when processing unstructured stimuli, have been proposed to underlie the wide executive impairments associated with the disorder. However, in the case of high psychoticism or schizotypy functional individuals, it is unlikely that they would manifest outright top-down deficits but would instead reveal only semblances of this defective processing in the form of diffuse top-down control. Evidence for the same has been found across a range of top-down tasks, mainly with reference to schizotypy, including reduced negative priming (Stavridou & Furnham, 1996), subtle insufficiencies in sustained attention (Obiols et al., 1993) reduced working memory (e.g. Park & McTigue, 1997) and disturbances in eye tracking on anti-saccade tasks (e.g. O’Driscoll et al., 1998).
Enhanced creative ability has for long been equated with fundamental differences at the level of information processing. Martindale (1989, 1999) developed his model of defocused attention in relation to creative ability on the basis of three early theories of creativity. Kris (1952), for instance, proposed that greater levels of creativity are a result of being able to effortlessly vacillate between states of primary process cognition and secondary process cognition. The former refers to thought processes that are characteristically free-associative, analogical, concrete and autistic which occur in normal states, such as fantasy and reverie, but can also arise during abnormal states, as in some forms of psychosis. Secondary process cognition, on the other hand, reflects the abstract and logical thought processes that are grounded in conscious reality. The ability to be creative within this formulation calls for a “regression” to primary process cognition states where wider associative thinking allows for the novel combinations of elements.

In arguing that individual differences in the how attention is focused underlies differences in creative ability, Mendelsohn (1976) highlighted the role of defocused attention or widened attentional capacity. The principle of this argument is that to arrive at a creative idea, the elements need to be combined within the focus of attention. The greater the number of elements present in one’s attentional stream, the greater the number of resulting combinations. For instance, if one is able to only attend to two elements at the same time only one combination would arise, but if one is able to attend to four elements at the same time, six permutations would be possible.

By relating the types of combinations or associations between elements to creativity, Mednick (1962) theorised that creative people are characterised by flat associative hierarchies. Ideas are associated to one another and the level to which a certain mental representation activates another reflects the remoteness of the representations, which varies widely from individual to individual. The word ‘table’, for example, would strongly activate the associate representation ‘chair’, less strongly activate associate representation ‘dinner’ and would only rarely activate the associate representation ‘multiplication’. Within the framework, a less creative person is believed to have a steep associative hierarchy such that a stimulus activates only closely associated representations. A highly creative person, in contrast, has a flat associative hierarchy such that they have access to more remote associations or representations.

All of these theories, although couched in different terminology, express very similar views. Defocused attention is a property of primary process cognition and both defocused attention
and flat associative hierarchies address the same phenomenon from cognitive and behavioural perspectives (Martindale, 1999). Evidence for all three theories accordingly stem from similar tasks that reflect widening of attention and access to more remote associates or the novel combination of mental elements. More remote associations on a word association task, unusual patterns of classification on object sorting tasks, and less narrowly focused attention during dichotic listening paradigms, have been reported across highly creative populations, patients with schizophrenia, and healthy individuals with high psychoticism or schizotypy personality traits (e.g. Dykes & McGhie, 1976; Rawlings & Claridge, 1984; Merten, 1993; Eysenck, 1995; Rawlings & Toogood, 1997).

4.4.3 Biological Underpinnings of Defocused Attention
Martindale (1999) took this further by conducting investigations aimed at identifying the biological correlates of such defocused attention. One candidate marker is that of cortical arousal. Arousal is reflected in terms of a continuum ranging from the state of sleep to that of alert wakefulness and through to emotional tension. Learning and performance are related to arousal in an inverted U-shaped manner such that too much or too little arousal creates inadequate conditions for optimal performance (Hebb, 1955).

On the premise that a state of defocused attention would be produced by lower levels of cortical activation, Martindale and Hines (1975) found that patterns of cortical arousal during the creative process appears to relate differentially to creative ability. Measuring cortical EEG alpha-wave activity, which provides an inverse index of cortical arousal, they found that medium and low creative groups showed no differences in cortical arousal while taking the remote associates test, the alternate uses task and an intelligence test. The high creative group, on the other hand, showed high levels of activation while taking the intelligence test but low levels of activation on the alternate uses test and slightly higher levels of arousal during the remote associates test, a task that is an index for both creativity and intelligence. In addition, the high creative group showed lower levels of arousal during the alternate uses task than during baseline recording.

The high activation on part of the less creative groups were hypothesised to arise due to their tendency to focus their attention too much which in turn prevented them from generating original ideas. This claim was put to test in a later study where EEG activity was recorded while participants thought about a story they would write and while writing the story. In line with predictions, the highly creative subjects exhibited lower level of cortical activation.
during the phase of idea generation relative to less creative subjects but there were no differences between the groups during the elaboration of ideas in the writing phase (Martindale & Hasenfus, 1978).

4.4.4 Arousal and Divergent Thinking

How the brain is activated during convergent and divergent thinking relative to states of mental relaxation as reflected in EEG activity was investigated in a recent study (Mölle et al., 1999). The divergent thinking tasks employed within this study were adapted from the Wallach and Kogan (1965) and Guilford (1967) divergent thinking measures. The comparison convergent thinking tasks necessitated the use of logical operations and mental arithmetic. The dimensional complexity of the EEG was found to be far greater during divergent thinking than during convergent thinking. In Hebbian terms, this pattern could be comprehended in terms of a higher number of simultaneously activated cell assemblies during divergent thinking when compared to convergent thinking. In a similar vein, greater EEG dimensional complexity was also found in states of mental relaxation, where thinking is characterised by the imposition of minimal demands and, consequently, a free flow of thoughts. These results suggest that a loosening of attentional control over thought processes are characteristic of states of mental relaxation and those associated with overinclusive and divergent thinking. Furthermore, subjects with better performance scores on the divergent measures exhibited lower EEG dimensional complexity, particularly over the frontal areas in comparison to participants who obtained lower scores.

Somewhat counter-intuitively however, the same study found that high performers on the divergent thinking tasks showed low levels of EEG dimensional complexity relative to the low performers, and this was especially so over frontal sites. This was interpreted at reflecting some degree of attentional control over free-associative thought processes as subjects were required to generate ideas during a period of 40 seconds and only after this period had elapsed were they allowed to write out their ideas. It is possible that the generation of novel ideas is represented in the form of increased activation or dimensional complexity, but that the appropriate selection and evaluation of the generated ideas could be employed to explain the lessened activation on part of the high performance subjects. Although these are post-hoc arguments, these findings serve to indicate that although a general picture can be attained from assessing the patterns of EEG activity, at the level of individual differences, various subtleties in differential activation can impede the derivation of unambiguous conclusions.
As yet, no study has directly addressed the issue of cortical activation during conditions of creative idea generation as a function of psychoticism. Eysenck postulated that high psychoticism individuals would be characterised by a lack of modulation of arousal for via dysregulation of mechanisms that maintain central nervous system homeostasis (Beh & Harrod, 1998). In line with these views (Eysenck, 1995), if creativity is related to psychoticism, it should be expected that there should be greater fluctuations in the level of physiological arousal in highly creative people. This idea has received some limited support as reflected in the previously presented study of Martindale and Hasenfus (1978) where greater levels of creativity were associated with greater variability in EEG alpha amplitude. In addition, highly creative people have been found to exhibit greater variability in galvanic skin responses and greater heart rate fluctuations (see Martindale, 1999).

4.4.5 Lateralization and Divergent Thinking

Another postulated marker for enhanced creativity ability is right-hemisphere dominated cortical activity. It is widely supposed that creativity is associated with the differential activation of the right and left hemispheres of the brain. Based on the findings that verbal, sequential and analytical processes are orchestrated via the left hemisphere while global, parallel and holistic processing is regulated by the right hemisphere, a number of theorists have argued for the critical role of the right hemisphere in creative thinking. The capacity to arrive at more remote semantic associations is thus hypothesised to depend on greater right hemisphere processing. An early study by Dimond and Beumont (1974), for example, demonstrated that words presented in the left visual field of participants elicited more unusual word associations than when words were presented in the right visual field. In a comparison of student artists with a group of subjects who were artistically untrained, the student artists were found to show greater right hemisphere activity during a drawing task, where the participants were required to draw a cow vertebra, but not on a control task, which involved reading an article about economics (Martindale et al., 1984).

Given that the strengthening of right hemisphere processing is associated with greater associative thinking, decreased left hemisphere dominance for language production should be associated with greater creative ability. There is evidence to suggest the same as demonstrated in a study by Poreh and his colleagues (1993-1994), where lower laterality index scores, indicating reduced left hemisphere advantage, positively correlated with performance on a verbal creativity test. Moreover, two recent studies have related reduced laterality to both high levels of creative thinking and a greater degree of schizotypy traits (Weinstein & Graves,
Responses on Remote Associates Test were positively correlated with reduced lateralization on a lexical decision task while higher right hemisphere localization sensitivity was associated with greater levels of creativity on the Thurstone Written Fluency Test. These measures in turn positively correlated with responses obtained on a schizotypy scale. It thus appears that individual differences in creativity and schizotypy are partly related to a response criterion that is notably sensitive to right hemisphere processing (Weinstein & Graves, 2002).

4.4.6 Psychoticism: An Adequate Approach?

The present study is limited in that only the construct of Psychoticism in the sense of Eysenck’s model was examined as a crucial personality variable in facilitating certain facets of creative cognition. However, not all researchers are in agreement about the adequacy of the psychoticism construct in representing the personality dimension that underlies the continuum between normality and psychosis and many instead favour the Schizotypy construct as being closer to schizophrenia. Given the heterogeneity of schizophrenia though, it is possible that no single construct is sufficient to represent it at the level of normal traits especially with regard to interaction of different traits with performance on the various measures.

A recent study, for instance, investigated perceptual grouping and segregation effects in schizotypy as a function of top-down processes using the Hidden Figures test (Tsakanikos & Reed, 2003). The objective of this test, which is considered a measure of frontal neuropsychological function (Della Salla et al., 1998), is to detect which of the five simple figures provided is embedded in each of the thirty-two complex figures of the task. Like schizophrenics who have been shown to display impaired performance on the hidden figures test, Tsakanikos and Reed (2003) found that poor performance on the test was negatively associated to the Introvertive Anhedonia subscale which represents negative schizotypy. This finding was held to be associated with frontal hypofunction that is typically associated with negative symptoms in schizophrenia and working memory deficits, as the simple figures needs to be actively maintained in order to match it with patterns that may appear while scanning the complex ground. However, a positive correlation between performance on this task and the impulsive nonconformity schizotypy subscale which largely corresponds to the construct of psychoticism was also found. Rapid attentional shifts as a function of impulsivity was used to account for this finding, as reflected in the allocation of attention across visual search paradigms (Dickman, 2000). Different facets of schizotypy then, like the symptom clusters of schizophrenia, are also dissociable in terms of subtleties in prefrontal function.
To obtain a more comprehensive representation of creative cognition within the dimensional normality-psychosis approach, the next study is thus targeted at investigated the dimension of schizotypy and its role as both a separable and a related personality construct to psychoticism with regard to creative cognition and frontal lobe function.
5.1 Introduction

A related construct to psychoticism within the continuity approach of viewing psychosis and normality, is that of schizotypy. While psychoticism stems from an unitary psychoses or Einheitpsychose conception of mental illness, schizotypy specifically relates to the schizophrenia spectrum of disorders: the schizophrenia subtypes at the level of psychosis and schizotypal, paranoid, and schizoid personality disorders at the level of less severe forms of psychopathology.

5.1.1 Schizotypy: The Construct

The concept of schizotypy was first introduced by the psychoanalyst Rado (1953) with the term ‘schizotype’ which referred to ‘schizophrenic genotype’ or the hereditary predisposition to develop schizophrenia. Meehl (1962, 1990) furthered these ideas in proposing the terms ‘schizotaxxia’, to denote the genotype for schizophrenia, and ‘schizotypy’ to describe its phenotype as indicated by four behavioural characteristics including interpersonal...
aversiveness, anhedonia, ambivalence, and cognitive slippage, which relates to thought disorder. Schizotypy is thus defined and identified by non-dysfunctional personality features that correspond to attenuated forms of psychotic symptoms typical of schizophrenia. Most investigations of the continuity or dimensionality of schizophrenic psychoses derives from this concept of schizotypy.

A wide variety of scales have been devised to measure schizotypy ranging from recent scales like the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) and the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE; Mason, Claridge & Jackson, 1995) to the more established scales like Schizotypal Personality Scale (STA; Claridge & Broks, 1984) and the Chapman Scales (for a review, see Chapman, Chapman & Kwapil, 1995). The classification of what symptoms make up the components of schizotypy differs somewhat from author to author. A range of factor analytic studies using principal components analysis have been carried out (for a review, see Claridge & Beech, 1995) and four factors appear most consistently (Claridge et al., 1996). The first factor of schizotypy is that of Unusual Experiences and it corresponds to the positive symptoms of schizophrenia as it includes traits of perceptual aberration, magical thinking, delusional beliefs, and a disposition to experience hallucinations. The second factor of Introvertive Anhedonia corresponds to the negative symptoms of schizophrenia and includes the traits of physical anhedonia, social anhedonia, introversion and conforming behaviour. The third factor is that of Cognitive Disorganization and chiefly involves the traits of attentional dysfunction and distractibility, neuroticism, and introversion, which is related to thought disorder in schizophrenia. The last and more marginal factor is that of Impulsive Nonconformity which relates to Eysenck’s psychoticism dimension, hypomanic personality and extraversion. While some evidence has shown that schizotypy relates to some aspects of the genetic basis for the predisposition to schizophrenia (Ingraham, 1995), which components of schizotypy are specifically implicated is as yet unclear although the prevalent view is that the positive symptom factors are the best predictors of psychosis-proneness.

5.1.2 Schizotypal Function: Parallels with Schizophrenic and Prefrontal Function

Evidence for the dimensionality of schizotypy with schizophrenia stems from a variety of sources. Chief among these is that from negative priming studies of attentional control which has been introduced in previous chapters. Healthy individuals with high schizotypy traits have been found to show reduced cognitive inhibition on negative priming tasks (e.g. Beech & Claridge, 1987; Beech et al., 1989b), as do patients with schizophrenia (e.g. Beech et al.,
Additionally, reduced negative priming is mainly associated with positive schizotypal traits (Peters, Pickering & Hemsley, 1994) while negative schizotypal traits have been linked to increased negative priming (Williams, 1995). Some studies have, however, reported mixed or conflicting findings (e.g. Green & Williams, 1999; Wuthrich & Bates, 2001), but the evidence on balance argues in favour of the association between reduced cognitive inhibition and schizotypy.

Further support for this idea comes from studies on the related concept of latent inhibition. Latent inhibition refers to the slowness in forming an association to a previously presented unreinforced stimulus. This tardiness in learning results as the initial inhibition of the unreinforced stimulus interferes with the subsequent excitatory conditioning. Like acute schizophrenics who failed to display latent inhibition (e.g. Baruch Hemsley & Gray, 1988), reduced latent inhibition is also associated with both high schizotypy and high psychoticism in healthy individuals (e.g. Lubow et al., 1992).

Still more evidence argues in favour of altered prefrontal functioning in schizotypy just as in the case of schizophrenia. Diminished top-down executive function in high schizotypy groups has been reported in terms of impairments on tasks measuring working memory (e.g. Park & McTigue, 1997), executive function (e.g. Lenzenweger & Korfine, 1994), sustained attention (e.g. Obiols et al., 1993), Stroop inhibitory control (Moritz et al., 1999), and eye tracking in anti-saccade tasks (e.g. O’Driscoll, Lenzenweger & Holzman, 1998). Analyses on specific schizotypy symptoms have revealed differentiable performance even within schizotypy. Moritz and his colleagues (1999) for instance, found that increased interference on a Stroop task was related to the disorganisation (thought disorder) factor from Raine’s Schizotypal Personality Questionnaire (SPQ).

With regard to working memory, the positive schizotypy symptom of Perceptual Aberration, while unrelated to auditory working memory performance (Lenzenweger & Gold, 2000), was associated with significantly more errors on a visuospatial working memory task (Holzman et al., 1995). Similar findings were obtained on the WCST, where high schizotypes on the Perceptual Aberration Scale relative to low schizotypes revealed a failure to maintain set and displayed more perseverative errors on the WCST (Lenzenweger & Korfine, 1994; Gooding, Kwapiil & Tallent, 1999) and a greater number of eye tracking errors on an anti-saccade task (Holzman et al., 1997). A recent study, that was introduced in the previous chapter, investigated schizotypy as a function of reduced top-down processing using the Hidden
Figures test, where the ability to segregate a simple figure that is embedded in a complex visual ground is assessed (Tsakanikos & Reed, 2003). It was found that poor performance on the test was negatively associated with negative schizotypy or Introvertive Anhedonia.

Although the bulk of the evidence suggests a high degree of resemblance between patterns of neuropsychological function in schizotypy and schizophrenia, the correspondence between the findings is not entirely one-to-one. Reduced proficiency in performance across frontal measure have been associated with positive, negative and disorganised symptoms in schizotypy, whereas in the case of schizophrenia frontal deficits are prominently associated with negative and disorganised symptoms but not positive symptoms. This is primarily because a large bulk of the studies on schizotypal functioning differentiates healthy samples on the basis of only one schizotypy symptom subtype, like magical ideation or perceptual aberration, which considerably limits the capacity to draw wide conclusions for the whole schizotypy construct and its implications with regard to schizophrenia function.

Nevertheless the general pattern that emerges from the wide variety of studies seems to vouch for the prevalent view that positive and negative schizotypy represent discrete factors. A recent study that employed a large student sample, for instance, revealed that negative schizotypy was associated with subtle deficits in prefrontal executive functions whereas positive schizotypy was associated with temperolimbic deficits, antisocial tendencies and impulsivity (Dinn et al., 2002). These findings have also been extended to the field of creativity where the cumulative evidence suggests that positive schizotypy is associated with enhanced creative ability and its markers (Fisher et al., 2003).

### 5.1.3 Schizotypy and Creativity

In comparison to the literature on psychoticism and creativity, evidence directly in favour of a relationship between schizotypy and creativity is scant, primarily because it has been the focus of far fewer studies. In addition, the use of a wide variety of schizotypy scales in research renders it difficult to make clear generalisations. A variety of studies have found a positive correlation between creative ability and schizotypy (e.g. Zanes et al., 1998; Cox & Leon, 1999; Green & Williams, 1999; Mohr et al., 2001; Schuldberg, 2001), but the implications of the findings in terms of symptomatology is mixed. One study has shown support for an association between negative schizotypy traits, particularly social anhedonia, and greater creative potential (Cox & Leon, 1999). However, most of the evidence is in favour of an association between positive schizotypy traits and creativity. Green and Williams
(1999), for instance, found a positive correlation between responses on the STA and divergent thinking measures. Loosely associated words were judged as being more closely related in a high magical ideation group relative to a low magical ideation group (Mohr et al., 2001). Using a range of creativity tasks, Schuldberg (2001) found that along with impulsivity-nonconformity and hypomanic traits, positive schizotypy traits, like perceptual aberration and magical ideation, were strongly correlated with creative ability.

5.1.4 Aims of the Study

As psychoticism and schizotypy are both dimensional constructs of psychoses, performances between high and low schizotypy groups should be comparable to that of the high and low psychoticism groups, as described in Chapter 4. This is especially so as diffuse or mildly diminished prefrontal top-down executive control has been strongly associated with greater levels of schizotypy. Given this, just as in the case of psychoticism in Study 3, the performance of a high schizotypy group is expected to be better than that of a low schizotypy group on the conceptual expansion task and on the originality component of the creative imagery task. This could be explained with reference diffuse top-down control and the Eysenckian conception of an overinclusive thinking style.

Although the results on the psychoticism sample with regard to the convergent problem solving measures were inconclusive, greater levels of schizotypy are expected to be associated with better performance on insight problems given the stronger links between schizotypy and evidence of diffuse top-down control, which should in turn facilitate the restructuring of the problem situation during solution finding. No differences between the groups are expected on the incremental problems as although diffuse top-down influence is likely to be disadvantageous as loosened associational thinking would disrupt goal-directed stepwise analyses of a problem, in the case of healthy individuals who differ in their traits of schizotypy, this diffuse top-down control is not predicted to be dysfunctional so as to be detrimental to problem solving.

Two other measures of creative cognition were used in this sample including the recently activated knowledge task and the alternate uses task. Following the same rationale as in the case of the previous tasks, the high schizotypy group is expected to be less constrained by the previously presented examples in comparison to the low schizotypy group while generating ideas for toys on the recently activated knowledge task owing to more diffuse top-down control, the consequent lack of constraints imposed by one’s conceptual repertoire, and
loosened associational thinking. In a similar vein, the high schizotypy group is expected to produce more unique responses on the alternate uses task in line with previous findings, whereas no differences between the groups are expected to result on the fluency measure of the alternate uses task.

A range of frontal tasks have also been assessed in this study to gauge how differential performance in schizotypy groups on tests of frontal neuropsychological function relate to creative cognition. Among the tasks used were three working memory measures which included the numerical or digit span, spatial span or Corsi block tapping test and the n-back task. The modified WCST was used to provide a measure of adequacies in set-shifting. The Stroop colour/word task, with a manipulation for negative priming, was utilised to gauge inhibitory control. The high schizotypy group relative to the low schizotypy group was predicted to show poorer performance on the working memory tasks, reduced negative priming on the Stroop task and increased number of errors on the WCST. No differences were expected between the groups on the interference condition of the Stroop task.

5.2 Methods

Sample Description, Materials and Procedure
The German version of the Schizotypal Personality Questionnaire (SPQ; Raine, 1991; Klein, Andresen & Jahn, 1997) was distributed to 170 psychology graduate students. Out of the 160 people who completed questionnaire, 40 individuals – 20 high schizotypy and 20 low schizotypy – were invited to participate in the study. The final sample consisted of 31 individuals comprising of 17 women and 14 men (mean age 24.19), of which 15 formed the low schizotypy or low-ST group (SPQ total score range: 0-8, Mean: 4.73) and 16 formed the high schizotypy or high-ST group (SPQ total score range : 32-51, Mean: 40.13). Analyses were carried out both at the general level of schizotypy (SPQ total score) and the more specific level of subscales. The SPQ (SPQ total score range 0-67) includes 9 subscales which are combined to form three factor scores. The Cognitive-Perceptual factor (Cog-Per, range 0-31) corresponds to the positive schizotypal dimension and includes scores combined from the following four SPQ subscales: ideas of reference, magical thinking or odd beliefs, unusual perceptual experiences and paranoid ideation. The sample was differentiated into low Cog-Per
(n=15, range 0-5, Mean: 1.87) and high Cog-Per (n=16, range 9-27; Mean: 18.69) groups for the assessment of positive schizotypy.

The Interpersonal factor (Intpn, range 0-32) corresponds to the negative schizotypal dimension and includes scores combined from the following four SPQ subscales: social anxiety, no close friends, constricted affect and paranoid ideation. The sample was differentiated into low Intpn (n=16, range 0-4, Mean: 1.81) and high Intpn (n=15, range 5-21; Mean: 13.87) groups for the assessment of negative schizotypy. As the sample was not as strongly differentiated on the Intpn factor as on the Cog-Per factor, the median scorers in the sample were omitted causing the sample to be differentiated anew into low Intpn (n=13, range 0-3, Mean: 1.31) and high Intpn (n=12, range 8-21; Mean: 15.83) groups for the assessment of negative schizotypy.

The last factor is the Disorganized factor (Disorg, range 0-16) which corresponds to the thought disorder dimension in schizophrenia and includes scores combined from two SPQ subscales: odd behavior and odd speech. The sample was differentiated into low Disorg (n=16, range 0-4, Mean: 1.63) and high Disorg (n=15, range 5-16; Mean: 11.93) groups for the assessment of schizotypal disorganisation. As the sample was not strongly differentiated on the Disorg factor compared to the Cog-Per factor, the median scorers in the sample were omitted causing the sample to be differentiated anew into low Disorg (n=13, range 0-3, Mean: 1.08) and high Disorg (n=14, range 8-16; Mean: 12.43) groups for the assessment of schizotypal disorganisation.

The creative cognition tasks used in the present study have been described in detail in previous chapters: the Conceptual Expansion task (refer to the Methods section in Chapter 2), and the Insight and Incremental problems (all except for the Tower of Hanoi and the Candle problem, refer to the Methods section in Chapter 2), the Creative Imagery task, Alternate Uses task and the Recently Activated Knowledge task (refer to the Methods section in Chapter 3). The following tasks were employed to tap frontal function in this study.

**Digit Span.** The digits forward and digits backward tasks of the digit span (from the HAWIE-R, Tewes, 1994) were used to assess numerical span and verbal working memory respectively. The participants were required to repeat a sequence of digits in the order called aloud by the experimenter in the digits forward task (verbal span), and in reverse order in the digits backward task (verbal working memory). A subject’s digit span in both cases is defined
as the maximum sequence length at which a correct response was produced in at least one out of two trials.

**Spatial Span.** Two parts of the block-tapping task (Milner, 1971; from the HAWIE-R, Tewes, 1994) were used to assess spatial working memory and visual-spatial memory span. Subjects are presented with a board comprising of eight 1-inch cubes or blocks that are fastened in a random order to the surface of the board. By tapping the top surfaces of the blocks, the experimenter makes a tapping sequence. These sequences increase in complexity over time and the subject is required to reproduce these sequences. A subject’s spatial span is defined as the maximum sequence length where a correct response was produced in at least one out of two trials. Spatial working memory was measured on the same basis except that on the backward spatial span trials where the subject was required to repeat the tapped sequence backwards.

**n-back task.** This task was administered using a PC (AMD XP 1600, 256 MB RAM, 40 GB hard dirk) with a 17-inch colour monitor and was an independently written program (by Andre Meiske). The subjects were seated approximately 50 cm from the screen. The stimuli and fixation cross were presented in white *Arial Standard* font and 65-font size in the centre of a black screen. Subjects were presented a series of single consonants one at a time on the screen and the task comprised of two conditions: 1-back and 2-back. On the 1-back condition, subjects were required to press a space bar on a keyboard as fast as possible when the letter presented on a trial (n) matched the letter presented on the previous trial (n-1). On the 2-back condition, subjects were required to respond as fast as possible when letter presented on a trial (n) matched the letter presented 2 trials before (n-2). Each trial commenced with a fixation cross (+) which was presented for 1000ms followed by a stimulus (e.g. the consonant ‘B’) which was presented for 2500 ms. The stimulus disappeared from the screen either after the presentation time had elapsed or with a key press by the subject. The variables under study in this task included the mean reaction time and the mean number of correctly detected targets in each condition.

**WCST.** The computerised modified Wisconsin Card Sorting test (Nelson, 1976) was employed. A series of cards comprising of a different forms of varying amounts and colours are presented on a screen which has to be sorted into one of three piles in accordance with three sorting rules (colour, number or form). The subject is not informed of the rules beforehand and is required to work out what the rule is. After each sorting, the subject is given automatic feedback about whether the sorting was correct. Once a correct sorting rules
has been found (six consecutive correct sorts) the subject is required to change to a different sorting rule that must again be identified by the subject. Three measures can be obtained from this task: the number of sort shifts or categories attained, the number of errors and the number of perseveratory errors that occur when the subject continues to sort according to a previously correct rule or to a rule that was indicated to be wrong in the immediately preceding trial.

**Stroop Colour-Word Interference Task with Negative Priming manipulation.** In this adaptation of the Stroop (1935) task (based on Salo et al., 2002), the stimuli comprised of four colour words and their corresponding ink colours: red, blue, green and yellow. There were 25 practice trials and 288 test trials in total which including 72 trials per condition. The trials were split into 4 blocks of 72 trials with 18 trials per condition in each block. The subject’s task across all conditions was to identify the ink colour of the stimulus presented as fast as possible. In the Control condition, neutral stimuli in the form of a string of Xs (XXXX) were presented in one of the four ink colours. The stimuli in the Congruent condition were colour words in the matching ink colour print (e.g. the word ‘RED’ in the ink colour ‘red’) whereas in the Incongruent condition, the stimuli included colour words written in an incongruent ink colour (e.g. the word ‘RED’ ink the ink colour ‘blue’). In the Negative Priming condition, the ink colour on target trial (n) is same as the colour word on the previous trial (n-1) which is a prime trial. For example, in trial (n-1) the prime ‘RED’ written in the ink colour ‘blue’ is followed by trial (n) where the target ‘GREEN’ is written in the ink colour ‘red’). Each trial was presented one-by-one with the a new trial appearing soon after the subject’s response to the previous trial. The variables under study in this task included the mean reaction time (RT) across each condition, mean interference RT (incongruent minus neutral) and mean negative priming (RT to target in the negative priming condition minus the RT to the negative prime). The subject had to respond to the stimuli by pressing the appropriate response key on a keyboard that corresponded to that particular colour. The button presses for each colour were varied randomly across subjects. This task was administered using a PC (AMD XP 1600, 256 MB RAM, 40 GB hard dirk) with a 17 inch colour monitor and was an independently written program (by Andre Meiske). The subjects were seated approximately 50 cm from the screen.

The whole array of tasks were administered across two sessions. In the first session, the order of the tasks was as follows: the n-back task, the conceptual expansion task, the spatial span task, the convergent problems: coin problem, card problem, water problem, egg problem, triangle problem, trace problem, the Stroop task. The order of tasks during the second session was as follows: the WCST, the recently activated knowledge task, the digit span task and the
creative imagery task. The scoring procedures of the tasks were the same as in the previous studies. The interrater correlation (Pearson’s correlation coefficient) on the creative imagery task measures were significant: Practicality Scale, +0.38 (p<0.035), and Originality Scale: +0.51 (p<0.003).

5.3 Results

Table 5.1 includes the means and standard error of mean values on all experimental variables for both the schizotypy groups. All analyses were two-sided and carried out using either Chi-Square test, t-tests or ANOVAs. Preliminary analyses revealed no sex differences across any of the variables under study. Analyses using t-tests revealed no differences between the schizotypy groups on the total conceptual expansion score, $t(29) = -1.196$, $p = .241$. Of all the subscales, the only significant difference was obtained on the bilateral asymmetry measure where high-ST group showed performed better than the low-ST group, $t(29) = -2.64$, $p < .013$. This difference is illustrated in Figure 5.1. The performance of both groups were significantly different on the recently activated knowledge task, such that the low-ST group generated toys that were more similar to the examples they were pre-exposed to in comparison to the high-ST group, $t(29) = 2.489$, $p < .019$. Figure 5.2 demonstrates the difference between the groups.

Significant differences were found between the groups on the insight convergent problems where the high-ST group was found to surpass the low-ST group, $t(29) = -2.369$, $p < .025$. Both the groups performed comparably on the incremental problems, $t(29) = -0.873$, $p = .39$, but the high-ST group performed better than the low-ST group on overall convergent problem solving, $t(29) = -2.185$, $p < .037$.

<table>
<thead>
<tr>
<th>Table 5.1: Descriptive Data on all Experimental Variables in Study 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Schizotypy</strong></td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Conceptual Expansion: Total Score</td>
</tr>
<tr>
<td>Conceptual Expansion-Asymmetry</td>
</tr>
<tr>
<td>Conceptual Expansion-Lack of appendages</td>
</tr>
<tr>
<td>Conceptual Expansion-Lack of sense organs</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Conceptual Expansion-Unusual sense organs</td>
</tr>
<tr>
<td>Recently Activated Knowledge-Total</td>
</tr>
<tr>
<td>RAK - Presence of a ball</td>
</tr>
<tr>
<td>RAK - Presence of high physical activity</td>
</tr>
<tr>
<td>RAK - Presence of an electronic device</td>
</tr>
<tr>
<td>Originality-Creative Imagery</td>
</tr>
<tr>
<td>Practicality-Creative Imagery</td>
</tr>
<tr>
<td>Alternate Uses task: Fluency</td>
</tr>
<tr>
<td>Alternate Uses task: Uniqueness</td>
</tr>
<tr>
<td>Total Solved: Insight problems</td>
</tr>
<tr>
<td>Total Solved: Incremental problems</td>
</tr>
<tr>
<td>Total Solved: All convergent problems</td>
</tr>
<tr>
<td>Insight – Coin problem</td>
</tr>
<tr>
<td>Insight – Egg problem</td>
</tr>
<tr>
<td>Insight – Triangle problem</td>
</tr>
<tr>
<td>Incremental – Card problem</td>
</tr>
<tr>
<td>Incremental – Water problem</td>
</tr>
<tr>
<td>Incremental – Trace problem</td>
</tr>
<tr>
<td>Digit Span: Digits Forward</td>
</tr>
<tr>
<td>Digit Span: Digits Backward</td>
</tr>
<tr>
<td>Spatial Span: Forward</td>
</tr>
<tr>
<td>Spatial Span: Backward</td>
</tr>
<tr>
<td>WCST: No. of categories</td>
</tr>
<tr>
<td>WCST: No. of errors</td>
</tr>
<tr>
<td>WCST: No. of perseveratory errors</td>
</tr>
<tr>
<td>1-back: RT (in secs)</td>
</tr>
<tr>
<td>2-back: RT</td>
</tr>
<tr>
<td>1-back: No. correctly detected</td>
</tr>
<tr>
<td>2-back: No. correctly detected</td>
</tr>
<tr>
<td>Stroop Control Condition: RT (in msecs)</td>
</tr>
<tr>
<td>Stroop Congruent Condition: RT</td>
</tr>
<tr>
<td>Stroop Incongruent Condition: RT</td>
</tr>
<tr>
<td>Stroop Negative Priming Condition: RT to prime</td>
</tr>
<tr>
<td>Stroop Negative Priming Condition: RT to target</td>
</tr>
<tr>
<td>Stroop: Interference (RT incongruent- RT neutral)</td>
</tr>
<tr>
<td>Stroop: Negative Priming (RT target- RT prime)</td>
</tr>
</tbody>
</table>
Figure 5.1: The mean and standard error of mean values for the low and high schizotypy groups are contrasted on the bilateral asymmetry sub-measure of the Conceptual Expansion task.

Figure 5.2: The mean and standard error of mean values for the low and high schizotypy groups are contrasted on the Recently-Activated Knowledge task.
The mean difference between the groups on insight problem solving is plotted in Figure 5.3. Performances between the groups across the frontal neuropsychological tasks revealed no significant differences. No significant differences were found between the groups on the alternate uses task on either the fluency, $t(29) = -0.211, p = .834$, or the uniqueness measures, $t(29) = -0.545, p = .59$, nor on the creative imagery task on either the originality, $t(29) = -0.825, p = .416$, or the practicality dimensions, $t(29) = -0.889, p = .381$.

### Table 5.2: Descriptive Data for the Factor 2 Interpersonal (Negative) Contrast

<table>
<thead>
<tr>
<th></th>
<th>Low Interpersonal</th>
<th></th>
<th>High Interpersonal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std Error</td>
<td>Mean</td>
<td>Std Error</td>
</tr>
<tr>
<td>Conceptual Expansion-Asymmetry</td>
<td>0.231</td>
<td>0.07</td>
<td>0.583</td>
<td>0.083</td>
</tr>
<tr>
<td>Recently Activated Knowledge-Total</td>
<td>1.385</td>
<td>0.21</td>
<td>0.833</td>
<td>0.167</td>
</tr>
<tr>
<td>Total Solved: Insight problems</td>
<td>1.231</td>
<td>0.28</td>
<td>2.167</td>
<td>0.207</td>
</tr>
<tr>
<td>Total Solved: All convergent problems</td>
<td>3.077</td>
<td>0.42</td>
<td>4.083</td>
<td>0.288</td>
</tr>
<tr>
<td>Stroop Congruent Condition: RT</td>
<td>935.5</td>
<td>62.9</td>
<td>826.5</td>
<td>55.49</td>
</tr>
<tr>
<td>Stroop Interference Condition: RT</td>
<td>903.3</td>
<td>59.1</td>
<td>760.6</td>
<td>43.84</td>
</tr>
<tr>
<td>Stroop: Interference (RT incongruent-RT neutral)</td>
<td>52.232</td>
<td>21.99</td>
<td>-6.86</td>
<td>20.02</td>
</tr>
<tr>
<td>Stroop: Negative Priming (RT target-RT prime)</td>
<td>-156,45</td>
<td>61,73</td>
<td>91,591</td>
<td>107,26</td>
</tr>
</tbody>
</table>
Further analyses were carried out at the level of the three schizotypy subtypes or factors: positive (Cog-Per), negative (Intpn) and disorganised (Disorg) schizotypy. The analyses contrasting the low Cog-Per and high Cog-Per groups revealed exactly the same results as the ones outlined above indicating that the schizotypy groups were chiefly differentiated on this positive schizotypy dimension. Analyses on the low Intpn and the high Intpn groups revealed significant differences on the convergent insight problems, \( t(23) = -2.645, p < .014 \), and the bilateral asymmetry element of the conceptual expansion task, \( t(23) = -3.216, p < .004 \), with superior performance on part of the high Intpn group. A strong trend was also found for the high Intpn group to demonstrate a lower degree of constraints on the recently activated knowledge task, \( t(23) = 2.015, p = .056 \) relative to the low Intpn group. Differences on the Stroop task were such that the high Intpn group tended to have faster reaction times on both the congruent condition, \( t(23) = 1.913, p = .068 \), and the incongruent condition, \( t(23) = 1.868, p = .075 \). Interestingly, the high Intpn group also revealed a strong propensity for reduced interference, \( t(23) = 1.197, p = .06 \), but increased negative priming, \( t(23) = -2.044, p = .053 \), on the Stroop task relative to the low Intpn group. The descriptive data for these variables are presented in Table 5.2.

**Table 5.3: Descriptive Data for the Factor 3 (Disorganized) Contrast**

<table>
<thead>
<tr>
<th></th>
<th>Low Disorganized</th>
<th></th>
<th>High Disorganised</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std Error</td>
<td>Mean</td>
<td>Std Error</td>
</tr>
<tr>
<td>Conceptual Expansion-Asymmetry</td>
<td>0.154</td>
<td>0.07</td>
<td>0.50</td>
<td>0.10</td>
</tr>
<tr>
<td>Recently Activated Knowledge-Total</td>
<td>1.308</td>
<td>0.21</td>
<td>0.857</td>
<td>0.14</td>
</tr>
<tr>
<td>Total Solved: Insight problems</td>
<td>1.538</td>
<td>0.27</td>
<td>2.214</td>
<td>0.21</td>
</tr>
<tr>
<td>Digit Span: Digits Backward</td>
<td>6.000</td>
<td>0.57</td>
<td>7.286</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Significant differences between the low Disorg and the high Disorg groups revealed better performance from the high Disorg group on the bilateral asymmetry element of the conceptual expansion task, \( t(25) = -2.739, p < .011 \). Trends were also found with the high Disorg tending to demonstrate superior insight problem solving, \( t(25) = -1.982, p = .059 \), more originality on the recently activated knowledge task, \( t(25) = -1.806, p = .083 \), and better working memory on the digits backward task, \( t(25) = -1.834, p = .079 \). The descriptive data for these variables are presented in Table 5.3.
5.4 Discussion

The present study was carried out in an effort to attain a more comprehensive understanding of how the construct of schizotypy relates to differential performance on tasks of creative cognition and frontal lobe function. The participants were classified into two groups based on the total score obtained on the Schizotypal Personality Questionnaire (SPQ). Schizotypy subscale analyses revealed that the groups were differentiated on the positive schizotypy dimension. Nevertheless, contrasts based on negative and disorganised schizotypy scales were also carried out and, on average, the picture that emerged from the findings was broadly consistent with the main schizotypy contrast. However, as the samples were originally selected on the basis of the total schizotypy score, and not the schizotypy subtype scores, only results from the high versus low schizotypy group contrasts will be discussed in detail.

5.4.1 Summary of Findings: Creative Cognition Tasks

A number of tasks were employed to assess creative cognitive processes of conceptual expansion, originality and practicality in creative imagery, convergent (insight and incremental) problem solving, recently activated knowledge and uniqueness and fluency on the alternate uses task. Contrary to the findings of the previous psychoticism study, no significant differences were found between the performances of the schizotypy groups, even across the subscale contrasts, on the conceptual expansion task. Only on the conceptual expansion element of bilateral asymmetry did the performance of the groups diverge such that the high schizotypy group generated animals that were more bilaterally asymmetrical than the low schizotypy group. In general however, both groups performed comparably on the conceptual expansion task.

This was also the case on the creative imagery task, where the schizotypy groups, again unlike the psychoticism groups, were found to be undifferentiable on the originality dimension of the creative imagery task. This lack of significant differences between the groups was again found on the alternate uses task where the performance of the schizotypy groups could not be distinguished on either the fluency or the uniqueness measures. This was an unexpected finding as previous research has demonstrated that better performance on the uniqueness measure of the alternate uses task was associated with a higher degree of schizotypy (e.g. Green & Williams, 1999). These discrepancies within the findings maybe due to the fact that the participants had to generate uses for only three objects in the present study compared to eight objects in the original version (Wallach & Kogan 1965) of the task. It is possible that
having only three trials on this type of task may not suffice in allowing for the detection of subtle discrepancies.

On the convergent tasks of insight problem solving though, the performance of the groups differed significantly. In line with the predictions made in the aims of the study, the high schizotypy group showed better insight problem solving abilities relative to the low schizotypy group while both schizotypy groups could not be differentiated on incremental problem solving. The high schizotypy group, as predicted, was better able to restructure their perspective in dealing with a problem situation and were thus able to arrive at insights during analytical reasoning tasks more effortlessly. This pattern of findings was different to that of the previous study where both psychoticism groups did not differ significantly on either convergent problem solving type. So this is yet another task on which the profiles of the psychoticism and schizotypy groups differ.

The recently activated task knowledge was not employed in the previous study, but due to its similarity, at least superficially, to the conceptual expansion task, it was predicted that the high schizotypy group would surpass the low schizotypy group on this task. While, as mentioned earlier, no differences between the schizotypy groups resulted on the conceptual expansion task, the high schizotypy group showed significantly better performance on the recently activated knowledge task. The low schizotypy group were more constrained by recently activated knowledge as they tended to invent toys that contained fundamental features of exemplars of novel toys that the participants were exposed to before they themselves were required to generate novel toys. This dissociation between the performances of schizotypy groups on the conceptual expansion task and the recently activated knowledge task is especially interesting with regard to the role of context in information processing, a point that will be elaborated upon later in this section.

5.4.2 Summary of Findings: Frontal Function Tasks

To assess how the schizotypy groups would perform across diverse measures of frontal lobe function, a number of tasks were employed. The n-back task, the spatial backwards span task, and the digits backward task were utilised to assess working memory function. The modified WCST was used to obtain a measure of perseveratory responses in set-shifting. Short-term memory span was assessed with the use of the spatial forward span task and digits forward task. Finally, the Stroop task was used to obtain a measure of the efficacy of response inhibition. A manipulation for negative priming was also included within the Stroop paradigm.
to gauge the degree of negative priming elicited. In line with previous findings in the literature, the high schizotypy group was expected to show worse performance relative to the low schizotypy group across working memory, set-shifting and inhibitory control measures. While the high schizotypy group was also expected to show reduced negative priming on the Stroop task, no differences were expected to result between the groups on the short-term memory span tasks.

The evidence gathered in this study was not in support of the previous literature as no significant differences were found between the schizotypy groups across any of the measures of frontal function. Neither working memory nor set-shifting impairments were found when contrasting the groups which is in direct contradiction with some of the established findings in the literature (e.g. Park & McTigue, 1997; Lenzenweger & Korfine, 1994; Tallent & Gooding, 1999). The present study deviates from it the published studies in two important ways. Schizotypy has been mainly associated with spatial working memory deficits and it is possible that only this paradigm is sensitive enough to tap mild working memory deficits that are latent in schizotypy. Lenzenweger and Gold (2000), for example, found that schizotypy as defined by performance on the Perceptual Aberration Scale was related to visuospatial working memory deficits but not auditory working memory deficits.

This very study is also revelatory of another fundamental way in which the present study diverged from that of its predecessors. Schizotypy has largely been defined in terms of performance on one or two selected schizotypy subscales such as the magical ideation or perceptual aberration scales. The current study used a more general measure of schizotypy and made finer contrasts based on scores obtained across subscales that load for a common schizotypy symptom cluster such as positive, negative or disorganised schizotypy. It is thus possible that the reduced efficiency in performances across executive and working memory tasks that is reported to characterise schizotypy are limited in that they reflect only altered function in relation to select symptoms and not the schizotypy dimension as a whole or even the major symptom clusters.

The high and low schizotypy groups were also found to not differ significantly on the Stroop task on neither the interference nor the negative priming condition. The few trends that resulted were only at the level of the subscale analyses. On the negative schizotypy contrast, the high negative schizotypy group tended to demonstrate faster reaction times across all conditions of the Stroop task and additionally displayed a trend for increased negative
priming. This pattern has been reported in a previous findings where negative schizotypal traits were linked to increased negative priming (Williams, 1995). However, the evidence did not support previous findings associating positive schizotypy with reduced negative priming (e.g. Beech et al., 1989b; Moritz & Mass, 1997), and instead belongs with the assemblage of findings that have reported no significant differences (e.g. Fisher & Weinman, 1989; Lipp, Siddle & Arnold, 1994).

In an effort to integrate these opposing findings in the negative priming literature on schizotypy, Moritz and his colleagues (2000) demonstrated that reduced negative priming was found to be diminished in highly schizotypal individuals only in situations where short stimulus onset asynchronies (SOA) were applied. As negative priming is also unaffected when unmasked negative priming tasks are employed, Moritz and Andresen (2004) recently postulated that the negative priming effects reported in previous studies may in fact only be an epiphenomenon that results from short prime presentation durations and backward masking. Additional evidence is, however, necessary to evaluate the validity of this claim.

In general then, the frontal tasks employed to measure executive functioning in terms of high and low schizotypy did not differentiate between the groups. This could be taken as evidence of no unaltered frontal functionality in high schizotypy individuals. However, it is also possible that the tasks used in the present study were not sensitive enough to detect subtle differences between the groups. This may be especially true in the case of working memory and executive functioning where the type of tasks used to assess the ability appears to play a critical role in detecting slight anomalies. The issue of varying connotations of schizotypy that are derived from using different scales of schizotypy along with whether schizotypy is investigated based on symptom subscales or symptom clusters or a general level of schizotypy is also critical.

Another significant contributing factor could be the method of sampling used in recruiting individuals. Some researchers favour the approach that was employed in the previous study on psychoticism where all participants in the randomly selected sample complete the psychoticism scale. The sample is then contrasted either by means of a division based on a median-split of their psychoticism scores or using analyses that are correlational in nature. In the alternative approach, participants are selected on the basis of the degree of their schizotypy scores and are accordingly assigned into high and low groups, just as in the present study. These kinds of sampling differences coupled with the other sources of
variability could also play a role in ability to tease apart these slight deficits in performance as a function of schizotypy. What is certainly apparent, however, is that the insufficiencies in frontal executive function that are reported in schizotypy are not explicit markers of schizotypal functionality, but instead operate at a very subtle level that can only be tapped under extremely sensitive conditions. This would be logical given that even extremely high schizotypy individuals are functional in daily life.

5.4.3 Schizotypy versus Psychoticism

A comparison of the results from the present study with that of the previous study where high and low psychoticism groups were contrasted reveals a fundamental dissociation in performance. As shown in Table 5.4, the psychoticism groups were differentiated on the creative cognition measures of conceptual expansion and originality in creative imagery where the schizotypy groups were distinguishable in terms of their performance on insight problem solving and the influence of recently activated knowledge. Only on this conceptual expansion submeasure of Bilateral Asymmetry did the high schizotypy and high psychoticism groups perform comparably such that both were more likely to generate animals with bilaterally asymmetrical forms, a deviation which constitutes one core element that is assessed in the expansion or the ‘animal’ concept (Ward, 1994).

<table>
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<tr>
<th></th>
<th>PSYCHOTICISM</th>
<th>SCHIZOTYPY</th>
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<tbody>
<tr>
<td>Conceptual expansion</td>
<td>High &gt; Low</td>
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</tr>
<tr>
<td>Originality-Creative imagery</td>
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<td>Practicality-Creative imagery</td>
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<tr>
<td>Insight problem solving</td>
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<td>High &gt; Low</td>
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<td>Incremental problem solving</td>
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<tr>
<td>Recently activated knowledge</td>
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<td>Alternate Uses: Uniqueness</td>
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<td>Alternate Uses: Fluency</td>
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This pattern of findings adds weight to the argument that Psychoticism and Schizotypy are fundamentally dissimilar constructs. However, the lack of parallel findings in both studies is not essentially problematic for the dimensional view of normality and psychosis especially
when considering the diversity in the symptomatology of schizophrenia and the altered levels of cognitive function associated with select schizophrenic symptom clusters. As schizotypy and psychoticism are differentiated in terms of the psychopathological symptoms they represent, in the same manner as in the case of schizophrenia, varied performance that is associated across these constructs allows for a more comprehensive understanding of their underlying diversity. This is especially so given that a chief objective when assessing of dimensional constructs of psychosis is to assess how far they mirror schizophrenic cognitive functioning, which in itself is marked by striking complexity.

In the present case, it may be possible to derive analogies on how the findings obtained on the psychoticism and schizotypy samples both reflect schizophrenic function by referring to effects that arise as a consequence of divergent types of contextual processing. The issue of context was previously introduced in the Discussion section of Study 2 where two types of context were differentiated. Long-term memory related ‘weak’ or ‘passive’ context effects were proposed to be tapped by the conceptual expansion task, where a context in form of representations of appropriate schema in stored memory are activated, whereas short-term memory related ‘strong’ or ‘active’ context effects, are implicated in the case of the recently activated knowledge task, where the exemplars induce a strong and immediate context that influences information processing.

5.4.4 Differential Contextual Modulation

In the case of the conceptual expansion task, a context, as provided by the word ‘animal’ in the expansion task used in the present study, activates the schema ‘animal’ which in turn actively guides ensuing actions, i.e., the ‘animal’ schema exerts a dominant influence while the subject generates a novel animal. Given circumstances where schemas that are not entirely appropriate or only loosely associated to a concept are also activated, one could presumably be better able to better expand the ‘animal’ concept as broader schemas exert less rigid influence and hence impose fewer limits in the capacity to expand one’s concepts. It would appear then that high psychoticism individuals are marked by more diffuse passive context top-down influence. This reasoning could also explain their enhanced performance on the originality dimension of the creative imagery task, which is another facet of creative cognition that would be abetted by diffuse top-down control as a broader and less focused influence of one’s stored knowledge would allow for the generation of more atypical and uncommon inventions.
On the other hand, an active context is induced during the recently activated knowledge task with the presentation of three exemplars of novel toys (that have 3 fundamental elements in common) directly prior to when the subject is required to generate a new toy. This type of context actively interferes 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. The diminished top-down influence of such an active context would result in superior performance on this task, as was found in the case of high schizotypy individuals. Better insight problem solving may also be understood within this frame as restructuring of an insight analytical problem would be aided by the reduced influence of active contexts as restrictions that ordinarily bias the problem solver to apply the most obvious or predetermined strategies in reaching a solution would be decreased. It is important to note that unimpaired goal-directed thinking is also a prerequisite for successful convergent problem solving, a factor that was controlled for as both schizotypy groups were comprised of healthy and functional individuals.

Deficits across both these forms of top-down or contextual processing have been reported in schizophrenia with some limited evidence linking passive context deficits to positive symptoms and active context deficits to thought disorder symptoms. Another form of top-down control, in terms of goal-directed thinking is also deficient in schizophrenia and is mainly linked to its negative symptoms. A caveat is necessary here though, as these differential characterisations based on symptomatology are broad generalisations deriving from published literature that is, as yet, limited. Although the schizotypy groups in the present study appeared to be chiefly contrasted on the positive schizotypy dimension, the subjects were selected during sampling only on the basis of their total schizotypy score. Clear distinctions based on select schizotypy symptoms in terms of contextual processing thus cannot be made. There is however, some literature linking contextual processing deficits as tested using perceptual grouping tasks across many schizotypy (and psychoticism) symptoms.

An investigation of local-global processing in perceptual grouping as a function of schizotypy, for instance, revealed a deficit in involuntary rapid global processing and consequent dominant local processing in high positive schizotypy individuals (Goodarzi, Wykes & Hemsley, 2000). This altered pattern of functioning was associated with both a general schizotypy measure that is undifferentiated in terms of symptom scores, as assessed by the STA, and with positive schizotypy, or the Unusual Experiences symptom cluster as assessed using the O-LIFE. In another type of perceptual grouping task that required the
segregation of a simple figure from a complex background, poor performance was negatively associated with negative schizotypy or Introvertive Anhedonia and positively associated with Impulsive Nonconformity, which is related to the construct of psychoticism (Tsakanikos & Reed, 2003). A recent study made a case for thought disorder or disorganised symptoms with regard to altered perceptual grouping function such that high thought disorder schizotypal subjects demonstrated poorer performance on a contour integration task, but superior performance on a visual size perception task relative to low thought disorder schizotypal individuals (Uhlhaas et al., 2004).

In conclusion, the evidence that emerged from the tasks tapping different creative cognitive processes appeared to indicate that both schizotypy and psychoticism exhibit diminished top-down control of information processing but that the nature of this influence differs. The former is characterised by diminished active context control while the latter displays diminished passive contextual influence. These post-hoc interpretations need to be supplemented with more fine-tuned and explicit investigations that are targeted at teasing apart diverse contextual effects on information processing along with its conjoined and disparate interactions with the constructs of schizotypy and psychoticism.
Chapter 6

Study 5: Developmental Psychopathology

In the fifth and final study, the examination of creative cognition with reference to prefrontal function was extended to include other populations that are characterised by frontal neuropsychological deficits. A clinical developmental perspective was adopted and the two populations of interest were that of adolescents with Attention-Deficit/Hyperactivity Disorder (ADHD) and Conduct Disorder. The Introduction section begins with an summary of the development of the prefrontal cortex and the diagnostic criteria of ADHD and conduct disorder. Contrasts between the neuropsychological profile and contemporary theories of ADHD and conduct disorder will follow. How creative cognition relates to developing prefrontal function in these pathological populations will be described in the aims of the study. The Methods section outlines the experimental design for Study 5 after which the Results section will focus on the findings. The obtained results will examined in detail in the Discussion section with reference to pertinent literature.

6.1 Introduction

The brain structure with the most prolonged period of postnatal development which continues into adolescence is the prefrontal cortex (Huttenlocher, 1990). The emergence of prefrontally-guided cognition, as demonstrated by successful performance on delayed-response paradigms (the A-not-B task in children) occurs during late infancy. A steady improvement in performance on frontal measures such as the spatial memory span, Tower of London, and the CANTAB continues through childhood with adult levels of performance attained only post-puberty on complex executive tasks, like the Tower of Hanoi, verbal fluency tests and some planning tasks (Welsh, Pennington & Groisser, 1991; Luciana 2003). A recent review by Eslinger, Flaherty-Craig, and Benton (2004) of studies examining neuropsychological
function in people with focal frontal lesions obtained during childhood observed that although performance on standardised IQ tests revealed preserved ‘crystallised intelligence’, cognitive impairments on tasks of planning, working memory, anticipation of consequences, inhibition and self-regulatory functions were extensive. Impairments on such ‘fluid intelligence’ measures that tap adaptive cognitive abilities are known to correlate well with functional activation in the lateral prefrontal cortex (Duncan et al., 2000). With regard to social and emotional functioning, the most common adult frontal syndrome resulting after such focal frontal lesions obtained during childhood is the pseudopsychopathic syndrome (Stuss & Benson, 1986), which is characterised chiefly by occasional hypomania, a lack of concern for others and disregard for ethical principles, which resembles the profile of conduct disorder (Pennington & Ozonoff, 1996). While the pseudopsychopathic frontal syndrome is associated with orbitofrontal lesions, frontal disorders of attention and hyperkinesis (Fuster, 1989) are associated with dorsolateral lesions and provide a frontal analogy for the behavioural pathology of ADHD (Pennington & Ozonoff, 1996).

6.1.1 Conduct Disorder and ADHD

As per the DSM-IV and the ICD-10 classifications, conduct disorder is a characterised by repetitive and persistent pattern of dissocial, aggressive or defiant conduct where the basic rights of others and/or age-appropriate societal norms are violated. Conduct disorder can develop during childhood or adolescence and among the major criteria used to diagnose this condition are aggression to people or animals, destruction of property and serious violations of rules. Most of the current knowledge on conduct disorder derives from studies on children or adolescents with conduct disorder, juvenile delinquents and sub-clinical antisocial individuals.

ADHD (DSM-IV), also known as Hyperkinetic Disorders according to the ICD-10 classification, is a group of disorders that usually develops during the first five years of life and is typified by a combination of pervasive and persistent characteristics of marked inattention, overactivity, impulsivity, lack of enduring task involvement, and disorganized and poorly modulated behaviour. Studies on ADHD examine children or adolescents with ADHD and adults with childhood-onset ADHD. Both ADHD and conduct disorder are highly comorbid disorders with 30% to 50% of children with ADHD also meeting the diagnostic criteria for conduct disorder and up to 70% of children with conduct disorder having comorbid ADHD (Biederman, Newcorn & Sprich, 1991; Klein et al, 1997). Children with comorbid ADHD and conduct disorder symptoms are at a high risk to develop persistent violent
and antisocial behaviour in adulthood (Toupin et al., 2000). Considerable parallels between in
europsychological profiles of people with ADHD and conduct disorder have been
documented as both groups have been shown to have deficits in tasks of frontal function.
What is problematic however is verifying which deficits are specific to both disorders
(Sergeant, Geurts & Oosterlaan, 2002) and how they relate to brain function. Inconsistencies
between findings result due to a wide range of methodological shortcomings, including co-
morbidity, and problems in sampling caused by heterogeneity within samples due to
differences in age of onset and current state of pathology during testing.

6.1.2 ADHD and Prefrontal Function
A lag or delay in the development of the prefrontal cortex has been attributed to underlie the
causes of ADHD (e.g. Rosenthal & Allen, 1978; Chelune et al., 1986). Impaired maturation of
fundamentally prefrontal processes of selective and exclusionary attention, that normally
develop by the age of 12, has been postulated to give rise to the core ADHD symptoms of
inattention, distractibility, impaired response inhibition and impulsivity, and excessive
restlessness (Fuster, 1997). In the 1930s, these behavioural symptoms were recognized as also
being exhibited by patients with frontal lobe lesions and with it the frontal lobe theory of
ADHD was born (Levin, 1938). The evidence gathered thus far appears to back this theory.

Studies using structural MRI, for instance, have showed in comparison to non-ADHD
controls, subjects with ADHD have bilaterally symmetrical and smaller anterior cortices
(Hynd et al., 1990), reduced regional brain sizes bilaterally in inferior portions of dorsal
prefrontal cortices (Sowell et al., 2003), and smaller genu, which is the part of the corpus
collosum that connects left and right frontal lobes (Giedd et al., 1994). Reversed patterns of
asymmetry were seen at the head of the caudate nucleus, which is a part of the basal ganglia
with strong connectivity to the prefrontal cortex, such that the left region was reduced in
comparison with its right counterpart in ADHD children but the opposite was reported in non-
ADHD children (Hynd et al., 1993). Furthermore, parents with residual ADHD and their
affected children were both shown to have reduced cerebral glucose utilisation using PET in
the right frontal lobe (Zametkin et al., 1993). In an rCBF study on ADHD children,
hypoperfusion in the frontal lobes was followed by hyperperfusion after the administration of
Ritalin, a widely prescribed stimulant medication for ADHD, along with reduced blood flow
to primary sensory and motor cortices, which was deemed to be a signal of increased
inhibitory control and reduced distractibility (Lou et al., 1989).
A plethora of studies have examined neuropsychological functioning in ADHD and the evidence argues strongly in favour of an executive dysfunction hypothesis as pervasive deficits have been reported across tasks that demand inhibition, attention, vigilance and motor control with intact function in non-executive domains like verbal memory, verbal skills and visuospatial skills. In their comprehensive review, Pennington and Ozonoff (1996) found the most consistent measures to reveal impaired functioning were those that called for attentional or motor inhibition, like the go no-go task, the stop task, the anti-saccade task, the Stroop colour-word test, the trailmaking test: Part B, the matching familiar figures test (MFFT), and the tower of Hanoi (e.g. Trommer et al., 1988; Gorenstein, Mammato & Sandy, 1989; Robins, 1992; Aman, Roberts & Pennington, 1998). While ADHD groups tend to display poorer performance on working memory tasks, like the Sequential Memory task and the Self-Ordered Pointing task, results on set-shifting tasks like the WCST are less clear-cut (Gorenstein et al., 1989; Shue & Douglas, 1992; Pennington, Groisser & Welsh, 1993). A recent review (Sergeant et al., 2002) found robust evidence for impaired inhibition on the Stop task (7 of 8 studies) and the Stroop task (10 of 12 studies) and comparatively good evidence for deficits on set-shifting on the WCST (17 of 26 studies), planning on the Tower of Hanoi and Tower of London tasks (5 of 7 studies), and working memory on the Self-Ordered Pointing task (2 of 2 studies). Mixed evidence, however, was found for fluency measures (6 of 9 studies for Letter Fluency but 2 of 9 studies for Category Fluency).

The Stop task as an inhibitory measure is of especial interest as studies using structural and functional MRI have revealed the involvement of frontostriatal circuitry in ADHD suggesting that both the prefrontal lobe and the basal ganglia may jointly mediate the inhibitory deficit in ADHD (Casey, et al., 1997; Rubia et al., 1999). In a typical Stop task, a child faces a computer screen and presses the appropriate key or button press in response to the appearance of an X or an O on the screen. When a tone sounds however, it is indicative of a stop signal trial and the child is not supposed to press the key. Children with ADHD have slower stop signal reaction times (SSRT) than normal comparison children, a finding that has been widely replicated (for a review, see Oosterlaan, Logan & Sergeant, 1998), which is suggestive of a central inhibitory deficit in this disorder. In light of this, most theories that seek to explain the neuropsychological deficits seen in ADHD are founded on an inhibition deficit hypothesis (Douglas, 1983; Schachar et al., 1993; Barkley, 1997).

The most influential of these is that of Barkley (1997), who proposed that the principal deficit in ADHD is behavioural disinhibition which forms the basis for other secondary executive
deficits in working memory, self-regulatory functions, internalisation of speech and reconstitution, that serve to modulate behaviour in terms of internally represented information and self-directed action. Goal-directed behaviour and task persistence are thus disrupted due to a lack of inhibitory control. Sergeant’s Cognitive-Energetic model (2000) postulates that the overall efficiency of information processing depends upon process (computational mechanisms of encoding, search, decision and motor organisation), state (effort, arousal and activation) and management (executive functions of planning, monitoring, error detection and correction) factors. ADHD, in this view, is characterised by state deficits. Swanson and his colleagues (1998), in line with the neuroanatomical network theory of attention, argue for a central role for attentional deficits in the form of alerting and executive control insufficiencies in ADHD. Sonuga-Barke (2002), in his model, proposed that impairments in inhibitory control, which are facilitated by the mesocortical control circuit, and motivational factors such as the delay-of-gratification, which are regulated by the mesolimbic reward circuit, both underlie the manifestation of behavioural dysregulation in ADHD. A final consequential theory is Quay’s (1988) adaptation of Jeffrey Gray’s neuropsychological theory of anxiety where poor inhibition or impulsiveness seen in ADHD is believed to arise from a malfunction of the brain’s behavioural inhibitory system. This theory will be explored in more detail in a later section as it also has a significant bearing on conduct disorder.

6.1.3 Conduct Disorder and Prefrontal Function

The neuropsychological picture of conduct disorder is less straightforward than that of ADHD as far fewer studies have been directed at investigating the cognitive underpinnings of conduct disorder. Moreover, even among the studies that do so, the issue of co-morbidity within samples particularly hinders the ability to derive confident and generalisable conclusions. As the evidence gathered stems from multiple sources ranging from juvenile delinquents and samples of sub-clinical antisocial individuals to individuals with antisocial personality disorder (which can be generally regarded as the more acute adult form of conduct disorder), incarcerated murderers and psychopaths, great caution needs to be exercised when interpreting and generalising findings.

On the basis of neuropsychological, neurological and brain imaging studies, Raine (2002) proposed a prefrontal dysfunction theory of antisocial behaviour. As the prefrontal cortex is involved in the regulation of arousal (Hellige, 1993; Dahl, 1998), deficits in autonomic arousal on part of antisocial individuals is indicative of impaired prefrontal function (Raine et al., 2000). Lower resting heart rate levels, a strong indicator of underarousal were reported
across fourteen studies in antisocial children and it constitutes one of the best replicated findings in antisocial psychophysiology literature (Raine, 1993). In studies using electrophysiology, a regression analysis of hemispheric EEG activation revealed that reduced left frontal activation was associated with an increased likelihood of the diagnosis of antisocial personality disorder (Deckel, Hesselbrock & Bauer, 1996). An ERP study of ‘at-risk’ conduct disorder individuals also support the frontal dysfunction hypothesis in finding that differences in P300 amplitudes between trials of matching and mismatching probes on a memory scanning task was significantly lower in the conduct disorder group relative to a control group (Bauer & Hesselbrock, 2001).

While no neuroimaging studies have been carried out thus far on conduct disordered, antisocial or aggressive children, studies on antisocial adults have indicated characteristic prefrontal abnormalities (Bassarath, 2001). In a structural magnetic resonance imaging study, relative to control groups, an 11% reduction in the volume of gray matter in the prefrontal cortex was found in the absence of ostensible brain lesions among adults with antisocial personality disorder (Raine et al., 2000). Additionally, single case and group studies have shown that patients with significant neurological damage to the prefrontal lobe tend to develop antisocial or psychopathic-like personality traits and additionally exhibit impairments in autonomic arousal and when attending to socially meaningful events. Both are indicative of prefrontal dysfunction given the role of the prefrontal cortex in modulating emotion, arousal and attention (Stuss & Benson, 1986; Damasio, Tranel & Damasio, 1990; Damasio, 1994). Studies of children with frontal lesions have indicated that the majority of them suffer from serious behavioural problems and typically display impulsive, aggressive and antisocial behaviour (Pennington & Benneto, 1993; Bechara et al., 1999).

What is known about the neuropsychological profile of conduct disorder is very limited due to the dearth of studies addressing this issue. Sergeant and his colleagues (2002) when reviewing neuropsychological studies of conduct disorder and/or oppositional defiant disorder samples without screening for comorbidity, found evidence for impaired response inhibition on the Stop task (4 of 4 studies) and the Stroop task (5 of 6 studies), deficits on set-shifting on the WCST (3 of 3 studies), reduced planning skills on the Tower of Hanoi and Tower of London tasks (1 study), poor working memory on the Self-Ordered Pointing task (2 of 2 studies), and impaired fluency (3 of 4 studies for Letter Fluency and 1 study for Category Fluency). There is consistent evidence for IQ-independent deficits on many executive function measures, like the Stroop colour-word task, trailmaking test-part B, WCST, Porteus maze and the Rey
Osterreith complex figure task, from both population and clinically referred samples of conduct disorder, but mainly only in the presence of co-morbid ADHD (Moffitt & Henry, 1989; Lueger & Gill, 1990; Hurt & Naglieri, 1992; Séguin et al., 1995; Déry et al., 1999). While some still argue in favour of executive function deficits in conduct disorder and antisocial individuals after controlling for ADHD (Séguin et al., 1999), the evidence is as yet too limited to make a clear case. Consistent associations, on the other hand, have been demonstrated between conduct disorder and lower IQ, particularly on verbal IQ measures (White et al., 1994; Moffitt, 1993), and poor performance on non-executive language tasks (Frost, Moffitt & McGee, 1989; Linz et al., 1990; Braggio et al., 1993; Déry et al., 1999).

Apart from a verbal dysfunction, other non-executive function measures that appear to be sensitive to conduct disorder are those of behavioural impulsivity and electrodermal activity. Increased behavioural impulsivity on part of antisocial and conduct disorder samples was found across tasks that tap motor inhibition, delay of gratification, and disinhibitory response styles (Shapiro et al., 1988; White et al., 1994). This behavioural impulsivity is thought to result from low levels of arousal as aggressive children exemplify chronic underarousal, which is gauged by electrodermal activity from resting heart rate level and resting skin conductance levels (Raine, 1993, 1996). A number of theories have been proposed to explain this pattern of chronic underarousal, increased impulsivity and behavioural difficulties. According to stimulation-seeking hypotheses, antisocial individuals are characterised by low resting arousal states which are sub-optimal physiological states that predispose them to seek stimulation in order to increase levels of arousal to normal levels (Eysenck, 1964, 1997; Quay, 1965; Raine, 1993). In contrast to high levels of basal arousal which is linked to an agreeable personality disposition, Crider (1993) has suggested that reduced skin-conductance levels are markers of an antagonistic personality disposition which includes features of impulsivity, hostility, irresponsible behaviour and unsocialised demeanour. In support of these ideas, two studies by Raine and his colleagues found that resting heart rate at age 3 years was shown to characterise stimulation-seeking and antisocial behaviour at 3 years and 11 years of age (Raine et al., 1997, 1998). Preschoolers who chose to watch videos depicting situations of intense anger were found to have lower heart rates relative to controls, which was in turn associated with externalising or conduct problems (El-Sheik et al., 1994).

6.1.4 ADHD versus CD: Impulsivity

Low electrodermal activity has also been reported in ADHD populations (Delameter & Lahey, 1983; McBurnett et al., 1993; Iaboni, Douglas & Ditto, 1997) and increased
impulsivity is a central characteristic of both individuals with conduct disorder and ADHD. Some researchers have used Gray’s motivational theory (1982, 1987) as a starting point to contrast the clinical profile of ADHD and conduct disorder, and to clarify the similarities and dissimilarities between the disorders within the same mould. According to Gray’s theory, three interdependent brain systems orchestrate separate classes of survival-related behaviours. The Behavioural Activation System (BAS) subserves approach and active avoidance behaviours and is responsible for maximising rewards and minimising punishments in situations that call for behavioural responses. The Behavioural Inhibition System (BIS) controls aversive motivation functions and exerts control in situations that warrant passive avoidance and extinction. The emotional by-products of the BAS system are pleasure and relief, and that of the BIS system are fear and anxiety.

Behavioural disinhibition results from an imbalance in BAS and BIS functioning where impulsivity occurs because punishment cues do not elicit sufficient anxiety to inhibit or control appetitive responding in the presence of competing reward contingencies. Although Quay (1993) attributed impulsivity in ADHD to attenuated BIS activity and in conduct disorder to excessive BAS activity, the published literature makes a case for BIS dysregulation in both disorders (for a review, see Beauchaine et al., 2001). While the disinhibition seen in both conduct disorder and ADHD could be explained by motivational accounts, aggressiveness is a fundamental characteristic of conduct disorder, but not ADHD. Although not central to theories of conduct disorder, it appears that Gray’s third Fight/Flight System may serve to differentiate these two disorders with regard to the aggressiveness dimension (Beauchaine et al., 2001).

6.1.5 Aims of the Study
Creative ability has only limitedly been investigated in conduct disorder and ADHD populations. An early observation of Torrance and Dauw (1965) of highly creative children being characterised by behavioural and conduct problems which are attributed as being due to repressed creative needs provided some limited initial impetus. Farley (1985) hypothesised that low innate arousability, characteristic of both ADHD and conduct disordered populations, would give rise to a higher sensation seeking drive or an increase in stimulation seeking behaviours and consequently enhanced creative ability in the form of greater flexibility, openness to experience, risk-taking behaviours, preference for complexity, and receptivity to novel ideas and experiences.
The evidence for this hypothesis however, is rather mixed. While an early study by Kuo (1967), for instance, found that non-delinquent children surpassed delinquent children on the Torrance Test of Creative Thinking (TTCT), Anderson and Stoffer (1979), found that this pattern was only true on the verbal creativity measures of verbal fluency, verbal flexibility and verbal originality. A different pattern was found on the figural creativity measures with delinquents exhibiting better performance than non-delinquents on the figural fluency measure, whereas no difference between the groups resulted on the figural flexibility and figural originality dimensions. More recently, Eisenman (1992) tested young prisoners on preference for complexity, which is held to be an indicator of greater creative ability, and found that the conduct disorder prisoners showed greater preference for complex figures than psychotic prisoners but that the prisoners in general showed reduced creative ability in contrast to control groups. In the case of ADHD, studies by Shaw and Brown (1990, 1991) have shown greater figural creativity among ADHD subjects in addition to the usage of more diverse nonverbal and poorly focused information in problem solving. These findings are far from conclusive, however, as an independent study demonstrated that figural creativity was not enhanced in ADHD boys relative to controls and, moreover, that the administration of Ritalin did not influence performance either (Funk et al., 1993).

All of these studies are limited, in terms of their sampling techniques and use of methodology, and limiting, given that they do not allow for the drawing of generalisable conclusions. As these findings do not lend much additional knowledge in order to allow for predictions on the processes of creative cognition explored within this thesis, all hypotheses are largely based on the neuropsychological profile of each disorder. The executive frontal deficits seen in ADHD are akin to that of schizophrenia, but the former population is far less impaired in terms of overall functionality. Predictions of differences between the ADHD and healthy control groups are held to arise as a result of diminished as opposed to impaired top-down control of information processing.

On the convergent tasks, the ADHD group is predicted to show worse performance relative to the control group on the Tower of Hanoi incremental problem, given their deficits in executive planning abilities, but comparable performance on the Candle insight problem, where increased distractibility would not pose a hindrance. On the alternate uses task, no differences were expected on the fluency measure between the groups, given that the ADHD groups do not show extensive category verbal fluency deficits. The ADHD group was predicted to show better performance on the uniqueness measure though, given that diffuse
top-down control in the form of executive disinhibition would result in access to wider or more remote associations. By the same token, on the conceptual expansion task and the recently activated knowledge task, the ADHD group was also expected to surpass the healthy control group. Although there is evidence to suggest that children ADHD have a tendency to make perseveratory responses, on the WCST for instance, the ADHD group would find it easier to generate exemplars on such creative thinking measures as a clearly defined objective is not prescribed and it is profitable to be able to free-associate and not be constrained by examples or stored knowledge. Finally, on the creative imagery task, no differences in performance was expected on either the originality or practicality measure as although reduced inhibitory control may grant easier access to remote associations, better performance on this complex task appears to be linked with enhanced intellectual capacity.

The conduct disorder group is included as a clinical control group within this study. Although limitedly investigated, the deficits seen in conduct disorder seem to parallel that of ADHD. However, despite the issue of co-morbidity, these are two distinct disorders and the inhibition deficits seen in conduct disorder are proposed to arise from a motivational rather than an executive dysfunction. How the performance of the conduct disorder group deviates from that of ADHD would allow for a better understanding of its neuropsychological profile.

6.2 Methods

Sample Description
The participants were comprised of two clinical case groups and a healthy control group. The patients with ADHD and conduct disorder (CD) were recruited with the guidance of the chief consultant psychiatrist (Dr. Rainer Siefen) from a local Child and Adolescence Psychiatry Unit (Westfälische Klinik für Kinder- und Jugendpsychiatrie und Psychotherapie in der Haard, Marl, Germany). Patients with a diagnosis of Hyperkinetic Conduct Disorder (F90.1), which refer to a clinical disorder of extensively comorbid ADHD and CD, were excluded from the sample. 11 ADHD (3 girls, 8 boys) patients were included in the final sample of which five had a diagnosis of ‘attention deficit disorder: predominantly inattentive type’ (314.00 in the DSM-IV; F98.8 in the ICD-10) and the remaining six were classified under ‘attention deficit disorder: combined type, with hyperactivity’ (314.01 / F90.0). All except for three patients were taking medication during the period of testing. One among these three was
undergoing a placebo treatment trial. All the other patients were prescribed stimulant medication in the form of amphetamine or methylphenidate (Ritalin, Concerta, Medikinet). Only one patient was reported as having co-morbid emotional disturbances.

A total of 12 patients with CD (4 girls, 8 boys) were included in the final sample of which one was diagnosed as having ‘conduct disorder: childhood onset type’ (312.81 / F91.1), two were classified as having ‘oppositional defiant disorder’ (313.81 / F91.3) and the rest were classified as ‘conduct disorder: unspecified onset’ (312.89 / F91.8). Only three patients in this group were taking medication at the time of testing which included methylphenidate (Ritalin), pipamperone (Dipiperon) and citalopram (Cipramil). With respect to mild co-morbidity, one of the patients had depressive disturbances, three had emotional disturbances, one had attentional disturbances, and two had both emotional and attentional disturbances.

The mean age for the ADHD group was 13.18 years and the CD group was 13.5 years (for both groups – minimum = 12 years; maximum = 15 years). The control group was recruited via newspaper advertisements and consisted of 21 children (9 girls, 12 boys) who had no history of mental illness. They were matched to the clinical case groups based on age (mean: 13.48 years; minimum = 12; maximum = 15) and IQ scores. The average score obtained on three IQ subscales (Verbal Factor, Reasoning, and Closure) from the Leistungsprüfsystem (LPS; Horn, 1983) were used to obtain a measure of IQ. Statistical analyses using t-tests revealed no differences on the LPS between the ADHD group and the control group, \( t (30) = -1.488, p = .15 \), or the CD group and the control group, \( t (31) = -0.282, p = .78 \).

Prior to participation, the parents of all the children were provided an information sheet concerning the study and the type of tasks the child would be asked to perform. To be able to participate, the children had to obtain a signed informed consent form from their parents. The children in the control group received payment (EUR 15) for their participation.

**Materials and Procedure**

The experimental tasks used in the present study have been described in detail in earlier chapters: the Conceptual Expansion task (refer to the Method section in Chapter 2), the Creative Imagery task (refer to the Method section in Chapter 4), the Recently-Activated Knowledge task (refer to the Method section in Chapter 3), the Alternate Uses task (refer to the Method section in Chapter 3), and the Duncker Candle task and the Tower of Hanoi (refer to the Method section in Chapter 2).
The array of tasks were administered within one session lasting approximately 1½ hours (with as many breaks as the participant wanted). Each session began the completion of the LPS subscales followed by the conceptual expansion task. The alternate uses test was then carried out after which the recently activated knowledge task and the two convergent tasks, the candle task and the tower of Hanoi, were completed. The final task in the session was the creative imagery task. The interrater correlation (Pearson’s correlation coefficient) on the Practicality Scale was +0.59 (p < .0001), and the Originality Scale was +0.37 (p<.006).

6.3 Results

Table 6.1 includes the means and the standard error of mean values across all tasks for the case and control groups. All analyses were two-sided and carried out using either Chi-Square analyses, t-tests and ANOVAs.

**Table 6.1:** Descriptive Data for the ADHD, CD and Control groups across all the Experimental Variables in Study 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADHD group</th>
<th>CD group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std Error</td>
<td>Mean</td>
</tr>
<tr>
<td>LPS: Average Score</td>
<td>46.80</td>
<td>2.39</td>
<td>49.58</td>
</tr>
<tr>
<td>LPS - Verbal</td>
<td>45.00</td>
<td>2.24</td>
<td>47.50</td>
</tr>
<tr>
<td>LPS - Reasoning</td>
<td>45.91</td>
<td>2.22</td>
<td>47.92</td>
</tr>
<tr>
<td>LPS - Closure</td>
<td>49.55</td>
<td>3.19</td>
<td>53.33</td>
</tr>
<tr>
<td>Conceptual Expansion: Total</td>
<td>1.09</td>
<td>0.18</td>
<td>1.33</td>
</tr>
<tr>
<td>Originality - Creative Imagery</td>
<td>2.36</td>
<td>0.12</td>
<td>2.05</td>
</tr>
<tr>
<td>Practicality - Creative Imagery</td>
<td>2.60</td>
<td>0.13</td>
<td>2.75</td>
</tr>
<tr>
<td>Recently Activated Knowledge-Total</td>
<td>1.20</td>
<td>0.20</td>
<td>1.45</td>
</tr>
<tr>
<td>RAK - Presence of a ball</td>
<td>0.20</td>
<td>0.13</td>
<td>0.27</td>
</tr>
<tr>
<td>RAK - Presence of a high physical activity</td>
<td>0.20</td>
<td>0.13</td>
<td>0.27</td>
</tr>
<tr>
<td>RAK - Presence of an electronic device</td>
<td>0.80</td>
<td>0.13</td>
<td>0.91</td>
</tr>
<tr>
<td>Insight - Candle problem</td>
<td>0.18</td>
<td>0.12</td>
<td>0.25</td>
</tr>
<tr>
<td>Incremental - Tower of Hanoi problem</td>
<td>0.73</td>
<td>0.14</td>
<td>1.00</td>
</tr>
</tbody>
</table>
On the Candle task, the performance of ADHD group did not differ significantly from the control group, $\chi^2(1, N = 32) = 0.134, p = 1$, and the same was true of the comparison between the CD group and the control group, $\chi^2(1, N = 33) = 0.006, p = 1$. There was an unexpected trend to suggest that the CD group tended to perform better on the Tower of Hanoi task relative to the control group, $\chi^2(1, N = 33) = 4.19, p = .065$, but no differences were resulted between the ADHD and control groups, $\chi^2(1, N = 32) = 0.006, p = 1$.

On the recently activated knowledge task, the control group showed significantly poorer performance relative to the ADHD group, $t(29) = -2.807, p < .009$, while the comparison with the CD group revealed a strong trend for the same pattern, $t(30) = -2.014, p = .053$. The performances of the three groups on the recently activated knowledge task are shown in Figure 6.1. No differences were however found on the conceptual expansion task with both the ADHD group, $t(30) = -0.072, p = .94$, and the CD group, $t(31) = 0.793, p = .43$, exhibiting comparable performance to the control group. A closer look at the each sub-element of the conceptual expansion task also revealed no differences between the three groups.

There was a dissociation between the performance of both clinical groups on the creative imagery task such that the ADHD group performed no differently from the control group on the originality dimension, $t(30) = -1.388, p = .18$, but was significantly poorer on the practicality dimension, $t(30) = -2.121, p < .042$. The CD group, on other hand, performed comparably to the control group on the practicality dimension, $t(31) = -1.314, p = .20$, but was significantly poorer on the originality dimension, $t(31) = -3.842, p < .001$. Figures 6.2 and 6.3 display the differences between the groups on the originality-imagery dimension and the practicality-imagery dimension, respectively.

On the alternate uses task, no significant differences were found on the fluency dimension between the ADHD and control groups, $t(30) = 0.546, p = .59$, or the CD and control groups, $t(31) = -1.502, p = .14$. The same pattern was true of the uniqueness dimension, where the performances of the ADHD group, $t(30) = 0.162, p = .872$, and the CD group, $t(31) = -0.963, p = .34$, were not significantly differentiable from the healthy control group.
**Figure 6.1:** The mean and standard error of mean values for the ADHD, CD and control groups are contrasted on the recently activated knowledge task.

![Graph showing degree of similarity to examples for ADHD, CD, and control groups.]

**Figure 6.2:** The mean and standard error of mean values for the ADHD, CD and control groups are contrasted on the originality dimension of the creative imagery task.

![Graph showing mean originality-imagery for ADHD, CD, and control groups.]

As a check, all the analyses on the CD group were repeated after excluding the three patients with mildly co-morbid attentional disturbances (n=9). Results on the conceptual expansion task, creative imagery task and the alternate uses task remained essentially unchanged. The CD group still showed significantly poorer performance on the originality-imagery measure, $t(28) = -3.081$, $p < .005$, but was otherwise not differentiable from the control group on the practicality-imagery score, $t(28) = -1.188$, $p = .25$, fluency-alternate uses measure, $t(28) = -1.271$, $p = .21$, uniqueness-alternate uses measure, $t(28) = 0.915$, $p = .37$, or the total expansion score, $t(28) = 0.888$, $p = .38$.

Slight differences were seen in the obtained results on the recently activated knowledge task and the tower of Hanoi problem when excluding the three CD patients with attentional disturbances. Interestingly, the strong trend for superior performance on part of the CD group relative to the control group was no longer present on the recently activated knowledge task, $t(28) = -1.567$, $p = .13$. The trend for better performance of CD group on the Tower of Hanoi problem was also not found anymore, $\chi^2(1, N = 30) = 3.214$, $p = .14$. 

Figure 6.3: The mean and standard error of mean values for the ADHD, CD and control groups are contrasted on the practicality dimension of the creative imagery task.
6.4 Discussion

The aim of this study was to investigate altered functionality in two clinical adolescent samples on diverse processes of creative cognition in comparison to a matched healthy control group. Advantages and disadvantages were predicted to characterise the ADHD group’s performance relative to the control group based on their frontal lobe function profile. While the performance of the conduct disorder group were expected to closely resemble that of the ADHD group, differences between the two clinical groups were expected to abet clarification about the differences between the cognitive operations in these two disorders.

6.4.1 Summary of Findings and Contextual Influences

With regard to the two convergent tasks of incremental and insight problem solving skills, the ADHD group was hypothesised to demonstrate worse performance on the tower of Hanoi incremental problem relative to the control group while no differences were expected on the candle insight problem. However, the analyses revealed that neither the ADHD nor the conduct disorder group performed differently from controls on either of these problems. It is important to note that an easier version of the tower of Hanoi task was used in this study as all participants were only required to complete the task successfully and no demands were made on the number of moves. It is possible that only the more stringent versions of the tower of Hanoi task could reveal the presence of planning and goal-directed processing impairments. In addition, it may be necessary to investigate more incremental problems in adolescent populations to verify whether any deficits in problem solving would emerge. The incremental and insight problems used in the previous studies were not employed in the present study as those tasks have primarily been used on adult populations. Some of the problems require a minimal level of math and general knowledge to enable successful solving and this would be difficult to gauge and regulate in an adolescent population.

On the alternate uses task, it was predicted that the ADHD group would show better performance on the uniqueness dimension but would be no different from the control group on the fluency dimension. However, there were no differences between the groups on either dimension. This indicates that lack of inhibitory control and increased distractibility did not confer the expected advantage to the ADHD group on the uniqueness measure of the alternate uses. The performance of the conduct disorder group paralleled that of the ADHD group as they were also not significantly different from the control group on either dimension of the
alternate uses task. In some ways this was a surprising results as there is some cause to expect worse performance on part of the conduct disorder group on the fluency measure given that, as mentioned in the Introduction section, dysfunctions across non-executive verbal tasks have been quite widely reported in this population. It is possible however that the discriminatory power of this task was reduced as participants had to generate uses for only three objects in the present study compared to eight objects in the original version (Wallach & Kogan, 1965) of the task. It is possible that having only three trials on this type of task may not suffice to allow for the detection of subtle discrepancies that could result.

With regard to the conceptual expansion task and the recently activated knowledge task, the ADHD group was expected to show better performance relative to the control group as their increased distractibility would facilitate the ability to dissociate from the restrictions imposed in each of the tasks. Although this prediction did not hold true for the conceptual expansion task where the ADHD and control groups performed comparably, the hypothesis was confirmed in the case of the recently activated knowledge task. The ADHD group was far less likely to be impeded by the toy exemplars presented prior to the generation of a novel toy in comparison to the control group. Although there was a strong trend to suggest that the performance of the conduct disorder group tended to correspond with that of the ADHD group, this trend disappeared when the three conduct disorder individuals with attentional disturbances were excluded from the sample. The conduct disorder group then were not significantly different from the control group on either the recently activated knowledge task or the conceptual expansion task. Although performance across both these tasks reflect the influence of context on information processing, they differ in terms of the kind of context that is necessitated.

As highlighted in the previous studies, long-term memory related ‘weak’ or ‘passive’ context effects were proposed to be tapped by the conceptual expansion task, where a context in the form of representations of appropriate schema in stored memory are activated. In the case of the expansion task used in the present study, a context, as provided by the word ‘animal’, activates the schema ‘animal’ which in turn guides actions, i.e., the ‘animal’ schema exerts a dominant influence while the subject generates a novel animal. On the other hand, short-term memory related ‘strong’ or ‘active’ context effects, are implicated in the case of the recently activated knowledge task, a strong and immediate context is induced with the presentation of three exemplars of novel toys (that have three fundamental elements in common) directly prior to when the subject is required to create a new toy. This type of context actively
interferes with the ability to generate a new toy as inhibiting explicit recently activated information that is directly pertinent to the task at hand is difficult. For both the ADHD then, it appears that diffuse top-down control on information processing occurs at the level of the influence of active contexts as gauged by the recently activated knowledge task.

The issue of context also has a direct bearing on the creative imagery task. A fascinating dissociation emerged between the performances of the ADHD and conduct disorder groups in contrast to that of the control group such that the ADHD group were poorer on the practicality dimension of the task while the conduct disorder group were worse off on the originality dimension of the task. The practicality dimension of the creative imagery task taps the ability to make inventions that are functional and usable. The significantly lower score obtained by the ADHD group could be attributed to the hyperactive and impulsive tendencies that characterise the group. Hasty or erratic responses and the resulting by a lack of appropriate planning in this type of generative situation could result in the creation of inventions that are less functional and practical than otherwise.

With regard to the originality dimension on the creative imagery task where the propensity to make unusual and unique inventions are gauged, the ADHD and control groups performed comparably while the conduct disorder group was significantly poorer. Enhanced performance on the originality dimension of the creative imagery task has been posited in previous studies to be abetted by diffuse top-down control as a broader and less focused influence of one’s stored knowledge (passive contextual modulation) would allow for the generation of more atypical and uncommon inventions. By the same token then, poor performance on this dimension would be related to a stronger than customary influence of passive contextual control.

While it may be possible to relate the poor performance on part of the conduct disorder group on the originality dimension to a perseverative type of responding induced in situations that provoke passive contextual processing, it must be also noted that the conduct disorder group exhibited no insufficiencies in performance relative to the control group on the conceptual expansion task, which should also be affected by such alterations in passive contextual processing. Of course there are core differences between the conceptual expansion task and the creative imagery task with the latter involving much more abstraction. Strong correlations for instance, were found in the Psychoticism study between performance on the imagery task, and particularly the originality measure, and IQ measures but not the conceptual expansion
task suggesting that the level of intellectual capacity exerts a vital influence on performance on the imagery task. Conduct disorder has been reliably associated with lower levels of intellectual function (e.g. White et al., 1994; Moffitt, 1993) and this could also possibly explain the reduced performance of the conduct disorder group on this measure.

In general then, the ADHD and conduct disorder groups exhibit divergent patterns of performance across the practicality and originality dimensions of the creative imagery task in contrast to the healthy control group while only the ADHD group exhibit an enhanced ability to be less constricted by examples in the recently activated knowledge task. These findings were chiefly explained with reference to the effect of altered contextual processing arising as a result of reduced inhibitory control in the case of ADHD and a perseverative response style in the case of conduct disorder. How these results relate to the wider spectrum of neuropsychological deficits and theories of ADHD and conduct disorder functioning is less clear-cut because, to date, only a handful of studies have been carried out to directly contrasts ADHD and conduct disorder populations in terms of frontal and executive functions.

6.4.2 Developmental Delay versus Developmental Deviation

One underlying theoretical commonality between ADHD and conduct disorder is that both have been attributed to be brought about by some form of developmental lag or maturational delay in development. The terms by which this developmental delay is defined, however, differs across both these clinical disorders. In the case of conduct disorder, the hypothesis is largely based on observations in the field of social cognition, from which perspective it has been more widely investigated when compared to the neuropsychological domain. Conduct disorder adolescents are characterised by lack of empathic behaviour, a failure to take responsibility for their own actions, and deficits in social information processing in the form of hostile attribution biases and misperceptions of their own and others’ behaviour in that they minimise the maladaptive nature of their own conduct (from Cramer & Kelly, 2004). As these behaviours are more typically exhibited by young children, the deficits in social cognition in conduct disorder are attributed to arise as a result of a developmental lag.

The earliest speculation of the developmental delay hypothesis with regard to brain function in conduct disorder was by Pontius and Ruttiger (1976) where the neurophysiological dysfunction typifying the disorder was attributed to the retardation of the maturing frontal lobe system. Using clinical narrative tests to examine frontal lobe maturity levels in children aged 9-16, juvenile delinquent and non-delinquent samples were found to differ in their stages
of maturity. While 70% of the control subjects exhibited a stage IV level of maturation which marked the ability to switch the principle of ongoing actions and modify it appropriately in the light of new circumstances, only 47% of the delinquents were able to do so. A special case was made for the impact of language dysfunction in facilitating these kinds of executive deficits in light of the maturational delay hypothesis of conduct disorder (Linz et al., 1990).

As mentioned earlier in the Introduction, the delayed development of the frontal lobe has also been put forward to explain the executive deficits seen in ADHD. Studies investigating EEG activity in children with ADHD contributed vitally to this idea. While performing cognitive tasks, ADHD children were shown to have increased theta activity in frontal and central regions, and complementary decreases in beta activity in posterior and temporal regions (e.g. Mann et al., 1992). Given that theta activity increases and beta activity decreases with development, the resemblance of the ADHD EEG profile to that of younger unimpaired children imply that there is a delayed functional maturation of the ADHD brain. However, this pattern appeared to be characteristic of only one type of ADHD that was widely investigated and studies that differentiated between the subtypes of the disorder found quantitative EEG differences, which suggested that the anomalous EEG patterns in ADHD brains was the result of a developmental deviation rather than a lag in the developmental process (e.g. Chabot & Serfontein, 1996).

More recently, a two-component model of ADHD function has been proposed that assimilates both these views (Clarke et al., 2001). The maturational lag principle was backed by hyperactivity/impulsivity component as it matures with age and diminishes in adulthood. The inattentive component, which characterises all ADHD subtypes, however, does not change with development and is thus in line with the developmental deviation hypothesis. As yet, no developmental deviation hypothesis has been put forward to explain the pathophysiology of conduct disorder. It is still too early to pass a verdict on the significance of either the developmental lag or deviation hypotheses primarily because only few studies from limited perspectives have addressed this issue.

6.4.3 Differences in Executive Function

With regard to more specific aspects of cognitive functioning, only a small number of studies have directly contrasted executive functions in ADHD and conduct disorder. Clark, Prior and Kinsella (2000) compared four groups of adolescents categorised as ADHD only, conduct disorder/oppositional defiant disorder only, co-morbid ADHD and conduct disorder and a
normal community sample on two tasks of frontal executive function. The six elements test (Burgess et al., 1997) assesses planning, organising and monitoring behaviour. Participants are instructed to carry out three tasks that involve dictation, arithmetic and picture naming. Each of these tasks is subdivided into two parts, A and B. The participant is required to attempt a part of each of the six sub-tasks within a ten-minute period while keeping in mind is that it is not acceptable to attempt two parts of the same task consecutively. The test score gauges the number of tasks attempted within the ten minutes minus the number of rule breaks, which in turn reflects how well participants organise their actions. The Hayling sentence completion test (Burgess & Shallice, 1997), which was partially introduced in Study 2, provides a measure of response initiation speed and response suppression. Executive deficits across both these tasks characterised the ADHD group but not the conduct disorder group suggesting that the type of impulsivity displayed by both groups are inherently different. The ADHD only group and the co-morbid group were more impaired in their ability to generate strategies and to monitor their ongoing behaviour relative to matched healthy controls and the conduct disorder only group. The executive deficits in the co-morbid groups were therefore attributed as arising from the ADHD component of impaired neuropsychological functionality.

Using the stop-signal paradigm to assess response inhibition, Schachar and his colleagues (2000) found that in a 7-12 year old sample, children with a diagnosis of ADHD displayed deficient inhibitory control when compared to a healthy control sample, a conduct disorder only sample and co-morbid ADHD and conduct disorder children. In another investigation of performance on the Stop task which was compared to performance on the Choice-Delay task, which is a measure of delay aversion, a recent study sought to clarify the utility of the disinhibition hypothesis (Barkley, 1997) in comparison to the delay aversion hypothesis (Sonuga-Barke, 2002) of ADHD neuropsychological function (Solanto et al., 2001). While the ADHD groups performed worse than the healthy control subjects on both measures, the tasks were found to display modest discriminant validity when used alone and excellent discriminant validity when used in combination. The obtained results signified that delay aversion is associated with a broad range of ADHD characteristics whereas inhibitory failure related specifically to the construct of top-down executive control.

Recording event-related potentials (ERP) during a cued continuous performance test (CPT-A-X), another study contrasted four groups of children aged 8-14 years comprising an ADHD-only sample, a conduct disorder/oppositional defiant disorder only sample, a co-morbid
ADHD and conduct disorder sample and a sample of normal children (Banaschewski et al., 2003). Significantly reduced P300 amplitudes were characteristic of both the ADHD only and the conduct disorder only groups to cues and specific distractors linked to attentional orienting. However, only the ADHD group displayed slower and more variable reaction times in comparison to the other clinical and control groups. Ossman and Mulligan (2003), on the other hand, have also investigated ADHD performance on the continuous performance task and reported no significant evidence of a working memory deficit in ADHD but instead found evidence of a deficit on two tasks of inhibitory control, i.e., a negative priming task and the stop task. Another study contrasted a conduct disorder group, a hyperactive (ADHD-related) group and a co-morbid hyperactive/conduct disorder group relative to a healthy control group on specific inhibitory control and impulsivity measures in the form of a delayed reaction time task and a priming task (Leung & Connolly, 1997). The hyperactive group relative to all the other groups were found to be disinhibited at the output stage as they failed to temporarily hold back activated responses.

While specifically looking at inhibitory control deficits in ADHD adults using the anti-saccade task and a negative priming task, Nigg and his colleagues (2002), for instance, found that the ADHD group showed worse performance relative to controls on the anti-saccade task but not the negative priming task. This implied that distinct inhibitory systems were involved in these tasks and that the inhibitory deficit in ADHD was restricted to the reduced ability to prevent a reflexive or anticipated oculomotor motor response. Input inhibitory mechanisms that control the ability to suppress irrelevant information, as assessed by the negative priming task, were spared. Negative priming in ADHD needs to be subject to further investigation as there is evidence for and against the finding of reduced negative priming in ADHD. There is however, much clearer support for the weakening of the executive motor inhibition system in ADHD. Evidence for the same was provided by an ERP study using a Posner attention-shifting paradigm (Perchet et al., 2001). In this task, participants are required to respond with a spatially concordant motor response to left or right visual targets, which are either preceded by a spatial cue or presented uncued. The ADHD characteristic mode of response was characterised by "motor impulsivity" as faster reaction times and more errors indicated that motor responses are carried out before stimulus processing is adequately completed. The ADHD children also showed a lack of strategic planning or anticipatory mechanisms in the absence of warning stimulus, as signalled by the absence of the readiness ERP potential in ADHD patients preceding targets in non-cue conditions. These deficits were partially attributed to deficient maturation of executive frontal functions in ADHD.
So the direct contrasts ADHD and conduct disorder populations, few as they are, indicate that the inhibitory control deficit in neuropsychological functioning is more characteristic of ADHD than of conduct disorder although there is limited evidence to suggest some form of disinhibition in conduct disorder as well. Only recently has a theory been proposed to account for the similarities and discrepancies seen in ADHD and conduct disorder populations. Nigg (2004) suggested that the impulsivity or response inhibition deficits, that are typical of both ADHD-combined type and early-onset conduct disorder, can be differentiated in terms of the conceptual level at which they occur. In the case of ADHD, response inhibition deficits occurs at the level of ‘executive inhibition’ which involves the purposeful suppression of prepotent but task-inappropriate responses in service of a distal goal and can be assessed using the go/no go task, the stop task and the anti-saccade task. Response inhibition deficits seen in conduct disorder arise due to reactive or ‘motivational inhibition’ which refers to the anxiety-motivated interruption of behaviour occurring in context of novel, unexpected or punishment-cue indicators. Any executive inhibitory deficit that arises is held to be secondary to this motivational inhibition.

Executive inhibition is subserved by the fronto-striatal-thalamic system which exerts executive control. Structural and functional imaging studies of ADHD have shown that abnormalities in frontal and striatal regions (e.g. Giedd et al., 2001). Motivational inhibition, on the other hand, is hypothesised to be associated with the Behavioural Inhibition System (BIS) and involves limbic activation. As noted earlier, the BIS or the “punishment-inhibition system” controls is a reactive motivational system given its responsiveness to emotionally salient incentive cues. O’Brien and Frick (1996), for instance, investigated performance in children with conduct disorder and other psychiatric control groups on a task with a steadily increasing ratio of punished to rewarded responses. Children with conduct disorder were found to play more trials in comparison to a normal control group, an ADHD group and an anxiety disorder group, a result which is indicative of a fundamental dysfunction at the level of motivational inhibition. Motivational or reactive control processes and executive control processes are in reality closely associated during the regulation of behaviour. A number of studies have, however, conceptually differentiated between the two. Investigating temporal stability, discriminant validity, and factor structures from an array of performance measures of impulsivity in children with externalising disorders relative to a healthy control group, a two-factor solution emerged which was interpreted as representing cognitive (inhibitory control) and motivational (insensitivity to punishment) components of impulsivity (Kindlon, Mezzacappa, & Earls, 1995).
Given the abundance of evidence in favour of an inhibitory control deficit in ADHD as gauged by cognitive paradigms, it appears that this executive inhibition hypothesis can explain much of the patterns of neuropsychological deficits typical of ADHD. While conduct disorder is also marked by some degree of executive dysfunction, the sparse evidence is very limited with regard to impairments in the absence of co-morbid ADHD. Although motivational disinhibition seems to involved in the case of conduct disorder, it is unclear how this deficit would interact with cognitive performance to produce secondary executive deficits in the face of no obvious punishment or reward incentive.

6.4.4 Implications of the Findings

The present study revealed that the ADHD group exhibited superior performance relative to the healthy control group on the recently activated knowledge task. This enhanced performance was predicted to arise as a consequence of altered active contextual processing which in turn results due to greater distractibility and reduced inhibitory control of immediate contexts in ADHD. This rationale was also used to explain the impaired performance of the ADHD group on the practicality measure of the creative imagery task as they produced less functional and usable inventions. The conduct disorder group was significantly poorer than the healthy control group in generating original responses on the creative imagery task. This discrepant pattern of performance on the creative cognition measures can be explained using the following reasons. It is possible that the greater level of distractibility and poor inhibitory control on part of the ADHD group allowed for more non-stereotypical generation of responses which enabled the creation of more unusual inventions and accordingly, comparable performance to the control group on the originality measure. By the same token however, a concurrent trade-off for less functional inventions could also result, which would account for their reduced performance on the practicality measure.

As executive inhibitory control deficits appear to be secondary to conduct disorder, the worse performance on the originality measures alongside comparable performance on the practicality measure were attributed as resulting from a perseveratory response style which is induced in situations that provoke passive contextual processing which may be not diminished but defective in conduct disorder. Alternatively, given that there was no difference in performance of the conduct disorder group on the conceptual expansion task which would also be detrimentally affected by deficient passive contextual processing, this finding may have resulted due to generally reduced intellectual function which has been widely reported to be typical of the disorder. What appears to be certain is that the degree of distractibility seen
in conduct disorder is lower than the ADHD group, otherwise the performance of the conduct disorder group would have paralleled that of the ADHD group on the creative imagery and recently activated knowledge tasks. The divergence in performance of both clinical groups on the more complex creative imagery task indicates the differential influence of the type and level of contextual influences. Many more explicitly targeted studies are necessary before all of these postulations can be clearly ascertained.

The results obtained in the present study can be extended in many ways to allow for a more thorough understanding of creative cognition with regard to select facets of developmental psychopathology. Although the relatively co-morbidity free sample of ADHD and conduct disorder adolescents in the present study allowed for clear comparisons between the groups, one limiting factor was its small sample size. By recruiting not just more participants per clinical group but also introducing more detailed classifications within the samples, it would be possible to obtain a full spectrum of the wide-ranging differences both across and within clinical samples. Distinguishing between the variable syndromes caused by different ages of onset and between subtypes of the clinical syndromes as, for instance, contrasting patients with ADHD-combined type from those ADHD-inattentive type, would allow for more subtle and fine-grained analyses. Comparisons with other pathological developmental populations, like that of autism, that are not highly co-morbid with ADHD and conduct disorder but where altered prefrontal function is also implicated, would also reveal more about the possible underlying frontal mechanisms of these creative cognitive processes. Cross-sectional studies across different age groups would additionally help determine whether the findings of the present study can be more readily aligned with a developmental lag or a developmental deviation hypothesis.
Chapter 7

General Discussion

In this final chapter, the general implications of the findings that have emerged from the five studies described in the previous chapters will be explored. Diverse processes of creative cognition were investigated in different clinical and non-clinical populations with reference to altered prefrontal function, the degree of which varied considerably depending on the population under study. Schizophrenia is characterised by gross cognitive deficits in frontal function whereas ADHD and conduct disorder exhibit less severe insufficiencies. In the case of the healthy samples who were contrasted based on their degree of psychoticism and schizotypy traits, the extent of altered function is only mild. The ensuing sections will be directed at integrating and weaving a common thread through the heterogeneous pattern of intriguing findings that surfaced in the studies.

7.1 How is Creativity Facilitated and Hampered?

At the root of the various processes of creative cognition – conceptual expansion, originality and practicality in creative imagery, the influence of recently activated knowledge in generativity, insight problem solving, and the degree of novelty and fluency in producing multiple uses for common objects – all of which have been examined throughout this treatise, is the pivotal role of “concepts” in driving thought and action. According to the online Oxford English Dictionary, in the tradition of logic and philosophy, a “concept” is defined as “the product of the faculty of conception; an idea of a class of objects; a general notion or idea.” As opposed to a “percept” which is a single representation, “a concept is a collective (general or universal) representation of a whole class of things”. In essence then, a concept can be said to represent an assemblage of attributes concerning an object, event or notion. Such assemblages or groupings are guided by the principle of associativity and the mental
representations that code for the various attributes of a concept are associated with one another differentially based on the degree to which the attribute is fundamental to the underlying concept. For example, the word “bank” would sooner activate the stronger associate conceptual representation of “money” than the weaker or more remote associate conceptual representation of “river”.

Human cognition is operationally concept-driven. In an effort to make sense of the ever-changing dynamic world around us, our brains are attuned to perceiving “wholes” and not details that make up the “whole”. This is in fact the reason why we readily perceive illusions (even when aware of how the illusion is brought about), and fail to notice small omissions or simple mistakes in sentences. Consider the following example (from Snyder et al., 2003).

\[
A \text{ bird in the } \\
\text{ the hand is worth } \\
\text{ two in the bush}
\]

While reading this proverb, it is unlikely that many would consciously perceive the appearance of the definite article “the” twice consecutively. Another powerful example of the related phenomenon is presented below

\[
\text{THE DOG CHASED THE CAT.} \\
\text{THE CAT RAN AWAY FROM THE DOG.}
\]

In the second line, although the letter ‘a’ in the word ‘cat’ and the letter ‘h’ in the word ‘the’ is virtually the same, the induced context makes one perceive the word ‘cat’ and ‘the’ instead of ‘cht’ or ‘tae’. The brain is thus able to efficiently facilitate comprehension of the constant influx of information by relating incoming stimuli to what is already known. One’s prior knowledge (i.e. acquired concepts), and expectations that derive thereof, exert top-down control on information processing and, in doing so, crucially shapes perception.

It is no wonder then that a vital role for the influence of concepts in the ability to think creatively has been widely advocated. In a series of recent papers, Allan Snyder, for instance, has argued that a breakdown in concept-driven thinking would aid the ability to be creative (1997, 1999, 2004). By examining autistic savants who, despite their brain impairments, display excellent skills in domains such as drawing, music, memory and arithmetic, it was postulated that their exceptional abilities arise as a consequence of their atypical access to
lower levels of “raw” information that is not readily available to normal individuals. Evidence offered in way of this argument were the well-documented case of Nadia, a mentally retarded three-and-a-half year old who could draw from memory with a lifelike perspective and was able to do so untrained and without having passed through the scribbling stage (Selfe, 1977, Snyder & Thomas, 1997). Other savant skills have also been accounted for in a similar manner. Absolute pitch, for instance, is rare in the normal population with an occurrence of one in 10,000 individuals. However, all musical savants exhibit perfect pitch which is indicative of access to lower levels of auditory information that escapes the normal population (Miller, 1989). The ability to recall remarkably detailed information, unusual olfactory and tactile discrimination, and other such savant skills all serve to reinforce this line of reasoning.

As concepts are continually acquired with experience, vestiges of such skills as seen in autistic savants should also be found to vary as a function of development. Evidence for the same has in fact been brought to light. The capacity for eidetic imagery, for instance, has been found to diminish with age (e.g. Giray et al., 1976). More recently, 6-month old infants were able to discriminate between human and monkey faces but by the age of 9-months, infants could only discriminate between faces within their own species (Pascalis, De Haan & Nelson, 2002). Similarly, in the auditory domain, infants between 4-6 months of age were able to discriminate between phonetic differences in foreign languages but by the age of 10-12 months, only differences in the native language could be identified (e.g. Kuhl et al. 1992; Cheour et al, 1993). Also, there is some evidence to suggest that infants are likely to have absolute pitch (e.g. Saffran & Griepentrog, 2001).

According to the model developed by Snyder and his colleagues (2004) then, there is a shift through the course of development from sensory-driven cognition to concept-driven cognition. With the formation of a concept, sensory details or object attributes are removed from the purview of conscious or “executive” awareness. The world is experienced and information processing is efficiently managed through these “mental templates” or concepts in the brain. A case in point here is that of the well-known Dalmatian illusion where the Dalmatian dog in the picture can be readily perceived within a few seconds of presentation. However, when presenting this illusion to a person who was brought up in Africa and was unfamiliar with Dalmatians, he identified a hyena instead, which faced the opposite direction from the Dalmatian (Snyder et al., 2004; pages 40-42). This implies that unless one knows what a Dalmatian looks like or has acquired the concept of Dalmatian dog, it would not be possible to perceive a Dalmatian dog in this picture. A similar argument could likewise be
applicable in the case of the perception of a hyena in the illusion. Although familiar with the concept of hyena and the animal looks like, most people in the West would be far less familiar with the form of hyenas than Dalmatians and are thus unlikely to recognise the form of a hyena in the illusion as the Dalmatian concept would exert an overriding influence on perception.

While the importance of accessing lower-level sensory information in the capacity to develop exceptional savant skills may be notable, the allusions of this formulation with regard to normative processes of creative cognition seems to be limited. Most formulations with regard to normative creative cognition or divergent thinking instead focus on differential aspects of functionality within the influence of top-down or concept-driven processes. This is because although human beings are bound to become more concept-driven with development there is no evidence to suggest that development is accompanied by a corresponding decrease in creative output. In general, concept-driven (top-down) and sensory-driven (bottom-up) processes dynamically interact to facilitate information processing and, given the multidimensional nature of creativity, there are many generative situations that are affected by variables within concept-driven processing.

In accordance with this line of reasoning, most theories and formulations of creativity that have been introduced throughout this treatise account for the emergence of normative divergent thought processes from what can be largely defined as a connectionist framework (Martindale, 1995). In operationally defining different aspects of cognition, a connectionist or neural network model consists of a number of components including a set of processing units or nodes that are activated beyond a threshold, a pattern of connections between nodes that can be either excitatory or inhibitory, and input rules, concerning how a node combines its input, and output rules about how output relates to current activation. Along with an appropriate environment for such a network, learning rules also need to be established and contemporary theorists usually employ Hebbian learning principles (1949) such that if two nodes are simultaneously activated, the connection between them is strengthened.

By and large, most formulations of creative thinking contrast the differing abilities of highly creative individuals from those less creative on the basis of differences in the distributed pattern of cortical activation. As highly creative individuals are believed to have a wider associative horizon than customary, there is a greater likelihood of two distant nodes being simultaneously activated during the spread of activation and, with it, the emergence of
unusual and original associations (Kasof, 1997; Mendelsohn, 1976). This would account for how original ideas are formulated as they constitute new combinations of existing ideas. A poet, for instance, does not conjure up new words but instead combines known words in novel ways (Martindale, 1995). Virtually all of the critical cognitive variables that have been proposed to account for enhanced creative abilities can be understood within this mould be it the Eysenkian conception of overinclusive thinking, Mendelsohn’s theory of defocused attention, or flat associative hierarchies as proposed by Mednick. Central to all of these conceptualisations is the significance of loosened associational thinking.

The significance of hemispheric specialisation in this light has been outlined in chapter 5 where the strengthening of right hemisphere processing is associated with greater associative thinking. That a decrease in left hemisphere dominance would be related to wider associational thinking and enhanced creative ability has been demonstrated in laterality studies (Poreh et al., 1993-1994; Weinstein & Graves, 2001, 2002). Some researchers have taken this a step further by directly studying circumscribed lesions in the brain and the manner in which they affect creative output. Bruce Miller and his colleagues (1998, 2003) have identified that in a minority of patients with fronto-temporal dementia (FTD), remarkable artistic abilities have developed post-stroke in individuals even with no prior training or background knowledge in art. Such abilities were mainly found in patients with the temporal lobe variant of FTD, i.e., where the dorsolateral prefrontal cortex is spared. In addition, enhanced creative ability was found to occur most often in FTD patients with left hemisphere damage. Damage to the left hemisphere which is dominant for language, memory and emotional control thus appears to allow the right hemisphere which is dominant for musical and imagery capabilities to emerge unfettered.

One contemporary study used Transcranial Magnetic Stimulation (TMS) to induce “virtual lesions” (Pascual-Leone, et al., 1999), in investigating this phenomenon of reduced left hemisphere dominance and creative output (Snyder et al., 2003). Participants were required to complete two drawing tasks. The first task involved drawing a horse and a dog over two sessions separated by a week and the second task involved having to reproduce the image of a female face that they were exposed to for 30 seconds beforehand. TMS was found to affect the drawing ability in four out of eleven participants. Whether the drawings produced during and shortly after the TMS were more “creative” is a debatable matter, but changes in the stylistic elements of the drawings were seen such that low-frequency TMS of the left fronto-temporal lobe was accompanied by changes in the schemas or conventions of the drawings of
the participants, as opposed to the placebo stimulation condition in which no such changes emerged. These are, as yet, very preliminary results and far stronger tests and manipulations will be required to verify these findings. Using this novel paradigm, this study does however, bring to light yet another avenue by which these ideas of creative thinking and brain function can be further explored.

7.2 Relating Creative Cognition to Cortical Function: The Present Approach

The approach adopted in the cohort of studies introduced in the previous chapters was guided with a view to relating atypical prefrontal function and consequent alterations in top-down executive function with differences in performance along varied creative cognition variables. Different clinical populations – schizophrenia, ADHD and conduct disorder – that demonstrate varying levels of pathophysiology of the prefrontal cortex were contrasted.

The fronto-striatal system has been found to be crucially involved in facilitating conceptual reasoning faculties in human beings (Rao et al., 1997). Conceptual reasoning deficits arise not only as a consequence of lesions of the dorsolateral prefrontal lobes but also in the presence of subcortical lesions of the basal ganglia, the thalamus and the cerebellum which is suggestive of a wide neural network that supports this primary executive function. Pathophysiology of the frontal and basal ganglia systems have been reported across ADHD and schizophrenic populations, although the precise nature of the pathology is still contentious. Structural and functional abnormalities of the frontal and basal ganglia regions have been reported in schizophrenia (e.g. Hirayasu et al., 2001; Bogerts et al., 1985) and in ADHD (e.g. Castellanos et al., 1996; Vaidya et al., 1998).

A significant role for the neurotransmitter dopamine has been postulated in both disorders. Genetic variants in genes that are known to contribute to the function of dopaminergic neurons, the Dopamine Transporter (DAT1) and catechol-O-methyltransferase (COMT) genes, have been implicated in ADHD and schizophrenia (Casey, Tottenham & Fossella, 2001). Just as in the case of positive symptoms in schizophrenia, hyperactivity in ADHD has been posited to result from excess dopaminergic activity in the striatum (e.g. Ernst et al., 1999). Grace (2001) in his model of dopaminergic dysfunction in ADHD has proposed that due to the reduced stimulation of the prefrontal cortex, children with ADHD exhibit low tonic
dopaminergic activity in limbic regions which in turn brings about high phasic activity in the nucleus accumbens that gives rise to poor impulse control and motor dysregulation. Stimulant medication increases synaptic dopamine by blocking dopamine reuptake which in turn increases tonic dopamine levels by diffusing to the extracellular space. This allows for phasic dopamine release to reduce to normal levels.

Both schizophrenia and ADHD populations also show similar neuropsychological deficits on tasks of frontal function with schizophrenics showing more severe deficits of almost all facets of executive function, especially working memory, inhibitory control and set-shifting. Patients with ADHD also manifest executive impairments but most of the evidence is primarily points to an inhibitory control deficit. It must also be noted that ADHD individuals manifest higher levels of general intellectual and neuropsychological functioning in comparison to schizophrenia as ADHD is a far less debilitating disorder. A recent model of cognitive control has sought to differentiate between two aspects of executive control, namely the ability to inhibit competing inappropriate thoughts and behaviours, and the maintenance of representations of relevant information for action (Casey et al., 2001). The former is held to be implemented by the basal ganglia while the latter is the domain of the prefrontal cortex and in accordance with this, ADHD is held to arise from primary deficits in basal ganglia function while impaired cognitive function in schizophrenia is associated with deficits at the level of prefrontal function. As of now, it is still too early to assess the validity of this distinction especially when considering that although there are many theoretically dissociable facets of executive function (Robbins, 1996), they constantly interact with one another which makes it problematic to tease apart the effects of only individual aspects of executive cognition.

In the case of conduct disorder, as far fewer studies have been targeted at uncovering the neurobiological and neuropsychological markers of this disorder. As outlined in chapter 6, there is some limited evidence of altered frontal lobe function which is fitting given the role of the orbitofrontal cortex in facilitating antisocial behaviours and the dorsolateral prefrontal cortex in cognitive functioning (Séguin, 2004). In line with this, Raine (2002) has advocated a prefrontal hypothesis to account for the underpinnings of antisocial personality disorder, which is the more severe analogue of conduct disorder. The neuropsychological deficits associated with this disorder are primarily related to language dysfunction and a generally lower level of intellectual functioning. While there is limited evidence for executive function impairments in conduct disorder, these insufficiencies seem to manifest primarily when conduct disorder is co-morbid with ADHD. In an study comparing ADHD and conduct
disorder children across a range of cognitive and behavioural measures, the ADHD group were found to be more impaired on inhibitory control and response alteration cognitive measures and showed a greater delay in development, whereas the conduct disorder group was characterised by poorer arithmetic performance and psychosocial problems (Schachar & Tannock, 1995). In contrasting the seemingly parallel findings of impulsivity in responding in ADHD and conduct disorder, Nigg (2004) proposed that while ADHD is characterised by deficits in executive inhibition, while conduct disorder is marked by deficits in motivational inhibition which could bring about secondary executive function impairments.

Alongside these clinical populations, samples deriving from non-clinical populations based on the degree of select personality variables – psychoticism and schizotypy – were also examined. These constructs are held to represent the normal analogue within the dimensional psychosis-normality approach. There is some evidence relating slight alterations in prefrontal neuropsychological function in the presence of a high degree of such personality traits, especially in the case of schizotypy. Although evidence for the same was not found in the present investigations, a lack of sensitivity in the frontal measures employed in study 5 may be responsible for the non-significant findings. While the level to which either of these constructs best represents the dimensional equivalence of schizophrenic psychosis is still contentious, given the heterogeneity of schizophrenia, its possible that both schizotypy and psychoticism represent different constellations of the same disease entity. Apart from being able to avoid confounding factors such as the duration of illness, age of onset and medication effects, the advantage of investigating non-clinical samples also allows for the extension of the implications deriving from the results to the normal population. The parallels and divergences between the patterns of performance from the differing groups would thus enable the development of a more thorough understanding of some aspects of creative cognitive function.

7.3 Integration of the Findings

A crucial factor guiding the approach adopted in the present treatise was recognition of the heterogeneity of creativity and the realisation that various aspects of creative thinking or creative cognition can be teased apart and examined differentially. The differences in the performances of the investigated clinical and non-clinical groups across different processes of creative cognition were predicted on the basis of their altered patterns of neuropsychological
functioning. The results were revealing in that they uncovered the cognitive constructs tapped by each of the creative cognition tasks, and, most significantly, subtle differences in performance across different experimental clinical and non-clinical groups were detected. Considering the related neuropsychological profiles of the groups, the resultant pattern of findings with regard to similarities and differences may be useful in differentiating subtle aspects of altered cognitive functionality.

The summary of all the results from all the studies across all the creative cognition variables is presented in Table 7.1. Contrasts include that between the high and low psychoticism groups, the high and low schizotypy groups, the ADHD clinical group versus a healthy control group, and the conduct disorder clinical group versus a healthy control group. Six contrasts on the patients with schizophrenia were carried out in comparison to a healthy control group using an undifferentiated schizophrenic sample (first study), an enlarged undifferentiated schizophrenic sample, a low positive/low negative symptom schizophrenic subgroup, a low positive/high negative symptom schizophrenic subgroup, a high positive/low negative symptom schizophrenic subgroup, and a high positive/high negative symptom schizophrenic subgroup. The performances across the groups will be contrasted individually for each process of creative cognition.

7.3.1 Conceptual Expansion
Performance on this task was expected to be reliant on the type of influence exerted by stored conceptual structures in long-term memory on information processing. The terms “passive context” were coined to reflect this kind of top-down influence. Top-down or concept-driven control was differentiated into two types depending on whether the influence was directed by prior knowledge (passive context) or was implicitly goal-related, but not goal directed (active context). In the case of the conceptual expansion task, constraints on being able to expand the ‘animal’ concept are imposed by the extent to which top-down factors such as one’s past experience and existing knowledge in the form of conceptual structures of animals influence the ability to generate of a novel kind of animal. A diffuse activation of more loosely associated stored conceptual structures (passive context) would abet performance on this task. Conversely, a severe disruption in the activation of associated conceptual structures would result in a perseveratory response style and consequently, reduced conceptual expansion. This task was employed in all the studies and the results revealed no differences on this task for the ADHD, conduct disorder and schizotypy groups. The high psychoticism group, however, showed better performance on this task relative to a low psychoticism group.
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**Table 7.1:** A compilation of the findings on each of the creative cognition variables for all samples from the five studies.

Guide to abbreviations:

- SZ – schizophrenia
- RAK – recently activated knowledge
- Ctrl – age matched control group
- CD – schizotypy
- ADHD – attention deficit hyperactivity disorder
- Ctrl – age matched control group
- (T) – trend
- N/T – not tested
- lpos – low positive symptoms (schizophrenia)
- lneg – low negative symptoms (schizophrenia)
- hpos – high positive symptoms (schizophrenia)
- hneg – high negative symptoms (schizophrenia)

= – no differences between the groups
=* – only one convergent problem tested
This implies that the high psychoticism group were characterised by more diffuse top-down control with regard to passive contextual processing as they were able to activate more loosely associated representations and were thus able to better expand the animal concept. In contrast, almost all the comparisons on the patients with schizophrenia showed worse performance on part of the schizophrenic group in that they were poor at expanding concepts. The only two contrasts on which the schizophrenics performed comparably to the control group were those with the high positive symptom schizophrenic groups. Given that the positive symptoms in schizophrenia have been related to a disrupted relationship between long-term memory representations and sensory input (Hemsley, 1994), it would appear that the more diffuse activation of long-term memory representations allowed for these schizophrenic subgroups to expand in animal concept in a comparable manner to that of the control group.

7.3.2 Recently Activated Knowledge

The type of top-down influence that was believed to modulate performance on this task was active contextual control. A strong or active context is induced in the recently activated knowledge task with the presentation of three exemplars of novel toys (that have three fundamental elements in common) directly prior to when the subject is required to generate a new toy. This type of context actively interferes with the ability to generate a new toy as inhibiting explicit recently activated information that is highly relevant to the task at hand is difficult. Reduced inhibitory control would thus be advantageous in performing well on this task as increased distractibility gets in the way of maintaining relevant information.

This task was not carried out in the psychoticism study so it is not possible to allude to how the performance on this task would be affected as a function of psychoticism. The conduct disorder group was found to perform comparably to the healthy control group on this task. Although not tested in the first study on schizophrenia, this task was employed in the second larger schizophrenia study. Both the general group contrast and the symptom group contrasts revealed no significant differences between the patients with schizophrenia and a matched control group in terms of their performance on this task. In the case of the ADHD, the clinical group showed superior performance relative to the matched control group on this task. The same was true for the schizotypy comparison such that the high schizotypy group was better able to invent toys that were dissimilar to the previously presented examples when compared to the low schizotypy group.
The performance of ADHD and high schizotypy groups can be accounted for with reference to diminished top-down control with regard to active contextual processing, considering that inhibitory control deficits have been associated with these populations, albeit less so in the case of schizotypy. Considering that schizophrenics also show severe inhibitory control deficits, it is likely that they were able to perform comparably to the control group given that their increased distractibility would allow them to bypass the constraints imposed by the induced context and would enable them to produce toys that differed from those of the previously presented examples. However, unlike the case of the ADHD and high schizotypy groups, this tendency does not allow for a clear advantage as they do not show superior performance relative to the control group. This may be because the degree of their general level of neuropsychological function is far more markedly impaired in comparison to ADHD.

7.3.3 Creative Imagery: Originality

With regard to the originality dimension on the creative imagery task where the propensity to make unusual and unique objects are assessed, enhanced performance was posited to be abetted by diffuse top-down control as a broader and less focused influence of one’s stored knowledge (passive context) would allow for the generation of more atypical and uncommon inventions. In the same way, poor performance on this dimension would be related to a stronger than customary influence of passive contexts or stored representations in long-term memory. Furthermore, the level of general intellectual function was also deemed to play a role in the performance of this task given the level of abstraction required while carrying out the creative imagery task.

This task was employed in all the five studies. No differences emerged in the ADHD contrast as the ADHD group showed comparable performance to that of the control group. The high and low schizotypy groups were also indistinguishable on this dimension. The psychoticism contrast showed differences such that the high psychoticism group were better able to generate original inventions compared to the low psychoticism group. The conduct disorder group, however, showed worse performance relative to the control group on the originality-imagery dimension. While no differences were found between schizophrenics and matched controls in the first study, using a modified version of the creative imagery task, the second general level contrast revealed that the schizophrenics made less original inventions than the control group. The symptom contrasts, however, did not lend additional information to this finding as no there were no differences between any of the symptom groups and the control group on this measure. As psychoticism was associated with better performance and
schizophrenics showed worse performance, results on the conceptual expansion task paralleled those of the originality-imagery measures and this pattern fits given that both tasks are affected by passive contextual processing. Although they performed no differently relative to the control group on the conceptual expansion task, the worse performance of the conduct disorder group on the originality-imagery measure, which is a comparatively more complex and demanding task, was believed to be related to the lower level of intellectual function that is generally reported in this population.

7.3.4 Creative Imagery: Practicality

The practicality-imagery dimension of the creative imagery task taps the propensity to invent objects that are functional and usable. In contrast to the originality-imagery measure, a perseverative style of responding was predicted to aid performance on this dimension. A erratic or hasty response style and a lack of appropriate planning would result in poor performance on this measure as it would result in the invention of objects that are less usable and practical. There was thus a strong chance of some form of a trade-off occurring such that a very low originality-imagery score would be accompanied by adequate performance on the practicality-imagery measure, and conversely, a significantly low practicality score would be accompanied by comparable performance relative to that of a control group on the originality-imagery measure. No specific assumptions were made about the influence of contextual processing on this aspect of creative cognition.

Neither the psychoticism nor the schizotypy contrasts revealed any differences in performance on the practicality-imagery dimension. The same pattern was true of the two schizophrenia studies where both general level contrasts revealed no significant differences between the patients with schizophrenia and the control group. One symptom group contrast, however, found that the high positive/high negative schizophrenic group was worse at producing functional and workable inventions compared to the control group. Poorer performance on this measure was also recorded for the ADHD group while the conduct disorder group performed comparably to the control group. So no experimental group was noted to have an advantage in being able to generate useful and practical inventions in this task which provides a measure of the creative cognitive process of “relevance”. The ADHD and the high positive/high negative schizophrenic groups, however, showed poorer performance and this was held to be related to inadequate planning and consequent impulsive and erratic responding when faced with having to invent an object in this task.
7.3.5 Convergent Problem Solving: Insight

As insight analytical problems involve reaching a goal under conditions imposed by a given “means” state, functional goal-directed thinking is essential for adequate task performance on insight problems. However, as restructuring of the problem situation is required to able to successfully reach a solution, a greater activation of loosely associated representations in contextual processing, which would aid restructuring, could confer an advantage on this type of task. As a strong context is also induced during this task with “means” state, both active and passive contextual effects would jointly influence the capacity to perform well on this type of task.

The findings across the studies revealed that the performance on insight problems was not affected as a function of psychoticism. Only one insight problem (the candle task) was investigated in the ADHD and the conduct disorder study so the implications of the results on this study are limited. Both clinical groups were found to show comparable performance to that of the control group on this task. Significant differences were, however, found in the case of schizotypy where the high schizotypy showed better performance relative to the low schizotypy group. While no differences were found in the first schizophrenic study, the general level comparison in second study revealed worse performance on part of the schizophrenics on insight problem solving. Symptom group analyses revealed that this poor performance was only true for the high negative symptom schizophrenic groups. This pattern of findings suggests that convergent problem solving skills are impaired in schizophrenics and as this pattern was especially true of the negative symptom subgroups that manifest severe executive function deficits, this poor performance can be related to impaired goal-directed thinking. However, in schizotypy where goal-directed thinking is not defective and diffuse top-down control on contextual processing is operant, superior performance on the insight problem solving task was found to characterise the high schizotypy group relative to the low schizotypy group.

7.3.6 Convergent Problem Solving: Incremental

As in the case of insight problems, incremental problem solving also involve reaching a particular goal state under conditions of a given “means” state. Successful goal-directed thinking is thus also crucial for adequate task performance on incremental problems. However, unlike in the case of insight problems, incremental problems can be solved in a step-wise manner and do not require restructuring. A greater activation of loosely associated
representations would thus not be advantageous in solving this kind of problem. In fact too much of the same would impair goal-directed thinking and lead to poorer performance.

No differences were found on either the psychoticism of the schizotypy contrasts on this task. Similarly in the case of ADHD and conduct disorder where only one incremental problem (Tower of Hanoi) was investigated there were no significant differences in the performance of these clinical groups relative to a control group. However, the schizophrenia contrasts revealed impaired performance on part of the patients relative to the control group. Symptom subtype contrasts revealed that apart from the low positive/low negative group, who also showed least impairments in terms of executive deficits, all other groups showed a trend and in the case of the high positive/high negative group significantly poorer performance on the incremental problems. These results and those of the previous section implicate the crucial role of functional goal-directed thinking in incremental and insight problem solving.

7.3.7 Alternate Uses task: Uniqueness

One of the more widely used tests in the field of creativity research is the alternate uses task. The uniqueness measure of this task gauges the extent to which novel and unusual uses can be generated for common objects. Diffuse top-down control in the form of passive contextual processing would abet performance on this task as the ability to tap loosely associated stored representations to the concept in question would give rise to more remotely associated and unique responses.

Unfortunately, this task was not used in the psychoticism study so it is not possible to match the performance of the psychoticism groups on this measure with that of the conceptual expansion and originality-imagery measures. No differences in performance were found on the uniqueness measure in either the ADHD contrast or the conduct disorder contrast. Likewise, there were also no differences between the high and low schizotypy groups on this measure. The schizophrenia contrast however revealed poorer performance on part of the patients in comparison to the control group. Worse performance was primarily associated with the low positive symptom groups as both the high positive symptom groups showed comparable performance to the control group. This pattern of performance of the schizophrenic sample on the uniqueness measure mirrored that of their performance on the conceptual expansion task and this divergence in performance based on symptom clusters was held to been brought about by loosened associational thinking which accompanies positive schizophrenic symptoms.
### 7.3.8 Alternate Uses task: Fluency

The second measure of the alternate uses task is that of fluency which assesses the total number of responses generated on this task. Diffuse top-down control would not necessarily aid this task as the activation of more widely associated representations does not translate to having more representations that can be used effectively to give rise to more responses. Fluency is widely regarded as one of the core features of frontal lobe function and impairments across varied types of verbal fluency measures have been reported in ADHD, conduct disorder and schizophrenia.

On the creative cognition process of fluency, similar to the case for the uniqueness measure, no differences were found on the schizotypy, ADHD or conduct disorder contrasts. Again, as the alternate uses task was not used in the psychoticism study, no conclusions can be reached about this measure with regard to psychoticism. However, in the case of schizophrenia, the results unequivocally demonstrate that schizophrenics have much poorer levels of fluency in comparison to controls. This pattern was found regardless of the degree of symptoms as all the schizophrenic symptom subgroups showed poor performance on the alternate uses fluency measure.

### 7.4 The Global Picture

The significant role of contextual factors in information processing was first brought to light in the early 20th century by the advocates of the Gestalt school of psychology in stressing that one’s experience of the world is more than what is provided by the senses. These early ideas concerning the role of context and the organizational abilities of the brain in efficiently perceiving the ever-changing world have been widely adopted in numerous ways to explain its crucial role in shaping cognition (e.g. Phillips & Silverstein. 2003).

In identifying a vital and multifaceted role for contextual factors in facilitating different aspects of creative cognition, this large pool of findings can be better understood by classifying the influences of context or top-down control on information processing to be of three types: active context-related (largely short-term memory related in that a strong current context is induced which has an interference effect), passive context-related (predominantly long-term memory related), and goal-related (chiefly working memory related in that relevant
information needs to be actively maintained in service of a goal). The recently activated knowledge task seems to tap purely active context-related processing effects while the conceptual expansion task, the originality-imagery measure and the uniqueness measure of the alternate uses task gauge passive context-related processing effects to varying degrees. Goal-related processing affects incremental problem solving, whereas all three types of top-down mechanisms seem to play a role in insight problem solving. The practicality-imagery and fluency measures are distinct from the others in that the former gauges the usefulness or relevance of responses while the latter assesses the yield or total number of responses generated. Top-down processing factors are presumed to play a less predictable or straightforward role on these creative cognition measures.

With regard to differential top-down processing patterns, schizotypy is associated with active context-related diminished processing while psychoticism is associated with more passive context-related diffuse top-down control. The schizophrenic group exhibited pronounced top-down control deficits as they manifest passive context-related insufficiencies as well as impaired goal-directed processing, both of which were primarily associated with a high degree of negative symptoms in schizophrenia. The only experimental task on which the schizophrenic groups showed comparable performance to the control group was the recently activated knowledge task, the purely active-context related processing task. On this particular type of contextual processing, just as in the case of schizotypy, the ADHD group also exhibited diminished active context processing. Disrupted inhibitory control appears to allow for schizophrenic performance to be comparable to that of the control group whereas less severe degrees of diminished inhibitory control as seen in ADHD and only to a slight extent in the case of schizotypy, seems to confer an advantage on this active context task. The conduct disorder group like the schizophrenic group displayed some degree of passive context deficits but only in complex processes of creative cognition. The performance of the ADHD group paralleled that of the schizophrenic group in so far as both show a worsened ability to make useful and functional responses on the practicality-imagery measure.Markedly reduced fluency abilities were only characteristic of schizophrenia.

It is possible to partially align these differences in the modulatory role of contextual factors on creative cognition within a connectionist framework, as has been done earlier (Martindale, 1995) in relating loosened associational thinking with the enhanced capacity to generate original responses. Diffuse active and passive context processing would result in the activation of distant nodes that are simultaneously activated during the spread of activation,
allowing for the emergence of unusual and unique associations. Active and passive context effects however, differ in terms of the level or the depth of processing at which this spread of activation takes place. In active contextual processing, exemplars provide immediate and concrete representations from which the activation of related associations ensues. Passive contextual processing, however, relies upon the activation of stored conceptual structures and prototypical representations which gives rise to the activation of related associate representations. Goal-directed contextual information would serve to taper the number and extent of the activated associations to only the most salient and relevant ones.

7.5 Conclusions and Implications

In conclusion, the findings from the series of studies in this treatise that tackled the issue of top-down executive influence of information processing on various facets of normative creative cognition suggest that the effects of alterations in top-down control can be best understood as having an inverted-U shaped function. Defective top-down control as seen in schizophrenia is accompanied by markedly poor performance across most creative cognition measures. On the other hand, more diffuse top-down processing that is characteristic of a far less severely impaired clinical group like ADHD, and is also present to a mild extent in the presence of a high degree of schizotypy and psychoticism traits, is associated with enhanced performance on some of the creative cognitive measures. So while diffuse top-down activation appears to confer some degree of a “cognitive advantage” on select processes of creative cognition, too much top-down control (customary levels) or too little top-down control (completely disrupted or impaired top-down control) poses a hindrance.

Furthermore, distinguishing between various types of top-down influences in facilitating subtle differences in the performances of the clinical and non-clinical groups appears to have merit as it allows for a more thorough understanding of the diverse effects that emerged. The schizophrenics exhibited goal-related processing and passive context processing deficits but no impairments in active context processing. Poorer performance on the creative cognition measures was primarily associated with negative symptoms while comparable performance to the healthy control group was related to a greater degree of positive symptoms. High levels of schizotypy were associated with active context advantages whereas passive context processing advantages were related to the presence of high psychoticism traits. These two
constructs thus seem to represent rather unrelated facets with regard to the dimensional conception of schizophrenia. The ADHD group exhibited active context processing advantages while the conduct disorder group revealed deficits in some facets of complex passive context processing. Apart from the facet of ‘originality’ which was generally tapped by most of the measures, the ability to make relevant responses was impaired in both the ADHD and schizophrenic groups while inadequate ideational fluency was typical only for the latter group.

The implications of the diverse findings that resulted from the studies are vast and have a vital bearing across a diverse range of research domains including that of creativity, prefrontal function, personality theory, and the neuropsychology of schizophrenia, ADHD and conduct disorder. In demonstrating that both the “degree” and “type” of contextual or top-down influences can differentiate varied clinical and non-clinical groups in terms of their normative creative cognition faculties, the present findings have allowed for a deeper understanding of the diversity in the cognitive functioning of these altered states. Furthermore, a more complicated role for top-down executive functions than previously assumed has been shown to have a vital bearing on the cognitive profiles of these varied conditions. More comprehensive investigations are necessary to ratify the validity of the proposed classification of the effects of top-down contextual modulation which could in turn allow for the development of more precise indices and markers to characterise these populations. The adoption of a broader “systems” approach in examining the interaction of the prefrontal cortex with other brain structures in orchestrating executive control would allow for a more thorough appreciation of the immense complexities and subtleties of top-down contextual control in information processing.

With regard to the domain of creativity research, as most of the measures employed in the studies primarily tapped various facets of the originality construct, the findings demonstrate the tremendous diversity that can result from subtle manipulations within the construct of originality itself. Several key issues were found to be critical in this light including defining the cognitive process in question, identifying the task used to tap the process, and outlining the cognitive operations that are called for during the task and the contextual processing factors that influence it. The insights gained from the present treatise could conceivably provide the catalyst for an increased impetus in the multidisciplinary study of creativity – a field that is of utmost fascination but to which the clinging shroud of mystery repels concerted scientific investigation.
Bibliography


Thesis Summary

Little is known about the dynamics of creative thinking with regard to brain function. Given the extremely heterogeneous nature of creative cognition, select creative mental operations were teased apart, defined and investigated with reference to the role of prefrontal cortex, which is the chief structure that has been implicated in higher-order cognition as it is the area known to integrate diverse streams of information from different parts of the brain. The prefrontal lobe exerts top-down control on information processing which refers to the influence of goals, knowledge and expectations that derive thereof on the processing of incoming information.

In general, a product is judged to be creative in the extent that it is both original and relevant to a particular end. An enhanced ability to generate original responses has been posited to arise as a result of loosened associational thinking which refers to the activation of more remotely associated mental representations than customary. Defocused attention or reduced inhibitory executive control plays a critical role in facilitating loosened associational or overinclusive thinking. This is especially significant with regard to top-down control on information processing as it involves the influence of existing conceptual structures. If broader associational thinking is related to a greater ability to generate original responses, investigating varying populations with altered prefrontal top-down function should reveal differences in the capacity to produce original responses in an explicitly generative situation.

Three studies were conducted using a clinical approach where samples of patients with schizophrenia, attention-deficit/hyperactivity disorder (ADHD) and conduct disorder, populations that are characterised by varying degrees of prefrontal executive deficits, were investigated. Two further studies were carried out from a non-clinical perspective on healthy samples that were differentiated based on the magnitude of select personality traits, psychoticism and schizotypy, that are associated with mild insufficiencies in executive
function. The collective pattern of findings suggests a complicated and critical role for diverse factors within top-down executive control of information processing. Selective aspects of contextual modulation were differentiated based on the type of creative cognitive operation in question: active contextual processing, which was short-term memory related; passive contextual processing, which was long-term memory related; and explicitly goal-directed processing, which was working-memory related.

Enhanced performance on some facets of creative cognition, where a diffuse influence of top-down active contextual processing would be beneficial, were found in the high schizotypy and ADHD samples. In generative situations where diffuse top-down passive processing influences would be profitable, the high psychoticism sample demonstrated some limited advantage. The schizophrenics showed markedly poorer performance which was related to reduced top-down control with reference to passive and goal-related context effects. This poor performance was, however, chiefly found in the presence of negative symptoms and not positive symptoms.

The general picture that emerged from the evidence outlines a crucial role for both the “degree” and “type” of top-down control in orchestrating certain aspects of creative cognition. The adoption of a wider “systems” approach would allow for a more comprehensive understanding of the many complexities and subtleties within the creative cognition domain.
This dissertation has been completed and written independently without external assistance. Furthermore, this dissertation has never been submitted in this or a similar form at this or any other domestic or foreign institution of higher learning as a dissertation. The "Guidelines for Good Scientific Practice" (Leitlinien guter wissenschaftlicher Praxis und Grundsätze für das Verfahren bei vermutetem wissenschaftlichen Fehlverhaltens) according to § 9, Sec. 3 of the Promotionsordnung der International Graduate School of Neuroscience der Ruhr-Universität Bochum were followed.
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