Creativity and Attention: A Multi-Method Investigation

Lindsey Carruthers
Edinburgh Napier University

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Dedication

To Peter and Judy Carruthers, my wonderful parents. Your kind words, encouraging texts, supportive phone calls, reassuring hugs, endless handouts, and free meals, it has all meant the world to me. Thank you for your patience with me, and thank you for pretending to believe me when I said I wasn't procrastinating. You've been with me on every step of this journey and I have appreciated *everything* you have done for me.

Katrina, my adoring sister. You are my inspiration and my hero. My studies have helped me understand you a little better, and I hope this makes me a better, more patient person. Thank you for your relentless (?!) texts and phone calls, and for always being happy for me.

To my grandparents, Hazel and Harold Reid, and Peter Carruthers, thank you for your encouragement, understanding, and support over the years. I love spending time with you all, and I always enjoy our conversations and the comfort you provide. You have all believed in me from the beginning, I very much appreciate it.

Mum, Dad, and Katrina, Nana and Grandad, and Grandad, I love you all very much. I dedicate my work to you, even if you never read it all.

Acknowledgements

Abstract

Creativity is a valuable attribute that involves the generation of original ideas; attention is a vital function that facilitates information selection. Past research has related these cognitive constructs, having found that highly creative people tend to be more distractible than those less creative, which allows them to produce more novel associations.

This thesis aimed to test the relationship between these two processes using multiple tests of creativity (e.g., achievement, divergent thinking, and collage-making) and attention (e.g., focused, sustained, selective, and divided attention), which represented the complexity of each construct, and improved upon the methods previously reported. Additionally, the performance of participants with Attention Deficit Hyperactivity Disorder (ADHD) was compared to those without.

Four studies were carried out. Within the first two, creativity scores were compared and related to attention scores, within and between control and ADHD groups. No consistent relationships were found. The ADHD group had higher creativity scores on average, but the differences were not significant.

Study three incorporated eye-tracking techniques to explore the effect of visual stimulation on creativity and attention performance between-groups. It was found that the ADHD group looked at the attention task targets significantly less, yet their performance was not significantly worse. No between-group differences in creativity were found. The visually stimulating environment did not affect performance.

Study four investigated the effect of an incubation period on creativity. Results showed that incubation increased the proportion of original ideas, but performance did not vary according to incubation task demand. However, self-report responses indicated that participants did not sufficiently engage in the incubation period, as they continued to think consciously of solutions.

The link between creativity and attention is not supported, and the idea that ADHD is beneficial to creativity is not fully upheld. Further research should examine creativity and attention in work or university settings, to consider the existence of a 'real life' relationship.

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Abbreviations

AB: Attentional Blink

AOI: Area of Interest

ASRS-v1.1: Adult ADHD Self Report Scale, version 1.1

CAQ: Creative Achievement Questionnaire

CAT: Consensual Assessment Technique

CEM: Cognitive Energetic Model

CPT: Continuous Performance Task

CT: Convergent Thinking

DDFS: Daydreaming Frequency Scale

DLPFC: Dorsolateral Prefrontal Cortex

DT: Divergent Thinking

DTAP: Dysregulation of Thought and Action Pathway

EEG: Electroencephalography

EDF: Executive Dysfunction

EF: Executive Function

ISI: Inter-Stimulus Interval

MBAM: Moderate Brain Arousal Model

MSP: Motivational Style Pathway

MWQ: Mind-Wandering Questionnaire

OST: Optimal Stimulation Theory

PCA: Principal Component Analysis

PIQ: Post-Incubation Questionnaire

RAT: Remote Associates Task

REM: Rapid Eye Movement

RSVP: Rapid Serial Visual Presentation

SI: Structure of Intelligence

SMI: SensoMotoric Instruments

T: Target

TMS: Transcranial magnetic Stimulation

TTCT: Torrance Tests of Creative Thinking

UUT-CB: Unusual uses Task – Cardboard Box Version

UUT-TC: Unusual Uses Task – Tin Can Version

Chapter 1 - Introduction & Creativity Literature Review

1.1 Introduction

"A well-published university Professor and inventor was stopped from walking down a corridor by a student asking for help with a maths problem. After explaining and solving the problem, the Professor asked the student to help him, by reminding him in which direction he had been travelling. When the student answered, his reply was 'thank you very much, that means I haven't had lunch yet'" (Douglas, 1995, p15).

The idea that there is a link between creativity and attention originated with a stereotype of the 'absent-minded genius' (Necka, 1999: p85) and anecdotal reports from notable creators (Kasof, 1997). The stereotype refers to inventors, creators, and scientists whose attention would jump from one issue to another, meaning that they would struggle to concentrate on one task at a time, but would manage to create items or theories that could dramatically change and improve their field. For instance, the anecdote above illustrates that although a genius in his field, the Professor was unable to remember where he was going, or even if he had eaten or not, after being briefly distracted. Similarly, it has been commented that Albert Einstein, despite being a scientific genius, would forget to wear socks, again showing that no matter his scientific contribution, he could not pay attention to one task (e.g., dressing) for long enough to complete it (Radcliff, 2008).

Further anecdotal evidence for a relationship between creativity and attention includes statements from people such as Charles Darwin and Edgar A. Poe who both indicated that they were highly distractible, and both have said that they felt they noticed more, things that could simply evade the attention of others (Darwin, 1958; Silverman 1991; both as cited in Kasof, 1997). The famous inventor Thomas Edison was highly distractible and impulsive to the extent that he was expelled from school (Hartmann, 2003). Additionally, many creative scientists have themselves declared that before the moment of insight, their attention is broad and dispersed, but becomes more focused after a possible solution has been identified (Kasof, 1997; Necka, 1999).

Anecdotally, there appears to be a relationship between creativity and attention, and this will be the focus of this thesis. On the basis of the literature that will be reviewed, the research presented in this thesis used multiple measures of

creativity and attention in order to determine exactly what a relationship between creativity and attention may look like, if it at all exists. Does a scattered mind lead to better creativity? Or is the ability to focus attention more important?

1.2 Creativity: A Literature Review

1.2.1 What is Creativity?

A common statement in discussions of creativity is: 'I'm not creative; I can't draw very well'. One's ability to draw, however, holds no bearing on their creative potential. The results of a simple internet search questioning 'what is creativity?' will lead the user to learn that it is synonymous with inventiveness or innovation, and is the ability to 'see things in new ways', or to 'think outside the box'. Many online popular-culture articles generically list the 'things that creative people do differently'. These commonly include linking existing concepts to create new ones, resisting perceived boundaries, and observing the world more than others.

Although these clichés and suggestions of what creativity is may not be clear or precise, a further exploration of the psychological definitions of creativity shows that they are represented in theory and evidence.

In a psychological context, creativity is defined as the generation of original, appropriate, useful, and valuable ideas, products, or solutions (Hennessey & Amabile, 2010; Schmajuk, Aziz, & Bates, 2009; Sternberg & Lubart, 1999). Combining seemingly unrelated ideas to form new solutions (Ansburg & Hill, 2003; Mednick, 1962), the production of multiple responses to a problem (divergent thinking; Guilford, 1967; Runco, 2004; Torrance, 1966) and the invention of unexpected, novel concepts (Memmert, 2011) are all descriptors of creative behaviour.

One thing in common with almost all definitions and articles regarding creativity, is that it is deemed a valuable and desirable attribute within the fields of business, sports, the arts, and science. In fact, the arts and science would not exist at all if it were not for creativity (Feist, 1998). Creativity represents a relatively small research field in psychology, despite its worth and attraction.

The study of creativity within psychology grew from almost nothing in the 1950s, after J. P. Guilford used his Presidential speech at the American Psychological

Association (APA) to highlight that the subject area had been neglected, leaving a research gap to be filled. In a subsequent review, Guilford (1987) stated that this lack of investigation was "appalling" (p.34) and that he himself approached the area with caution, as it was ordinarily "feared" (p.33) by psychologists. One reason for the absence of creativity research cited the difficulty of inducing creativity in a laboratory setting, and in measuring a concept that tends to occur by accident (in moments of insight, for example). Guilford (1987) argued that if researchers reviewed their understanding that creativity was limited to discoveries of "unquestioned excellence" (p.34), and instead considered that there are discernible differences between the creative potential of individuals on a smaller scale, then there would be more examinable acts to study. Since 1950, and with this in mind, it was determined that typical tests of intelligence (as were used in the measurement of creativity up to that point) did not provide the opportunity for individuals to portray their creativity, as they required convergent thinking (CT), the production of one correct answer. This led to a departure from the traditional intelligence tests in measuring creativity, and to the development of tests designed specifically to measure creativity and creative potential.

The antithesis of CT is divergent thinking (DT), which involves the production of numerous answers for one given question or problem, an example being 'list unusual uses for a tin can' (Torrance, Ball, & Safter, 1992). DT tests were recognised as facilitating the measurement of creativity, as the participant has an opportunity to provide multiple original, appropriate, useful, and valuable ideas or answers, thus conforming to the definition of creativity itself. Specifically, fluency, flexibility, originality, and occasionally elaboration (mainly used in tasks requiring drawn responses) scores can all be recorded from one DT task. Fluency is the number of ideas the participant produced, flexibility is the number of different types of response, originality is a measure of how unique or novel the idea is, and elaboration refers to the amount of detail the participant provided. These terms, and the measurement of creativity using DT tasks as well as other methods, are explained in more detail in the following section.

The invention of tasks measuring DT (a creative act in itself) aided the rise in creativity research as requested by Guilford in his speech, and most of the research publications measuring creativity empirically have used a form of a DT task.

The study of creativity should be of interest so that it can be spotted, harnessed, and encouraged (Guilford, 1950), and as it could develop our understanding of how different cognitive processes may work interdependently. It is a common misconception that creativity is limited to gifted individuals or geniuses, and that few people can be legitimately creative (Guilford, 1987; Ward, Smith, & Finke, 1999). Conversely, Ward and colleagues (1999), from the cognitive psychology point of view, argue that the capability to be creative is embedded within human cognition, allowing it to be examined in the general population.

Researchers from various perspectives have studied creativity, leading to a broad range of theories including those based on cognition, intelligence, and personality. All three of these are heavily represented in the field so are therefore discussed in this chapter. The study of creativity in psychology has also taken various forms in terms of focus: for example, researchers have looked at the type of person that behaves creatively, the internal and external processes involved, the products of creativity, and the effects of the individual's environment (e.g., resources, support, pressures) on creative potential.

A cognitive approach was adopted in this thesis. The study of creativity from a cognitive point of view is concerned with determining which processes underlie creativity. Experimental methods are often used, and there has been more research carried out in the cognitive approach than any of the others (Runco, 2007). In general, researchers aim to draw links between creativity and other cognitive functions such as attention, perception, and information processing, as well as with factors such as association making and problem solving.

Broadly, this thesis examines the relationship between two cognitive processes: creativity and attention. The source of the conception that there could be a relationship between these two ostensibly disparate processes is based on literature alleging that a link exists between high levels of creativity and distractedness. This postulation is detailed in chapter three.

1.2.2 Divergent Thinking

Creativity has been measured in many different ways: through divergent thinking (DT) tasks, convergent thinking tasks (e.g., Mednick, 1962), the creation of a

product (e.g., collages; Amabile, 1982; Baer, 1996; poems: Kasof, 1997; and stories; Wolfradt & Pretz, 2001), and also with larger batteries of multiple types of test (e.g., Guilford, 1967; Torrance, from 1974).

Tests of DT are the most commonly used method of measuring the creative process and are considered to be predictors of creative potential (Kuhn & Holling, 2009; Runco, 2004; Torrance, Ball & Safter, 1992). In some articles, DT has become synonymous with creativity, which does not reflect the complex nature of creativity, but does give merit to the importance of DT tasks in the measurement of creativity. This stems from their development in the 1950s with the majority of creativity research focusing solely on these until the 1980s (Kaufman, Plucker, & Baer, 2008). For these reasons, this section will describe divergent thinking and its measurement, with the aims of providing context for some of the future arguments presented in this thesis, and to illustrate the presence of these ideas in the wider literature.

DT is considered to be a significant element of the creative process, and is valuable for assessing the potential for creative thought (Runco, 2007). Although everyone is capable of DT (Baer, 2014), it is thought that by measuring the responses for aspects of creativity, this can separate those inclined to be creative from those not (Hocevar & Bachelor, 1989).

There are two main types of DT task: verbal DT, which is the production of written responses, and figural DT, which requires drawn responses. Verbal DT tasks tend to request that the participant produces multiple ideas for unusual uses for an everyday item, or ways to improve an item, or alternative endings to a story, for example. Figural DT tasks will usually present the participant with a series of identical shapes or line sets, which they have to incorporate in to multiple different pictures. These resulting idea lists or drawings are scored for fluency, flexibility, originality, and in the case of figural DT tasks, elaboration.

DT is the main feature in the three most widely used test batteries for creativity: the divergent production tests by Guilford (1967), similar tests by Wallach and Kogan (1965), and the Torrance Tests of Creative Thinking (TTCT) battery, by Torrance (1974). These particular sets of tests have been widely used and tend to be held in high regard. However, there have been criticisms about the heavy reliance upon DT tests in creativity research.

Firstly, it has often been posited that fluency confounds the scores of flexibility and originality: that is, a high fluency score is required for flexibility and originality scores to be high (see Kim, 2006). Indeed, there are strong correlations between the three scores, and fluency scores can predict flexibility and originality scores (Runco, 2008). However, this may just point to the relationship between quantity and quality, and show that with numerous ideas, it is more likely that there will be creative and original ideas (Simonton, 1990, Torrance & Safter, 1999). When the aim is to consider creative potential, then it is flexibility and originality that are the important indices, as they measure aspects specific to the definition of creativity. It has been determined that even when fluency scores are controlled, the variance in flexibility and originality scores are reliable (Runco, 2008).

A further criticism is that the tests are vulnerable to administration and scoring biases (Plucker & Renzulli, 1999). This is because the tasks can be administered by anyone who has bought the materials, and although this is mostly carried out by competent individuals in research or education, this leaves room for uneven confounding variables and test environment differences across studies (Plucker & Renzulli, 1999). Although it can be argued that this is the case for all manually scored measures in psychology and beyond, the scoring of originality may be particularly subjective when responses lie outwith the comprehensive guides provided by the authors of the tasks.

Cattell (1971, as cited in Sternberg & O'Hara, 1999) went further to complain that the part of divergent thinking in the study of creativity is overvalued, and that originality scores merely come from the scorer viewing a response as odd in comparison to the others. Cattell's (1971) alternative was that real life creativity is a more suitable measure, which may be fair, but he then states that this is reliant on an individual's intelligence, which, as later argued, is not necessarily the case.

Facing the criticism are high levels of statistical support. The TTCT battery in particular has had empirical support from a range of studies, and the vast amount of research on this bank of tests generally indicate high levels of reliability and validity (Kaufman et al., 2008). Test-retest reliability scores have varied from .50 to .93 (Torrance 1966; 1974), which is a large range but in favour of the tests. It was stressed that this range was due to the complexity of creative performance

(Kim, 2006). Inter-scorer reliability of over .90 has also been found between the official TTCT analysts where tests from 88,355 participants were scored (Torrance, 1990). A longitudinal study found evidence of predictive validity, when the TTCT was completed seven years after it was initially carried out by the participants, with scores on the three divergent thinking scales (fluency, flexibility, and originality) being moderately, positively related to real life creative achievement (r = .39 to .48, $p < .01$; Torrance, 1972; Kim 2006). Plucker (1999) reanalysed the data provided from Torrance's longitudinal studies and concluded that the TTCT was the most proficient predictor of adult creative achievement (r = .60), especially compared to that of varying intelligence measures (r = .19). Further, it was found that divergent thinking scores better predicted creative achievement than IQ scores, academic attainment, or scores by peers (Kim, 2006). The TTCT has fewer limitations than other creativity tests, and has more supporting evidence than any other creativity measure. Tests of divergent thinking are therefore still widely used measures of creativity today (Plucker & Renzulli, 1999).

Although DT tasks are now used as a measure of creative potential in their own right, independent from the measurement of intelligence, the production of DT tasks started with research in to the relationship between creativity and intelligence.

1.2.3 Creativity and Intelligence

The relationship between creativity and intelligence was a divisive debate in the 1950-60s (Runco, 2007). In order to justify research into creativity, it was necessary to find a distinction between the two concepts, otherwise creativity would be merely considered as an aspect of intelligence (Runco, 2007). However, many researchers found that intelligence was indeed related to creativity (for a review, see Hasan & Butcher, 1966; Sternberg & O'Hara, 1999). The arguments for and against the relationship will be presented, followed by an explanation of the threshold theory for creativity and intelligence.

Guilford (1950) had a huge influence on the field of creativity research when he suggested that creativity as a construct was under-examined, which encouraged others to pay more attention to the relatively overlooked topic (Barron &

Harrington, 1981; Sternberg & Lubart, 1999). He created a Structure of Intellect (SI) model (1967), which contained three dimensions of intelligence: 1. Operations (cognition, memory, divergent production, convergent production, and evaluation), 2. Content (figural, symbolic, semantic, and behavioural), and 3. Products (units, classes, relations, systems, transformations, and implications).

In particular reference to creativity, is the cognitive process of divergent production or divergent thinking (Kuhn & Holling, 2009; Sternberg & O'Hara, 1999). Guilford (1967) developed a comprehensive battery of tasks aimed at measuring DT, and found that performance on these tests was positively correlated to intelligence ($r = .37$, Guilford & Hoepfner, 1966, as cited in Sternberg & O'Hara, 1999). It was therefore concluded that creativity was a subset of intelligence (Guilford & Christensen, 1973; Sternberg & O'Hara, 1999).

In agreement with Guilford and his various colleagues, Cattell (1971) also viewed fluency and originality as subsets of intellectual abilities. However, subsequent investigations found very few or low correlations between creative measures and Cattell's intelligence types (Rossman & Horn, 1972). Similarly, Gardner (1983) suggested that creativity was a subset of multiple intelligences, and that individuals could have different forms of creative intelligence. For example, a musician is intelligent in a way that is different to the way of an interior designer, and although some will have strengths over many fields, there will inevitably be fields that are weaker. Yet, within his research, Gardner (1993) found that when seven renowned high achievers had their largest breakthroughs, they were surrounded by a high standard of support, and that they sacrificed their social and personal time in order to achieve at the highest level. This implies that creativity goes beyond a requirement for intelligence, but also depends on personality traits, encouragement, motivation, resources, and commitment.

Others have argued that creativity and intelligence are the same thing, and that creativity is merely an extraction of intelligence (Haensly & Reynolds, 1989). This is the 'nothing special' view (Perkins, 1981, as cited in Sternberg & O'Hara, 1999, p.263), where it is thought that the same cognitive processes are used for creativity as for normal, non-creative problem solving tasks.

The strongest arguments however, are that creativity and intelligence are distinct from each other, and can therefore be measured separately, yet no one has

stated that they are entirely unrelated (Sternberg & O'Hara, 1999). One study used two groups of school pupils, one high in creativity (based on the scores of five measures, including word association, DT, drawing, problem solving, and storytelling) and lower on IQ, and one lower on creativity and high on IQ. Both groups were found to perform better in standard school tests than the rest of the school population (Getzels & Jackson, 1962). Despite this commonality in achievement, the groups behaved differently from each other in terms of personality, ambitions, priorities, and task strategy. For example, in a drawing task, those in the high IQ group drew detailed, annotated drawings, where as those in the high creativity group were more likely to disregard perceived task boundaries, and were less concerned with communicating effectively (Getzels & Jackson, 1962).

Wallach and Kogan (1965) developed their own set of creativity tests that were not unlike those used by Getzels and Jackson (1962), and adopted a game-like approach to their creativity and intelligence testing, in response to previous studies, who they criticised for using inflexible and stringent methods. It was argued that by using a casual game-like procedure during testing, that creativity would be measured distinctly from intelligence, as the awareness and stress related to a time limit would be diminished. In the end, Wallach and Kogan (1965) again found that there were qualitative differences between those who were high or low on creativity and intelligence. Summarising, differences existed in personality traits (particularly extraversion and conscientiousness), concentration and focus levels, self-confidence, academic achievement, and peer engagement.

Torrance's (1975) findings further supported this work. Through empirical research and reviews, Torrance concluded that there was, at best, only a moderate relationship between creativity and intelligence. Furthermore, he trialled his testing sessions with various time allowances and instruction types, finding that the participant stress levels cited by Wallach and Kogan (1965) were unfounded, and a time-consuming game-like approach was unnecessary.

That intelligence is a central factor for creativity, as illustrated, is a disputed point. The consensus tends to be that intelligence is a 'threshold characteristic' that is necessary but not sufficient for creativity (Hughson & Hughson, 2004; Plucker & Renzulli, 1999; Runco, 2007).

Threshold theory is perhaps a compromise in the creativity and intelligence relationship debate. It concludes that there is a relationship between intelligence and creativity, but only in terms of the standard of intelligence necessary to enable creative thinking. There is a lower threshold, or minimum level of intelligence required in order for it to be possible for an individual to be creative (Kim, 2005; Runco, 2007; Sternberg & O'Hara, 1999). Creative potential is not, and cannot be, present in those with low intelligence scores, but creativity is not necessarily present in those with higher intelligence scores, although these individuals have the capacity to be creative (Kim, 2005; Runco, 2007; Sternberg & O'Hara, 1999). There must be more than above threshold intelligence to lead to creative behaviour, beyond that, factors such as personality, resources, attention, and motivation could limit or enhance creativity, to name but a few. Creativity and intelligence are therefore related according to threshold theory, but only in that one is required for the other to exist.

According to the existing literature, until recently only one attempt had been made to propose a minimum general IQ score for creative behaviour (IQ of 120; Barron, 1963, as cited in Sternberg & O'Hara, 1999; see also Batey & Furnham, 2006; Kim, 2005; Runco & Albert, 1986) and the results of studies retesting this claim have been varied and inconclusive (see Healey & Rucklidge, 2006; Kim, 2005; Plucker & Renzulli, 1999; Preckel, Holling, & Wiese, 2006; Runco & Albert, 1986). This value was based on a number of studies using inconsistent measures of IQ. Recently however, it has been posited that the threshold of 120 was repeatedly tested without convincing justification, and without empirical evidence to support it (Jauk, Benedek, Dunst, & Neubauer, 2013). After a comprehensive investigation using 297 participants, it was concluded that IQ (based on a German measure of general intelligence) thresholds exist for scores on creative potential tasks (i.e., DT tests) but not for measures of creative achievement. There was a threshold of 85 IQ points for the production of ideas (fluency only), the threshold for producing two original ideas was 100 IQ points, but that rose to 120 when many original ideas were requested (Jauk et al., 2013). This supports the theory that a certain level of intelligence is required for creative potential, but, as with the previous findings presented, it was determined that personality factors, specifically openness to experience, affect creative potential after the threshold IQ has been reached.

With fairly contentious debates about the relationship between creativity and intelligence, it is argued here that the threshold theory provides a plausible description and explanation of the extent of the relationship, without overstating it. This literature has been discussed in order to provide context for the importance of creativity, and the study of creativity. A frequent feature of these arguments has been the influence of personality on creative behaviour.

1.2.4 Creativity and Personality

As with intelligence, there are varying perceptions and theories about the links between creativity and personality. Many studies, especially the earlier ones, measured both creativity and personality in inconsistent ways, using various measures and definitions, making it difficult to find patterns in the findings (Batey & Furnham, 2006).

Barron and Harrington (1981) conducted a review of several personality studies over many creative domains and drew out what they describe as a "fairly stable set of core characteristics" (p.15) of highly creative people:

"high valuation of aesthetic qualities in experience, broad interests, attraction to complexity, high energy, independence of judgment, autonomy, intuition, self-confidence, ability to resolve antinomies or to accommodate apparently opposite or conflicting traits in one's self-concept, and, finally, a firm sense of self as 'creative'". (Barron & Harrington, 1981, p.15).

Feist (1998) published the first meta-analysis on the topic and resolved that it was likely that creative individuals have a set of personality traits and characteristics that are distinct from those who are not, and that these traits are related to creative achievement. From an array of personality traits, some of the largest effects found that creative people are more impulsive, and less conscientious. These aspects in particular have been identified in individuals with attention disorders (Nigg et al., 2002), which points to a link between poor levels of attention and/or focus, and creativity. Other aspects such as openness (Furnham, Zhang & Chamorro-Premuzic, 2005-2006), extraversion (Sen & Hagtvet, 1993), and intrinsic motivation (Amabile, 1985) have all been positively related to creative behaviour.

Looking specifically at the results of studies comparing artists and/or scientists against norm groups, the meta-analysis indicated that a distinct representation of a creative personality exists, irrespective of the measures used to measure both creativity and personality (Feist, 1998). The largest differences lay between scores on the traits of openness, conscientiousness, self-acceptance, hostility, and impulsivity, although this trait profile was not mutual to both artists and scientists. Precisely, it was found that artists were more emotionally unstable and were more able to discard group customs than scientists were. Differences in scales of responsibility, socialisation, good impression, and conformity separated artists (lower scorers) and non-artists, whereas highly creative scientists were less conscientious and more open-minded than their non-creative counterparts.

A study of art students found that the students who scored higher in creativity spent more time in preparation before working (Getzels & Csikszentmikalyi, 1976, as cited in Runco, 2007). A follow up study 18 years later found that this group of students, compared to their less creative peers, had more successful art careers, scored higher on personality traits such as introspection, imaginativeness, and sensitivity, and lower on traits such as conformity, conscientiousness, and cheerfulness (Csikszentmikalyi, 1990, in Runco, 2007). It is unclear what the preparation difference means, that is, were these students creative because they prepared, or did they prepare because they were creative?

Eysenck and Eysenck (1985) theorised that personality was structured around three traits: neuroticism, extraversion, and psychoticism, and suggested that creative behaviour was related to variations in psychoticism. Psychoticism specifically is comprised of attributes such as aggressiveness, impersonal behaviour, coldness, egocentricity, impulsiveness, stubbornness, and creativeness (Batey & Furnham, 2006). In order to explain this relationship, Eysenck (1993) proposed that there are differences between individuals in their understanding of relevance. Those with a broad or wide definition of relevance are referred to as 'over-inclusive thinkers', and are more likely to produce unusual responses or make original associations in tasks measuring creativity, in turn making them more creative than those with a narrow definition of relevance. Further to this, those with an over-inclusive thought tendency have high scores on the trait of psychoticism, but are unlikely to actually be psychotic (Eysenck, 1993). It was argued that psychoticism has been the most widely found trait linked

to creativity (Eysenck, 1995), and that this was due to unusual ideation, mental illness, illusive thinking, and emotional instability being qualities of both creative and psychotic thinkers (Batey & Furnham, 2006).

In support of this position, evidence of the relationship between creative thinking and creative achievement with psychoticism has been found from many studies, particularly between the personalities of creative people and those with schizophrenia or bipolar disorder (see Batey & Furnham, 2006; Zabelina, Condon, & Beeman, 2014). Studies have also highlighted the relationship between psychoticism in its extreme form and those who are regarded as highly creative, for example, in artist Vincent van Gogh (Wolf, 2001) and writer Ernest Hemingway (Post, 1994). Further, in a comparison of creative writers and matched controls, the writers were more likely to have bipolar tendencies (Andreasen, 1987). There is a large amount of evidence for a relationship between creativity and psychoticism, however this should not be over generalised, as not all creative individuals will have mental health issues (Gilhooly, 2002). Accordingly, Waddell (1998) conducted a review of the creativity and mental illness literature, with the results indicating that findings fluctuated too much in order to reach a reliable and consistent conclusion.

Art and music therapy are common in mental health centres or hospitals, and given the relationship described above, this may be seen as a way of channelling challenging behaviours in those with various disorders. Interestingly, despite the range of evidence linking creativity and mental illness, online articles and guides regularly proclaim creativity to have a positive effect on mental health. Recently, it has been determined that both negative and positive correlations can be found between creativity and mental illness/disorder, and that this depends on the sample and methods used by the researcher (Simonton, 2014).

The relationship between creativity and personality, as is standard with concepts of this nature, remains to be unclear. However, there is a strong argument that creative individuals have a different personality type compared to non-creative people, with aspects such as impulsiveness, lack of conformity, and emotional instability appearing time and again in the literature. It is perhaps easy to understand why these traits co-exist with creativity, as by their nature, they would be of benefit to the production of novel and original ideas, or products that break

from the norm. Furthermore, these traits and the ability to break from the norm may help an individual to make creative associations between ideas or concepts.

1.2.5 Creativity and Association

It has been posited that successful creative thinking may be the result of forming new and useful associations between previously disparate concepts (e.g. Gilhooly, 2002; Mednick, 1962; Schmajuk et al., 2009). The thought that creativity consists of an associative process is an "old and sturdy" (Barron & Harrington, 1981, p.12) theory in psychology, with the most well-known contribution being from Mednick (1962). The associative theory of the creative process is thought to explain creative thought across fields, and was produced following biographical reports by scientists and artists, who claimed to have combined seemingly unrelated concepts in the creation of their work (Mednick, 1962). This theory can coexist with the work on divergent thinking, as it aims to differentiate between the production of creative concepts, as opposed to non-creative concepts.

An association is a link between two ideas, elements, or stimuli, which can be strong or weak, although Mednick (1962) argued that the weaker or more remote the association is, the more creative it is. In order to be creative, the associations must also be original and useful.

Using an unusual uses for a cardboard box DT task as an example, to combine the box with the idea of storage is to make a strong, useful association, but the idea is not original. To combine the box with the solution of making it into a boat is a weaker association, and is therefore more original, but less practical and useful. To combine the box with the idea of visual equipment, to make it in to a viewing screen for an eclipse for example, is useful, and has a weak association, so is therefore original too.

Within the associative theory, word association tasks are frequently used. So to use one as an example, strong associations with the word 'table', would be 'chair' and 'cloth', whereas less common (remote) associations could include 'food' and 'fable' (Abraham & Windmann, 2007; Friedman, Fishbach, Forster, & Werth, 2003; Mednick, 1962). To produce remote associations is thought to indicate that the individual was able to process and produce solutions beyond the obvious,

these are therefore creative (Abraham & Windmann, 2007; Friedman et al*.,* 2003).

Mednick (1962) argued that there are three methods of reaching a creative solution by association: serendipity, similarity, and mediation. Serendipity is the accidental or unplanned combination of stimuli by the individual and has been used to describe discoveries such as x-ray and penicillin. Similarity is when combinations are made because each element is similar in nature. An example of this would be the use of rhyme in the creation of poetry, or rhythm and riffs in the creation of music. Mediation describes the combination of items that have elements in common. Mednick explains that this is particularly important in fields where symbols and formulas are used (e.g., maths, chemistry, physics), or where symptoms or manifestations might be common (e.g., psychology, or medicine). Creative output is consequently due to the ability to make such combinations and associations, whereas a preference to follow existing ideas would limit creativity.

There are some prerequisite criteria that determine whether or not an individual will efficiently arrive at a creative solution. Firstly, a knowledge of the separate concepts must be present, as these cannot be combined or associated with one another if the individual does not know about their existence in the first place (Mednick, 1962). Knowledge of these parts, as well as cognitive access to them, may imply an overlap with intelligence (Sternberg & O'Hara, 1999).

Secondly, Mednick (1962) describes associative hierarchies, which are an illustration of how quickly associations will be made, how they are organised, and how remote they could be. Using the example provided above, an individual with a steep associative hierarchy would combine the words 'table' and 'chair' together, as they are closely related semantically and are therefore easily accessed. Those with a flatter associative hierarchy would be more likely to combine the word 'table' with 'food' as they are less obviously associated (see Gilhooly, 2002 for a summary). This coincides with Eysenck's (1993) theory of over-inclusive thinking. It was concluded that creative individuals are regarded as having flatter hierarchies, allowing them to make weaker, and thus more creative, associations (Gilhooly, 2002; Mednick, 1962). This is measured by the Remote Associates Test (RAT: Mednick & Mednick, 1967), where participants are presented with three apparently unrelated words, and they have to find a fourth

word that independently links to each one (e.g., wheel, electric, and high, are all related to the answer, which is chair: Bowden & Jung-Beeman, 2003; Mednick, 1962; Sternberg & O'Hara, 1999, p. 263). This is a departure from DT and a focus towards CT.

The associative theory of creativity and the RAT were influential in their time, but have received little adaptation since their creation. In particular, the methods for making associations (i.e., serendipity, similarity, and mediation) have little discussion surrounding them, and investigations of the steep and flat associative slopes have been unsuccessful in their aim to return supporting data (e.g., Yahav, 1965, as cited in Mendelsohn, 1976). Gilhooly (2002) suggests that overall, the associative theory seems too simple.

The studies run by Mednick and his associates claiming to have found constructive and predictive validity for the RAT did not control for intelligence, and featured participants who were arguably both highly intelligent and creative; architects, scientists, and engineers (see Mendelsohn, 1976 for a review). Whereas it has been demonstrated that tests of DT have predictive validity with other measures of creativity (e.g. Runco, 2004), the RAT has rarely been even moderately related to DT (Lee, Huggins, & Therriault, 2014). This implies that the RAT involves processes outwith those in creative thinking. Furthermore, beyond the study of creativity, the RAT has been used in studies investigating bipolar and manic-depressive disorders (Fodor, 1999), the effect of feedback on performance (McFarlin & Blascovich, 1984), search strategies (Smith, Huber, & Vul, 2013), social intelligence (Keating, 1978), and even erotomania in celebrity worship (McCutcheon, Ashe, Houran, & Maltby, 2003). This highlights that the RAT is a flexible measure, which thereby demonstrates its lack of construct validity.

It can be argued that the RAT may not be manageable for participants with limited vocabulary or knowledge of the verbal cues used, thus the reliance on CT and intelligence, rather than creative thinking, may be too high. In support of this, it was found that the RAT has higher correlational values with IQ, specifically aspects of verbal IQ, working memory, cognitive speed and accuracy, and school achievement, than it does with any DT score (Lee et al., 2014; Taft & Rossiter, 1966). With DT being indicative of creative thought (Guilford, 1956; Mendelsohn, 1976), accordingly, the RAT has been criticised as measuring CT and analytical

processes rather than creativity. It is generally accepted now that the RAT measures CT, but it is still unclear if it examines CT within creativity, or separate analytical cognition (Lee et al., 2014).

Mendelsohn (1976) responded to the poor RAT support by suggesting that when verbal intelligence is controlled, it is differences between individuals in their attentional processes that relate the RAT to creativity. It was found that those with high RAT scores were more likely than low scorers to notice and use cues from their environment during problem solving tasks. It was also reported that the ability to hold and use several streams of information in mind at once (i.e., holding several RAT problems in mind whilst considering various solutions, and whilst utilising environmental cues) is indicative of a large cognitive capacity. This was referred to as having broad attention, in that one can spread their focus broadly over numerous stimuli, facilitating their chances of producing original associations (Kasof, 1997; Mendelsohn, 1976). However, attention may not be the only cognitive process in use as this theory suggests, as working memory is likely to be heavily involved too. Nevertheless, Mendelsohn pointed out that attention and intelligence have been found to be independent processes, yet both are related to RAT performance. This could indicate that differences in attentional 'traits' or patterns could be related to differences in creativity.

Overall, the associative theory has to be recognised as having an impact on the field of creativity research, as it has been so frequently reported over the years, even though the evidence for both the theory and the assessment tool has been contentious. The argument that the RAT is not an optimal measure for creativity is convincing, so it has therefore not been used in the present thesis.

Although methods by which creative ideas can come together were offered by the associative theory, little was clarified about the cognitive process involved in creativity. The arguments for a creative process are therefore presented in the next section.

1.2.6 The Creative Process

In order to illustrate how creativity might occur in our cognition, and how creativity may be related to attention, there are several models that have been produced

to map or at least explain the cognitive process of creativity. These aid in the understanding of the different stages in the act of thinking up a creative solution. Most of these theories concern creative problem solving specifically, which involves using or producing novel and original methods or solutions to a problem, by combining seemingly unrelated stimuli in a useful way (Isen, Daubman, & Nowicki, 1987).

Wallas (1926) provided one of the first cognitive models concerning the creative problem solving process and the importance of different attentional stages, and it has been used as a base for theories ever since (Kristensen, 2004). This model is highly regarded, and is still accepted, usually without challenge, in the literature today. It was developed from anecdotal and introspective information from creators and problem solvers such as Poincaré and Helmholtz, who both had similarities in their descriptions of the process by which they came to their solutions (Gilhooly, 2002).

Wallas's model has four stages: preparation, incubation, illumination, and revision. The preparation stage involves the solver exploring, focusing on, and becoming familiar with the problem. This requires focused attention and concentration as the individual learns the construct of the problem, the constraints and limitations, and systematically and actively attempts to work towards the solution, usually without success. This early stage is thought to be crucial in order to successfully solve the problem at a later stage (Gilhooly, 2002; Wallas, 1926).

Incubation is a period of time post-preparation, during which focused attention is not required, as the problem is not consciously attended to (Wallas, 1926). Experimental studies have investigated the effect of incubation during a creative problem solving task, with findings determining that in certain conditions, incubation can increase the quantity and quality of solutions (Baird et al., 2012; Gilhooly, Georgiou, & Devery, 2013; Snyder, Mitchell, Ellwood, Yates, & Pallier, 2004). There are four main theories that have aimed to clarify why a period of incubation would be useful and how it works to improve problem solving success. The first two are the relief of fatigue (Wallas, 1926), and the relief of mindset/beneficial forgetting (Gilhooly et al., 2013; Posner, 1973 in Snyder et al., 2004) theories, both of which regard incubation as a time for the mind to rest and recover capacity, with the latter specifying that this allows the individual to forget

the misleading assumptions or barriers that are inhibiting the production of a solution. The third, the intermittent conscious work theory, proposes that short periods of conscious work on the problem occur during incubation, which eventually leads to the formation of a solution (Seifert, Meyer, Davidson, Patalano, & Yaniv, 1995). Lastly, the non-conscious work theory (Dijksterhuis & Meurs, 2006; Gilhooly et al., 2013) suggests that incubation is successful as it allows for the problem to be considered non-consciously whilst the conscious mind is distracted with an alternative, unrelated task. Wallas (1926) himself stated that resting the mind would be most beneficial during incubation, although work on easy, everyday tasks that require little cognitive effort could also be constructive. (More details on incubation and these theories are provided in chapter eight).

The third stage is illumination. At this stage, a possible idea, solution, or a hint to the solution comes to light in the solver's mind. If a feeling of pending illumination is sensed, the individual should eliminate distractions and focus in order for the idea to come, according to Wallas (1926).

Last is the verification stage. During this phase, the solver concentrates on consciously considering the ideas and potential solutions that were produced at the illumination phase. They are processed for their appropriateness, usefulness, and effectiveness, before being accepted or rejected. Problem solvers can revert to earlier stages if ideas are deemed unsuitable in this revision stage, and more than one stage can be experienced at once if there is more than one problem in hand (Lubart, 2000-2001; Wallas, 1926). The model assumes that aspects of creative thinking occur subconsciously (Lubart, 2000-2001), for example the coming together of remote ideas and solutions is a process out-with conscious thought. This four-stage model is still influential in the field, and can be applied to creative behaviour as measured by many different tasks, including DT and association tasks.

Attention appears to be an important variable within this four stage analysis of the creative process. The preparation stage requires focus and concentration, whereas the incubation stage requires broad and dispersed focus of attention in order it to be successful. The illumination stage appears to require a switch from broad to narrow attention, as an idea comes to mind and must be focused on.

Finally, the verification stage appears to be rather like the preparation stage, in that the individual must pay attention to the ideas they have produced, and concentrate on deciding on their usefulness. It therefore seems reasonable to assume that there may be a link between creativity and attention.

Empirical evidence for Wallas's four-stage model has been provided by Patrick (1935, 1937, as cited in Gilhooly, 2002). Patrick recorded the words, strategies, and techniques used by both artists and non-artists during a sketching task. After splitting the task completion time in to four equal periods, it was consistently found that preparation occurred in the first quarter, illumination instances took place in the third, and most verification took place in the final quarter thus matching the proposed stage model. The evidence for incubation in this study was questioned, as work continued on the task continuously, without an incubation period. However, as mentioned above, further empirical evidence has been found separately from this study in support of the existence and benefit of the incubation period.

Wallas's model places a heavy influence on subconscious progressions. However, it is not accepted across the board that creativity is mostly a subconscious process. It may be more likely that the moment of insight, or idea realisation, is led to by subconscious associations, but the processes leading to and beyond that point require consciousness and awareness. One particular cognitive model that holds this point of view is the geneplore model of the creative process by Finke, Ward, and Smith (1992). This model features two phases both requiring conscious processing by the individual: these are the generative phase and exploratory phase (generate + explore = geneplore; Finke et al., 1992). The generative phase is when an individual brainstorms possible solutions to a particular problem and develops mental representations of these options. Existing cognitive structures are used at this point, with unique combinations of these structures producing more creative solutions (Finke, 1996). The exploratory phase sees these solutions and ideas being focused on and analysed for appropriateness and usefulness, with the best option(s) being chosen for further development (Finke et al., 1992).

The geneplore model of the creative process is simpler than the four stage model by Wallas (1926), although it is clear that influences from this were taken, as the

exploratory phase features similar processes as the revision stage previously mentioned. The two-phase model recognises that creative problem solving requires conscious work, focused attention, and information manipulation by the individual, although the bringing together of seemingly unrelated cognitive structures (existing ideas) leading to insight can be a subconscious process (Finke, 1996). Again, features of attention have been utilised in this theory.

Some forms of research have not found empirical evidence to support these stage-specific models of the creative process. Studies analysing the process of artists creating a picture that represented a story over a period of weeks, regularly recorded work progress and the thought processes of the individuals (by way of the diaries they were asked to keep), and found no evidence for two or four distinct stages (Eindhoven & Vinacke, 1952; see similar work by Ghiselin 1952/1985). Instead, it was proposed that creativity is a dynamic, integrated process that involves the fluctuation between aspects featured in Wallas' model (1926) and/or generation and exploration.

With the uncertainty of exactly which cognitive processes are at work during creativity, it is therefore necessary to isolate distinct processes in order to determine the extent of their effect on creativity (for example the roles of attention, working/long term memory, decision making, etc.). Attention seems to be an important feature that is required to be flexible between the stages of the creative process, regardless of preferred model. It is for this reason that the present study focuses on the cognitive process of attention and its relationship with creativity.

1.3 Conclusions

From being regarded as a neglected, underdeveloped field in the 1950, creativity research has expanded, with dispute and uncertainties encircling almost every theory and perspective. The historical debates within the creativity research have stemmed from the relationship with intelligence and personality, with broad results that are difficult to refine. This chapter concludes that creativity can be measured experimentally, and separately from the constructs of intelligence and personality.

Creativity in the field of psychology is not concerned with how artistic an individual is, as the opinion may be in the general domain, but rather how well one can produce original, appropriate, useful, and valuable ideas, products or solutions (Hennessey & Amabile, 2010). The theories of divergent thinking and association can coincide, and richly describe the production of creative ideas, and what separates them from non-creative ideas. The creative process models help in the understanding of how these ideas may be generated in cognition.

Many of the theories discussed in this chapter made reference to, or could be allied with, the cognitive function of attention. It seems that a commonality throughout most of the research is that our focus and concentration must, at some point be, dispersed or broad, to allow creative solutions to be produced, for original associations to be made, or at least to allow the unoriginal and unhelpful mindsets to be forgotten. Further exploration of a potential relationship between creativity and attention led to the discovery of a wealth of research linking the two concepts. A literature review of attention is presented next, followed by further details on the correlation between creativity and attention.

Chapter 2 – Attention Literature Review

A student attending a lecture hears the voice of the lecturer, as well as the background sounds of hushed conversations, rustling papers, the inevitable ringtone, and the one classmate who insists on eating a full packed lunch. The student also contends with the PowerPoint presentation, the lecturer themselves, their notes and their thoughts, the actions of surrounding attendees, the temperature in the draughty classroom, their comfort in the chair, all the way down to the colour of the carpet, and the feeling of their clothes on their skin. Despite this vast amount of information available to the student, their job is to concentrate on the information being provided, whilst attempting to comprehend it and frantically write notes, and whilst ignoring all of the information that is not relevant to this goal.

2.1 What is Attention?

The senses are continuously inundated with information in various forms, some of which is important and relevant to the goals of the individual, but most is not. Attention refers to the conscious or unconscious selection of information for cognitive processing. This involves the brain directing focus and managing sensory inputs so an individual can process what is important in any given situation. The cognitive processing capacity for new information is limited, meaning that the selection of only relevant, goal-related stimuli for further processing is crucial (e.g., Chun, Golomb, & Turk-Browne, 2011; Lachter, Forster, & Ruthruff, 2004). As with any cognitive ability, attention is vulnerable to dysfunction, and attention deficit hyperactivity disorder (ADHD) will be discussed later to contribute to our understanding of the function of attention.

Definitions of attention in the psychology literature are rarely precise, and it has been proposed that it is an umbrella term for multiple psychological processes (Styles, 2006), which is not constructive to the study of the phenomenon. Some attempts have been made though, as James (1890, as cited in Styles, 2006) defined attention as "the taking possession of mind in clear and vivid form…it implies withdrawal from some things in order to deal effectively with others" (p.1).

James (1890) also famously suggested that "everyone knows what attention is", however research has uncovered the complexity of attention, with authors of more recent work opting to support the stance that no one knows exactly what attention is (e.g., Frey, Ruhnau, & Weisz, 2015; Pashler 1999; Styles, 2006). Still, there is a general consensus that attention is the purposeful distribution of limited resources for information processing (Styles, 2006).

Attention is thought to underpin most other cognitive functions (e.g., Cooley & Morris, 1990). The mechanisms by which sensory information is selected and transformed into short term memory for immediate use, or to then be rehearsed for long term memory, has been the focus of past studies and has formed the base of most attention-related research (see, for example, Driver, 2001). Broadbent (1958) was one of the first to provide a model of how information is selected with his filter theory. This theory was largely influential in the psychological study of attention, and has led to the production of adapted versions, such as the attenuation theory by Treisman (1969). Preceded by an explanation of the different types of attention, both of these early selection theories will be discussed as they are viewed as two of the most important in the field of attention research.

There are arguably various types of attention that lend themselves to different tasks, goals, and environments. Many different types of attention have been recognised, with varying amounts of empirical support.

Researchers have identified a hierarchy of five main types of attention, each being a more complex process than the one before - focused, sustained, selective, alternating, and divided attention (e.g., Bajaj et al., 2008; Bennett, Raymond, Malia, Bewick, & Linton, 1998). Although each of these types of attention can involve both conscious and unconscious processing, a combination of both is necessary for most tasks (Bennett et al., 1998). Due to time constraints and in an attempt to avoid excessive cognitive fatigue, a measure of alternating attention was not included in the present research. As alternating and divided attention are regarded as the two most challenging processes, it was determined that only one of these would be included, and divided attention was chosen as there appeared to be more relevant research in this area. The remaining four

types of attention are described below, with the definitions based on the work by Bajaj and colleagues (2008) and Bennett and colleagues (1998).

2.1.1 Focused Attention

Focused attention is the ability to identify and respond to single items of task-relevant information, and is thought to be the simplest form of attention (Bajaj et al., 2008; Bennett et al., 1998). This involves the concentrated processing of a selected stimulus and the reduction of awareness of non-selected stimuli, such as background noise. It has been suggested that focused attention, being the simplest form, is a precondition for all other modes of attention (Egeland & Kovalik-Gran, 2010; Van der Meere, 2002). As focused attention requires the individual to directly observe and react only to task-relevant stimuli, all tests of attention require focused attention to varying degrees (Bennett et al., 1998), but the attentional blink paradigm may be the purest task of focused attention.

An attentional blink (AB) occurs when the detection of a second target (T2) is compromised if it appears within approximately 500 milliseconds (ms) of the first target (T1) (Di Lollo, Kawahara, Shahab Ghorashi, & Enns, 2005; Shapiro, Arnell & Raymond, 1997; Vogel & Luck, 2002). It is normal to find that participants can easily report T1 but T2 is much less commonly reported within the 500ms timeframe (Giesbrecht & Di Lollo, 1998; Vogel & Luck 2002). AB tasks involve the participant consciously reporting if they saw either or both of the pre-specified target stimuli amongst a stream of flashing stimuli, with the second normally being missed due to the processing of the first (Shapiro et al., 1997).

Explanations for the occurrence of the AB include; the inhibition model, the interference theory, bottleneck models, the temporary loss of control hypothesis, and the delayed attentional re-engagement account. The inhibition model (Raymond, Shapiro, & Arnell, 1992) suggests that the stimuli following the presentation and identification of T1 are perceptually suppressed and inhibited, in order to limit confusion between the features of T1 and the distractors. If T2 is presented during this period of suppression, it cannot be processed and subsequently, goes unreported. The interference theory (Shapiro, Raymond, & Arnell, 1994) was an update of the inhibition model, and indicated that the processing of T2 is diminished due to an inefficiency within the working memory

system to separate the target from distractors before their features are crossed, or interfered. However, evidence was found by Chun and Potter (1995) demonstrating that the AB can occur even when there is no potential for the target features to be confused. This led to their proposal of a two stage 'bottleneck' model of the AB. Firstly, the stimuli are recognised by their stored cognitive representations, which leads to stage two, where the representations are consolidated into working memory. The AB may therefore be due to either decayed or overwritten representations, but more likely, the limited capacities in both attention and working memory lead to the displacement of T2.

The temporary loss of control hypothesis states that an attentional filter, controlled by a central processor, is programmed to select targets and ignore distractors (Di Lollo et al., 2005). When T1 appears, the central processor switches from observing the incoming data, to consolidating the target information. As the central processor is said to be capable of completing just one task at a time, this leads to the deficit seen in the AB. Finally, the delayed attentional re-engagement theory suggests that the presentation of T1 interrupts the top-down processing of the task (Nieuwenstein, 2006), which does not have sufficient time to recover or re-engage when T2 is presented within 500ms of T1.

The commonality amongst these theories, although only briefly described, is the limited capacity both in time and space for items to be attended to and processed. The study of focused attention in this manner therefore illustrates the restricted ability of humans to consciously perceive stimuli over short periods of time (Dux & Marois, 2009), and indicates that the processing of one pre-specified target may take up to 500ms, before another stimulus can be managed.

2.1.2 Sustained Attention

Sustained attention is the ability to maintain focused attention, vigilance, and response consistency over a period of time, usually whilst completing a repetitive task (Bajaj et al., 2008; Bennett et al., 1998). This is different from focused attention as it requires the direct focus of concentration to be maintained for a relatively long time, whilst ignoring distractor stimuli, a task that is particularly difficult during mundane, repetitive circumstances. Continuous performance tasks (CPTs) are the most commonly used tool for measuring sustained attention

both in clinical and research environments (Riccio, Reynolds, Lowe, & Moore, 2002), and have been found to be reliable and impervious to practice effects (Halperin, Sharma, Greenblatt, & Schwartz, 1991). These tasks have been valuable in developing a comprehension of attentional control and deficits in attention (Helton & Warm, 2008). When completing a CPT, participants must view a constant stream of stimuli, and respond only to a pre-specified target whilst ignoring the distractors (e.g., Egeland & Kovalik-Gran, 2010; Helton & Warm, 2008). Generally, the stimuli are presented for around 100ms, and inter-stimulus intervals (ISIs) vary from 1000ms to 2500ms (e.g., Shalev, Ben-Simon, Mevorach, Cohen, & Tsal, 2011), as is necessary to avoid the AB from affecting performance. Error rates and reaction time (RT) scores are recorded across the length of the task. Specifically, omission errors (missing the targets) are thought to be indicative of inattention, and commission errors (responding to non-targets) are said to be representative of impulsivity (e.g., Marchetta, Hurks, De Sonneville, Krabbendam, & Jolles, 2007). It has been suggested that if attention is not "tightly focused" (Unsworth, Redick, Lakey, & Young, 2010, p.112) on the task, then RTs will increase and there will be lapses in performance.

An example of the common findings of this task was provided by Shalev and colleagues (2011). When 91 participants were asked to respond only to a red square amongst distractors of several colour and shape combinations, it was found that RT increased over the length of the CPT (approximately 12 minutes; Shalev et al., 2011). This increase in RT across a sustained attention task has been so frequently found that it has been named 'vigilance decrement', and is thought to be due to a reduction in cognitive arousal as a result of low levels of stimulation (Corkum & Siegel, 1993; Helton, Weil, Middlemiss, & Sawers, 2010; MacLean et al., 2010; Warm, Parasuraman, & Matthews, 2008). In support of this, it was found that extraverts (who are typically low on cognitive arousal; Eysenck, 1976) make more errors, and do not perform as efficiently as introverts on measures of sustained attention (Corkum & Siegel, 1993).

There are another two opposing theories that aim to explain the vigilance decrement, the mindlessness theory and the resource theory. Both theories can be credited to multiple authors and are summarised by Helton and Warm (2008). The mindlessness theory proposes that lapses in sustained attention are due to a switch from controlled, focused responding to automatic responding, especially

when the stimuli appear at infrequent and unpredictable intervals. Monotony and the lack of cognitive stimulation during CPTs are thought to lead to task unrelated thoughts, which contribute to this switch, leading to an increase in RTs and errors. The resource theory alternatively suggests that the deterioration in vigilance performance is due to an exhaustion of the attentional processing capacity, which does not have an opportunity to be restored during such a lengthy cognitive task. Concluding their research, which combined the measurement of self-report states of arousal and CPT performance, Helton and Warm (2008) found little supporting evidence for the mindlessness theory, and instead attributed vigilance decrements to decreasing resources and mental fatigue, and not boredom.

Measuring sustained attention can demonstrate the participant's ability to maintain alertness and focus over time, and their capacity to ignore distractors.

2.1.3 Selective Attention

Selective attention describes the ability to select and respond actively to relevant information whilst ignoring distractions and irrelevant stimuli (Bajaj et al., 2008; Bennett et al., 1998). In keeping with the role of attention, the process of selection is an important part of attention in order to preserve the limited processing capacity only for goal related stimuli (Chun et al., 2011; Lachter et al., 2004). To inhibit a natural response to irrelevant stimuli can be difficult when the target and the distracters are similar or conflicting.

The Stroop test (Stroop, 1935) is a popular task for measuring selective attention and response inhibition (e.g., Ben-David, Tewari, Shakuf, & Van Lieshout, 2014; Clarke, Hart, & MacLeod, 2014; Kane & Engle, 2003; Vendrell et al., 1995). The Stroop task has been adapted several times using a variety of stimuli; however the most common version involves the presentation of colour words (red, green, and blue) written in either a congruent colour (i.e., the word green written in green) or an incongruent colour (i.e., the word green written in red). The participants are required to state the font colour, not the word itself, which should force the active suppression of the natural response, which is to read the word (Kane & Engle, 2003). Reaction times and accuracy rates are recorded.

It is normally found that participants take more time to ignore the irrelevant factor within the Stroop test resulting in slower RTs for incongruent trials (see MacLeod, 1991 for a review, more recent examples include Ben-David et al., 2014; Cohen Kadosh, Gevers, & Notebaert, 2011; Kane & Engle, 2003). This RT can be compared to the time taken for congruent trials in order to determine if there is a significant difference between the two, which would illustrate the extent of the deficit. The incongruity effect illustrates the limited capacity of attention, as when conflicting information is presented, the individual cannot seem to process the information speedily, as shown by the RT deficit.

There are two key theories that aim to explain the Stroop effect: the relative speed of processing theory, and the automaticity theories. Each theory has been proposed in slightly different words by various authors and were summarised by MacLeod (1991) in his review. The first simply advocates that words are read quicker than colours are named, a difference that is accentuated when the stimulus consists of two conflicting cues. Included in this theory is the idea of response competition, as Treisman (1969) for example understood that the response delay in incongruent trials was due to the indecision of which cue to respond to: the word or the colour. The automaticity theory is similar, and suggests that the processing of a colour requires more attentional resources than the reading of a word, and further states that reading a word is an automatic, everyday process, whereas naming colours is not.

2.1.4 Divided Attention

Divided attention is thought to be the most complex task for attention, and reflects the ability to react concurrently to the demands of two or more tasks (Bajaj et al., 2008; Bennett et al., 1998), in other words, dual/multi-tasking.

Dual-tasking is used in psychological research to measure divided attention and attentional control abilities in participants (Della Sala, Foley, Beschin, Allerhand, & Logie, 2010; Strayer & Johnston, 2001). Within laboratory settings, this involves participants carrying out two single cognitive tasks and the recording of the appropriate scores (e.g., reaction time and/or accuracy), before combining the tasks together for them to be carried out at the same time, thus dividing attention (Della Sala et al., 2010). By measuring single task scores first, it is possible to

determine if there is a deficit in one or both of the tasks when they are combined, and to ascertain the extent to which one task is cognitively favoured over the other, if at all (Della Sala et al., 2010; Strayer & Johnston, 2001). Within non-clinical samples, it is ordinary to find that participants perform less well in the dual-task condition (e.g., Moisala et al., 2015; Pashler, 1994; Strayer & Johnston, 2001; Wood et al., 2011).

For most individuals, carrying out two things at once should not present any major problems if they are procedural, everyday tasks, for example conversing whilst exercising. If the tasks involved use similar cognitive resources (e.g., two visual tasks), it has been suggested that they are more difficult to carry out simultaneously than tasks using diverse resources (e.g., a visual task and an auditory task), due to constraints on processing capacities (Bennett et al., 1998; Wickens, 2002). However, a deficit in performance can still be found when attention is divided between two dissimilar tasks (e.g., Spence and Driver, 1997). The theory of a bottleneck system in dual-tasking is well established within the literature, and asserts that when two paths of information are being simultaneously processed, a cognitive bottleneck-like structure results in the perceptual slowing and impairment of reaction and response (e.g., Fischer & Hommel, 2012; Pashler, 1994; Wood et al., 2011).

Existing studies that used the dual-tasking method have included tasks ranging in complexity, with some researchers using difficult tasks such as verbal shadowing (Hermer-Vazquez, Spelke, & Katsnelson, 1999), sending/receiving messages on social media (Wood et al., 2011), and others using fairly simple tasks such as walking (Yamada et al., 2011), and maze tracking (Della Sala et al., 2010). However, a review found that using simple tasks is more effective and can reveal far more about an individual's ability to divide attention than if complicated tasks are used (Pashler, 1994). It was argued that even when two tasks seem relatively easy they can yield severe limitations in cognitive functioning when they are combined.

The existence of these distinctive types of attention is not widely accepted, as for example, focused and selective attention are frequently presented as the same thing (e.g., Marchetta et al., 2007), and focused/selective and divided attention have been seen as the two main types. However, it is clear that attention has

been deemed a flexible process that is required to work in different ways depending on the immediate goal.

2.2 How does Attention Work?

There are two main sets of theories that aim to explain how attention may work: the early selection and the late selection theories. Early selection theories are based on the assumption that it is beneficial, practical, and intuitive to select the relevant information for processing early, before too much cognitive effort is deployed. Late selection theories adopt the alternative standpoint that information selection occurs after an initial analysis of the available information has taken place (Pashler, 1999).

2.2.1 Early Selection Theories

The most well-known early selection theory is the filter theory by Broadbent, published in 1958. This theory consists of three stages: the sensory register, the selective filter, and the short-term memory store (see, for example, Lachter, Forster, & Ruthruff, 2004, for a review). Input from the senses enters the sensory register where the rudimentary, physical properties of each piece of information are established (e.g., tone, pitch, colour, orientation). The representations of these characteristics are then passed to the selective filter, where those that are irrelevant for the task in hand are dropped (filtered) from processing, and important, relevant information is transferred to the short-term memory store, in order for a response to be made.

Broadbent (1958) argued that the successful filtering and subsequent processing of relevant information is due to the individual's ability to attune to a definable (by sensory characteristics) stream or channel of information. This means that information that does not correlate to the attended channel is filtered from processing. For example, if an individual is listening for their mother's voice in a situation where multiple sounds are present, then information that does not match this characteristic (i.e., male voices, background noise, and different tones) is not carried on for further processing. Another example would be visually searching for a friend wearing a red hat in a crowd, where everything red is attended to and

other stimuli are filtered out and ignored. This procedure can be either, or a combination of both, top-down (pre-specifying a channel) and bottom-up (filtering according to sensory information) processes.

The filter theory was based on the idea that processing capacity is limited, yet these exact limits are unclear and were not alluded to by Broadbent himself (Lachter et al., 2004). It was also argued that the information that was deemed irrelevant and therefore filtered out of processing left no traces in the individual's memory (Broadbent, 1958; Cherry, 1953; Driver, 2001; Moray, 1959). However, this idea became controversial after studies using dichotic listening tasks found that individuals were able to repeat samples of information or answer questions on what they had heard from the unattended ear (Treisman, 1960). Moreover, Broadbent (1958) hypothesised that information was filtered according to physical characteristics only (such as sounds, colour, etc.), yet when participants were conditioned (by use of electric shock) to fear certain words, a physiological reaction of an increase in galvanic skin response was found when these words were presented to the unattended ear (Corteen & Dunn, 1974).

These findings demonstrate that although the unattended ear may not be fully processed, small amounts of information can be. In order to meet these new experimental findings, Treisman (1969) presented an adaptation to Broadbent's filter theory.

Treisman's attenuation theory (1969) looks almost the same as the filter theory. However, the selective filter has become the attenuator, where most irrelevant information is filtered from processing, but small amounts leak through to short term memory. It was suggested that the attenuator deciphers which channel of information is important for processing based on more than just physical properties, as suggested by Broadbent (1958). Rather, it was proposed that stimuli were analysed systematically, first for physical characteristics, then for semantic meaning.

It was argued that the type of task-irrelevant information that was likely to leak in to the short term memory store would be primed as personally relevant or interesting to the individual, for example, the person's name (Driver, 2001; Lachter et al., 2004; Treisman, 1969). Anticipated and relevant sensory input require less processing capacity as the unexpected, which allows space for

unattended information to leak through the filter. The unattended information that does enter the short term memory store is not as strongly processed as the relevant information, and therefore may not always induce a response from the participant, but is not so weak that it cannot be extracted and used if it becomes necessary (Driver, 2001; Treisman 1969). The attenuation theory therefore predicts that a little irrelevant information can still be processed at a basic level, which accounts for the findings from the dichotic listening trials (Treisman, 1960), and the physiological response tests (Corteen & Dunn, 1974).

Support for the early selection models of attention has come from research into visual search and preattentive processes, culminating in the feature-integration theory by Treisman and Gelade (1980). Studies have shown that when a visual target has features that are particularly salient and easily differentiated from surrounding distractors, it appears to "pop-out" (Treisman, 1985, p.170), that is, it is recognised instantly. Single, salient targets can be identified amongst large arrays in as little as 200-250ms, and given that a saccade takes around 200ms to begin, this identification takes place in one look, in less time than is required to process the entire scene (Healey & Enns, 2012). This indicates that some featural processing may precede awareness. When the features of the target are not easily discernible, individuals take longer to identify the target, indicating that they may be analysing each stimulus separately (Treisman, 1985).

The feature-integration theory was proposed as an explanation of these findings. It reasons that preattentive processes in visual tasks identify basic physical features separately, such as colour, movement, and orientation, before the application of focal attention is required (Treisman, 1985; also see Müller & Krummenacher, 2006 for a review). These processes are said to be effortless, fast, and run in parallel, as they incorporate whole visual sets, ultimately providing a spatial map or representation of the identified physical features (Treisman, 1985; Treisman & Gelade, 1980). Preattentive processes are then thought to guide attention to the most important or most relevant item in view. Thereafter, visual attention is engaged, and the location of the stimuli are identified serially, with features being combined or 'integrated' when they appear within the same focal point (Treisman & Gelade, 1980).

The early selection theories have been influential in the area of attention research, and both highlight the role and importance of attention. Furthermore, it is agreed on both parts that the processing capacity for new information is very limited and therefore successful filtration of at least most of the irrelevant sensory stimuli in our environments is important for cognitive functioning. Preattentive processes may help with this.

2.2.2 Late Selection Theories

Both early and late selection theorists support the idea of two systems governing the selection of information for attention. For early selection theorists, the first is the filter or attenuator, and the second system has a limited capacity that selects information for further processing. Late selection theories disregard the partial analysis made by the early filter as being key to the selection of relevant information for processing. Instead, they tend to suggest that information is fully analysed for meaning as well as physical characteristics in the first stage, before the selection of what is important is made in an intermediary period, in the limited capacity processor (Duncan, 1980). The second stage is the awareness to and response by the participant. This stance was adopted by Deutsch and Deutsch (1963) and Duncan (1980), the latter being described below.

The first stage of the late selection model of attention involves a complete analysis of all available sensory stimuli, in parallel, and without the use of divided attention (Duncan, 1980). This analysis is supplemented by any available data from memory, and includes the detection of form, colour, size, and location, as well as meaning, and stimuli classification. This is possible according to late selection theorists, as there is no limitation on the capacity of the initial identification process. During this first stage, it is proposed that the individual cannot make a response according to what they see or hear, as the information has not yet reached awareness, which also means that they are vulnerable and open to interference. Before the second response stage can be reached, the analysed information must pass through the selection system, which is limited in working and storage capacity (Duncan, 1980).

This model specifies that any and all of the information processed in stage one can cross over in to the selection phase, yet only information that fits the goal

(i.e., targets) is forwarded for a response, according to the classifications made in stage one. This was called a selection schedule by Duncan (1980), with information that has been identified as useful and featuring on the selection schedule being passed through the limited capacity system to reach stage two. However, if only the targets are gaining entry to the limited capacity processor, then a form of selection or filtering must have already taken place. The existence of a selection schedule, and the claim that this can guide the type of information that reaches the selection system and therefore stage two of the model, implies a top-down process that must involve an earlier filter. Duncan (1980) seems to effectively describe a filter, as in the early-selection theories, but just does not refer to it as one.

Late selection theories that propose a full semantic analysis of the available information takes place in parallel before selection, are mainly based on findings from studies using single word cues, or very short sentences (Pashler, 1999), which of course does not reflect the nature of real life speech and language use. As shown by the literature, the simultaneous processing of two paths of information results in the perceptual slowing of the reaction and response (Fischer & Hommel, 2012; Pashler, 1994). If these information streams were being analysed fully at the same time pre-selection, the process would be slow, cumbersome, and inefficient. As we pay attention and can respond to stimuli extremely quickly, and usually with ease, as illustrated by Healey and Enns (2012), the late selection theories seem unlikely.

More recently, and in response to late selection theories, there has been an attempt at a revival of Broadbent's theory. Lachter, Forster, and Ruthruff (2004) carried out a series of experiments that indicated the unattended and irrelevant information that made it to short term memory (as found in the dichotic listening tasks, and as explained by Treisman's theory, 1969) was not due to leakage, but due to slips in the focus of attention. This means that the individual briefly attended to and, therefore, processed the irrelevant information, even though it was unrelated to the task (Lachter et al., 2004), a finding that also was reported, by Dykes and McGhie (1976). Slips in attention had not been controlled for in previous studies, as determined by their review of the literature. This is certainly a plausible alternative explanation as to why participants had memory of, or reacted to, 'unattended' information. Studies have shown that it is difficult to

maintain concentration and focus on a single task (e.g., Bajaj et al., 2008; Bennett et al., 1998), which could explain why attention occasionally slips, in the way described by Lachter, Forster, and Ruthruff (2004). The authors state that their findings provide evidence against attention models that account for 'leakage' during selection, that attentional slippage is well reported, and that this explains the findings of those who adapted or rejected Broadbent's filter theory (1958).

2.2.3 Visual Attention Systems

Within the research field of visual attention, it has been proposed that two major attentional systems exist, one based on top-down processing, and the other, bottom-up processing. Top-down processing uses the individual's aims, existing knowledge, and expectations to guide attention, whereas bottom-up processing utilises environmental and sensory information, irrespective of the individual's goals, to guide attention (Corbetta & Shulman, 2002). These two systems are said to govern visual attention. Posner's (1980) theory and Corbetta and Shulman's (2002) theory will be presented here in illustration of this view point.

Posner (1980) carried out experiments in which he claimed to study "complex human activity" (p.4). The participants of these studies were required to react as quickly as possible to the onset of a light. Before the light appeared, a valid, invalid, or neutral cue was presented to participants in either their central, or peripheral visual field. The valid cues consisted of an arrow pointing to the side the light would show, the invalid cues pointed to the incorrect side, and the neutral cues consisted of a central cross (see figure 1). For arrowed trials, the cue was valid on 80% and invalid on 20% of the presentations.
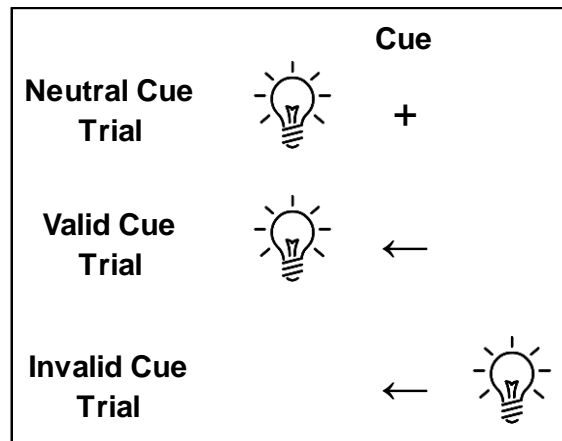
Figure 1: Cueing paradigm. Illustration adapted from Posner (1980).

It was found that valid cues led to the fastest response times, followed by the neutral cues, then the invalid cues. It was also found that invalid central cues could be more easily inhibited than peripheral cues. Posner likened attention to a spotlight that can move around flexibly, where processing is focused and clear at the centre of the beam of light, and little is processed beyond it. It was therefore concluded that processing is enhanced at the point of focus for attention, and that valid cues can guide or 'zoom' attention to facilitate this effect.

The results of these experiments directed Posner (1980) to differentiate between two systems of how we orientate our attention, an endogenous attention system and an exogenous attention system. It was proposed that the endogenous system is a top-down system, managed by the objectives and expectations of the individual, and is in use when peripheral cues are involved. The exogenous system is a bottom-up, automatic system as it moves attention to unexpected or salient information, and is in use when the peripheral cues are unhelpful (Posner, 1980).

Corbetta and Shulman (2002) proposed a very similar theory to that by Posner (1980), and attempted to identify the neural basis for top-down and bottom-up processing. The first of their two attentional systems was the dorsal network, and the second was the ventral network. The dorsal network, named so as neural analysis found that activation was concentrated in the dorsal posterior parietal and the frontal cortex, is occupied with the task of cognitively selecting information and producing a response This is a top-down process that bears similarities to Posner's endogenous system (1980). Activation in the

temporoparietal and ventral frontal cortex is apparent during the use of the ventral network, which is used during the identification of sensory information. This is a bottom-up process, and is aligned with Posner's exogenous system (1980).

The dorsal network is thought to be goal-directed, therefore guiding attention according to the aims of the individual (e.g., Asplund, Todd, Snyder, & Marois, 2010; Corbetta & Shulman, 2002; Shulman et al., 2009). This system is able to facilitate processing by biasing it towards goal related information according to the ability of the individual to form a cognitive representation of the pre-set information (i.e., the ability of the individual to set their goal to only searching for the colour red, when searching for their friend wearing a red hat). By doing so, this would conserve an amount of the limited processing space, as irrelevant (i.e., non-red) information would not be processed and attended to (Corbetta & Shulman, 2002). This explains the finding that participants can locate a target more quickly after being given information about its nature (i.e., location, appearance) as participants can attend to the target relevant information, which in turn leads to a quicker response.

The ventral network is stimulus-driven, so is controlled by sensory input and will guide attention either when there are no overriding goals, or with the presence of salient stimuli. In relation to stimuli that appear suddenly, such as a spark from an electrical appliance, it was suggested that these can immediately gain control of the information selection process (Lachter et al., 2004). It is thought that the unconscious redirection of attention, eye-gaze, and behavioural response to unexpected, salient information occurs in a circuit breaker system in the ventral network (Corbetta & Shulman, 2002). Information selection is interrupted in the presence of an unexpected stimulus, especially if a behavioural response is required (i.e., to attend to the spark, or to leave a building if a fire alarm goes off). This circuit breaker system is consequently advantageous for the well-being of an individual, and can be quickly overridden by conscious processors if logical analysis indicates that there is no need for a behavioural reaction (i.e., if the spark was in fact a reflection, the appliance was turned off, or if the fire alarm was a practice) and the individual can return to the normal filtering of information.

More recently, an investigation using functional magnetic resonance imaging (fMRI) found that the dorsal and ventral networks do not only exist in relation to

external attention (i.e., attention paid to external stimuli), but also in relation to internal brain activity, independent of external task demands (Fox, Corbetta, Snyder, Vincent, & Raichle, 2006). Furthermore, support for Corbetta and Shulman's (2002) model has been provided in neuroimaging studies concerning colour or orientation target detection (Giesbrecht, Woldorff, Song, & Mangun, 2003), spatial navigation (Iaria, Fox, Chen, Petrides, and Barton, 2008), and target prediction (Hahn, Ross, & Stein, 2006).

Although the two systems approach was proposed decades after Broadbent's filter theory, they seem to be compatible. Both the dorsal and the ventral systems can work together, as the ventral system selects information from the senses according to the goals controlling the dorsal system (Corbetta & Shulman, 2002). The ventral system relates to the filter, as they both work from sensory characteristics, and the dorsal system is comparable to the limited capacity processor, as both select information according to what is important to the individual at that point in time. Broadbent (1958) had alluded to the existence of a circuit breaker system in the presence of unexpected stimuli, and the version proposed by Corbetta and Shulman (2002) could seamlessly coincide with the filter theory, as well as with Treisman's (1969) attenuator theory. Therefore, it is suggested that these theories complement each other, with the Filter theory (Broadbent, 1958) providing detail of how selection works, and the visual attention networks theory (Corbetta & Shulman, 2002) giving more detail on how the processing system of attention works, with evidence from neuroscience.

The studies contributing to the theories and support for the visual attention systems used measures of focused attention in various forms. Neuroimaging studies comparing the differences between selective and divided attention have demonstrated that attention can be considered an executive function, as discussed below.

2.3 Attention and Executive Function

Attention is a complex function that enables information to be processed, the ability to concentrate and learn, and ultimately, it allows for goals to be attained. Within the literature, attention is often referred to as one of the executive functions

(EFs), which are a diverse set of processes that serve to enhance and manage performance on a range of tasks (e.g., Hawthorne et al., 2014; Robbins, 2000).

Broadly, it has been suggested that EFs are all-purpose control processes that govern the complexities of human cognition (Miyake et al., 2000). EFs have also been described as crucial, high-level cognitive processes that govern the abilities to perform appropriately, effectively, responsibly, and socially (e.g., Lezak, 1983), and to form goals, plan, and implement goal related plans (e.g., Jurado & Rosselli, 2007). More specifically, there are thought to be three key constituents of EF: "1) *attentional control*: selective attention and sustained attention; 2) *cognitive flexibility*: working memory, attentional shift, self-monitoring, and conceptual transfer; and 3) *goal setting*: initiating planning, problem solving, and strategic behaviour" (e.g., Anderson, Northam, Hendy, & Wrennall, 2001, p.93).

Attention is a regularly featured concept in discussions of EF, highlighting its importance as a function and its substantial involvement in cognition. Neurologically solidifying the status of attention as an EF, imaging studies have determined that most attentional processing, including distraction prevention, occurs in the frontal lobes (Filley, 2002; Vendrell et al., 1995), where EFs are known to operate (e.g., Jurado & Rosselli, 2007; Miyake et al., 2000; Stuss & Alexander, 2000).

Further neuroimaging evidence for the role of attention in EF has shown neural differences in selective and divided attention processing (Johnson & Zatorre, 2006). Participants were given two simple tasks (one auditory, one visual) and were requested to either attend to one (selective attention) or both (divided attention). Using fMRI, it was found that during selective attention, neural activation was increased in the relevant sensory cortices, and was reduced in the irrelevant sensory cortices (Johnson & Zatorre, 2006; Loose, Kaufmann, Auer, & Lange, 2003). During divided attention, there was additional activation in the dorsolateral prefrontal cortex (DLPFC), and reduced activation in the sensory cortices, thought to be due to capacity limitations being reached (Johnson & Zatorre, 2006; Loose et al., 2003, see also Moisala et al., 2015). As divided attention is a more difficult task than selective attention, the authors suggested that neural activity during divided attention was moved to the prefrontal cortex in order to maintain and manage processing and functioning with the increase of

task demand, and the subsequent reduction of available working capacity in the cortices where selective attention took place.

A follow up study by Johnson, Strafella, and Zatorre (2007), featuring the same two tasks and conditions, used transcranial magnetic stimulation (TMS) to temporarily interfere with the functioning of the DLPFC. This interference led to an inability in processing both tasks simultaneously, with performance resembling that of selective attention rather than divided attention. Therefore, by location association and the nature of divided attention, it can be suggested that divided attention is an EF.

The evidence and literature presented illustrate both the roles of EF, and of attention within EF. Recognising and appreciating the important roles of attention and EF can aid with the understanding of the symptomatology of attention disorders. This will be discussed further, after an explanation of attention deficit hyperactivity disorder, which follows.

2.4 Attention Deficit Hyperactivity Disorder

As with any cognitive ability, attention is vulnerable to dysfunction. This overview will highlight the symptoms and deficits associated with attention deficit hyperactivity disorder (ADHD) – the most common and best understood deficit of attention. By understanding ADHD, we can learn more about attention.

"The essential feature of [ADHD] is a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development" (American Psychiatric Association [APA], 2013, p.61). According to the Diagnostic and Statistical Manual of Mental Disorders (fifth edition) (DSM-V; APA, 2013), ADHD has chronic, impairing symptoms including inattention, disorganisation, impulsivity, and hyperactivity, as well as indicators such as failure to pay attention to detail, the production of thoughtless mistakes, forgetfulness, and the appearance of not listening when spoken to. Individuals with ADHD will experience all or a selection of these impairments across different settings (i.e., at home, school, work, and when socialising), although the presentation or severity of each symptom can vary across environments.

The DSM-V (APA, 2013) specifies that there are three main subtypes of ADHD: impulsive type, inattentive type, and combined type. The difference is, those with impulsive type display more outward behavioural symptoms of ADHD, such as hyperactivity, fidgeting, excessive movements when the expectation is to be still (e.g., in situations like classrooms or meetings), and disproportionate talking. Those with ADHD-inattentive type tend not to display these behaviours, but can be more internally distracted, restless, and struggle to stay on task. Those with ADHD-combined type display the symptoms of both the inattentive and the impulsive types. From this point, the author will refer just to ADHD without further specification of subtypes.

According to the DSM-V, there are comorbid conditions that are frequent in individuals with ADHD. Specifically, oppositional defiant disorder co-occurs most commonly, within about a 25-50% of children with ADHD (APA, 2013). With children and adolescents with ADHD, conduct disorder can be experienced in around a quarter of cases. Specific learning difficulties and disruptive mood dysregulation disorder can also be comorbid with ADHD. Adults with ADHD are more likely to have comorbid conditions such as anti-social and other personality disorders, and intermittent explosive disorder. Other disorders that only a minority of those with ADHD will have, but appear more frequently in those with ADHD than in the general population, include anxiety and depression, and substance misuse (APA. 2013). Other comorbidities include obsessive-compulsive disorder, tic disorders, and autistic spectrum disorder.

2.4.1 Prevalence of ADHD

ADHD is one of the most pervasive psychological conditions in children (e.g., Gomez & Condon, 1999), and contrary to common opinion, is a prevailing condition in adulthood (Harpin, 2005; Murphy & Barkley, 1996; Simon, Czobor, Bálint, Mészáros, & Bitter, 2009), and can even originate in adulthood (Moffitt et al., 2015). Many studies have aimed to determine the exact prevalence of ADHD in society. Surveys have shown that ADHD exists across cultures, with around 5% of children and 2.5% of adults having the condition (APA, 2013). In the USA alone in 2011, 11% of children had been officially diagnosed with ADHD with 6.1% of those children receiving treatment by medication (Centres for Disease

Control & Prevention, 2013). Approximately 65-80% of children with ADHD will also have the condition in adolescence and adulthood (Faraone, Sergeant, Gillberg, & Biederman, 2003; Faraone, Biederman, & Mick, 2006). One systematic literature review found that the worldwide incidence of ADHD was 5.29% (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007).

ADHD is diagnosed significantly more in the United States compared to both Africa and the Middle East (Polanczyk et al., 2007), but the same study found that there were no prevalence differences between the United States and Europe, South America, Asia, or Oceania. Cultural differences exist in the attitude toward and management of ADHD. For example in Germany, it is thought to be caused by dietary deficiencies, or food sensitivities, meaning it is treated with diet adjustments (Schmidt et al., 1997), yet elsewhere it is more likely to be treated with medication and/or therapy (Dopheide & Pliszka, 2012: treatment is further discussed in section 2.4.3).

There is also a lack of consistency across nations in how ADHD is measured, diagnosed, and treated, and it is thought that there is a high rate of under-diagnosis (Asherson et al., 2012). It is possible that this is due to the misconception that ADHD is a childhood disorder, given that it was only inaugurated in to the DSM as an adult disorder for the first time in 1994. The lack of understanding and diagnosis of the disorder is also thought to be due to inconsistent measuring methods (Asherson et al., 2012), misinterpretations in the media (i.e., ADHD is an excuse for bad behaviour or bad parenting), and a reluctance of general practitioners to identify and deal with the disorder (Shaw, Wagner, Eastwood, & Mitchell, 2003).

ADHD is a debilitating condition that can affect all areas of an individual's life and can lead to poor academic achievement, low self-esteem, decreased employment opportunities and lower occupational status, poor relationships, anxiety and depression, and substance misuse (Advokat, Lane, & Luo, 2011; APA, 2013; Barkley, 1997; Faraone et al., 2003; Harpin, 2005). In the USA it is thought to be a significant public health issue and the cause of a substantial financial weight upon both families and society (Polanczyk, et al., 2007). Despite the large impact that ADHD can have on individuals and society, the cause of ADHD is still unknown.

2.4.2 Possible Causes of ADHD

Neurological studies have determined that the rate of cortical development of the prefrontal regions of the brain is significantly slower in those with ADHD when compared to control individuals (Shaw et al., 2007; Shaw et al., 2012). This indicates that it is possible for abnormalities in neural development to cause EF impairment, which in turn could cause ADHD. This is one of many proposed causes of ADHD, yet a recent review found that no single factor can be attributed to the cause of ADHD (Thaper, Cooper, Eyre, & Langley, 2013)

The authors of the review listed the potential causes of ADHD, according to previous research, as factors such as genetics, pre- and perinatal risks, psychosocial stability, and environmental contaminants (Thaper et al., 2013). ADHD is heritable (up to 75%: Faraone et al., 2005; Freitag, Rohde, Lempp, & Romanos, 2010; 75-91% Levy, Hay, McStephen, Wood, & Waldman, 1997), but there are numerous variables that can affect this, such as family members, excessive early hardship, birth weight, and gene variants/expressions. Maternal smoking and stress are two pre- and perinatal factors that have been considered in previous studies, leading to their recognition as risks to ADHD, but there is no evidence of a causal relationship between these and ADHD. Environmental toxins such as pesticides and lead have also been highlighted as risk factors, but no causation has been determined. As for psychosocial factors, low income, adversity, and parent/child conflict have been correlated with the presentation of ADHD, but the link is not causal. Of all of the variables deliberated, severe early childhood deprivation was the only aspect to be considered a "likely causal risk factor" (Thaper et al., 2013, p.8).

However, not all individuals with ADHD have been exposed to severe deprivation in their childhood. In the absence of a definitive cause, psychological research has led to the development of theories of how ADHD may be caused and how it works. These are elaborated upon following a discussion of treatments for ADHD.

2.4.3 Treatment of ADHD

Unfortunately, there is no cure for ADHD, but treatments such as medication, therapy, and a combination of both, have been found to lessen the symptoms,

leading to the improved management of day to day life (MTA Cooperative Group, 1999; NHS, 2014).

There are two different categories of licensed medications that can treat ADHD: stimulants or non-stimulants (NHS, 2014). The stimulants aim to increase neural activity in areas controlling attention, in order to limit distractedness and impulsiveness. Non-stimulants on the other hand, increase noradrenaline, which can aid concentration and help to control impulses. Therapies for ADHD offered within the UK include psychoeducation to improve the individual's awareness of their symptoms, behaviour therapy using rewards for good behaviour (for use with children), social skills training, and cognitive behavioural therapy to alter faulty thought patterns (NHS, 2014).

In a review of medication use in the USA, it was reported that in 2005, 4.4% of children (this rose to 6.1% by 2011: Centres for Disease Control & Prevention, 2013) and 0.8% of adults were prescribed medication for ADHD (Castle, Aubert, Verbrugge, Khalid, & Epstein, 2007). In the UK, the number of ADHD medication prescriptions increased by 9.36% between 2013 and 2014, to 793,749 (Care Quality Commission, 2015), but to date and to the author's knowledge, there is no report of the statistics in the UK similar to that by Castle and colleagues for the USA.

The effectiveness of treatment options for ADHD was tested with a randomised clinical trial involving 579 children with ADHD over a 14-month period. There were four conditions: medication management, intensive behavioural treatment, a combination of both, or ordinary community care (MTA Cooperative Group, 1999). The findings indicated that all participants had a reduction of outward ADHD symptoms, but the medication management and the combination group members showed significantly better improvement than the others. Interestingly however, these differences did not persist, as three year (Jensen et al., 2007) and eight year (Molina et al., 2009) follow up studies determined that there were no significant differences between the treatment groups.

Past research has found that the use of medication to treat ADHD can improve the outward behavioural symptoms, but it can have little or no effect on an individual's ability to learn and utilise knowledge (Gualtieri & Johnson, 2008; Advokat et al., 2011). Furthermore, it has been found that those with ADHD find

it very difficult to self-motivate, especially if they find tasks mundane and uninteresting, and if there are no immediate benefits from completing the task (Carlson, Booth, Shin, & Canu, 2002). This leads to the individual committing less effort to unexciting tasks than those without ADHD, who can more easily understand the importance of such tasks (Egeland, Nordby Johansen, & Ueland, 2010).

Studies looking at the effect of teacher-based interventions on the behavioural and academic difficulties seen in ADHD children have found that although behaviour can be improved, there are only very small, if any, advances to an individual's academic work (DuPaul & Eckert, 1998; Iseman & Naglieri, 2011; Reid, Vasa, Maag, & Wright, 1994). Furthermore, it has been stated that the environment in which students with ADHD study should be "sensitive" (Harpin, 2005, p.i2) to the requirements of the individual, although there are no details provided stating what this would consist of.

It has been posited that as ADHD is a chronic disorder, brief and time-bound treatments, regardless of their method, are inappropriate (Pelham & Fabiano, 2008). Following from inconsistent findings of treatment effectiveness and longevity, and a lack of studies with adult samples, more evidence based research is required to inform clinicians, patients, and their families of the best options for them.

Having presented the nature, symptoms, and impairments associated with ADHD, there follows a summary of how the disorder affects the four types of attention previously discussed; focused, sustained, selective, and divided attention.

2.5 ADHD and Types of Attention

Although ADHD can be a hugely debilitating condition in children and adults in everyday life, traditional laboratory based tasks of attention do not always exhibit the expected deficits in performance. Research has considered ADHD in relation to the different types of attention, as illustrated here.

Focused Attention. The rapid serial visual presentation (RSVP) task demonstrating the AB paradigm has been used to test for differences in focused

attention between those with and without ADHD. In children, it was found that those with the disorder made more errors during an AB task, but there were no significant differences between the groups in processing recovery times (Mason, Humphreys, & Kent, 2005). Yet, between-group differences in AB performance have been found elsewhere, with poorer scores for those with ADHD (e.g., Li, Lin, Chang, & Hung, 2004; López et al., 2008), and a related study found AB deficits in highly impulsive children compared to those low in impulsivity (Li, Chen, Lin, & Yang, 2005).

In research with adults, it has been reported that those with ADHD missed more targets and took longer to recover following an AB (Armstrong & Munoz, 2003a; Hollingsworth, McAuliffe, & Knowlton, 2001). In a manipulation of the time between T1 and T2 presentation, adults with ADHD performed as well as control adults after a very short interval (90ms), but significantly poorer after longer intervals (450-720ms; Hollingsworth et al., 2001). It was therefore suggested by these authors that there was a deficit in the recovery of controlled processing, but not in automatic processing (also found in children: Li et al., 2004). More research is required in this area, and measuring adult ADHD and control groups on AB performance could highlight any differences in the ability to reinstate processing following the detection of a target.

Sustained Attention. There appear to be more studies concerning sustained attention in ADHD than focused attention. Findings have shown that children with ADHD perform poorer than control groups in measures of sustained attention (e.g., Börger et al., 1999; Christakou et al., 2013; Epstein et al., 2003; Harper & Ottinger, 1992; Johnson et al., 2007; Liu et al., 2015; Stern & Shalev, 2013; Tucha et al., 2008; van der Meere, Shalev, Börger, & Gross-Tsur,1995). These studies outweigh the findings that there were no between-group differences (e.g., Corkum & Siegel, 1993; van der Meere & Sergeant, 1988). Still, in these cases, differences on RTs and errors were found, but there were no significant interactions with group.

In studies with adults, it has so far been found that those with ADHD have slower and more variable RTs during sustained attention tasks (Advokat, Martino, Hill & Gouvier, 2007; Marchetta et al., 2007; Riccio & Reynolds, 2001; Rodriguez-Jimenez et al., 2006; Tucha et al., 2008). These summarised findings show that

sustained attention may be affected by ADHD. However, caution is encouraged by Riccio and Reynolds (2001), who illustrate that continuous performance tasks are also sensitive to disorders comorbid with ADHD.

Selective Attention. It is often intimated that the underperformance of selective attention and response inhibition is indicative of ADHD by definition. Indeed, inattention, distractibility, and impulsivity, core components of ADHD, can be thought of as failure to select and attend to information, and a failure to suppress irrelevant stimuli, respectively. Studies have shown this to be the case, with poorer performance on selective attention measures found in those with ADHD (e.g., Brodeur & Pond, 2001; Lansbergen, Kenemans, & van Engeland, 2007; Marije Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Mason, Humphreys, & Kent, 2003). However, it is still a debate within the literature if selective attention is a primary deficit in ADHD or not, as it has also been the case that no performance differences between the groups have been found (e.g., Huang-Pollock, Nigg, & Carr, 2005; Schwartz & Verhaeghen, 2008) and in one study, only those with ADHD and a comorbidity had deficits in selective attention (Marchetta et al., 2007). It is possible that the main reason for a lack of consensus on the efficacy of selective attention in ADHD is the inconsistent array of measures used.

Divided Attention. There is a debate in the literature regarding divided attention and ADHD. With the consideration of the impairments featured in ADHD, it would be expected that carrying out two tasks at once would be very difficult, and would lead to errors and reduced RTs. This assumption was supported by some empirical findings (e.g., Karatekin, 2004; Savage, Cornish, Manly, & Hollis, 2006). However, there is an alternative thought that those with ADHD may perform as well as, (e.g., Miyahara, Piek, & Barrett, 2006) or even better than non-ADHD adults in tasks requiring divided attention (e.g., Hartmann, 1993). This may be because they are habituated to contending with numerous stimuli at once (due to their inattention), and having more than one task to attend to could in fact increase their cognitive stimulation to a level that allows them to perform efficiently (e.g., Zentall & Zentall, 1983). There are no clear results pertaining to either argument.

It appears that performance on attention tasks by those with ADHD is not always as poor as would be expected, given the definition and symptoms of the disorder. It has been argued that much less is known about the presentation of ADHD in adults compared to children, and that this leaves uncertainties over the deficits in attentional processes in adults (Marchetta et al., 2007). The vast majority of the available research concerning ADHD use samples of children (Riccio & Reynolds, 2001).

2.6 Psychological Theories of ADHD

Most of the research and publications in relation to ADHD has been descriptive and atheoretical (Castellanos & Tannock, 2002). For example, despite a large volume of research and publications in the fields of both early selection theory and ADHD, an explicit projection of how these concepts work together could not be found. It could be the case that ADHD is indicative of a fault at any stage of the early selection models of attention. At the sensory register stage of both Broadbent's (1958) and Treisman's (1969) models, a fault may consist of the incomplete pre-selection analysis of the physical characteristics of stimuli: however the evidence presented so far does not lend itself to this suggestion. It could be assumed though, that the filter (Broadbent, 1958) or attenuator (Treisman, 1969) is somehow faulty.

There are three possible faults with the filter/attenuator that could be existent in ADHD. Firstly, it may be that those with ADHD are unable to make the distinction between what is relevant and what is not. This could stem from their inability in the first place to focus on the task in hand, in order to determine what is relevant, creating a circle of inattention. Secondly, Bush (2010) mused that there may be an inability to filter out irrelevant data from the environment, meaning that too much information gains access through the filter or attenuator, and would enter the limited capacity processor, thus slowing down processing and increasing inattention and distraction. Thirdly and alternatively, it may be the case that not enough information is passing through the filter or attenuator, which leaves the individual looking for more information to process, leading to distractedness.

Defects could also exist at the processing stage, which is limited in capacity. It could be the case that those with ADHD have too little capacity, leading to an

inefficient and blocked processing system. On the other hand, the capacity may not be as limited as in those without the disorder, leading to an overload of information reaching short term memory.

The final stage of each model is the short-term memory store, where information is either rehearsed for memory storage, or lost. A fault at this stage would be coherent with the theories of EF impairment in ADHD, meaning that individuals would be unable to successfully rehearse the information in order to make an appropriate response.

This application of the early selection theories to ADHD is new in this thesis, and although it may make logical sense, publications making the same links have not been found. In review of the literature then, firstly, one of the newer neuroscience theories will be introduced, the dynamic developmental theory of ADHD, before four of the more established theories of ADHD are summarised, namely the cognitive energetic model, the unified theory, the delay-aversion theory, and the dual-pathway model of ADHD.

There has been a recent surge in neuroscience research in to ADHD, with most of the theories now implicating dopamine and dopamine dysfunction in the possible cause of ADHD (see Gizer, Ficks, & Waldman, 2009 for a review). One example of these theories is exemplified below, and was published by Sagvolden, Johansen, Aase, and Russell (2005).

2.6.1 Dynamic Developmental Theory

The dynamic developmental theory of ADHD is grounded in the proposal that an interaction between hypofunctioning dopamine branches and the environment can predict the symptoms of ADHD (Sagvolden et al., 2005). Dopamine is a vital neurotransmitter that plays a key role in cognitive, motor, and limbic functions (Nieoullon, 2002), and it regulates activity in the prefrontal cortex (Sagvolden et al., 2005). Low levels of dopamine can therefore lead to behavioural and EF impairments, and these hypofunctioning dopamine branches can lead to a number of difficulties. A difficulty in distinguishing between types of behavioural reinforcement (caused by a hypofunctioning mesolimbic dopamine branch) can result in hyperactivity, impulsiveness, poor sustained attention, and disinhibited

behaviour. A problem with producing attentional responses and planning (caused by a hypofunctioning mesocortical dopamine branch) can lead to disoriented responses, poor focus and response to targets, and impaired EFs. Difficulties with poor motor and non-declarative memory management (caused by a hypofunctioning nigrostriatal dopamine branch) could result in delayed development, clumsiness, and poor response inhibition. The composition of these dopamine branches may be different between individuals, and the expression of these, along with influences from the environment and medication can yield the enduring behavioural patterns seen in ADHD (Sagvolden et al., 2005).

Although support for the role of dopamine dysfunction in ADHD has been granted (e.g., Söderlund, Sikström, & Smart, 2007; Spencer et al., 2007), Karatekin (2005) argues that this theory is too broad and that it requires refinement in order to be testable. It may be the case, that following refinement, this theory can enhance and inform the cognitive theories of ADHD, and its emphasis on the workings of dopamine could be what underpins them.

The first of these cognitive theories of ADHD is the cognitive energetic model, which discusses an interplay between attentional processes, states of arousal, and EFs.

2.6.2 Cognitive Energetic Model

The cognitive energetic model (CEM) was proposed by Sergeant, Oosterlaan, and van der Meere (1999; reviewed by Sergeant, 2005) and considers that proficient information processing is governed by the interaction between three levels: computational mechanisms of attention, state factors, and EF (Sergeant, 2005). The first level, computational mechanisms of attention, consists of four attentional processing stages: search, encoding, decision, and motor configuration. The second level, state factors, includes three distinctive energetic pools: effort, arousal, and activation. Effort can be affected by cognitive load and motivation, and is identified as the energy required to fulfil the demands of a task. Arousal is regarded as the variable level of stimulation that can be affected by novelty, interest, and signal intensity. Activation is the readiness to respond, and can be affected by preparedness, alertness, time of day, and task duration.

Sergeant (2005) emphasises that the relationship between these three state pools is of specific relevance to ADHD, as it can have an effect on motor output and outward behaviour. The third level of the CEM is EF, and incorporates the cognitive functions previously associated with the prefrontal cortex.

It is hypothesised that these three levels work together in a bottom-up or top-down manner, context and task dependent, and that ADHD can cause weaknesses at each of these three levels of the CEM (Sergeant, 2005). An instability or defect at any of these stages, or the aspects within the stages, would lead to inefficient information processing, which is thought to lead to the symptoms of ADHD. The lead author of the CEM admits that more research and the production of precise tests for the measures of the state factors are necessary in order to support this theory fully. Furthermore, it is suggested that neuropsychological studies that investigated the CEM could be affected by inconsistent methods, and variable cortical development and maturation stages, resulting in the mixed support for the theory. Rapport, Chung, Shore, and Isaacs (2001) argue that the CEM works in theory, but is untestable and lacking in verifiable support. However, other have emphasised the importance of considering the cognitive energetic factors in theories of ADHD (Schatz & Rostain, 2006; Sonuga-Barke, 2003), and findings have supported the inclusion of EF management in the CEM, as discussed in relation to Barkley's theory (1997).

2.6.3 Unified Theory

Barkley's unified theory of ADHD (1997) suggests that there are four key deficits to the disorder: "(a) poor investment and maintenance of effort, (b) poor modulation of arousal to meet situational demands, (c) a strong inclination to seek immediate reinforcement, along with (d) […] difficulties with impulse control" (p.65). These four factors corroborate with the symptoms of ADHD.

According to this theory, a proposed cause of ADHD is a deficit in EF, as EF impairment is often found in individuals with the disorder. Barkley (1997) advocated that poor response inhibition was the main problem (this assertion is supported by many others, for example: Berlin & Bohlin, 2002; Groman, James, & Jentsch, 2009; Nigg, 1999; Slaats-Willemse, Swaab-Barneveld, De Sonneville,

Van Der Meulen, & Buitelaar, 2003) and attributed this to the functioning of the frontal lobes, where EFs are operated from. Inhibition is the process of diminishing neuronal, intellectual, or behavioural action (Clark, 1996), and this is thought to play an important role in the management of behaviour. Inhibition can be cognitively assessed by the individual's ability to withhold or delay a response, the termination of an existing response, and resistance to distraction (Barkley, 1997). It was further stated that there are four EFs that specifically guide self-regulation and goal-directed behaviour, which depend on successful behavioural inhibition. The four EFs are working memory (e.g., keeping information in mind, and manipulating or using it), self-regulation of affect/motivation/arousal (e.g., emotional, drive, and stimulation control), internalisation of speech (e.g., reasoning, problem solving, and rule following), and reconstitution (e.g., behaviour analysis, verbal/behavioural fluency, creativity). A deficiency in inhibition leads to an impairment in these four EFs that affect self-regulatory behaviour and behavioural fluency, a lack of which is evident in the symptoms of ADHD.

Support for Barkley's (1997) unified theory was evidenced by a meta-analysis of 83 studies that tested those with and without ADHD on measures of EF. It was concluded that those with the disorder had significantly poorer performances on all of the EF tasks utilised (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Medium effect sizes were shown for these findings, with the greatest and most stable deficits being in response inhibition, vigilance, working memory, and planning (Willcutt et al., 2005). The differences could not be explained by variation in IQ or the symptoms of comorbid conditions.

In further support, children with non-medicated ADHD were tested on five EF tasks (the Wisconsin Card Sorting Test, the Stroop Test, the Matching Familiar Figures Test, the Trail Making Test, and the Tower of London), and their performance was compared to a control group without ADHD (Houghton et al., 1999). It was found that those with ADHD had poorer behavioural and response inhibition scores than those in the control group. As the ADHD group were clear of any comorbid conditions, it was determined that the deficits in EF were an ailment of ADHD itself. Furthermore, when tested on the EFs of response inhibition, working memory, and flexibility (akin to Barkley's (1997) reconstitution), it was observed that those with ADHD had significantly more impairments than

those who did not, and that they showed no improvement in EF with age (Happé, Booth, Charlton, & Hughes, 2006).

It has been clarified that the behaviour of those with ADHD is likely to be influenced by situational context, more so than for those without the disorder (Brown, 2013; Houghton et al., 1999). This means that it should not be taken for granted that those with ADHD will have EF impairment irrespective of what they are doing and the context they are in. It is probable that those with ADHD will have a range of tasks that they will be fully able to engage with, without EF decrement, leading to their successful completion. Brown (2013) explained that these tasks are usually of high personal interest to the individual, which therefore enhances their motivation, resulting in higher levels of concentration. For instance, one may find it very difficult to read an instruction manual, but may have no problem with reading a book from their favourite genre. There is also a second type of situation that would lead to higher levels of focus, which is when the incompletion of a task is perceived to have immediate negative consequences. For example, a student with ADHD may find report writing very challenging and may therefore procrastinate as much as possible, but when the deadline is closer, they should find it easier to produce the work due to the worry of acquiring a failed assessment.

That some tasks are carried out more successfully than others should not lead to the opinion that those with ADHD have a lack of willpower on the tasks they struggle with. Concentration cannot always be enforced by the person with ADHD as EFs are automatic procedures (Brown, 2013). Factors that are thought to influence this fluctuation in EF performance are contextual and include personal interest, perceived reward/reinforcement, task type and requirements, and internal cognitive and physiological elements (Brown, 2013).

2.6.4 Delay-Aversion Theory

The ADHD as a 'motivational style' argument is less dominant in the literature, and purports that ADHD symptoms are a function of a drive to avoid delay (e.g., Haenlein & Caul, 1987; summarised by Sonuga-Barke, 2002). Studies have supported this idea, by demonstrating that those with ADHD prefer smaller immediate rewards, rather than waiting longer to receive a more substantial

reward (e.g., Marco et al., 2009; Paloyelis, Asherson, & Kuntsi, 2010). It is therefore inferred that when no choice is available, those with ADHD show inattention and/or hyperactivity, and use their environment, in an effort to lessen their awareness of time. This position relates delay aversion to deficits in EFs such as time-management, working memory, and planning (Sonuga-Barke, 2002).

Sonuga-Barke (2002) argued that these theories that attempt to find one cause of ADHD are insufficient, and undermine the intricacies of the disorder. In response, he introduced the dual-pathway model, a neuro-cognitive model of ADHD.

2.6.5 Dual-Pathway Model

The two competing accounts of ADHD regarded the disorder as either a condition of executive dysfunction (EDF) that is sustained by poor inhibition (e.g., Barkley, 1997) and hyperdopaminergic branches (e.g., Sagvolden et al., 2005), or as a motivational type, characterised by delay aversion (e.g., Sonuga-Barke, 2002). That EDF is a feature of ADHD is relatively accepted within the recent literature, and Sonuga-Barke (2002) maintains Barkley's (1997) emphasis on the problems with behavioural disinhibition. The motivational style argument also has supporting evidence. When the two theories were directly compared in a 'head to head' study, it was found that performance on an inhibitory control task correlated with observed ADHD behaviour, and performance on a delay-aversion task correlated with observed behaviour, teacher ratings, hyperactivity, and aggression (Solanto et al., 2001). Performance on the tasks was not correlated, yet both were found to individually discriminate those with ADHD from those without, and their discriminant validity was higher when they were combined, with performance analysis detecting nearly 90% of ADHD cases. This led to the conclusion that ADHD is the consequence of two discrete processes, and the production of the dual-pathway model of ADHD.

The dual-pathway model has two routes that lead to the same ADHD-combined type diagnosis, the dysregulation of thought and action pathway (DTAP – representing the theories on EDF), and the motivational style/delay aversion pathway (MSP; Sonuga-Barke, 2002). It is suggested that those who appear to

reach ADHD through the DTAP will exhibit more severe cognitive deficits, whereas those on the MSP have more control over their EFs, and are affected by their underdeveloped ability to process time, and their impatience for reward. Social factors are considered within the MSP, as inflexible parenting and high expectations of self-control are thought to lead to delay aversion (Sonuga-Barke, 2002). Furthermore, the DTAP is also thought to be indicative of a hypofunctioning mesocortical dopamine branch, and the MSP of a hypofunctioning mesolimbic dopamine branch, as is consistent with the dynamic developmental theory of ADHD (Sagvolden et al., 2005).

As it stands, the dual-pathway model appears to be the most comprehensive theory of ADHD, and explains the variation in the results of previous studies by combining two previously established theories. It acknowledges the complexity of ADHD, and illustrates the importance of avoiding unitary theories. Models published since the dual-pathway theory was proposed appear to corroborate with it (e.g., Bunford et al., 2014; de Wit, 2009), specifically neurobiological evidence has been provided that matches the symptoms expressed from each pathway.

Despite the profound and widespread interest in ADHD, scholars frequently comment on the lack of consensus and evidence about the cause and nature of the disorder. Investigations of the psychological causes of ADHD still yield incongruous results as illustrated, even with the advances in neurological methods, as convincing findings are often followed by convincing counter-findings. When consistencies are established, they are often accompanied by small effect sizes (Sonuga-Barke, 2002). With consideration of the evidence presented, along with the definitions of EFs, and the symptoms of ADHD, all that is clear is that deficits of EF are related to the attention disorder.

2.6 Conclusions

Attention is a complex cognitive process that selects information from the senses and our minds for further analysis and processing. As cognitive systems are limited in capacity, it is important that only task-relevant information is processed in order to achieve immediate goals.

Early selection theories have been proposed that emphasise the limited capacity of processing, and provide detail on how selective attention may work. Late selection theories of attention have also been offered, however there are gaps and criticisms, as previously presented, which leave these ideas in the shadow of early selection theories. Research in to the existence of two visual attention systems was evaluated, both of which are similar, and illustrate the difference between bottom-up and top-down processing,

This chapter concludes that there are clear differences in the behavioural patterns between those with and without ADHD, making it possible to compare the groups across different tasks. The present study aimed to fill some of the gaps in the field in relation to ADHD specifically in adults, and how it affects the processes of focused, sustained, selective, and divided attention. It also aimed to investigate the relationship between creativity and attention, and the differences between those with and without ADHD.

So far, the processes of creativity and attention have been discussed separately. There now follows a chapter about the research so far on the relationship between attention and creativity.

Chapter 3 – Creativity and Attention Literature Review

Attention, one of the EFs, has been found to be related to creativity (Hawthorne et al., 2014). The creative person has often been typified as having poorer attention than non-creative people (e.g., Carson, Peterson, & Higgins, 2003; Finke et al., 1992; Kasof, 1997; Memmert, 2011; Vartanian, Martindale, & Kwiatkowski, 2007). There are several anecdotes and illustrations of creative geniuses who appear absent minded and inattentive (such as Einstein, Darwin, Poe, and Edison), and some researchers have attempted to examine this empirically, typically using just one or two measures of creativity and attention.

From a review of this small literature field, most of which is dated, the main argument about the nature of the relationship between creativity and attention appears to be that creative individuals may have 'broad' or 'leaky' attention.

3.1 Creativity and Broad Attention

A poor attentional system allows too much irrelevant information to pass through into the limited capacity processor (Vartanian et al., 2007). In the literature that relates creativity to attention, this has often been referred to as a 'leaky filter', or as 'broad' attention.

Broad attention is a description of diffused attention. It is defined as increased distractibility due a deficit in cognitive inhibition, meaning that irrelevant information from the environment is often processed further than it should be, and is therefore a cause of distraction (Kasof, 1997; Rowe, Hirsh, & Anderson, 2007; Vartanian et al., 2007). Breadth of attention is said to relate to the number and range of stimuli being focused on, with those with broad attention focusing on many different stimuli at once (e.g., Memmert, 2011). Narrow attention is the opposite, the ability to focus on task and to ignore irrelevant information (Kasof, 1997; Rowe et al., 2007). Those with narrow attention only focus on a small number of items at once, and tend to remain impervious to what is within their environments.

3.1.1 Anecdotal Evidence of a Relationship between Creativity and Attention

A number of renowned creators have voiced their difficulties with having broad attention. Kasof (1997) provided a summary of those who found themselves particularly distracted by incidental noise. Richard Wagner, the composer, conductor, and theatre director, claimed that calmness and quietness were imperative needs to creative individuals, a statement that is emphasised by Arthur Schopenhauer (philosopher) who said that incidental noises had been a daily torment he had endured his whole life. Both Marcel Proust and Thomas Carlyle (writers) reported soundproofing the rooms they worked in to limit their distractibility, with people even laying hay on the ground in front of Carlyle's home to reduce the noise they made when walking by (Kasof, 1997). Franz Kafka, a prolific writer, said himself: "I need isolation in order to write, not like a hermit, but like a dead man" (as cited in Blanchot, 1997, p.280), as he described his preferred manner of writing. It appears to be the case that these creators were distracted by nature, but required focus to develop their ideas.

These well-established creators found that they could not pay attention to the task in hand when there was background noise distracting them. This shows that they had difficulty in only selecting relevant information for processing, and that irrelevant information was often prioritised. As the cognitive capacity for processing new information is very limited (Chun et al., 2011; Lachter et al., 2004), this meant that these individuals may not have had the 'space' to process both the irrelevant and relevant information in their environments, leading to distraction and a lack of productivity. Their attempts to reduce distractions in order to focus shows that both broad and narrow attention seem to be important for creativity.

Besides the moderate amount of anecdotal evidence, empirical evidence also exists in support of this leaky attentional filter, or broad attention idea. Most of this has been based on measures of selective attention.

3.1.2 Empirical Evidence of a Relationship between Creativity and Broad Attention

It is argued that creative individuals have broad, defocused attention that enables their ability to produce original responses (e.g., Kasof, 1997; Kharkhurin, 2011; Necka, 1999).

The main feature of broad attention is poor selective attention and response inhibition, which has again been related to creativity, this time in the form of creative achievement. Creative achievement is the total number of creative products (e.g., patents, ideas, inventions, or artistic/musical pieces) made in the lifetime to date (Carson, Peterson, & Higgins, 2005). According to Carson, Peterson, and Higgins (2003), in order to for an item to be 'creative', the product should be appropriate to reality, useful, and relatively unique. Their analysis of two studies found that those with particularly high scores on creative achievement measures had significantly lower inhibition (selective attention) scores. This relates to the idea that broad attention is crucial, as the highly creative individuals were seven times more likely than low creativity scorers to have broad, uninhibited attention (Carson, et al., 2003).

Dichotic listening tasks have been used as measures of selective attention (Ansburg & Hill, 2003; Necka, 1999) in the investigation of the relationship between creativity and attention. These tasks require the participant to attend to (select) the information being channelled in to one ear, whilst ignoring a different channel of information as it is presented in the other ear. Dykes and McGhie (1976) provided participants with assessments from the Wallach and Kogan (1965) tests of creative thinking. From a group of 300 students, the 24 highest and the 24 lowest scorers were categorised in to high and low creativity comparison groups. It was found that those in the high creativity group reported significantly more stimuli from the irrelevant listening channel than those in the low creativity group, a finding that could not have been attributed to word association or mode of presentation (i.e., prose or single word list). The authors also compared these findings to a group with schizophrenia, finding that individuals with the disorder had very similar attentional profiles to the highly creative group members. The main difference was that the performance of those with schizophrenia suffered due to the wide attentional range, whereas as those with high creativity could cope with the broader than average stimuli input, with

the ability to process this information successfully and without overload (Dykes & McGhie, 1976).

Rawlings (1985) designed a similar experiment, where participants were asked to either follow one channel of information as a focused/selective attention task, or to follow both channels as a divided attention task. Highly creative participants, as determined by two tests of the Wallach and Kogan (1965) battery, made significantly more intrusion mistakes on the divided attention task than the low creativity group did. It was hypothesised that this may be due to an aspect of impulsivity, however this was related specifically to those with psychoticism (Rawlings, 1985).

In a task involving the detection of a pre-specified visual stimulus amongst distracter stimuli, it was found that the more creative participants, as estimated by a DT task, made more errors than the less creative participants (Necka, 1999). The scores of the creative people worsened as the number of irrelevant stimuli increased, perhaps showing that they were less able to separate relevant information from the irrelevant (Necka, 1999).

Vartanian, Martindale, and Kwiatkowski (2007) found that when there were no distracting stimuli, creative individuals had faster reaction times to the appearance of a light, and faster rule comprehension times, than non-creative people. Conversely, when in-task response inhibition was required in the presence of irrelevant, interfering cues, those high in creative potential had slower reaction times than others, indicating that they were distracted by, paid more attention to, and therefore processed the irrelevant information (see also Dorfman, Martindale, Gassimova, & Vartanian, 2008; Kwiatkowski, Vartanian, & Martindale, 1999). Carson, Peterson, and Higgins (2003) also found that participants who scored highly in their measure of creative achievement, had significantly lower latent inhibition scores, meaning they were less able to filter out from awareness stimuli that had previously been viewed as irrelevant. This reduction in latent inhibition may be the key to the creation of original ideas, as there is an increased opportunity to combine unrelated concepts to produce novel ideas (see also Zabelina, O'Leary, Pornpattananangkul, Nusslock, & Beeman, 2015).

Additionally, Ansburg and Hill (2003) stipulated that as original solutions come from the combination of seemingly unrelated concepts, creative thinkers must have the capacity to process the problem in hand whilst remaining aware of the supposed irrelevant information around them that may be useful in finding a creative solution. In contrast, analytic thinkers would utilise focused, sustained, and directed attention in an attempt to solve a problem in their manner. With this difference in thinking style noted, the authors hypothesised that high scorers on the RAT would make more use of peripheral, environmental cues when completing an anagram task than low scorers. Indeed, it was found that those who were successful in making atypical combinations in the RAT were more likely to attend to information outwith the focus of the task, as they "allocate their attention in a diffuse manner" (Ansburg & Hill, 2003, p.1148). However, it was suggested that not all problem solvers use the broad attention strategy. Instead, the adoption of this technique differentiated creative thinkers from analytic thinkers (see also Wegbreit, Suzuki, Grabowecky, Kounios, & Beeman, 2012; Wiley & Jarosz, 2012).

3.1.3 Empirical Evidence for a Relationship between Creativity and Attention from the use of Environmental Cues

The argument so far has illustrated that a broad attentional scope is related to higher creativity scores. If this was the case, then creative individuals should utilise cues from the environment, more so than non-creative people. Evidence for this has been found.

Revisiting the RAT, it has been claimed that broad attention is conducive to creative behaviour as the distractibility allows for more remote associations to be made (as opposed to strong associations) by using the stimuli present in the environment as cues (Abraham & Windmann, 2007; Carson et al., 2003; Vartanian et al., 2007). It is therefore commonly suggested that those with broad attention are likely to unknowingly use this as an advantage in situations requiring aspects of creativity (e.g., problem-solving), as they can make remote associations between the stimuli that are distracting them, whereas those with trait narrow attention are less likely to spot these (Ansburg & Hill, 2003; Fink,

Grabner, Benedek et al., 2009; Friedman, et al., 2003; Kasof, 1997; Necka, 1999; Vartanian et al., 2007).

The common method of examining this is to provide participants with a task for which the answers have previously been implicitly or explicitly exposed (Ansburg & Hill, 2003; Dewing & Battye, 1971; Friedman et al., 2003). For instance, participants were provided with a list of words to memorise (focal cues) whilst a different list was read aloud in the background with the instruction to ignore them (peripheral/conceptual cues: Ansburg & Hill, 2003; Dewing & Battye, 1971; Mendelsohn & Griswold, 1964). Following this, anagram problems were given to participants, of which ten answers had appeared in the memorised list and ten had appeared in the peripheral list. Tasks to measure creativity, usually the RAT (Mednick, 1962), were also deployed. It was found that those who had scored more highly on creativity tests used more of the environmental cues than low creativity scorers for the anagrams task (Ansburg & Hill, 2003; Dewing & Battye, 1971; Mendelsohn & Griswold, 1964). Furthermore, it was found that children who scored well on DT fluency were more successful in a cue-rich environment in comparison to plain surroundings, whereas low DT scorers performed consistently across both environments (Friedman, Raymond & Feldhusen, 1978).

These studies show a potential relationship between high creativity scores and the use of environmental cues (see also Clapham, 2001; Memmert, 2009). As it has been stated that those with broad attention have a wider attentional scope, it is more likely that they would utilise information from the environment in this way.

Although there is research showing a link between creativity and broad attention, that this is a fixed trait is controversial (e.g., Dewing & Battye, 1971; Eysenck, 1995; Kasof, 1997; Memmert, 2007; Mendelsohn, 1976; Necka, 1999). The problem lies in the development of potential ideas. For example, broad attention is suited to producing creative and novel ideas (by making remote associations), but broad attention would be a problem when the idea needs to be evaluated and honed for their relevancy (Martindale, 1999). This is why some authors indicate that a fluctuation with narrow attention is also required for creativity (e.g., Ansburg & Hill, 2003; Dykes & McGhie, 1976; Friedman et al., 2003; Martindale, 1999; Vartanian et al., 2007).

3.1.4 Creativity and Attention as a Flexible Process

It has recently been tentatively suggested that focus and concentration (narrow attention) are necessary to produce original solutions (Zabelina et al., 2015). Some distinguished creators have in fact corroborated this idea. Writer E. B. White (1969) stated in an interview that he did not have the mind-set to listen to music whilst writing, but he did work in his busy living room, which he described as a 'carnival' of activity. He also stated that "a writer who waits for ideal conditions under which to work will die without putting a word on paper" (White, 1969, in response to interview question 12). Zabelina and colleagues (2015) also describe scientist Marie Curie as entirely focused on her work irrespective of surrounding noise, and Leonardo da Vinci as having "obsessive attention to detail" (p.78) and the ability to ignore distractions. These anecdotes portray an ability of these highly creative individuals to focus solely on their work, whilst remaining productive and unaffected by immediate distractions.

As a part of this argument, it has been suggested that successful creative problem solving comes first from a period of preparation, where one gets to know the problem, as described by Wallas (1926), and that persistence and focus on a problem leads to a creative solution (Zabelina et al., 2015). However, as previously described, Wallas (1926) also emphasises the importance of a period of incubation when working towards the production of an original solution, which by definition, involves broad attention and not focusing on the problem.

This stance is weak compared to the evidence presented for the importance of broad attention in creativity.

Other studies have shown that highly creative individuals are at least capable of having narrow attention. For example, using a Stroop task, which measures response inhibition and selective attention, Gamble and Kellner (1968) and Golden (1975) found that those who scored highly on creativity measures were less affected by irrelevant information and therefore performed better than those less creative individuals. Furthermore, Stavridou and Furnham (1996) and Green and Williams (1999) both found that creativity in terms of DT is unrelated to broad attention. These findings were boldly stated by the researchers in question, as the relationship between creativity and attention was not the focus of their research (they mainly investigated personality disorders), and their sample sizes

were small. By using samples of participants with disparities in cognition, it is to be expected that results may differ from those without disorders.

It had earlier been postulated that creative people "deployed their attention more widely, were more aware of and receptive and retained more prior stimulus experience in usable form, tending not to screen out the irrelevant" (Dellas & Gaier, 1970, p.55). This statement implies that although creative individuals took in and processed more irrelevant information, they seemed to be able to manage this successfully, as the information was usable. Accordingly, Dykes and McGhie (1976) established that an ability and inclination to incorporate a broader range of accessible information, and to consider the usefulness of all available data, may be more beneficial to the production of novel and original solutions than the ability to focus attention and to solely concentrate on the problem in hand.

However, Martindale (1999), who is frequently cited in the literature, proposed that a general trait of broad attention or narrow attention is not what is involved in creativity, but rather that an attention fluctuation from broad to narrow (and vice versa) is required (see also De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012; Vartanian, 2009; Zabelina & Robinson, 2010). It was argued that during the generative stage of problem solving, the creative individual uses defocused, broad attention to search for clues, but when the solution begins to become clear, narrow attention is used to define and organise the idea (Martindale, 1999; Vartanian et al., 2007). This idea was also present in Wallas's (1926) model of the creative process, with broad, diffused attention required at the incubation stage, and narrow, focused attention being necessary at the preparation and verification stages. This means that creative people are better at adjusting their attentional focus, rather than being affected by one type or another.

On one hand, it is argued and evidenced that broad, diffused attention is a trait found in creative individuals and is used for the successful production of creative ideas and solutions (Kasof, 1997; Necka, 1999), but the studies of this type do not go further to explain how those with broad attention go on to reduce and enrich their ideas. The theory by Martindale (1999) attempts to explain this idea development issue by proposing that creative individuals actually have more attentional control than previously thought, as they can switch flexibly from broad

to narrow attention, as and when required. However, the evidence for this argument is limited.

Broad and narrow attention are terms that seem only to be used by creativity researchers. This shows that this distinction is perhaps only relevant to the field of creativity, and not cognitive psychology in general.

Perhaps some of the most compelling observable evidence of a relationship between creativity and attention, comes from studies of individuals with ADHD. Broad attention has been used synonymously with distractible, and diffused attention, and those with broad attention perform poorly on measures of attention. It could therefore be assumed that those with ADHD have broad attention.

3.2 Creativity and ADHD

Broad, diffused attention and decreased inhibitory control are thought to be indications of both ADHD and creativity (Barkley, 1997; White & Shah, 2006), therefore, studies have aimed to determine if those with the condition are generally more creative than those without.

3.2.1 ADHD as a Benefit for Creativity

Armstrong (2012) has emphasised that ADHD can be beneficial in an environment that allows creativity. Few studies have directly studied creative performance between those with and without ADHD, those that have been found are described here. White and Shah (2006) compared a group of students with ADHD and a non-ADHD control group. Creativity was measured by an unusual uses DT task and the RAT, and inhibition was measured as a feature of selective attention. The authors found that those with ADHD outperformed the control group on the DT task, but performed poorly on the RAT, a result that was partly mediated by inhibition differences (White & Shah, 2006; 2011). A similar comparison study also considered past creative achievement as a measure of creativity, as well as DT tasks. It was found that those with ADHD had higher scores in creative achievement, and the previous finding was replicated in that those with the disorder performed better on DT tasks than those without.

However, a convergent thinking task may not measure creativity in those with ADHD. As previously described, the RAT in particular relies heavily upon verbal intelligence, vocabulary, and less on creativity. It could be that inhibitory control is needed in order to complete the RAT, so that incorrect solutions and constructs can be inhibited. If this is the case, it may circuitously explain why the ADHD group did not perform as well on this task. Accordingly, it has been found that performance on DT tasks by those with ADHD is significantly better than convergent thinking task performance (Merkt et al., 2013).

In a comparison of an ADHD group, a group with conduct disorder, and a control group, it was found that those with ADHD were more likely to overcome the limitations of previously activated knowledge in the production of ideas for a new toy (the participants were shown three examples of toys before being asked to create their own: Abraham, Windmann, Siefen, Daum, & Gunturkun, 2006). This meant that they were more mentally flexible, and were able to break away from what others perceived as constraints on their ideas. This was mediated by a habit of producing impractical ideas, compared to the other two groups who focused on practicality. It was proposed that the ability to think beyond the previously activated 'constraints' was due to poor attention, in that those with ADHD did not concentrate on the exemplars for long enough for them to have a restricting effect (Abraham et al., 2006).

When gifted children with symptoms of ADHD were matched to gifted children without symptoms, it was determined that the ADHD group produced more creative responses in tasks from the TTCT, despite having poorer working memory abilities (Fugate, Zentall, & Gentry, 2013). It was concluded that in the face of the educational difficulties encountered by individuals with ADHD, a combination of inattentiveness and impulsivity, as indicative of ADHD, positively influences creativity.

Russell Barkley (e.g., 2011), one of the world's leading experts in ADHD, has frequently and repeatedly stated that ADHD is not a gift, and that there is no research evidencing a benefit to having the disorder. Despite this, the studies presented support the positive link between creativity and ADHD. In fact, evidence has been found that highly creative people and those with ADHD have very similar characteristics.

3.2.2 Similarities between Creative Individuals and those with ADHD

Due to the similarities between those with ADHD and those with high levels of creativity, it has been suggested that highly creative children may exhibit cognitive deficits similar to those with ADHD (Healey, 2014; Healey & Rucklidge, 2006; Lee & Olenchak, 2014; Mullet & Rinn, 2015). Guenther (1995) explicitly argued that the traits of those with ADHD are also found in creative people. For example, Dawson (1997) recorded teacher descriptions of creative children as "make up the rules as they go along; impulsive; non-conformist; and emotional" (as cited in Healey, 2014, p.236), with similar descriptions having been applied to children with ADHD. Cramond (1995) pointed out however, that these traits are negatively reported in discussions of ADHD (e.g., those with ADHD are inattentive, so they are frequently distracted leading to their failure to complete tasks before starting another), but positively reported in discussions of creative individuals (e.g., creative individuals have many ideas, and tend to play with several ideas at once) (see also Armstrong, 2012).

Direct comparisons led to the finding that 40% (as opposed to a predicted 9%) of the highly creative children tested (n=89) presented significant levels of ADHD symptoms that were within a clinical diagnosis range (Healey & Rucklidge, 2006; 26% from Cramond, 1994a; 1994b). It is worth noting however, that only figural divergent thinking was measured (TTCT, Figural Form A; Torrance, 1998). It was also found that creative individuals with ADHD performed slightly less well on tasks involving reaction time and processing speed than creative individuals without ADHD (Healey & Rucklidge, 2006). This may be indicative of the cognitive distinction between these two groups: performance on cognitive tasks.

Taken together, these studies could suggest that creative individuals, and those with ADHD, have similar attentional profiles, in that they process more irrelevant information than is useful to the task in hand. The difference may be that those without ADHD can cope with their 'leaky filter', and use it to make unique combinations, which leads to creative ideas, products, or solutions, but the results so far are few.

3.3 Conclusions

The role of attention in creativity has had mixed results (Benedek, Franz, Heene, & Neubauer, 2012), and attention has been related to creativity in a variety of ways. Autobiographical and anecdotal evidence from creators, such as creative scientists and writers, provided the first indication of a relationship between attention levels and creativity, with successful inhibition of irrelevant stimuli being a commonly reported problem (Kasof, 1997).

According to some of the literature on the topic, broad, diffused attention is beneficial for creativity, and narrow attention is not (Kasof, 1997). This is because the nature of distraction allows individuals to combine and generate solutions to problems that may be missed by those who focus solely on the task in hand (Abraham & Windmann, 2007; Carson et al., 2003; Vartanian et al., 2007). However, the opposing argument within the literature is that narrow attention is also required to enable the development and refining of creative solutions (Martindale, 1999; Wallas, 1926). The strongest argument seems to be that an attentional switch is required, and that both broad and narrow attention are important for creativity.

The relationship between creativity and ADHD has been explored, with results tending to find a benefit of having the disorder to creativity. Yet, it may be the case that there is a key difference between creative individuals with and without ADHD, in that those without can successfully manage their leaky attentional filters for cognitive tasks, and those with, cannot.

Overall, the various forms of evidence showing that broad attention is related to and necessary for creativity are plentiful. However, each study has used a different method for measuring both creativity and attention, making the exact relationship unclear. The majority of the work relating creativity to attention has focused on selective attention and response inhibition. The research presented in this thesis will expand on this by measuring the relationship between aspects of creativity and self-report attention, ADHD, attentional control, sustained attention, divided attention, as well as selective attention.

3.4 Thesis Overview

Having reviewed the literature in the fields of creativity, attention, and the link between the two, there are some unanswered questions:

1. Are the processes of creativity and attention related?
2. If so, what is the nature of this relationship?
3. Will broad and narrow attention both be related to aspects of creativity?
4. Is ADHD beneficial for creativity?
5. Can creativity be improved?

This thesis contains four studies that aimed to answer these questions.

The first study (chapter 5) examined the relationship between creativity and attention within 100 participants. Multiple measures were used in order to analyse the outcomes in detail. Creativity was measured by self-report, past creative achievement, verbal and figural DT, and the production of a collage. Attention was assessed with a self-report questionnaire, as well as measures of focused, sustained, selective, and divided attention.

The second study (chapter 6) was a replication of the first study, but this time used a sample of 50 participants with ADHD, in order to understand the relationship between deficits in attention and creativity. Between-group differences were examined using the data from the first study to compare performance on each measure.

The third study (chapter 7) was the first to consider methods of improving creativity, by enhancing visual stimulation in the testing environment. Eye-tracking methods were employed, and a group of 15 control participants were compared to a group of 15 participants who had ADHD. Creativity was measured using verbal and figural DT tasks, and self-report, sustained and selective attention were measured.

The fourth study (chapter 8) also attempted to improve creativity. This time, the effects of aspects of attention on a period of incubation were investigated. Creativity was measured with a verbal DT task, and sustained, selective, and divided attention were measured, along with self-report questionnaires.

Chapter 4 – General Methods

This chapter provides an overview of the methods adopted in the four studies presented in this thesis. Details of the specific methods used in each study are reported in the corresponding chapter.

4.1 Ethics

Each study was granted ethical approval by the Faculty of Health, Life, and Social Sciences Research Integrity Approvals Group at Edinburgh Napier University. Participants were provided with information sheets, consent forms, and debrief sheets for each study. Each individual provided their informed consent to take part. The information sheets stipulated that they were free to withdraw at any time, their data would be anonymous and kept securely, and the researcher's contact details were provided for any follow up questions, or for participants to extract their data from the study. Each participant was assigned a number, and each measure (both paper- and computer-based) was coded with that number. This would allow for the simple deletion of their data should they wish, but no participant has made this request. Although the experimental conditions and participant groups were not blind to the researcher, each task was coded and the scoring carried out in bulk after the completion of data collection, meaning that individuals could not be identified.

4.2 Participants

The participants who took part in this research were students at Edinburgh Napier University or members of the general public, all aged 18 years or older. Participants were recruited using an opportunity sampling framework by the use of university wide research recruitment emails, advertising on social media and community websites, posters and leaflets, as well as word-of-mouth from one participant to their friends. Specific details regarding the participant groups are provided with each study.

Of the 315 participants who took part in the studies, 65 had or strongly believed they had ADHD. As an adult, it is very difficult to receive a diagnosis of ADHD if it was not identified in childhood. This is why not every participant within the ADHD groups was specifically diagnosed, but through conversation the

researcher was able to ascertain that the participants believed they had the disorder, as each one volunteered anecdotes and details that contributed to their belief. This was supported with the use of an ADHD checklist questionnaire. Furthermore, the recruitment advertisements were very clear that only participants with diagnosed or strongly suspected ADHD were required, and it was also made clear within the testing appointment arrangement conversations that the researcher would not and could not provide a diagnosis. An Edinburgh based support group for adults with ADHD, called Addressing the Balance, supported the research carried out here and aided in the recruitment process.

4.3 Materials

All testing took place in a small room within the psychology department at Edinburgh Napier University. The room was equipped with one Windows computer with a QWERTY keyboard and a mouse, a desk area, two chairs, and a larger separate desk. This was suited to the requirements of the research as the space was adequate, the blank walls limited the opportunity for distraction, and its location within the laboratories ensured that the proximate area was quiet and free from interruptions.

In total, 14 tasks are detailed here: six measured aspects of creativity, eight tested aspects of attention, and all were common to at least two of the four main studies.

4.3.1 Self-Report Measures of Creativity and Attention

Details of five self-report measures are provided in this section: The Preliminary Questionnaire covered aspects of both creativity and attention; the Creative Achievement Questionnaire contained creativity-related items; the self-report ADHD scale, the Mind-Wandering Questionnaire, and the Daydreaming Frequency Scale all measured attentional factors.

Preliminary Questionnaire. Questions regarding an individual's gender, age, creative self-efficacy, and general distractibility were combined into one 13-item questionnaire for the purpose of this study, called the Preliminary Questionnaire.

This was carried out at the beginning of the sessions for the first two studies without a time-limit, although completion rarely exceeded two minutes.

Creative self-efficacy is someone's own self-belief and judgements about their own creativity (Kaufman et al., 2008; Tierney & Farmer, 2002). This is important here as those with high self-efficacy are more likely to gear their behaviour towards fulfilling a specific goal as they believe they can achieve this, whereas those with low self-efficacy are likely to envisage failing to achieve, and will therefore place obstacles in their way (Bandura, 1993). By measuring self-efficacy, it is possible to determine an individual's attitude towards creativity. It has been stipulated that strong self-efficacy in this context is essential for creative production, motivation, and the ability to behave creatively (Bandura, 1997; Tierney & Farmer, 2002).

Creative self-efficacy was measured in this questionnaire by combining the items from two established questionnaires, by Beghetto (2006) and Jaussi, Randel, and Dionne (2007; see appendix 1). The three questions from Beghetto (2006) allude to the act of being creative, in relation to the production of ideas. Alternatively, the four questions by Jaussi and colleagues (2007) refer to the effect that creativity has on the individual, in terms of who they are as a person, and how important creativity is to them. The two questionnaires were combined as they each measured creative self-efficacy in a different way.

Altogether there were seven self-efficacy statements: '1) I am good at coming up with new ideas', 2) 'I have a lot of good ideas', 3) 'I have a good imagination' (Beghetto, 2006), and 4) 'In general, creativity is an important part of my self image', 5) 'My creativity is an important part of who I am', 6) 'Overall, my creativity has little to do with who I am' (reversed scoring), and 7) 'My ability to be creative is an important reflection of who I am' (Jaussi et al., 2007). The statements were answered with a five-point Likert scale ranging from 'strongly disagree' (one point) to 'strongly agree' (five points), with a 'neither agree nor disagree' (three points) option included.

The attention items within the Preliminary Questionnaire were created by the researcher and were included so that the participants had the opportunity to show how they judged their own abilities in concentrating and focusing on tasks. The questions asked the individual to judge some of their own attentional abilities. The

questions were 1) 'I am easily distracted' (reversed scoring), 2) 'I am good at focusing my attention on one thing at a time', 3) 'I can easily concentrate on one task until it is finished', and 4) 'I struggle to fully focus my attention on one task' (reversed scoring). These items used the same five-point Likert scale and were designed by the researcher to be simple, and similar in style and language to the creative self-efficacy items.

From the Preliminary Questionnaire, two scores were calculated: a creative self-efficacy total score, and a self-report attention total score.

In addition to the creativity score taken from the Preliminary Questionnaire, a second self-report creativity measure used was the Creative Achievement Questionnaire (CAQ; Carson et al*.,* 2005: appendix 2).

Creative Achievement Questionnaire. The CAQ provided individuals with the opportunity to disclose their achievements in ten domains: visual arts, music, dance, architectural design, creative writing, humour, inventions, scientific discovery, theatre and film, and the culinary arts. Space was also available for participants to provide further examples of their creativity that did not fall within the set fields. The CAQ makes it easy for researchers to compare individual or group differences in past creative achievement, and allows for a distinction to be made between those who are creative in one domain and those who are creative across many (Carson et al*.,* 2005; White & Shah, 2011). Again this task did not have a time limit but generally took between one and five minutes to complete.

For each creative domain, participants were asked to select from eight statements, those that applied to their achievements. The first statement was always 'I have no training or recognised talent in this area', which scored zero points. The statements then progressed from 'I have taken lessons in this area' scoring one point, to 'my work has been critiqued in national publications', which scored seven points (Carson et al*.,* 2005). The exact wording of the answer options for each domain varied slightly in order to be appropriate to the field. When the seven-point statement was suitable, the participant was also asked to indicate the number of times this had occurred, and extra points were added accordingly. The scores were added to make a single, total CAQ score for each participant.

The CAQ has been found to be valid and reliable with test-retest scores of r = .81, p < .001, and an internal consistency score of Cronbach's alpha = .96 (Carson et al*.,* 2005). Carson et al. (2005) also determined that performance on this measure was related to higher creativity scores for an artistic item produced by participants (r = .59, p < .001), and to divergent thinking scores (r = .47, p < .001).

The Adult ADHD Self-Report Scale (ASRS-v1.1). The ASRS-v1.1 Symptom Checklist (Kessler et al., 2005: appendix 3) was developed in cooperation with the World Health Organisation and has been found to be a reliable and valid measurement of the symptoms of ADHD (Adler et al., 2006; Kessler et al*.,* 2007; Reuter, Kirsch, & Hennig, 2006). The questionnaire generally takes about three minutes to complete and consists of 18 items that have been found to be internally consistent, concurrently valid when compared to the ratings of others, and strongly correlated with clinician diagnosis (Adler et al*.,* 2006; Kessler et al*.,* 2005). An example item is 'How often do you have difficulty keeping your attention when you are doing boring or repetitive work?' The participant has five answer options: never, rarely, sometimes, often, and very often. The first six items have been found to be reliable within themselves (Cronbach's alpha = .63 to .72; Kessler et al*.,* 2007), and four or more answers in the 'often' or 'very often' boxes here is thought to indicate the existence of ADHD (Kessler et al*.,* 2005). The remaining 12 items are there to indicate where individuals may have specific problems, and were included in this study in order to compare the scores with those from the other attention tasks involved in the study. One point is awarded for each answer in the shaded boxes (see appendix 3), and these points are totalled to provide an overall ASRS score.

The Daydreaming Frequency Scale (DDFS). The DDFS (appendix 4: Giambra, 1993) consists of 12 multiple choice questions taken from the Imaginal Processes Inventory (by Singer & Antrobus, 1970). The DDFS is the most commonly used measure of self-report daydreaming and mind-wandering (Stawarczyk, Majerus, Van der Linden, & D'Argembeau, 2012) and has been found to be related to probing measures of daydreaming (Mrazek, Smallwood, & Schooler, 2012; Stawarczyk et al*.,* 2012). Internal reliability has been measured with typically high Cronbach's alpha values, for example 0.91, and test-retest has shown a Cronbach's alpha score of 0.76 with one year between tests (both values from

Giambra, 1993). Each question has a five-point answer scale indicative of varying frequencies of daydreaming and participants are asked to tick the box corresponding to the most appropriate description of their daydreaming habits (answer options vary according to the question). The DDFS instructions contain an explanation of what daydreaming is and how it differs from purposeful thinking. The answers are scored from zero to four, with the sum of all responses taken as a total DDFS score (ranging from 0-48), as per the instructions provided by Giambra (1993).

Mind-Wandering Questionnaire. The final self-report attention measure was the Mind-wandering Questionnaire (MWQ: appendix 5). This was developed by Mrazek, Phillips, Franklin, Broadway, and Schooler (2013) and has been shown to hold internal consistency, face validity, and convergent validity with other measures (Mrazek et al*.,* 2013). The newly designed questionnaire has yet to be cited in other publications. There are five items: 1) 'I have difficulty maintaining focus on simple or repetitive work', 2) 'While reading, I find I haven't been thinking about the text and must therefore read it again', 3) 'I do things without paying full attention', 4) 'I find myself listening with one ear, thinking about something else at the same time', and 5) 'I mind-wander during lectures or presentations'. Each item has six answer options (scored 1-6 respectively) of: 'Almost Never', 'Very Infrequently', 'Somewhat Infrequently', 'Somewhat Frequently', 'Very Frequently', and 'Almost Always'. The higher the score, the more likely the individual is to mind-wander frequently. The questionnaire does not have a time limit, but generally took two minutes or less for the participant to complete.

4.3.2 Measures of Creative Performance

Of the remaining four creativity tasks used in this thesis, three were divergent thinking tasks from the Torrance Test for Creative Thinking (TTCT) battery (Torrance, 1966, 1990; Torrance, Ball, & Safter, 1992). Divergent thinking (DT) tasks are popular measures of creativity and creative problem-solving in previous research, as they require multiple responses or ideas to one question or problem (see section 1.2.2). Two of the tasks used in the present study tested verbal DT which is the production of written responses, and the third tested figural DT, which required drawn responses. The original DT tasks set by Torrance lasted ten

minutes each; however, in this study, all three had a five-minute time limit, as it has been found that five minutes was an optimal time for this type of task, and that there was no benefit to having more time (Snyder et al., 2004).

Verbal Divergent Thinking: Unusual Uses Tasks (UUT; Torrance et al., 1992). Verbal DT was measured by the Unusual Uses Tasks, where participants were required to list as many ideas as possible for unusual uses of everyday objects. The first task featured a tin can (UUT-TC, appendix 6), and the second a cardboard box (UUT-CB: appendix 7). The administration of the TTCT has undergone extensive investigation, with results showing that explicit instructions emphasising the importance of originality in the production of the ideas is important. For example, an instruction such as 'think of ideas that other people might not think of' (Torrance et al., 1992) helps to raise creativity scores as it encourages participants to avoid listing menial, 'normal' ideas. This was therefore implemented and specified in each of the sets of instructions.

In order to score the unusual uses tasks, Torrance (1990) has provided an extensive guide. There were three measures taken from each verbal DT task: fluency, flexibility, and originality. Fluency was scored by counting the number of responses, excluding duplicate ideas. To score flexibility, the number of types or categories of ideas, a table of 28 categories that many responses could fall into was provided in the guide. This was to make it simpler for scorers to quantify the flexibility or diversity of the participants' ideas. If any ideas did not fit into the given categories, it was acceptable to create a new category. For the scoring of originality, a checklist was provided by Torrance (1990) that lists common responses or ideas that should not score a point for originality. In the case of both the cardboard box and the tin can for example, to use them to store or carry things in, or as animal houses were popular answers and therefore were not deemed to be unique, creative, or original. Suggestions such as using these items as protection (e.g., as a shield or armour), or to make tools, were statistically less common, and therefore each scored a point for originality (Torrance et al., 1992).

When both UUTs were used within one study, the fluency, flexibility, and originality scores from each were added together, to create one verbal divergent thinking task score per participant.

Figural Divergent Thinking: Circles Task. To measure figural DT, the Circles task was used. Participants were given an A4 sheet of paper with rows of small, simple circles on the front and back (60 circles total, each with a 2.5cm diameter: appendix 8). The instructions were to draw as many different objects or pictures incorporating the circles as possible, using only a pen. Fluency and originality scores were allocated in the same way as described above. Responses such as faces and fruit (apple/orange) were among the ideas that were not considered to be creative or original by Torrance and others (1992), with items such as cell depictions or bicycles being significantly less frequent, and therefore each scoring an originality point. Flexibility was not accounted for in this task, as ideas are limited to the shape of the circle. Instead, points were awarded for elaboration (according to the instructions by Torrance et al*.,* 1992), such as the joining of more than one circle for one idea, or by adding details. Participants were also asked to title each response to allow the researcher to identify unique pictures. The titles were not scored.

Creative Production: Collage Task. The final task for measuring creativity was the production of a collage. Participants were provided with a piece of A3 white card, scissors, PVA glue, and a selection of arts and crafts materials (a detailed list of all the materials used can be found in appendix 9). Every participant had identical craft items available to them, to avoid the possibility of a variance in available materials determining what was created and ultimately scored. The task lasted ten minutes and the instructions (appendix 10) were to be as creative as possible, and to produce something that others may not think of. Participants were also asked to title their collage on completion. This has been used extensively in previous research to assess creativity (e.g., Amabile, 1982, 1983; Amabile, Hennessey, & Grossman, 1986)

The lack of a scientific consensus of a definition for creativity, and perhaps the reluctance by some to pursue one, is problematic when it comes to analysing and scoring real-life creative products produced within experimental settings. The scoring of such products by the researcher could lead (intentionally or unintentionally) to biased results, especially if s/he is a novice in the field, and/or if the study was not blind. This led to the method of having creative products scored by field experts.

Having expert judges complete a checklist when they score products would limit generalisability and would inhibit the personal input of the judge. To counter this, Amabile (1982) developed the Consensual Assessment Technique (CAT) that allows judges (usually experts in the relevant field, although not exclusively) to use their own subjective definitions and opinions of what is creative, to assign a mark out of five or ten to each product. Reliability ratings between judges and across tests using Cronbach's alpha coefficient have been found to be high, with scores typically ranging from .7 to .9 (Kaufman et al., 2008). The collages produced in this study were therefore scored using the CAT, which is thought to be ecologically valid as it is similar to the method by which art is judged in real life, by critics.

Eight participants with expertise in an area of visual art or design volunteered to be the judges, and scored 150 collages altogether (from the first two studies). Six were recruited from the School of Creative Industries at Edinburgh Napier University, and two were artists and interior designers known to the researcher. The collages were presented to the judges anonymously, and they did not know of any experimental conditions featuring within the study, but they were debriefed afterwards. The judges worked independently and were shown the exact materials that the participants had had on offer to make their collages. Each collage was scored out of ten by each of the eight judges, the scores were combined, and the mean determined, which acted as an overall collage score (Kaufman et al., 2008). Reliability analysis provided a Cronbach's alpha score of .588 with the inclusion of all eight judges. However, with the removal of judge number eight, whose scores were particularly low, alpha increased to a more reliable .693. The removal of these scores did not create a significant difference between the mean collage scores, therefore the remaining analysis was based on the scores by judges one to seven.

4.3.3 Measures of Attention Performance

In this thesis, four tasks were employed to evaluate different aspects of attention: attentional control (the attentional blink task), sustained attention (the continuous performance task), selective attention and response inhibition (the Stroop task), and divided attention (dual-tasking).

Focused Attention/Attentional Control: Attentional Blink - Rapid Serial Visual Presentation (RSVP) task. In order to measure attentional control, the attentional blink paradigm was adopted. An attentional blink occurs when the identification of a second pre-specified target (T2) is unknowingly missed by the participant if it appeared within 500ms of the first known target (T1) (Di Lollo et al., 2005; Shapiro et al., 1997; Vogel & Luck, 2002). If T1 is still being processed when T2 is displayed, there may not be enough processing capacity left to deal with it, so it will be missed by the participant. A contrasting view is that the attentional blink is caused by a brief break in visual control after viewing T1, whilst attention switches strategy to prepare for the processing of T2 (Di Lollo et al*., 2005). This task therefore measures the participant's ability to switch and control attention.

In the present research, an attentional blink rapid serial visual presentation (RSVP) computer task was used, which was designed by Shapiro, Raymond, and Arnell (1994) and required the use of software E-Prime 1.0.

On-screen instructions (appendix 11) were presented to the participants and any questions were answered by the researcher if necessary. The task consisted of 32 trials, each containing a rapid sequence of 24 uppercase black letters ('courier new' font, size 18) presented in the middle of a grey screen. The stream of letters lasted between 2 and 2.4 seconds, and each letter was presented for 15ms followed by a 75ms blank pause. The task was to detect the one white letter within the sequence, which the participants knew would be a B, G, or S (T1). The white letter was the cue to look for T2, a black letter X, which was presented on 50% of trials. Of the 50% of trials where T2 appeared, its position in the sequence varied equally from being one to eight letters (i.e., 90 to 720ms) after T1. Each T2 position was presented twice, for example T2 appeared twice after 90 milliseconds, twice after 180 milliseconds (figure 2), and so on, in a random order.
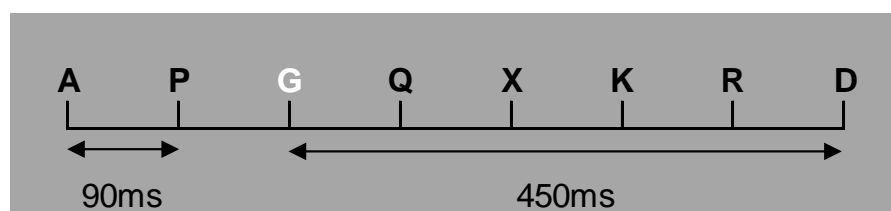
Figure 2: Illustration of rapid serial visual presentation task sequence.

Following each sequence, the task required the participants to indicate whether they had seen a B, G, or S in white, which they answered by pressing the corresponding key on the computer's keyboard. Immediately after this, the question 'was the letter X present following the presentation of the target B, G, or S' was presented on screen, and participants pressed the 1 key for 'yes', or 2 for 'no'. The measures gained from this task were T1 and T2 identification accuracy as a percentage, and accuracy at each of the T2 lag positions, post T1. The time taken to answer the questions was not important, so reaction time was not measured.

Sustained Attention: Continuous Performance Task (CPT). CPTs are a measure of sustained attention, as participants are asked to maintain concentration for a relatively long period of time, to a mundane, repetitive task. The visual CPT as described by Shalev, Ben-Simon, Mevorach, Cohen, and Tsal (2011) was used in the present study. Shalev and colleagues (2011) reported high levels of internal consistency, a high test-retest reliability score (r = .83), and that performance on the CPT was in line with expectations and comparisons with previous versions of sustained performance tasks.

The computer software programme E-Prime 2.0 was used to create this task that comprised one block of 15 practice trials followed by one block of 320 measured trials. The stimuli consisted of a continuous stream of 16 coloured shapes, made up of all possible combinations of four shapes (square, triangle, circle, and star) and four colours (red, blue, green, and yellow). The shapes were approximately 1.5-1.8cm in size and were displayed one at a time, in the centre of an all-black computer screen for 100 milliseconds each. Each shape was followed by an inter-stimulus interval (ISI) of either 1000, 1500, 2000, or 2500 milliseconds, during which time a blank, black screen was displayed. The presentation of the stimuli and the ISIs was randomised, see figure 3 for an example.
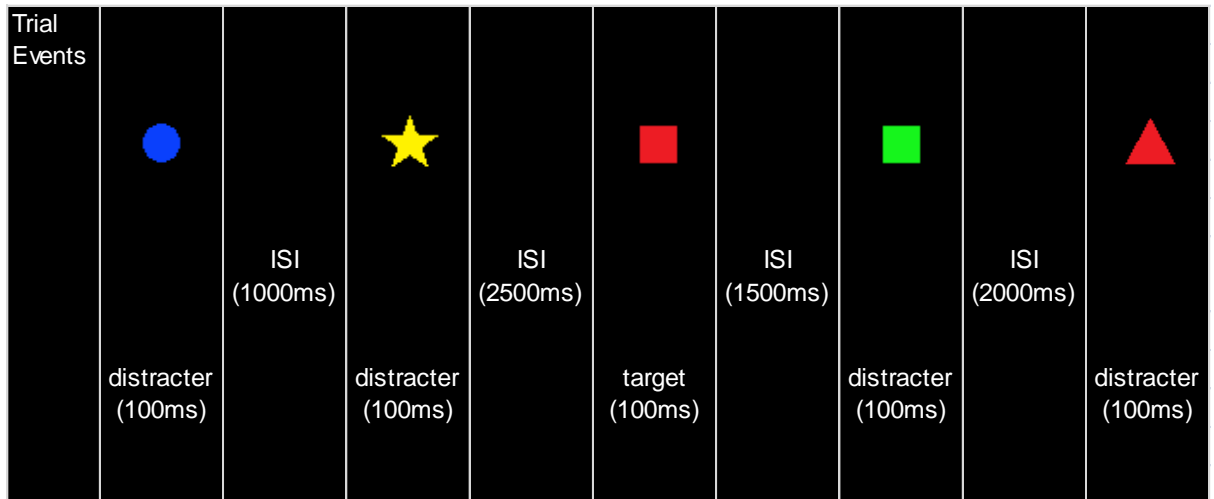
Figure 3: Illustration of CPT sequence.

Instructions for the participants were displayed on screen before the task began (appendix 12), after the practice trials (appendix 13), and a 'thank you' message appeared at the end. The task for participants was to react only to the red square stimulus (target) by pressing the spacebar, whilst ignoring all other stimuli. The instructions were precise and the participants were given the opportunity to ask the researcher questions, before continuing on to the recorded trials.

Of the 320 timed trial presentations, the target was presented 96 times (30% of trials), the other red shapes were used 19 times each (17.5%), and the other coloured squares were also shown 19 times each (17.5%). These were the distracter stimuli, as these items are more likely to be accidentally considered the target by the participant for their red colour or square shape (Shalev et al*., 2011). The remaining stimuli (e.g., yellow triangle, green star, etc.) were shown 12 times each (35% of overall trials). The whole CPT lasted approximately 12 minutes, therefore measuring the participant's ability to remain attentive to one repetitive task over a reasonably long period of time.

The main score for this task was mean RT across the length of the task, and this was used in analysis of sustained attention. To look closer at the pattern of sustained attention (particularly in chapters five and six), the 320 trials were split into five blocks of 64 trials, although this was not apparent to the participant as they ran smoothly from one to the other. This decision was made by the researcher as it enabled the calculation of a mean reaction time (in milliseconds) for each block, for each participant, which was thought to be sufficient to show

the pattern of response speed and accuracy over the course of the task. The number of omissions (red squares missed by participant) and commissions (an alternative stimuli mistakenly being identified as the target) were also extracted for analysis. Specifically, omission errors (missing the targets) are thought to be indicative of inattention, and commission errors (responding to non-targets) are said to be representative of impulsivity (e.g., Marchetta, Hurks, De Sonneville, Krabbendam, & Jolles, 2007).

Selective Attention and Response Inhibition: Stroop Task. In order to measure the participants' ability to select relevant information and ignore the irrelevant (selective attention; see section 2.1.3), they performed the Stroop task (Stroop, 1935). The task used CogLab 3.0, a software programme containing various psychology related tests. Participants were shown the instructions (appendix 14) and the researcher clarified with the participant that they knew what to do.

The computer screen was black, and the word 'red', 'green', or 'blue' ('arial' font, size 18) appeared one at a time in the centre, just above a small fixation dot. The words either appeared in their congruent colour (i.e., the word green written in green) or an incongruent colour (i.e., the word green written in red). Participants had to identify the colour of the font only, whilst ignoring the word itself, by pressing the suitable key. The correct keys were 'h' if the colour was red, 'j' for green, and 'k' for blue. These keys were preferable as they are adjacent to each other on the keyboard, making it easy to switch from one to the next. The word remained on screen until a response was made by the participant, and reaction times were measured. The space bar was pressed after each trial when the participant was ready to continue onto the next. As previous studies have shown, it is likely that the mean RT for incongruent trials would be higher than for congruent trials (Kane & Engle, 2003; see section 2.1.3), due to the conflicting information presented on screen, thus taking the participant longer to process.

In total there were 45 trials, 15 of which were congruent, and 30 of which were incongruent. If the individual answered incorrectly or too slowly, then this trial was discounted and was later repeated. This ensured that all of the trials were eventually completed correctly. The final scores were a mean reaction time (RT) for congruent trials and a mean RT for incongruent trials. This was changed in to

a difference score for analysis, with the congruent RT being subtracted from the incongruent RT to determine the extent of the difference between the conditions.

Divided Attention: Dual-Tasking. The dual-tasking measure explored the participant's ability to carry out two tasks simultaneously, which measures divided attention and attentional control (Della Sala, Foley, Beschin, Allerhand, & Logie, 2010; see section 2.1.4). In the present study, participants completed a paper and pencil based task, as described by Della Sala and colleagues (2010), where they were required to repeat lists of numbers back to the researcher, whilst tracing a simple maze with a pen (number lists at appendix 15, and an illustration of the maze at figure 4). Test-retest correlational analysis for this task have recorded medium to high values of $r = .59$ to $.73$ ($p < .001$; Della Sala, Foley, Beschin, et al., 2010). There were four parts to the dual-task measure:

Part one: Digit Span Determination

Part two: List Memory (single task)

Part three: Tracking (single task)

Part four: List Memory + Tracking (dual-task)

The four parts were carried out sequentially to ensure that the participants understood how to complete each task. In part one, each participant's individual digit span, the number of digits they could hold in working memory and repeat back in order, was determined in order to tailor the rest of the task to their specific abilities, and to ensure the participants were working to capacity. Number lists were read aloud by the researcher at an approximate rate of two digits per second. These lists gradually increased in length from two to a maximum of ten digits; six trials of each list length were used. When a participant could no longer repeat all of the digits back to the researcher in the correct sequential order, their digit span was recorded as the number of digits they could previously state confidently. For example, if a participant was able to recall a list of six digits sequentially, but could not do so for lists of seven digits, then their digit span was recorded as six.

Part two of this exercise involved the single task of the researcher reading aloud different lists of digits according to the participant's digit span, determined in the previous phase. Participants were required to immediately repeat the digits back

in order, as the researcher manually recorded their accuracy. This task lasted 90 seconds. The participant's accuracy for each digit string was transformed into a percentage (e.g., a score of 3 correct from 6 is 50%), and the mean percentage for the total amount of digit strings completed was calculated, therefore acting as the participants overall score for this section. This measured the participant's ability to carry out this task on their own.

The third part of the paradigm also featured a single task, which involved the participant using a pen to trace a maze-like line, intercepting circles as required (Della Sala et al., 2010; see figure 4). The circles were approximately 1.5 centimetres apart from each other along the line, and the participant's score was the number of circles passed through in 90 seconds. A smaller, untimed version of this task was provided before the main task began to allow the participant to practice, and to ensure their understanding of the task.
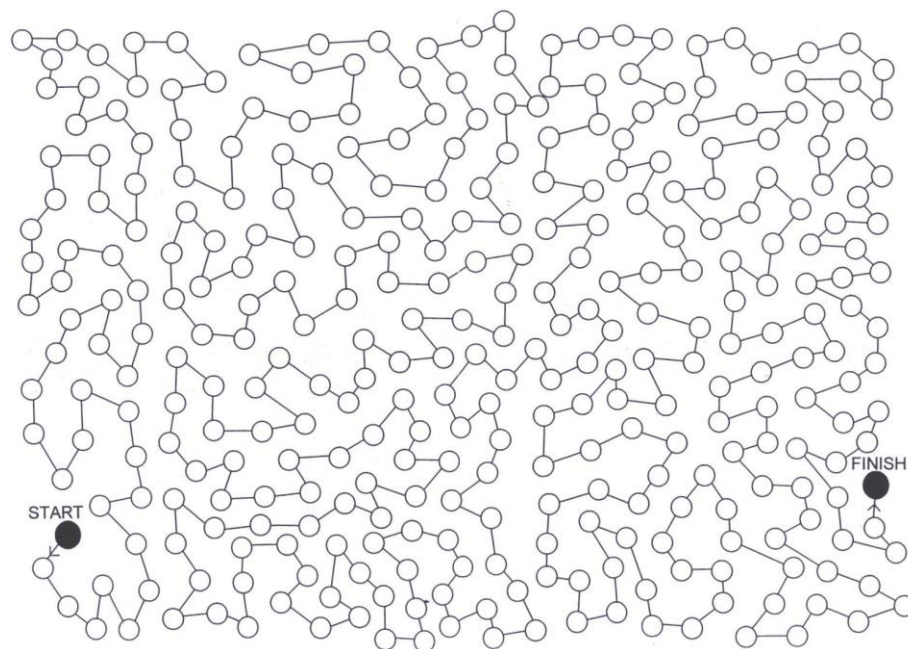
Figure 4: Illustration of the dual-task tracking maze. The maze was A4 size for the task.

Section four was the dual-task phase where the participants were required to carry out part two and part three at the same time. This time, the digit lists were different from previous lists, but were still at span capacity. Section four also lasted for 90 seconds, and two scores were obtained: list memory accuracy (mean percentage) and the tracking score (number of circles crossed through).

Altogether, four raw scores per participant were obtained for this task: single-task digit list accuracy, dual-task digit list accuracy, single-task tracking score, and dual-task tracking score. Using the formulae provided by Della Sala et al. (2010; figure 5), it was possible to create one score representing the proportion of accuracy across the single- and dual-task conditions for the digit list task, and a single score representing proportional performance across the two conditions in the maze tracking task. With these new scores, a measure of proportional performance was calculated that combined the scores form both tasks.

Proportional performance in digit recall (P_m) was calculated by measuring the change in digit recall between single- (m_{single}) and dual-task (m_{dual}) conditions, where m is the proportion of digits recalled accurately, and using:

$$P_m = 100 - \frac{(m_{single} - m_{dual}) \times 100}{m_{single}}$$

Proportional performance in tracking (P_t) was calculated by measuring the change in tracking between single- (t_{single}) and dual-task (t_{dual}) conditions, where t is the number of circles drawn through, and using:

$$P_t = 100 - \frac{(t_{single} - t_{dual}) \times 100}{t_{single}}$$

Proportional performance in both tasks combined (μ) was calculated by using:

$$\mu = \frac{P_m + P_t}{2}$$

Figure 5: Excerpt from Della Sala, Foley, Beschin, Allerhand, and Logie (2010, p.412), which explains the calculation process of determining a single proportional performance score for the dual-task.

With this calculation, a score of 100 would indicate no effect of the dual-task condition, above 100 would highlight a performance improvement in the dual-task condition, and below 100 shows a performance deficit in the dual-task condition. This final proportional performance score was used in subsequent analysis of the dual-task.

4.4 Procedure

Each participant was tested individually. Upon entering the testing room, each participant read an information sheet (specific to each study, see appendices 16.1, 16.2, and 16.3) and signed a consent form (appendix 17). After any questions had been answered, a selection of relevant questionnaires were completed. These were provided at the beginning of the session to avoid the participants own feelings about their performance during the testing to affect how they answered the questions.

In order to allow participants to habituate to the testing environment, a three minute warm-up task was supplied (appendix 18). Using a warm-up task in creativity research has been found to help participants relax, and therefore enrich their responses (Kim, 2006; Kaufman, Plucker, & Baer, 2008). In this case, a picture construction task was used (from Torrance, Ball, & Safter, 1992), where participants were provided with a sheet of paper showing a simple curved line on it. The instructions were that they should convert this into an interesting picture using the coloured felt-tip pens provided, and to give it a title. This would normally be scored as a test of figural creativity, for originality and elaboration as per the instructions of Torrance and colleagues (1992); however, for this study it acted as an acclimatisation task only, and was not scored. Participants were not aware at the time that it would not be scored, which was meant to encourage full effort to be made.

The order of the remaining tasks was pseudo-randomised to reduce order effects. There were varying orders to the tasks and this was predetermined by the researcher to ensure that any sequence was not overly repeated. Breaks were offered to participants in between each task, although these were generally rejected. If an individual did break, it was for one or two minutes.

A game-like approach (a casual setting and unrestricted timings) to creativity testing, as used by Wallach and Kogan (1965) was not adopted by Torrance, Ball, and Safter (1992) as it was viewed as being impractical when testing a large number of participants, and was therefore not implemented for this study. Instead each session was structured and time limits were imposed when practical and necessary.

Overall, the testing session lasted between 80 and 90 minutes for first two studies, and 50-55 minutes for the third and fourth studies within this thesis. At the end of the session, participants were encouraged to ask any questions they had, thanked, and were given a debrief sheet (see appendices 19.1, 19.2, 19.3), to take away with them.

All statistical analyses were conducted using SPSS 20, including correlational analyses, *t*-tests, ANOVA, ANCOVA, and regression analyses. The most appropriate tests were used throughout according to the guidance of Field (2013), with consideration of data type, data suitability, and the research aims. For significant *t*-tests, Cohen's *d* effect size was calculated, with scores of .2 indicating a small effect, .5 a medium effect, and .8 a large effect. For significant ANOVA/ANCOVA tests, effect size was calculated in the form of partial eta squared (η^2_p), with scores of .01 indicating a small effect, .06 a medium effect, and .14 a large effect size.

Chapter 5 - The Relationship between Creativity and Attention

5.1 Introduction and Research Aims

The research aim was to determine whether or not there are relationships between specific aspects of creativity (i.e., past creative achievement, divergent thinking, and the production of a creative product) and specific aspects of attention (i.e., attentional control, abilities in sustaining attention, ignoring irrelevant stimuli, and dual-tasking), as past research has suggested.

It was therefore hypothesised that a relationship would exist between several aspects of creativity and attention, in that as creativity scores increase, attention scores decrease (e.g., Carson et al., 2003; Finke et al., 1992; Kasof, 1997; Memmert, 2011; Vartanian, Martindale, & Kwiatkowski, 2007).

5.2 Methods

5.2.1 Design

A correlational approach was used, and each participant took part in all of the tasks. This allowed for within group analyses to be carried out to determine if relationships existed between creativity and attention.

There were several dependent variables (DVs), with some single measures having as many as seven scores or outcomes: however, on a simpler level, the main DVs were creativity and attention scores. The measures are specified in the Materials section (5.2.3).

5.2.2 Participants

The group consisted of 100 participants, most of whom were staff or students at Edinburgh Napier University, although members of the general public were also tested. There were 79 females and 21 males within the group, with ages ranging from 18 to 80 years (only one was aged over 59 years old). The mean age was 26.9 years, with a standard deviation (*SD*) of 11.4 years.

Individuals were invited to take part in the study if they were over the age of 18 years and were fluent in English, prerequisites that were stipulated on the information sheet (appendix 16.1) given to participants prior to testing.

In particular relevance to the Torrance creativity tests, gender differences in the responses of participants are seldom found and if they are, they are rarely replicated (Kaufman et al., 2008). Furthermore, the tests have been found to be fair in relation to race, culture, and socioeconomic status (Kim, 2006). Although some gender differences in attention tasks have been found (e.g., Giambra & Quilter, 1989; Merritt et al., 2007; Robinson & Kertzman, 1990), others have not supported this case (e.g., MacLeod, 1991; Spelke, 2005) or are cautious of studies that do (e.g., Halpern, 2013). These differences are not considered further.

5.2.3 Materials

There were six tests of creativity and five tests of attention used in this study, each are fully described in section 4.3.

The warm-up task (4.4) was provided. The creativity measures used were the Preliminary Questionnaire (creativity items), the CAQ, all three divergent thinking tasks (both UUTs and the Circles task), and collage production (see sections 4.3.1 and 4.3.2).

The attention measures used were the Preliminary Questionnaire (attention items: 4.3.1), the RSVP task, the CPT, the Stroop task, and the dual-task (see section 4.3.3).

5.2.4 Procedure

Upon entering the testing room, participants were given the information sheet (appendices 16.1) and consent form (appendix 17). After any questions had been answered, the Preliminary Questionnaire and then the CAQ were completed. It was decided that these tasks would be provided at the beginning of the session to avoid the participants' own feelings about their performance on the other tasks affecting how they answered the questions.

The warm-up task was then carried out, followed by the remaining creativity and attention tasks, which were presented in a quasi-random order. This was determined before data collection commenced, and ensured that the running order changed as many times as possible to minimise order effects.

Overall, the testing session lasted between 80 and 90 minutes. At the end of the session, participants were given a debrief sheet to take away with them, and they were provided with a £10 high street gift voucher in appreciation.

The possibility of using factor analysis (specifically principal component analysis: PCA) to simplify the creativity and the attention data at a preliminary stage was thoroughly explored. If successful, this would extract and group variables that appear to measure the same construct. Ideally, this would mean that the scores from the multiple tests used to measure creativity and attention could be reduced to fewer factors. However, the literature indicates that a sample size of N = 100 is too small to meet the assumptions of this type of analysis. For example, Tabachnick and Fidell (2012) suggest that a suitable sample size for factor analysis should be at least 300; Comrey and Lee (1992) regarded a sample size of 100 as poor, 300 as good, and 1000 as excellent. Guadagnoli and Velicer (1988, cited in Field, 2013) stated that sample size did not matter if factors had four or more loadings above .6. Furthermore, in order to be suitable for factor analysis, there should be medium sized (between .3 and .8; Field, 2013) relationships between the variables, and variables that did not fit with this assumption should not be included in the analysis. Correlational analysis indicated that most of the variables fell outwith these criteria as the correlation coefficients were mostly very low (correlational analyses are presented in the following section). In order to objectively justify the exclusion of factor analysis from this thesis, a PCA was conducted (despite the limitations in sample size), as doing so provides statistics on the suitability of the data, in the form of a Kaiser-Meyer-Olkin (KMO) value and anti-image correlations. PCA was considered the most appropriate form of factor analysis to use, according to the guidance of Field (2013).

A PCA was performed on the 11 creativity items, and separately on the eight attention items, with oblique rotation (direct oblimin). The KMO values of .545 (creativity measures) and .509 (attention measures) indicated that the sample was not adequate for PCA (deemed 'miserable' (Hutcheson & Sofroniou, 1999) and 'barely acceptable' (Kaiser, 1974; both cited in Field, 2013). KMO values for each variable were also calculated (anti-image correlations). Field (2013) states that the KMOs for the individual variables should be above .5 as a bare minimum, in order to be suitable for PCA, and should be removed if they fall below .5. This

would lead to five of the 11 creativity measures being removed (KMO < .5 for CAQ, Circle fluency, Circle originality, and UUT and Circle percentage of original ideas) and four of the eight attention measures being removed (KMO < .5 for self-report attention, and CPT RT, omission errors, and commission errors – additionally, the RSVP T2 and Stroop measures had KMOs of only .55). As a final check, although some factor loadings were above the .6 requirement, there were only a maximum of three variables on each factor, and not the four necessary to disregard sample size as an issue (Guadagnoli & Velicer, 1988, as cited in Field, 2013).

Taken together then, the inadequate sample size, insufficient correlations, poor KMO scores, and the literature lead to the confident conclusion that the data collected did not meet the assumptions for factor analysis, and so this did not proceed further.

As the main aim of this study was to identify relationships between the variables, the most appropriate inferential statistics consist of correlational analyses (Field, 2013).

5.3 Results

5.3.1 Creativity Measures

The Preliminary Questionnaire resulted in two scores per participant, one for creative self-efficacy (min. score = 7, max. = 35) and one for attention (min. = 4, max. = 20). The mean creative self-efficacy score across the group was 24.47 ($SD = 5.02$), and the mean attention score was 12.86 ($SD = 3.49$). These scores were not significantly related ($r = .139$, $p = 167$). The creative self-efficacy scale had a Cronbach's alpha of .874, and the self-report attention scale had an alpha of .847, showing that each measure had high inter-item reliability.

The CAQ returned one total score per participant. The mean score was 11.08 ($SD = 12.56$), the lowest score was zero, and the highest was 64. Reliability analysis was conducted for the CAQ and Cronbach's alpha returned as .186, which is a low score for inter-item reliability.

Mean UUT fluency (min. = 2, max. = 60), flexibility (min. = 2, max. = 35), and originality (min. = 0, max. = 31) scores were calculated for each participant. The

mean percentage of original ideas ((total originality / total fluency) * 100) was also calculated (min. = 0, max. = 100%). See table one for the means and standard deviations for both tasks combined (cardboard box and tin can, as detailed in section 4.3.2).

Table 1: Mean verbal divergent thinking scores with standard deviations, as measured by two Unusual Uses tasks.

		Mean	SD
Unusual Uses Task	Total Fluency	24.27	10.08
	Total Flexibility	16.84	5.89
	Total Originality	8.88	2.94
	Percentage of Original Ideas	36.27%	15.14%

The Circles task measured figural divergent thinking. Each participant's responses were scored for fluency, originality, and elaboration. The lowest scores were zero for each of the three aspects, and the highest scores were 25, 10, and 10 for fluency, originality, and elaboration respectively. The mean percentage of original ideas ((total originality / total fluency) * 100) was also calculated (min. = 0, max. = 100%). The means are displayed in table two.

Table 2: Mean figural divergent thinking scores with standard deviations, as measured by the Circles task.

		Mean	SD
Circles Task	Fluency	8.62	4.54
	Originality	3.49	2.21
	Elaboration	3.51	2.23
	Percentage of Original Ideas	43.71%	24.73%

The CAT was used to score the collages produced by the participants. The mean collage score was 5.06 (*SD* = 1.06), with the lowest score being 2.71, and the highest 7.71 out of ten. This indicates that none of the participants were awarded high scores for their work, even though the judges should have been rating the collages relative to the others.

5.3.2 Attention Measures

Analysis of the means and standard deviations indicates that the group performed as expected on the measures of attention.

The RSVP task measured attentional control and the attentional blink. Scores for identifying the second target ($M = 65.41\%$, $SD = 11.09\%$) were lower than for the first target ($M = 93.25\%$, $SD = 9.33\%$). A paired-sample *t*-test found that this difference was significant ($t(99) = 23.767$, $p < .001$, $d = 2.717$: large effect size) and shows the effect of the attentional blink: that processing of the first target inhibits the recognition of the second.

The CPT measured sustained attention. The group mean reaction time (RT) for the CPT was 441ms ($SD = 45.54$ms). RTs to the target in the CPT gradually increased from a mean of 415ms to 455ms as the task progressed. Mean RTs were calculated for each of the five time blocks (figure 6).
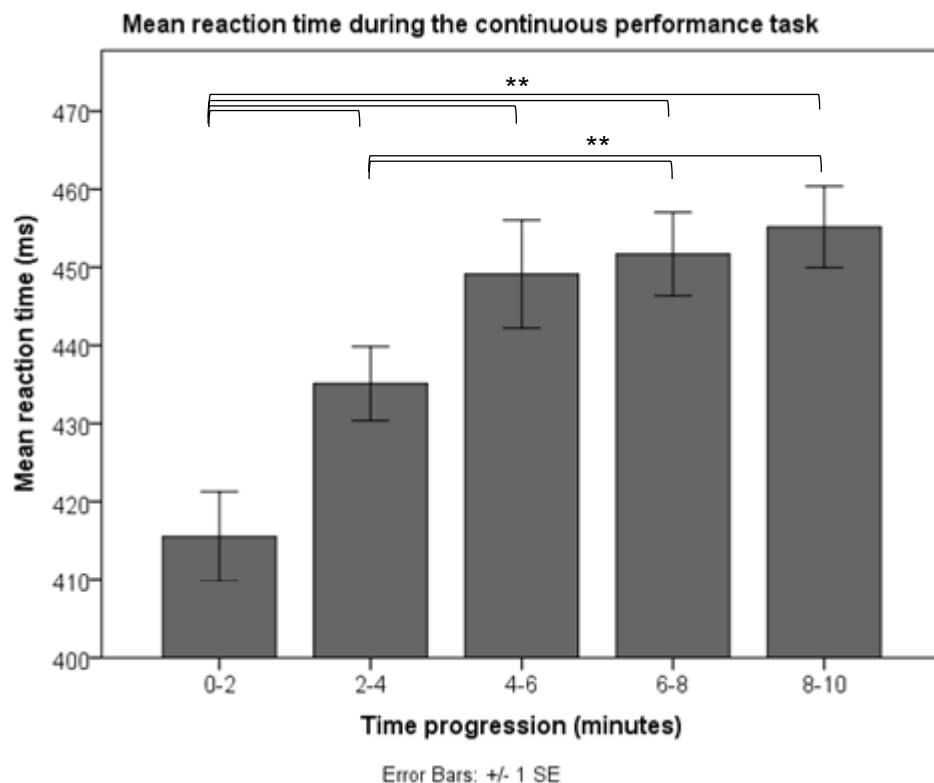
Figure 6: Mean RTs during the continuous performance task.
**indicates significance at 99% confidence level. Scale starts at 400ms in order to clearly illustrate between-block differences.

A significant within-subjects ANOVA ($F(2.42, 396.0) = 19.329$, $p = .001$, $\eta^2_p = .163$: large effect size) confirmed that the differences in RT with increasing time

were significant. The significant Bonferroni pairwise comparisons are shown by brackets (figure 6).

Omission and commission errors were also calculated for the CPT. As the target was presented on 96 of the 320 trials, there were 96 opportunities for each participant to make omission errors, and 224 (320-96, non-target trials) opportunities for the participants to make commission errors. The mean omission rate was .71 ($SD = 1.67$) and the mean commission rate was .30 ($SD = .92$).

To measure selective attention, the Stroop task was used. Two mean RTs per participant were obtained: one for congruent trials ($M = 840$ms, $SD = 330$ms), and the other for incongruent trials ($M = 923$ms, $SD = 287$ms). As explained in section 4.3.3, the mean congruent RT was subtracted from the mean incongruent RT for each participant, in order to analyse the extent of the difference between the two conditions. The mean difference score was 83.95ms ($SD = 198.47$ms). As this value is positive, it indicates that the participants were generally slower to respond in the incongruent condition.

The dual-task measured divided attention. In total, four scores were recorded per participant for the dual-task measure, two single task scores (digit list and maze tracking scores when carried out separately), and two dual-task scores (digit and maze scores when tasks are combined). As explained in section 4.3.3, these scores were transformed according to the instructions by Della Sala and colleagues (2010) to result in one score representing proportional performance across each task and each condition. A score of 100 would indicate no effect of the dual-task condition, above 100 would highlight a performance improvement in the dual-task condition, and below 100 shows a performance deficit in the dual-task condition. The mean dual-task score across the sample was 97.55 ($SD = 11.39$), indicating that the participants performed better in the single task condition compared to the dual-task condition.

In order to test for relationships between the creativity measures and the attention measures, multiple correlations were carried out. The Pearson correlations are listed in table three (the CAQ produced non-parametric data, therefore Spearman correlations are reported for the CAQ variable only). As a large number of correlations were calculated, the probability of reporting a type I error increased.

For this reason, only correlations with a probability value of less than .01 were further considered in the discussion, following the recommendation by Howell (2007). Although this decreases the likelihood of reporting a type I error, it does not eradicate the risk completely, so the results are treated with caution.

There was one significant relationship between creativity and attention. This was between figural divergent thinking originality (measured by the Circles task) and self-report attention (measured from the preliminary questionnaire), where higher originality scores were related to higher levels of concentration. There were no other significant correlations, as shown in table three.

Table 3: Pearson correlations between the creativity and attention measures

Measure	Self-Report Questionnaires			RSVP Task		CPT			Stroop Task	Dual-Task	Unusual Uses Task				Circles Task			
	Creativity	Attention	CAQ[a]	T1	T2	Mean RT	Omission Errors	Comission Errors	Stroop Score	Dual-Task Score	Total Fluency	Total Flexibility	Total Originality	% Original Ideas	Fluency	Originality	Elaboration	% Original Ideas
Attention	.14																	
CAQ[a]	**.40****	.14																
T1	- .03	.09	.04															
T2	- .05	- .10	- .00	**.35****														
Mean RT	.00	- .11	.03	- .17	- .10													
Omission Errors	- .11	- .03	- .08	- .15	- .10	.12												
Comission Errors	- .05	- .13	- .01	.04	.01	- **.22***	**.36****											
Stroop Score	- .09	.04	- **.25***	.02	.19	- .15	- .15	- .05										
Dual-Task Score	.10	.10	- .04	**.22***	**.28****	- .11	.09	.15	.09									
UUT: Total Fluency	.02	- .05	.14	- .06	- .07	- .12	- .09	- .01	- .05	.02								
UUT: Total Flexibility	.00	- .00	.10	.02	- .08	- .04	- .09	- .07	- .03	.10	**.91****							
UUT: Total Originality	.03	.03	.18	- .02	- **.22*†**	- .16	- .18	- .04	- .06	.12	**.83****	**.81****						
UUT: % Original Ideas	.10	.14	.15	.05	- **.24*†**	- .12	- **.22***	- .11	- .02	.12	.05	.13	**.51****					
Circle Fluency	.09	**.22***	.10	.11	.13	- **.22***	- .16	- .05	- .04	.17	**.37****	**.36****	**.29****	.00				
Circle Originality	.19	**.27****	**.22***	.13	- .07	- **.24***	- .18	- .02	- .10	.00	**.23***	**.21***	**.27****	.13	**.62****			
Circle Elaboration	**.21***	**.22***	.07	.14	.02	- **.24***	- .10	.08	- .02	.10	**.31****	**.29****	**.24***	- .04	**.51****	**.54****		
Circle % Original	.17	.08	.09	- .07	- **.23*†**	- .05	- .06	- .04	.02	- **.23*†**	- .13	- .14	- .04	.01	- **.25***	**.46****	.10	
Collage Score	.18	.00	.03	- **.21*†**	- .16	- .01	.00	.06	.04	- .10	.18	.18	.19	.09	.03	- .01	.13	- .03

* indicates $p < .05$, ** indicates $p < .01$. † = Correlation supports the hypothesis (i.e., poorer attention score related to better creativity score). [a] Indicates that Spearman correlations were reported for the CAQ task as the data were non-parametric.

5.4 Discussion

It was hypothesised that there would be a relationship between creativity and attention, and that creativity scores would increase as attention scores decreased. Ultimately, this hypothesis has not been supported in any way. There was one significant relationship ($p < .01$) found between measures of creativity and attention, as figural DT originality was positively related to self-report concentration levels (as measured by the Preliminary Questionnaire), the opposite of what was expected. This study, therefore, does not show support for the literature previously reported, which has found a link between creativity and poorer attentional control (Vartanian et al., 2007), selective attention (Ansburg & Hill, 2003; Dykes & McGhie, 1976; Kasof, 1997; Necka, 1999), and divided attention (Rawlings, 1985).

The significant correlation does not corroborate with the theory that poor attention is beneficial for creativity, but is in support of the claim that narrow attention could be best for creativity (e.g., Zabelina et al., 2015). However, as only one significant correlation was found, and as the correlation coefficient is weak at only .27, the value and wider application of this finding is fundamentally limited.

The unexpected lack of findings here suggests that past researchers may have been optimistic in their claims of finding a relationship between the two complex constructs of creativity and attention, having only measured them with one test each. In support of this, an examination of the correlations presented in table 3 determines that the two self-report measures of creativity are related, and the verbal and figural DT scores are related, but there are no relationships across the self-report, divergent thinking, and collage measures. This shows that each test may be measuring a different aspect of creativity, and that the results from one test cannot be generalised to represent creativity as a whole. Similarly, there is only one relationship between the attention measures (RSVP T2 accuracy and Dual-Task score), again indicating that the tests were not all measuring the same thing, but different facets of attention. This was a thorough study that aimed to clarify and strengthen previous findings by using a comprehensive set of tests representing the multifaceted nature of each construct. Unfortunately, it can only be determined here, that within this group of participants, and with the measures used, creativity and attention are not related to each other.

It was considered important to compare performance on creativity and attention measures in participants with and without ADHD, and this led to the creation of the next study of this thesis. This would allow for the examination of a relationship between these variables in a group that, as explained in the literature review, should have higher creativity scores and lower attention scores than a control group. It would enable the exploration of pattern differences in the correlational analyses, to test if the relationship exists in a group with attention disorder. It would also allow for between-group differences to be calculated, which would enhance the strength of this study.

For these reasons, the discussion of this study remains short in order to reduce repetition, as further ideas, limitations, and suggestions for future research are collated and presented following the details of an expansion of this study, with a sample of adults with ADHD. The ADHD group study is presented in the following chapter.

5.4.1 Limitations

A potentially important feature that was missing from the current study was a measure of ADHD. If the group was representative of the general population, then between 2-5% of the participants would have the condition, perhaps without knowing so. If a measure of this nature had been included, scores could have tested this, and could have led to further analysis of those with high and low scores. Accordingly, the Adult ADHD Self-Report Scale – v1.1 was utilised in all future studies contained in this thesis.

Further limitations are discussed in the following chapter.

5.5 Conclusions

The study presented in this chapter was an exploration of the relationship between creativity and attention. Many measures were used with the aim of solving the shortfall of previous studies. No consistent relationship between these constructs was found, with the one significant relationship highlighting the figural DT originality was weakly, positively related to higher levels of self-report concentration abilities.

This interim conclusion can suggest that the relationship between these constructs is not supported. In order to clarify the results and to further explore the area in more detail, another study was carried out using participants with ADHD as a comparison group.

Chapter 6 - Differences in Creativity and Attention between those with and without ADHD

6.1 Introduction and Research Aims

The study reported in the previous chapter was repeated on a sample of adults who had been diagnosed with, or strongly believed they had, ADHD.

The aims of this study were:

1: To determine whether or not there are relationships between specific aspects of creativity (i.e., past creative achievement, divergent thinking, and the production of a creative product) and specific aspects of attention (i.e., attentional control, abilities in sustaining attention, ignoring irrelevant stimuli, and dual-tasking) in those with ADHD, as past research has suggested (see chapter three).

2: To compare performances on creativity and attention tasks between those with and without ADHD.

3: To determine if a relationship exists between creativity and attention in those with ADHD, compared to the control group where it does not.

The hypotheses (H) were as follows:

H1: There will be a relationship between creativity and attention within the ADHD group. Specifically, as originality scores increase, attention scores will decrease.

H2: There will be significant differences between the groups in performance on creativity and attention measures. Specifically, the ADHD group will have better scores in the creativity measures (e.g., Abraham et al., 2006; Armstrong, 2012; Fugate et al., 2013; Healey & Rucklidge, 2006; White & Shah, 2006, 2011), and the control group will have better scores in the attention measures (as indicative if the symptoms of ADHD).

6.2 Methods

6.2.1 Design

A correlational design was used, and each participant completed all of the creativity and attention tasks. Independent samples also featured in the analysis stages, as the results from this study formed a comparison group for the results of the previous study. Between-group differences were therefore calculated in accordance with the hypotheses.

The DVs were the creativity and attention scores gained from each measure used, as detailed in the previous chapter.

6.2.2 Participants

The ADHD group consisted of 50 participants who had been diagnosed with, or who strongly believed they had ADHD (see section 4.2 for details). Those taking part were either Edinburgh Napier University staff or students or members of the Addressing the Balance Adult ADHD support group in Edinburgh. Within this test group there were 26 males and 24 females, with ages ranging from 18 to 59 years. The mean age was 32.56 years ($SD = 12.40$).

Participant recruitment involved the methods previously discussed in section 4.2, with additional emails sent to members of the Addressing the Balance support group. The recruitment statements explicitly stated that volunteers should have, or strongly believe they have, ADHD.

6.2.3 Materials

The same materials as used in the previous study (section 5.2.3) were used here. The ADHD group also completed the ASRS-v1.1, as detailed in section 4.3.1.

6.2.4 Procedure

This study repeated the procedure explained in the previous chapter (section 5.2.4). The ASRS-v1.1 was completed after the Preliminary Questionnaire and the CAQ.

6.3 Results

6.3.1 ADHD Group: Creativity Measures

The following results are based on data from all 50 participants in the ADHD group, unless otherwise stated.

Each ADHD group member completed the Preliminary Questionnaire. The mean score for creative self-efficacy was 28.48 (SD = 4.20), and the mean attention score was 7.72 (SD = 2.53).

The CAQ returned a group mean score of 16.74 (SD = 21.99). The lowest score was one, and the highest was 71.

Mean UUT fluency (min. = 9, max. = 59), flexibility (min. = 9, max. = 28), and originality (min. = 4, max. = 30) scores were calculated for each participant. The mean percentage of original ideas was also calculated (min. = 25.49%, max. = 92.31%). See table four for the means and standard deviations for both tasks combined (cardboard box and tin can, as detailed in section 4.3.2).

Table 4: Mean verbal divergent thinking scores with standard deviations, as measured by two Unusual Uses tasks.

		Mean	SD
Unusual Uses Task	Total Fluency	25.80	10.42
	Total Flexibility	18.10	5.09
	Total Originality	13.02	6.10
	Percentage of Original Ideas	51.05%	12.76%

Fluency, originality, and elaboration scores were determined from the participant's responses to the Circles task, with the lowest score being zero for each, and the highest scores being 20, 12, and 9 respectively. The percentage of original responses was also calculated. The means and SDs for the ADHD group are shown in table five.

Table 5: Mean scores with standard deviations for the Circles task for the ADHD group.

		Mean	SD
Circles	Fluency	7.92	4.34
	Originality	4.30	2.67
	Elaboration	3.16	2.52
	Percentage of Original Ideas	54.22%	25.87%

The ADHD group scored a mean of 5.29 (SD = 1.16) for their collages. The lowest score was 3.0 and the highest was 7.86.

6.3.2 ADHD Group: Attention Measures

Forty-eight members of the ADHD group completed the ASRS in addition to the tasks the control group participated in, with two choosing not to. The minimum possible score was 0, and the maximum score was 18. The mean score for the group was 13.96 ($SD = 2.83$). To provide context, the mean score of a non-clinical group outwith this study (n = 100, participants featured in chapter eight of this thesis) was 7.04 ($SD = 4.79$). An independent-samples t-test found that the difference between these groups was significant: $t(146) = -9.259$, $p = .001$, $d = 1.631$: large effect size.

The RSVP task was carried out by 47 participants, with three not completing the task correctly as they pressed the incorrect response keys. The mean accuracy score for T2 ($M = 66.09\%$, $SD = 11.59\%$) was lower than for T1 ($M = 90.04\%$, $SD = 11.25\%$). This difference was significant ($t(46) = 15.475$, $p < .001$, $d = 2.097$: large effect size) according to a paired-samples t-test.

Reaction times during the CPT were analysed in the same way as previously described. These results are based on the scores of 16 participants due to missing data. The overall mean RT was 462ms ($SD = 88$ms). The mean RT increased from 443ms in time block one to 475ms in block five, however there was a decrease in RT in the centre time block (figure 7).
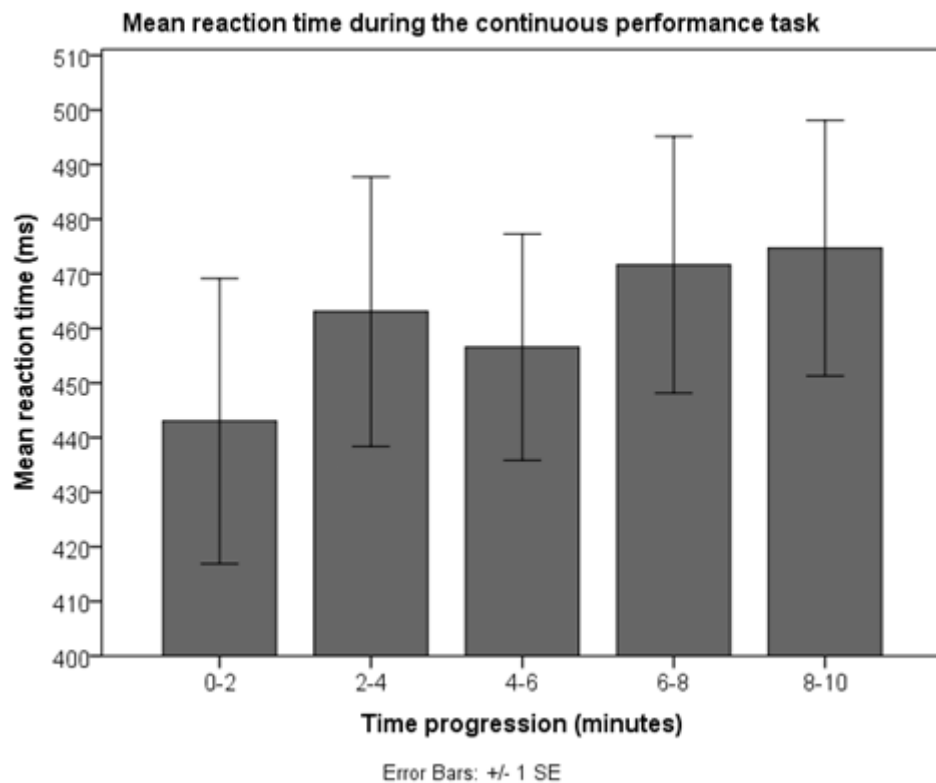
Figure 7: Mean reaction times during the continuous performance task.
Scale starts at 400ms in order to clearly illustrate between-block differences.

A repeated measures ANOVA returned a non-significant result for between-block differences in RT (F(2.384, 35.765) = 1.560, p = .222). From a possible maximum score of 96, the mean rate of omission errors within the ADHD group was 4.31 (SD = 8.36). From a possible maximum score of 224, the mean rate of commission errors was 1.38 (SD = 1.54).

The Stroop task measured selective attention. The mean difference score was 128.39ms (SD = 216.84ms). As this value is positive, it indicates that the participants were generally slower to respond in the incongruent condition.

The mean dual-task score across the ADHD group was 96.63 (SD = 9.78), indicating that the participants performed better in the single task condition compared to the dual-task condition.

Correlations were calculated to test for relationships between the creativity measures and the attention measures within the ADHD group, as shown in table six. Again, as a large number of correlations were calculated, the probability of

reporting a type I error increased. Therefore, only correlations with a probability value of less than .01 were further considered in the discussion.

With this restriction in place, no significant relationships were found to exist between the creativity and attention measures within the ADHD group.

Table 6: Pearson correlations between the creativity and attention measures within the ADHD group.

Measure	Self-Report Questionnaires				RSVP Task		CPT			Stroop Task	Dual-Task	Unusual Uses Task				Circles Task			
	Creativity	Attention	ASRS	CAQ^a	T1	T2	Mean RT	Omission Errors	Comission Errors	Stroop Score	Dual-Task Score	Total Fluency	Total Flexibility	Total Originality	% Original Ideas	Fluency	Originality	Elaboration	% Original Ideas
Attention	.23																		
ASRS	.27	- .07																	
CAQ^a	**.40**	.01	.21																
T1	.23	.01	.04	.02															
T2	- .01	- .02	.02	.04	**.58**														
Mean RT	.06	- .07	.17	.14	- .43	- .55													
Omission Errors	- .23	- .21	.39	.27	- .23	- .30	**.60***												
Comission Errors	- .17	- .30	.14	.04	- .13	- .22	- .43	.14											
Stroop Score	- .12	.19	- .06	.04	- **.35***	- .24	.38	.30	- .06										
Dual-Task Score	- .20	.02	- .17	- **.30*†**	.16	.08	.01	- .35	- .26	- **.29***									
UUT: Total Fluency	**.50**	.20	.14	.01	.23	.20	.09	.05	- .22	- .18	.01								
UUT: Total Flexibility	**.49**	.22	.11	- .01	.27	.19	.11	.02	- .30	- .16	.02	**.90**							
UUT: Total Originality	**.52**	**.32***	.02	.03	.26	.07	- .24	- .18	.03	- **.30***	.03	**.79**	**.78**						
UUT: % Original Ideas	.16	.16	- .06	- .04	.09	- .08	- .40	- .28	.33	- **.32***	.12	- .12	- .06	**.46**					
Circle Fluency	.16	.15	.12	.19	- .05	.03	.37	.06	- .03	- .03	.06	.27	.18	.26	.10				
Circle Originality	.21	.09	.02	.21	- .01	.00	.18	.07	.16	- .07	.09	**.30***	.27	**.38**	.23	**.85**			
Circle Elaboration	- .02	.21	.07	.13	- .09	- .04	.09	- .11	.13	- .11	.02	.12	.16	- .03	- .17	**.38**	**.54**		
Circle % Original	.07	.15	- .12	- .04	.04	- .11	- .09	.01	.13	- .06	.15	.11	.21	**.30***	**.29***	.01	**.43**	.20	
Collage Score	.13	.01	- .16	.08	- .27	.19	.08	.03	.07	- **.28***	.11	.21	.20	.22	.23	**.35***	**.34***	.13	- .03

* indicates $p < .05$, ** indicates $p < .01$. † = Correlation supports the hypothesis (i.e., poorer attention score related to better creativity score). [a] Indicates that Spearman correlations were reported for the CAQ task as the data were non-parametric.

6.3.3 Between-Group Differences

In order to test for differences in performance between the two groups, multiple independent samples *t*-tests were conducted, as they were deemed most appropriate. The possibility of using MANOVA to identify overall between-group differences was explored, however the data did not fit the assumptions required for this test due to unequal and low sample sizes (Field, 2013). The *t*-test results are shown in table seven below, with the significant findings accompanied by effect sizes. There were significant between-group differences in self-reported creative self-efficacy and attention, CPT commissions, originality and the percentage of original ideas in the UUT, and the percentage of original ideas in the Circles task.

Table 7: Independent-sample t-tests showing between-group differences across attention and creativity measures

	Control Group		ADHD Group						
	Mean	(*SD*)	Mean	(*SD*)	*t*	*df*	*p*	*d*	effect
Creative Self-Efficacy	24.47	(5.02)	28.48	(4.20)	- 4.861	148	< .001**	0.84	large
Self-Report Attention	12.86	(3.49)	7.72	(2.53)	10.284	128.73	< .001**	1.61	large
Total CAQ Score	11.08	(12.56)	14.46	(13.40)	- 1.519	148	.131		
RSVP: T1 Accuracy	93.25	(9.33)	90.04	(11.25)	1.832	146	.069		
RSVP: T2 Accuracy	65.41	(11.09)	66.09	(11.59)	- .343	145	.732		
CPT: RT	441.32	(45.54)	461.80	(87.81)	- .913	16.31	.374		
CPT: Omissions	0.71	(1.67)	4.31	(8.36)	- 1.717	15.19	.106		
CPT: Comissions	0.30	(0.92)	1.38	(1.54)	- 2.710	16.73	.015*	2.68	large
Stroop Task	83.95	(198.47)	128.39	(216.54)	- 1.245	147	.215		
Dual Task	97.55	(11.39)	96.63	(9.78)	.491	148	.624		
UUT Fluency	24.27	(10.08)	25.80	(10.42)	- .867	148	.387		
UUT Flexibility	16.84	(5.89)	18.10	(5.09)	- 1.290	148	.199		
UUT Originality	8.88	(5.58)	13.02	(6.10)	- 4.154	148	< .001**	0.72	medium/large
UUT Percentage of Original Ideas	36.27	(15.14)	51.05	(12.76)	- 5.925	148	< .001**	1.03	large
Circles Fluency	8.62	(4.54)	7.92	(4.34)	.903	148	.368		
Circles Originality	3.49	(2.21)	4.30	(2.67)	- 1.971	148	.051		
Circles Elaborations	3.51	(2.23)	3.16	(2.52)	.867	148	.387		
Circles Percentage of Original Ideas	43.71	(24.73)	54.22	(25.87)	- 2.418	148	.017*	0.42	small/medium
Collage	5.06	(1.06)	5.29	(1.16)	- 1.228	148	.222		

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

6.4 Discussion

6.4.1 The Relationship between Creativity and Attention in the ADHD Group

It was hypothesised that there would be a relationship between creativity and attention within the ADHD group, that is, as creativity scores increased, attention scores would decrease. This hypothesis was not upheld, as no significant relationships were found to exist that link performance on creativity tasks to

performance on attention measures. Within the control group, a significant correlation was found between higher levels of self-reported concentration, and higher figural DT originality scores, however the same finding was not shown in the analysis of the ADHD groups' performance. Taken together, these two studies do not corroborate the findings of previous research that have related the two constructs.

The second hypothesis predicted that the ADHD group would score higher than the control group on each of the creativity tasks, and lower on the measures of attention. This was generally found to be the case, however not all of the between-group differences were significant. The ADHD group were significantly better in creative self-efficacy, and aspects of verbal and figural DT originality. The control group had significantly better scores in self-report attention and CPT commission errors.

6.4.2 Self-Report Measures: Between-Group Differences and Relationships

Preliminary Questionnaire. It was expected that in the Preliminary Questionnaire, the control group would have a higher self-report attention score, and the ADHD group would have a higher creative self-efficacy score. This was found to be the case, and the between-group differences were significant. This means that the control group thought themselves to be good at focusing on one thing at a time, and could avoid being distracted. As the ADHD group participants knew, or strongly believed they had the disorder, this finding was likely. The ADHD group had significantly higher scores in creative self-efficacy. These findings were expected having reviewed the literature, but the pattern did not extend to all of the performance (non-self-report) measures of creativity and attention. The high Cronbach's alpha scores indicated that the questions in each scale were reliably measuring the same construct.

Higher scores for creative self-efficacy were moderately, positively related to CAQ score within both groups, and verbal DT fluency, flexibility, and originality scores within the ADHD group (see table 6). This could show that the ADHD group have a good understanding of their ability to produce creative ideas, where the control group may not.

There were no relationships between self-reported attention and any other measure of attention within either group. It is possible that there were no correlations in this case due to a poor understanding one one's own abilities, or a disparity in how an individual would rate their own attention (i.e., the ability to listen in lectures, or their propensity to mind-wandering) and how psychological tests measure attention. The participants may perceive their attention to be worse than it actually is. Future research could explore why self-report attention does not reflect attention task performance, and the use of ecologically valid measures, such as diary records, or self-report throughout the length of a working day, could yield more precise results.

Creative Achievement Questionnaire. The CAQ measured past creative achievement across the lifetime, by means of self-report. There were no between-group differences in scores. A positive relationship was found between creative self-efficacy and the CAQ within both groups, which was foreseeable, as each is a self-report measure covering the same topic. Having said that, the creative self-efficacy questionnaire measures the self-perception of creativity, and the CAQ measures objective achievements. This may indicate that the creative self-efficacy questionnaire is also representative, or can at least relate to, real life creative outputs. However, it is worth noting that the results were highly variable, as the mean scores for each group had large standard deviations, and ranged from zero to 71.

Some potential flaws with the CAQ were noted. It appeared that it is easy for exaggerations to be made by participants, some of the statements could be open to interpretation by the individual, and answers may not have equal meanings across participants. For example, most fields ask if lessons or training had been completed. It is possible that most individuals carried out compulsory music and art lessons at school, qualifying their answer selection. However, this does not match with an individual who took lessons in the pursuit of enjoyment and in order to improve on their craft.

Given the inconsistency and variability in scores, this research does not support the use of the CAQ as a valid measure of creativity. The only reliability statistics available in the literature (to the author's best knowledge) come from the authors of the questionnaire themselves (i.e., Carson et al., 2005), who can be said to

have an invested interest in supporting its reliability. It was also reported that CAQ scores were related to DT performance and the production of creative items (Carson et al., 2005), yet neither of these findings were replicated here.

Adult ADHD Self-Report Scale – v1.1. The ASRS-v1.1 was used with the ADHD group as a measure of symptoms of the disorder. The control group can be assumed to have been 'neurotypical', given the recruitment criteria and the consent they provided having read the information sheet, but they did not complete the ASRS-v1.1 so this cannot be statistically supported. The researcher learnt from this, and included the measure in all other studies for both control and ADHD participants.

When the scores on the ASRS-v1.1 were related to the scores of 100 control participants from a later study (chapter eight) however, there was a significant difference, indicating that the ADHD group had higher scores than those without the disorder. ASRS-v1.1 scores have been found to be related to the ratings of others and with clinician diagnosis (Adler et al*.,* 2006; Kessler et al*.,* 2005), though the present study did not have the capacity to test this. Scores on the ASRS-v1.1 were not related to any measure of creativity or attention. This could show that it measures aspects that are unique to the questionnaire that are not measured by other tasks. However, future research could investigate why self-reported attentional deficits are not related to performance on tests measuring attention. Again, it is possible that this is due to an overestimation on behalf of the participants of how poor their attention is.

6.4.3 Creativity Measures: Between-Group Differences

The ADHD group was predicted to perform consistently and significantly better on the measures of creativity, as broad, unfocused attention and distractedness (ADHD symptoms) were thought to be of benefit to the production of new and original ideas (Abraham et al., 2006; Healey & Rucklidge, 2006; Kasof, 1997; White & Shah, 2006, 2011). This benefit was not seen unanimously across each creativity task as only the differences between creative self-efficacy, UUT originality and percentage of original ideas, and Circle percentage of original ideas were statistically significant. An examination of the mean scores

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established that the ADHD group outperformed the control group on all of the creativity measures, apart from figural DT fluency and elaboration scores. Perhaps a larger ADHD group would lead to more significant differences.

Divergent Thinking. The UUT-TC and the UUT-CB were used to measure verbal DT (combined to produce an overall verbal DT score), and the Circles task was used to measure figural DT. The ADHD group scored significantly higher than the control group in verbal DT originality, and in the percentage of original ideas scores for both verbal and figural DT, which can support the findings of previous studies (e.g., Abraham et al., 2006; White & Shah, 2006; 2011). However, the key issue with this assertion is that the other measures of creativity did not show significant between group differences, meaning there is a limited scope for applying this result to creativity in general. It is worth considering though, the value of originality as a definitive function of creativity, and that these findings may be more important than differences in fluency alone, for example.

Originality is at the core of the definition of creativity. Asking participants to produce novel and original ideas is what separates a creative measure from a regular memory, recall, or problem solving task. It could be argued that the other DT measures (fluency, flexibility, and elaboration) are easier to score highly on, without engaging is creative behaviour at all, as an individual could list many uses for a tin can, covering various categories and adding detail, but these ideas might not necessarily be original or imaginative. Fluency does remain a crucial factor within DT tasks, as ideas are required in the first place in order for them to be original. However, the concepts of originality, novelty, or unusualness should be important aspects taken in to consideration in creativity research, potentially over and above the other scores.

Fluency and originality are often statistically correlated, and were in these studies, yet the significant between-group differences found for originality did not appear for fluency. It could be that high fluency scores require focus, organisation, and the use of strategies, whereas high originality scores are based on the combination of unusual ideas found in diffused and broad attentional states. This study can therefore determine that, in support of the literature discussed, those with ADHD had a greater proportion of original ideas in a verbal and a figural DT task than those without.

This interim conclusion can add to the field of creativity and adult ADHD, and could potentially be useful in educational or work settings. Further research could be conducted to refine this idea, and could also consider the effects of the work environment on creativity in those with ADHD. For example, scores may improve in a stimulating or cue-rich environment, compared to the bare laboratory room used within this study. It has been found that environmental stimulation can raise the cognitive arousal level in those with ADHD, thus enhancing their stimulation and therefore their concentration (Cooley & Morris, 1990; Zentall & Zentall, 1983). This idea was developed in the third study detailed in this thesis.

Collage Production. It was found that scores on the collage task were not related to any other creativity or attention measure within each group. There were no significant differences in the scores of the collages between the ADHD group and the control group. It was observed (although not statistically) that within the ADHD group, more participants complained of running out of time, and there were more collages that may be thought of as incomplete, compared to the control group. This may demonstrate a deficit in the EFs of planning and time management, as is frequently found in those with ADHD. This is conjecture on the part of the researcher, but it may be possible that the incompleteness influenced the judges' scores. However, it is more likely that between-group differences just do not exist for this measure.

Given that creativity is a socially judged concept in the real world, it may be that the production of a collage is the purest measure of creativity utilised in this study. The other tasks used (i.e., self-report, DT tasks) may rely more upon EFs such as attention or working memory than this task, meaning that they may not measure creativity alone. It could be the case that attention can be narrow or broad, and neither state would affect the production of a collage.

These findings indicate that the creative act of producing a collage is fundamentally different to the creative act of producing ideas. It may be that DT can relate to cognitive processes such as attention, given that the production of ideas requires targeted, purposeful thinking, whereas collage production is arguably less restricted. That is, perhaps the processes involved in DT are more similar to the processes required for attention, or indeed other EFs.

To the author's best knowledge, there are no existing studies that have compared ADHD and control group performance on the creation of a product. This study can conclude that as there were no between-group differences, the production of a collage is not a task that need be included in further research specifically investigating group differences.

However, the production of creative items could be studied with fewer time constraints, and with a broader range of measures. For example, the creation of short stories, poetry, paintings, or drawings could inform the field on differences in scores on alternative creative products. Furthermore, these types of tasks may leave the participant with more freedom of what to create. Although the current study provided each participant with numerous materials to make their collages, they were arguably still limited in what they could create based on what was available.

One last consideration in relation to the collages is that none of the participants were awarded the lowest score (the minimum score awarded was 2.71 across the groups) or the highest score for their work (maximum score was 7.86 across the groups), even though the judges should have been rating the collages relative to the others. The judges should have scored the collages that they thought to be the most creative with ten points, and the least creative with one point. This may have been due to a misunderstanding by the judges. The lack of variety within the scores may therefore explain the lack of significant differences.

6.4.4 Attention Measures: Between-Group Differences
Selective Attention. The RSVP task measured attentional control and the attentional blink. The longer it takes for the individual's processing to recover capacity and re-engage, the more likely they are to miss the second target. As expected, there was a significant decrease in target identification accuracy from T1 to T2 for both groups, and there was no significant between-group performance difference (see Di Lollo et al., 2005; Dux & Marois, 2009; Shapiro et al., 1997; Vogel & Luck, 2002). This highlights that the limited cognitive capacities in both time and space for processing a secondary target soon after the presentation of the first is common to both groups, and that attentional control

and the AB are not factors that, according to this study, separates the performance of those with ADHD from those without. It is worth noting however that there were high *SD*s indicating that there was a large variance in the scores in both groups.

In previous studies (section 2.5), mixed results have been reported on the differences between those with and without ADHD on RSVP task performance. Some reported that those with ADHD had poorer recovery times (Armstrong & Munoz, 2003a; Li et al., 2005; López et al., 2008), but no clear significant difference was found by Mason, Humphreys and Kent (2005). To the author's best knowledge, only Armstrong and Munoz (2003a) studied the AB paradigm in adults with ADHD. This study can conclude that performance on the RSVP task used here had highly variable scores for both groups, and that there are no significant differences between adults with and without ADHD. This means that there is not a clear deficit in attention recovery time that is unique to those with the disorder.

The identification of T1 itself does not measure attentional control nor the attentional blink, therefore only relationships between creativity measures and T2 are discussed further. There were no significant relationships between T2 accuracy and any of the creativity measures within the ADHD group. T2 accuracy was weakly, negatively correlated with verbal DT originality within the control group. This indicates that as accuracy scores increased, originality scores decreased. This finding supports the limited existing research stipulating that focused attention is generally beneficial for creativity (e.g., Zabelina et al., 2015), as opposed to broad, dispersed attention.

Sustained Attention. The CPT was used to measure sustained attention. It could be postulated that RTs during the CPT would get slower as the task progressed due to boredom and/or fatigue (Helton & Warm, 2008). Furthermore, due to the nature of ADHD, it has been found that the RT pattern across the duration of the task differs between-groups (e.g., Advokat et al., 2007; Börger et al., 1999; Epstein et al., 2003; Johnson et al., 2007; Marchetta et al., 2007; Rodriguez-Jimenez et al., 2006; Tucha et al., 2009; van der Meere, et al.,1995). Those in the control group had a significant vigilance decrement, as RT significantly increased over the course of the task, as has been found before in control

samples (Shalev et al., 2011; Unsworth et al., 2010). However, the ADHD group did not have a significant vigilance decrement, and their RTs did not follow the traditional pattern of decline (figure 8). There was not a between-group difference in mean RT for the CPT.
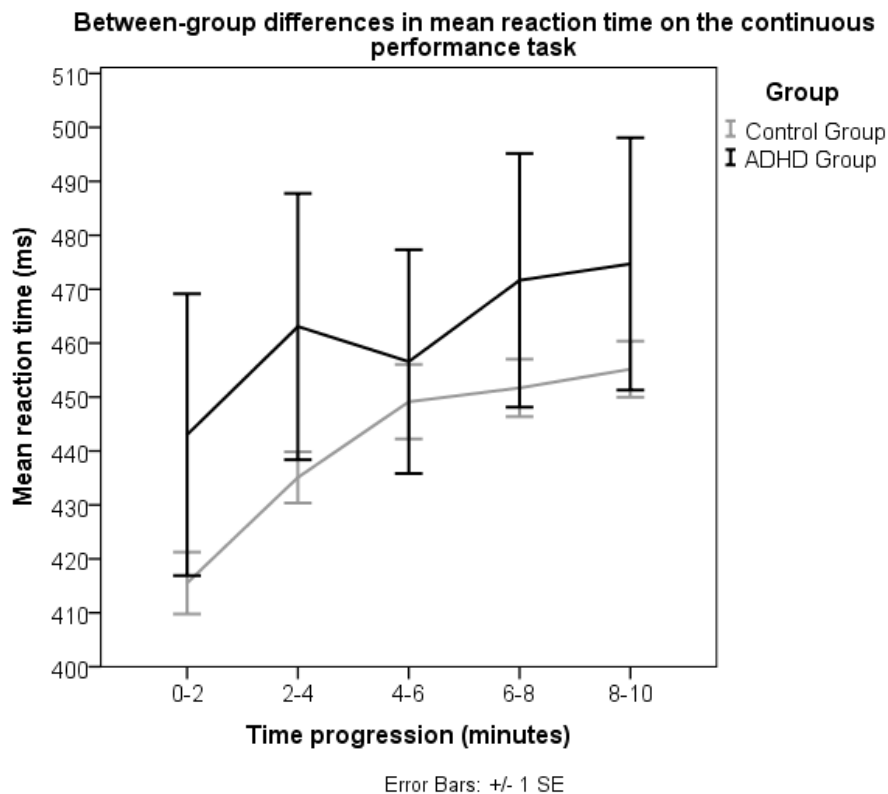
Figure 8: Mean RTs during the CPT for both groups.

Although RT did increase within the ADHD group from the beginning to the end of the task, there was a slight (non-significant) improvement in the central time block. As the ADHD group did not have a vigilance decrement, this indicates that the ADHD group managed to sustain and maintain their attention across the task, with more consistency and a lesser decline in performance than the control group. The slight decrease in RT in the middle of the task may be indicative of a conscious effort by the participants, knowing that they have ADHD, to pay attention to the task. Alternatively, this pattern could reflect the nature of their processing, in that they habitually drop in and out of concentration. However the variance within this group is large, which may explain the result. A longer CPT could be used in future research to investigate fluctuations in RT in those with ADHD over time.

It had also been suggested previously that the ADHD group would be more likely to make omission errors due to the symptom of inattention, and more commission errors due to impulsivity (Marchetta et al., 2007). Accordingly, there was a significant difference in commission errors between the two groups in this study, but not for omission errors.

Selective Attention. The Stroop task is known to reliably test selective attention and response inhibition, by consistently invoking slower RTs for incongruent trials compared to congruent trials (Ben-David et al., 2014; Cohen Kadosh et al., 2011; Kane & Engle, 2003; MacLeod, 1991). Given the EF deficits apparent in ADHD, as presented in section 2.3, it was unexpected that there would be no significant difference between performances on the Stroop task between the two groups. This may be due to the very high but similar standard deviations for both groups, which were around 200ms. Selective attention was not related to any other creativity or attention measure within either group.

Divided Attention. The divided attention dual-task should show a lapse in accuracy (digit list) and pace (tracking maze) when the tasks are combined, as opposed to when they are completed separately (Della Sala et al., 2010). An examination of the scores determined that this was the case, meaning that the participants performed as expected. There were no between-group differences in performance.

It may be expected that those with ADHD would be worse performers of dual-tasking compared to those without. However the lack of difference here may be because those with the disorder are accustomed to dealing with multiple stimuli at once (even if their processing of this is not always effective), so they could thrive in a dual-task condition, where both tasks are relatively simple and use difference cognitive resources (e.g., Hartmann, 1993; Zentall & Zentall, 1983).

As stated in the literature review of this thesis and as supported by the results of this study, performance on tests of attention by those with ADHD are not as poor as would be expected after exploring the definition and symptoms of the disorder. Existing research has focused on children with ADHD, and this study can contribute to the field results from adult participants. To summarise the between-group attention findings, there were significant differences in self-report attention

and commission errors, as those with ADHD had lower scores and a higher error rate. There were no significant differences in performance in measures of attentional control, sustained attention, selective attention, and divided attention.

It is important to remember that the quantity of statistical tests that have been carried out for this study is very high. This could mean that false positive results have been found, and some significant findings could have occurred through chance.

6.4.5 General Discussion

One of the overarching research aims for this study was to determine whether or not there were correlations between measures of creativity and measures of attention within the ADHD group. No significant relationships were found, showing that previous studies that have linked creativity to attention, having used just one or two measures, may be premature in their conclusions. By using multiple measures in this study, it has been determined that there is not a broad, all-encompassing link between the two constructs. Other researchers should therefore be cautious of using just one measure of creativity and one of attention to draw generalisations about the constructs as a whole.

There were only four significant differences between the control group and the ADHD group on creativity measures (self-report, UUT originality and percentage of original ideas, and Circles percentage of original ideas). The ADHD group outperformed the control group on each of these aspects. The importance of originality as the key criterion of creativity has been highlighted, and the present study shows that those with ADHD may not produce quantitatively more ideas, but that their ideas are of a better quality in relation to originality and creativity.

There were only two significant differences between the control and ADHD groups on attention measures (self-report and CPT commissions). Since, by definition, the ADHD group should have difficulties with attention tasks, this was unexpected. There are three reasons proposed as to why this may have been the case, each of which could have been a contributing factor. Firstly, the ADHD group is half the size of the control group. Furthermore, there were high levels of variance in scores amongst the ADHD group, meaning there was inconsistency

within the group and overlap across the groups. As the descriptive statistics indicated that the control group outperformed the ADHD group in most measures of attention, with an improvement in the ADHD group sample size, the trends seen may have extended and led to significant results.

Secondly, the participants were particularly interested in the study as they had volunteered to take part. In particular reference to the ADHD participants, this interest, or the novel environment, may have increased their cognitive arousal to a functional level, which allowed them to perform the tasks at a more successful rate that does not reflect the typical extent of their distractedness (e.g., Antrop, Roeyers, Van Oost, & Buysse, 2000; Cooley & Morris, 1990; Zentall & Zentall, 1983). Environmental stimulation was further explored in relation to this point, and is detailed in the following chapter.

Thirdly, it is possible that the tasks used within this study were not vulnerable to the symptoms of ADHD. For example, the CPT is a 12 minute task requiring sustained attention, but as it is easy, it may allow the participant's mind to wander, thus inhibiting the effect of distraction on RTs. ADHD becomes a problem when the symptoms inhibit the individual from focusing and achieving goals. Within this study, the short duration of the tasks may mean that focus was more easily maintained, than if the tasks had been much longer. It may also be the case that the participants were focused on acclimatising to the requirements of the task, which aided concentration. This may be the most plausible explanation for the absence of between-group differences in attention measures, as others have documented that measuring ADHD in laboratory settings can be difficult (e.g., Nichols & Waschbusch, 2004), and specifically in terms of ecological validity (Barkley, 1991).

Overall, it was thought that an individual's ability to think quickly could be advantageous in the creativity tasks. Accordingly, studies have found positive relationships between processing speed and creativity (see Rindermann & Neubauer, 2004, Preckel et al., 2006). If attentional skills in particular are transferable, then individuals may be able to select their best responses more quickly, allowing them to speedily move on to consider further ideas. Secondly, when an idea is thought of, attention may need to switch from being broad and diffused, to being narrow and focused in order to develop and articulate the idea

(Martindale & Hines, 1975; Vartanian et al., 2007; Wallas, 1926). This switch in attention may be very difficult to do for those with ADHD, meaning that ideas are not recorded efficiently, contributing to the low number of significantly better creativity scores in those with ADHD compared to those without. Conversely, participants may overcompensate for their ADHD by consciously trying to focus on fewer ideas. This could be investigated with research in to attentional switching abilities in those with ADHD, and perhaps a measure of creative insight could help clarify how easy it is for those with ADHD to go from broad to narrow attention when the solution is reached. Thirdly, as those with ADHD are naturally distracted, they may have struggled to stay on task, which may have limited their production of ideas. These considerations may have contributed to the lack of significant findings.

This research project is not without limitations, and these will be presented next.

6.4.6 Limitations and Directions for Future Research

There are three key limitations within this study that may have affected the results. These are ecological validity, restrictions on creative freedom, and participant bias, and each will be discussed in turn.

Ecological validity is arguably a prominent problem in all studies that use laboratory based experiments to test human behaviour and cognitive processes. Creativity in particular may not naturally occur in a laboratory setting, and attention tasks may not reflect the manner by which we pay attention in real life. Furthermore, differences between control and ADHD groups in attention tasks may not be found due to task demands, participant bias, and motivation (Brown, 2013; Houghton et al., 1999; Sergeant, 2005). However, it would be near impossible to measure natural creativity and attention, and to complete a broad range of tasks in an ordinary environment would lead to large differences in confounding variables. Distraction would also be a problem that would directly affect the results of the attention tasks, making laboratory testing the most appropriate option. This study is in line with previous studies in the field, although perhaps more consideration needs to be made in the future for the use of

ecologically valid measures of creativity and attention in order to improve generalisability.

This may be particularly useful in work or educational establishments, where both creativity and attention should be valued and encouraged. Studies of this nature could start by looking at individuals in creative occupations, such as writers or graphic designers. For example, if attention is recorded through the measurement of eye-movements, or intermittent self-report throughout a working day, this could be related to productivity and the creativity of a piece of work produced by the individual. This need not be an intrusive procedure, could be longitudinal, and may reflect real life creativity and how it may be affected by fluctuations in attention.

Within this study, there were restrictions within each task on how creative the participants could be. As discussed with consideration of the collage task, the materials available may have limited what the participants could design. Furthermore, the tasks used may not have provided participants with the opportunity to demonstrate their skills in a creative area where they may excel. It can be argued that collage design is not a common craft. Some participants commented that they had never made a collage before, or that they had not done so since they were young children. This may indicate that the task is not appropriate for use with adults, and it may not be representative of creativity in adults. On the other hand, a lack of experience with collage making should allow the separation of those who are willing to produce a creative piece compared to a non-creative, unimaginative image. It is a relatively low-level task that does not require specialist skill, and it has been used successfully in the past with different groups of participants.

In relation to the idea that creative freedom was limited, future research could investigate the effect of attention on creativity in those established within creative fields. For example, rather than comparing performance across groups differing in attentional behaviour (i.e., control group and ADHD group), a highly creative group could be compared to a group lower in creativity: different types of creative people could be studied. Existing organisations or groups could be utilised, and differences between creative fields could be examined. For example, a group of interior designers could have different creative strategies and attentional

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processes compared to a group of inventors within the field of technology, and musicians may be different to chefs. Studies of this nature may help to further examine the relationship between creativity and attention in real life.

The above suggestion for future research may help to resolve the participant bias limitation too. The materials used in the recruitment process of this research advertised a study investigating creativity and attention, and specified that participants 'need not be particularly creative to take part'. Accordingly, a score of 14 or less on the creative self-efficacy questionnaire would indicate that an individual had no interest in, or had no desire to be creative. Only two of the 150 participants in this study scored below 14. It was therefore the case that the participants regarded themselves as creative people. It is possible that the disparate results could be related to a bias within the participant pool. Only randomly selecting participants would solve this problem, a process that was not available to the researcher.

Throughout the discussion, other suggestions for future research have been made and reasons for these have been provided. These were to investigate the discord between self-report attention and performance on attention tasks, to use longer CPTs to study the fluctuation in RT in those with ADHD, and to use different methods of measuring creative production instead of collages. One of the main ideas, however, has been to assess the effect of the environment on creativity and attention in those with and without ADHD.

As mentioned, it could have been the case, that as the participants were in a novel situation that they may not be accustomed to, their performance could have been improved due to an increase in cognitive arousal (Antrop et al., 2000; Cooley & Morris, 1990; Zentall & Zentall, 1983). This could be studied further by manipulating the testing environment and the effect on creativity and attention scores. A study of this nature was carried out by the researcher and is presented in the following chapter.

6.5 Conclusions

This study investigated the relationship between creativity and attention. By using multiple measures to do this, the research improved on limited methodologies used in past studies. It was found that there is no evidence for a relationship between these two constructs, and it is not as simple as previously reported.

The study also aimed to establish the differences between those with and without ADHD. The groups performed differently at face value, but there were few statistically significant findings to fully support the hypotheses. Potential reasons for this have been explained, and limitations suggested.

It could be that the expected differences between those with and without ADHD were not found due to the changing nature of ADHD, in that intermittent focus and persistent distractedness make it difficult for any relationships to be fully clarified and understood. In order to investigate the effect of the environment in attentiveness, focus, and creativity in those with and without ADHD, an eye tracking study was developed, and is presented in the next chapter.

Chapter 7 - The effect of extraneous visual stimuli on the performance of creativity and attention tasks: An eye tracking study.

7.1 Introduction

Although distractibility is a core diagnostic criterion of ADHD, there has been little research on just how distractible those with the disorder are, and research that has been carried out in this area has yielded conflicting results (Pelham et al., 2011; Radosh & Gittleman, 1981; Rosenthal & Allen, 1980; Söderlund, Sikström, & Smart, 2007; van Mourik, Oosterlaan, Heslenfeld, Konig, & Sergeant, 2007).

This third study of the thesis aimed to compare eye movement behaviour in those with and without ADHD, while carrying out tests of sustained and selective attention, as well as verbal and figural DT tasks. It has long been understood that the location of eye-fixations represent where attention is focused, and eye-movements coincide with shifts in attention (e.g., Hoffman & Subramaniam, 1995; Leigh & Zee, 2015; Remington, 1980; Shepherd, Findlay, & Hockey, 1986). This time, the testing environment was visually stimulating as opposed to the plain room used during the studies investigating the relationship between creativity and attention. The aim of this study was twofold. Firstly, do visually stimulating surroundings affect creativity and attention scores? Secondly, in this setting, do adults with ADHD move their eyes differently compared to those without?

7.2 Literature Review

The theories described here offer explanations of distractibility and hyperactive behaviour, using examples from those with and without ADHD, from a biological and environmental point of view.

7.2.1 Overflow Theory

One of the first theories that attempted to explain hyperactive behaviour was the overflow theory, initially offered by Strauss and Lehtinen (1947, as cited in Zentall & Zentall, 1983). This theory stipulated that hyperactivity is a natural response to the cognitive overflow experienced as the amount of environmental stimulation reaches and surpasses the available processing capacity. Therefore, hyperactive and inattentive behaviour in children was a result of a high level of sensory stimuli in the immediate environment, and was thought to increase as sensory inputs

increased. By this stance, hyperactivity is an uninhibited response that initially cannot be controlled.

The overflow theory for inattentive and hyperactive behaviour received widespread support, which led to recommendations that children with such symptoms should live and work in environments that are free from extraneous visual and auditory stimuli (e.g., Cruickshank, Bentzen, Ratzeberg, & Tannhauser, 1961). This involved a separation from fellow pupils in classroom settings, as well as the concealment or removal of wall decorations, bright colours, excess equipment, and windows.

However, it has since been suggested that a certain level of noise may instead be advantageous for the execution of cognitive tasks in those with ADHD, a counterintuitive phenomenon that is called stochastic resonance (Söderlund et al., 2007; Söderlund, Sikström, Loftesnes, & Sonuga-Barke, 2010). One particular study investigated the effect of background white noise on cognitive performance, and directly compared children with ADHD to children without (Söderlund et al., 2007). Each participant carried out two memory tasks, while white noise was presented during the encoding stage to those in the appropriate conditions. It was found that the noise had a beneficial effect on the ADHD group, as they remembered significantly more sentences in the noise condition compared to the silent condition. In contrast, the performance of the control group significantly decreased in the noise condition when compared to the silent condition.

These results were replicated by Söderlund et al. (2010), when it was determined that background white noise improved the memory performance of those classed as 'inattentive' by their teacher, and led to a deterioration in performance of those classed as 'attentive'. Furthermore, a positive correlation was found between inattentiveness and noise, with the relationship and the effect of noise getting stronger as inattention scores increased (Söderlund et al., 2010). It has also been found that the presentation of a novel sound (i.e., environmental sounds, such as a dog barking) during the completion of a visual choice task led to those with ADHD committing fewer errors, compared to the presentation of a normal sound, or no sound at all (van Mourik et al., 2007). The novel sound, which should be

distracting, therefore seemed to act as a prompt for the individual to maintain alertness and concentration.

At this point, it is clear that the method of isolating children with ADHD that stemmed from the overflow theory would be counter intuitive, and would serve to worsen the behavioural symptoms of the disorder (see also Armstrong, 2012). More recent advice based on research for teachers working with pupils with ADHD includes the utilisation of frequent praise and rewards, immediate and powerful consequences for misbehaviour, clear and concise rules and instructions, and even the use of an infrequent auditory tone to cue a self-evaluation by the pupil of whether they were on task or not (Barkley, 2008).

Zentall and Zentall (1983) carried out a review and found that there was little supporting evidence for the overflow theory, and alternatively put forward their optimal stimulation theory (OST). This has been an influential paper in the field and is still frequently accepted and cited in behavioural explanations of ADHD (e.g., Antrop et al., 2000; Claesdotter-Hybbinette, Safdarzadeh-Haghighi, Råstam, & Lindvall, 2015; McAvinue et al., 2012; Oja et al., 2015; Sarver, Rapport, Kofler, Raiker, & Friedman, 2015).

7.2.2 Optimal Stimulation Theory

The OST maintains that environmental stimuli input affects behaviour output, but suggests that the mechanism by which this occurs is more complex than described by the overflow theory. The first postulation of the OST is that every person has an optimal level of stimulation, and that this is defined biologically (Zentall & Zentall, 1983). When the optimal level of stimulation is not available (i.e., stimulation is too low or too high), activity acts as a means to achieve homeostasis. So, when stimulation is too low, the individual implements stimulation-seeking behaviour (see also Antrop et al., 2000), and when it is too high, the individual would withdraw from activity and suppress or avoid stimulation. An optimal level of cognitive arousal is therefore necessary for concentration and response inhibition (see also Cooley & Morris, 1990).

In their paper outlining the OST, Zentall and Zentall (1983) provided an overview of research investigating responses to very low or high sensory stimulation. In

participants classed as 'normal', exposure to high levels of sensory input has been found to lead to conduct such as disorganised behaviour and thinking, repetitive and ritualistic behaviour, social withdrawal, and poor attention. Individuals with Autistic Spectrum Disorder were used as a clinical example of this type of behaviour by the authors. Autistic individuals often show distress to loud and novel stimuli, and a preference for controlled patterns, tones, and beats. It can be argued that those with autism consistently suffer from high levels of sensory input, leading to some of their stimulation-reducing symptoms, such as social withdrawal, gaze avoidance, strict behavioural routines, and suppressed reactions to stimuli in the environment (Zentall & Zentall, 1983). Although this idea relates to the observed behaviour of those with autism, it is not the only theory, and is included here for illustrative purposes only.

'Normal' responses to very low levels of sensory input, in studies where stimulation-seeking behaviour was permitted, included increased attention (shown by improved focus and concentration), and a general increase in physical activity. In studies where stimulus-seeking behaviour was not permitted (e.g., when participants could not move), it was reported that there was a deterioration in intellectual and writing abilities, poor concentration levels, physiological changes (such as slower EEG alpha frequencies and increased galvanic skin response), disorganised thoughts, and deficient visual-motor functioning (as per the review by Zentall & Zentall, 1983). The authors likened this type of behaviour to hyperactivity, suggesting that a normal amount of environmental sensory input is inadequate for those displaying symptoms of ADHD (note: these authors do not directly refer to the disorder by name, but they do describe the same symptoms; see also Antrop et al., 2000). The persistently low stimulation level, or underarousal, and consequent behavioural output such as inattentiveness, hyperactivity, physical movement, and disruption, is in polar contrast to the overarousal of those with autism, although both demonstrate how the OST operates.

Further support for the OST has been published outwith the work and review of Zentall and Zentall. In those without ADHD, and in corroboration with the literature presented in the previous section, past research has indicated that background noise (e.g., novel sounds, conversations) can have a detrimental effect on

cognitive performance, due to the inferred interference with both working memory (Baddeley, 2007; Dobbs, Furnham, & McClelland, 2010) and attention (Broadbent, 1958; Söderlund et al., 2007; Treisman, 1969) systems. This concept corroborates with the OST in a non-clinical population, as the additional stimulation created by the noise would likely create an imbalance in cognitive arousal, causing a distraction.

An investigation of the effect of background noise compared the impact that music, speech, or silence had on arithmetic performance in children with and without ADHD. In contrast, the results of this study showed that the non-ADHD group performed consistently across the conditions, with accuracy being unaffected by background sound. The ADHD group on the other hand, performed significantly better with higher accuracy scores under the music condition, compared to both speech and silent conditions (Abikoff, Courtney, Szeibel, & Koplewicz, 1996). It is likely that the speech condition interfered with their productivity due to the irrelevant speech effect (Beaman, Bridges, & Scott, 2007; Dige, Maahr, & Backenroth-Ohsako, 2009), leaving the participants more distracted than the music condition.

Furthermore, an experiment compared children with and without ADHD in a waiting situation with either a video for stimulation or no stimulation at all (Antrop et al., 2000). The children were required to wait for the experimenter for 15 minutes. Through the analysis of video recordings, it was found that those with ADHD displayed more physical movements, and benefitted from this physical form of stimulation seeking behaviour. The OST as well as the delay-aversion theory (section 2.6.4) were postulated to explain this outcome.

Zentall and Zentall (1983) effectively illustrated and provided comprehensive support for their theory through their review of studies using both control and clinical samples, and explained how their theory could be applied to other populations such as sensation seekers and deviant adults. They acknowledged that there are many other factors that can affect behaviour, for example, physiological needs (hunger, thirst), motivation, and task requirements, however the OST can coexist with these factors. The OST is therefore compelling, yet it is incomplete. The authors thoroughly explain the effects of under- or over-stimulation, but as it is a cognitive theory, they do not provide the biological details

of how stimulation may operate, and what causes these imbalances in cognitive arousal.

7.2.3 Moderate Brain Arousal Model

A newer theory called the Moderate Brain Arousal Model (MBAM) of ADHD and dopamine has been proposed by Söderlund, Sikström, and Smart (2007) that could fill this shortfall in the OST. The MBAM was created to explain the finding that those with ADHD, contrary to the overflow theory and models of working memory and attention, could have their performance improved in the presence of what would seem to be distracting stimuli (Söderlund et al., 2007). They posited that environmental sounds create noise in the neural system that can amend the low level of cognitive arousal and the hypofunctional dopamine system found in ADHD (Söderlund et al., 2007).

The amount of noise required to produce an ideal performance, or stimulation homeostasis, is controlled by levels of dopamine. Specifically, consistently having too little dopamine reflects the 'under-stimulated' state described by the OST, as seen in those with ADHD. Having too much dopamine matches the symptoms of 'over-stimulation', as observed in those with autism. Dopamine has been directly related to the regulation of attention (Nieoullon, 2002). Consequently, as those with ADHD have lower dopamine levels (Volkow et al., 2009) and therefore naturally seek higher levels of stimulation than those with a regular amount, it stands that the extra noise described in the above experiments, raised arousal to a manageable, optimal level, aiding with the performance of cognitive tasks.

With the addition of this explanation of the role of dopamine, and how imbalances in the neurotransmitter match with the conditions described in the OST, it is clear that the OST and the MBAM can coexist. The apparent gap in the OST is therefore arguably and effectively filled. States of low stimulation may originally be caused by low levels of dopamine, which leads to sensation-seeking, distraction, and hyperactive behaviour. States of high stimulation may be caused by high levels of dopamine, which leads to avoidance behaviour and withdrawal. Individuals in both of these groups behave as they do in order to seek a manageable, comfortable, stimulation equilibrium.

Given that cognitive stimulation has been discussed in relation to attention, the effects of external stimulation on creativity will be briefly summarised and presented below.

7.2.4 Creativity and Stimulation from the Environment

Many publications highlight the importance of an environment that enhances creative thinking in terms of structure and support. For example, it has been stated that in education, an environment conducive to creativity should include the following: allowance for risk and mistakes, open-mindedness, time to be and praise for being creative (Sternberg & Williams, 1996), the production of multiple hypotheses (divergent thinking), searching for problems, and thinking broadly (Starko, 1995). Other aspects thought to affect creativity in schools particularly, include social relationships, socioeconomic status, and student-teacher dynamics (de Souza Fleith, 2000; Dudek, Strobel, & Runco, 1993). Many of these factors are also considered important for workplace creativity, as well as leadership style and support (Rego, Sousa, Marques, Pina e Cunha, 2012; Zhou & Hoever, 2014), perceptions of both the ability to be creative and the requirement to be creative (Robinson-Morral, Reiter-Palmon, & Kaufman, 2013), moderate time pressure, routine, and job control (Ohly, Sonnentag, & Pluntke, 2006), and motivation style (Amabile, 2012; Sacramento, Fay, & West, 2013).

In terms of the physical environment in which creativity takes place, studies have focused on work psychology, and creativity in the workplace. It has been frequently argued that the immediate environment can affect cognitive load (e.g., Choi, Van Merrienboer, & Paas, 2014) and that creativity can be improved in work settings that are designed to stimulate cognition and perception (Amabile, 1996; Ceylan, Dul, & Aytac, 2008; Martens, 2008). Experienced designers have been found to create opportunities from the stimuli available in their environment in creative problem solving tasks (Goldschmidt & Smolkov, 2006). Specifically, evidence has shown that having certain features in the immediate environment, such as plants and windows (Shibata & Suzuki, 2002, 2004), scenic posters (Stone & English, 1998), warm and bright light (Knez, 1995), as well as books and a computer (Ceylan et al., 2008), can all enhance mood, productivity, and creative performance.

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Ceylan, Dul, and Aytac (2008) found that offices with low visual complexity and cool colours were rated as environments most likely to enhance creativity. This was based on the ratings of managers in manufacturing companies, but the creativity of the participants was not measured in the study. In contrast, environments that have complex visual detail, external views, use natural materials, and with warm colours were judged as being more stimulating for creativity by a group of 60 participants (McCoy & Evans, 2002). On the other hand, rooms were rated poorly for creative potential if they did not have windows, had manufactured materials, and if they had cool colours in the décor. In a second study, McCoy and Evans (2002) directly compared creative performance, as measured by the TTCT and collage making, within the two environments. It was found that the visually stimulating environment significantly improved collage creativity, but the TTCT DT test scores were not affected by the environment. Although interesting, each participant repeated the creativity tests twice, once in each environment (although this was counterbalanced). However, there is an indication here that the perceived potential for an environment to induce creative thinking can correlate with creative performance.

In a separate study, design students were asked to create both a drinking fountain and candy packaging whilst in either a visually rich (photos, artwork, models in sight), moderate (a small selection of sketches in sight), or a bare environment (Goldschmidt & Smolkov, 2006). It was found that nine designs were regarded as creative, six of which were produced in the rich environment, and three in the moderate condition. No creative ideas were produced in the visually bare environment. Studies comparing environments are limited (to the author's best knowledge), with most papers considering perceptions of an environment rather than experimentally testing the differences between them.

There are discrepancies between the effects of a visually busy and a visually bare environment, and which is more conducive to creative thinking. In the majority of the publications in this area, the importance of a stimulating environment is emphasised. With consideration of the OST and others previously discussed, it can be conjectured that a stimulating environment increases cognitive arousal. In those with ADHD, this could lead to an enhancement in concentration and productivity, which could allow them to perform on par with a control group on

tasks requiring focus, such as attention tasks. It is unclear how a visually stimulating environment would affect creativity performance in those with ADHD, but in a control group it has been found to improve creativity.

A discussion of eye-tracking technology and previous studies will now be discussed, as the location of fixations can inform what is being attended to, and what is not.

7.2.5 Eye Tracking

In order to focus on a stimulus in the visual field, the eyes move to that point so that we can clearly see what is at the centre of the gaze. With this, attention also shifts to the point being focused on, allowing the individual to concentrate on it (Duchowski, 2007; Henderson & Ferreira, 2012; Land, Mennie, & Rusted, 1999). It is therefore commonly assumed that tracking and recording an individual's eye movements can lead to an analysis of the distribution of visual attention, the stimuli that are prioritised for processing, and the time and location of fixations (Karatekin, 2007; Rosa et al., 2015).

Most commonly, fixations, saccades, and scan paths are analysed in the examination of visual attention. Fixations are relatively stable eye gazes that last for at least 80ms, and take up around 90% of all looking behaviour (Irwin, 1992). They are thought to innately coincide with an individual's focus on the stimulus of interest (Duchowski, 2007). A saccade is a single movement of the eyes, and a scan path is a map of fixations and saccades.[1]

It is generally accepted within the field of eye tracking research in relation to ADHD that those with ADHD have abnormalities in their ability to fixate (Armstrong & Munoz, 2003b), the length of their fixations (Munoz, Hampton, Moore, & Goldring, 1999), in their RT to visual stimuli (Matsuo et al., 2015), and in the inhibition of superfluous eye movements (Munoz, Armstrong, Hampton, & Moore, 2003). It is commonly reported that those with ADHD do not have abnormalities in oculomotor tasks or working memory, but that they do in

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[1] As the technology used within this study was not sensitive enough to measure saccades and scan paths accurately, only fixations were measured. Only fixations are discussed further.

response inhibition (see Castellanos et al., 2000; Jacobsen et al., 1996; Ross, Harris, Olincy, & Radant, 2000a; Ross, Olincy, Harris, Sullivan, & Radant., 2000b; Ross, Hommer, Breiger, Varley, & Radant, 1994). Findings supporting these contentions have focused on comparisons with control groups and/or individuals with schizophrenia, as both disorders have attention and inhibition deficits (Ross et al., 2000b), and have measured differences in eye movements.

When compared to control individuals, those with ADHD have difficulty in maintaining fixations on-target, and in inhibiting unnecessary saccades (Munoz et al., 2003). Furthermore, it has been found that voluntarily stopping an eye movement is particularly difficult for those with ADHD, especially with the appearance of a new stimulus outwith the focus of vision (Armstrong & Munoz, 2003b).

Children with ADHD have been found to have significantly shorter fixation lengths than those without, leading to poorer performance in change detection and sustained attention exercises (Türkan, Amado, Ercan, & Perçinel, 2016). In examination of the differences between control and ADHD children on their ability to fixate on one point for 21 seconds, it has been found that the ADHD group looked away from the target significantly more often than the control group did (Gould, Bastain, Isreal, Hommer, & Castellanos, 2001). This study was carried out in a completely dark room, without stimulation beyond the target, leading the authors to conclude that the faults within the ADHD group were not caused by distraction, but were due to a fundamental inability of the participants to fixate. It is argued here that this may not be the case, but rather the individuals were operating stimulation seeking behaviour.

The eye movement differences between ADHD and other groups are so frequently found that new research has advocated the use of eye tracking methods in the diagnosis of the disorder (e.g., Dosaj, Overlin, & Turnage, 2015; Matsuo et al., 2015; Tseng, Cameron, Munoz, & Itti, 2014).

To the writer's best knowledge, no eye tracking studies have been published that consider creativity, or the measurement of any aspect of creativity. This would be interesting to study in order to determine how focused or distracted individuals are, where they look, and what may inspire solutions during the completion of

creativity tasks. It is assumed that this lack of existing research is due to the fixed nature of past eye tracking equipment, and the necessity of participants to keep their heads still whilst focusing on a computer screen. It would be very difficult to measure creativity in this way, as individuals would, at the very least, have to look at a keyboard to type responses.

However, the techniques for measuring eye movements have become more accurate whilst being less invasive. From measuring electrical changes on the skin around the eye area, and from contact lenses with wires attached (Duchowski, 2007), methods these days include the use of mobile eye tracking glasses that are connected to a remodelled mobile phone or laptop.

7.2.6 Current Study

Most of the research described has used extraneous sound stimuli to test the OST and MBAM theories. The research into the effects of the physical environment on creativity has so far focused on visual stimuli. Therefore the present study changed the testing surrounding visually, to determine if the same effects would be found for both creativity and attention. Contrary to the first two studies in this thesis, where the testing room was very bare, with nothing on the walls, and only the necessary testing items on the tables, the present study room was designed to look like a typical office. The aim was to create a visually stimulating environment (see Amabile, 1996; Ceylan, Dul, & Aytac, 2008; Martens, 2008), to determine if that enriched or impaired performance on creativity and attention tasks, as the OST would suggest. For the ADHD group, it was thought that the participants would move their eyes away from the target more often than the control group, in an attempt to seek extra stimulation during both the creativity and attention tasks.

A simple approach was taken in this eye tracking study, by measuring the number of fixations on-target during the completion of verbal and figural divergent thinking tasks measuring creativity, and sustained and selective attention tasks. This was thought to be the clearest way of determining if differences in attention allocation and distraction exist between a control group and an ADHD group.

In consideration of the literature reviewed, the hypotheses were:

H1: The ADHD group will have significantly fewer fixations on-target than the control group, across the tasks.

H2: There will be a difference in fixation behaviour between the creativity and attention tasks, across both groups.

This hypothesis is included to support the assumption that the creativity and attention tasks are fundamentally different from each other, and are therefore processed and managed differently. Attention tasks should require more on-target fixations for their successful completion than the creativity tasks. Tracking eye movements can help with this clarification, as it can show us if the participant focuses their concentration on the task, or if they have diffused their attention.

H3: The visually stimulating testing environment in the present study will lead to an improvement in creativity and attention scores within both the control and the ADHD group, when compared to the results of tests carried out in a plain environment (as featured in chapters five and six).

The visually stimulating environment was implemented in this study to test the OST using a method other than sound, and to measure the effect that an office environment might have on the performance of creativity and attention tasks. As previous studies have shown, control group performance should either be unaffected or improved. The first two studies of this thesis investigating the relationship between creativity and attention used the same measures that feature in this study. This allowed for a direct comparison between performance in a visually plain environment, and a visually busy environment.

7.3 Methods

7.3.1 Design

An independent-samples design was used for this study, in order to test for differences in the number of fixations between a control group, and a group of people with ADHD. These were measured using eye tracking glasses during the performance of creativity and attention tasks. The independent variable was the group (i.e., control or ADHD), and the dependent variables were, for each task, the mean number and duration of fixations on-target.

7.3.2 Participants

Thirty participants took part in this study, 15 in the control group, and 15 in the ADHD group. Within the control group, there were four males and 11 females, aged between 18 and 40 years (M = 27.40, SD = 5.42 years). The ADHD group consisted of nine males and six females, aged between 20 and 60 years (M = 29.47, SD = 11.30 years). In keeping with the explanation in section 4.2, the ADHD group consisted of people who had, or strongly believed they had the disorder.

The environment comparison groups consist of the participants in the control group and the ADHD group, both described in chapters five and six.

7.3.3 Materials

Throughout the testing session, participants wore mobile eye tracking glasses by SensoMotoric Instruments (SMI; weighed 68g, sampling rate 60Hz binocular, typical accuracy to 0.5°). These are worn like a pair of large spectacles, and are connected to a laptop by a USB cable (see figure 9). Infrared cameras track the movement of the pupils, and a front facing camera above the nose records the direction in which the participant is looking. The video and the frame-by-frame pupil position are transposed together, resulting in a video with each fixation mapped on to it, so that the researcher can analyse gaze location.

When the glasses are put on, a simple, automated calibration is required. The participants were instructed to look at a small symbol at the top of the computer monitor. When the software identified the pupils, the tracking point (viewable only by the researcher) matches to the same symbol on the laptop screen. One click on the symbol then confirmed that the tracking point was in the correct place. It was necessary to recalibrate after each task the participants completed to ensure the analysis would be as accurate as possible.
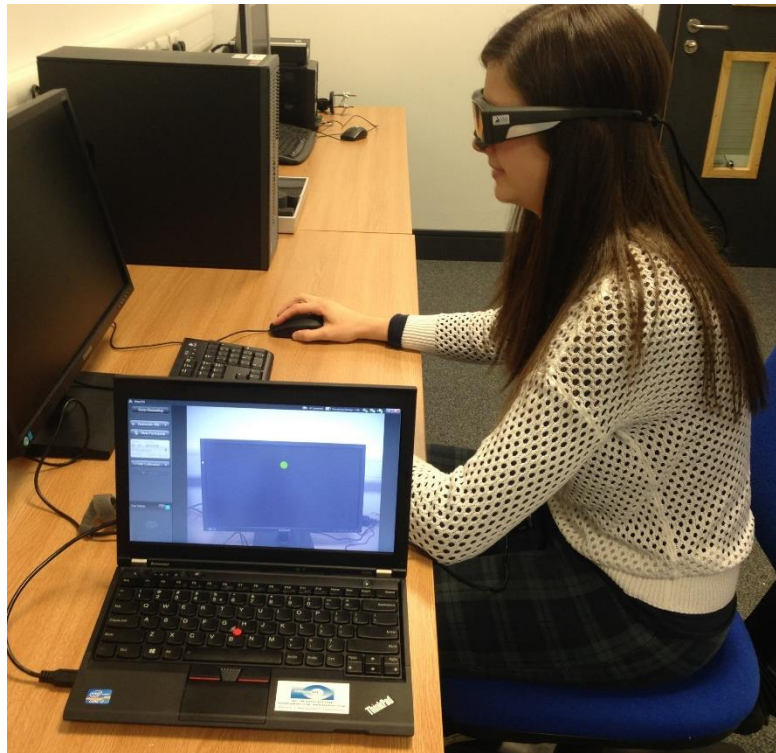
Figure 9: Photograph of the SMI eye tracking glasses on a participant, plugged in to the laptop.

The participants completed seven tasks altogether. In order to measure creativity, the UUT-CB testing verbal DT, and the Circles task measuring figural DT as detailed in section 4.3.2 were used. To measure attention, the ASRS-v1.1 (adult ADHD self-report scale), MWQ (mind-wandering questionnaire), DDFS (daydreaming frequency scale) each described in section 4.3.1, and the CPT (sustained attention test), and the Stroop (selective attention measure) tasks were all used, as described in section 4.3.3. The reliability of the MWQ and the DDFS within this study was calculated[2]. The MWQ returned a Cronbach's alpha score of .827, and the DDFS scored .943. These are high scores indicating strong inter-item reliability.

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[2] The scoring of the ASRS does not allow for reliability analysis in this study, but this has been previously researched by others. See section 4.3.1 for details.

7.3.4 Procedure

Each participant was welcomed in to the 'office' laboratory room at Edinburgh Napier University. To create a visually stimulating environment, there were notebooks, books, folders, a mug, and stationery on the table, and a calendar, spreadsheets, and lists on the wall behind the computer screen. A selection of collages (produced by participants in the previous study) were also displayed.

First, participants were presented with an information sheet and consent form to complete (appendices 16.2 and 17). The participant sat in front of the computer, with table space in front of them for the paperwork. After any questions had been answered by the researcher, the participant completed the ASRS-v1.1, the DDFS, and the MWQ in the order the participant chose to complete them in. The eye tracking glasses were then put on and the calibration procedure took place.

Once the glasses were in place, the participant carried out the CPT, Stroop test, UUT-CB, and the Circles task in a pseudo-random order that was predetermined by the researcher to limit order effects. Short breaks of two to three minutes were made available to each participant between the tasks, although these were generally refused. When all of the tasks were complete, the glasses were removed, a debrief sheet was provided (appendix 19.2), and the individual was thanked for their time with a £10 High Street gift voucher.

The paper data were scored manually and analysed using SPSS. The eye-tracking data were analysed using the SMI BeGaze software (version 3.4). Each fixation (>80ms gaze) was recorded, and later mapped by the researcher on to a reference view (i.e., a photo of the task; see figure 10). The accuracy level quoted from the manufacturer was .05°, however it was visibly clear that there was a greater degree of error. When participants reported that they were looking on-target, the fixation mark on the software was frequently not in the correct place, so calibration seemed to shift after some time. For this reason, Areas of Interest (AOIs) were drawn around the target of each task, each with a 3cm radius. This area was a limit that was imposed by the researcher as most fixations were within this space, and it allowed for error in the accuracy of the glasses. A fixation is therefore deemed to be 'on-target' if it appears within this AOI, and 'off-target' if it appears outwith the AOI. Once the fixations were mapped, focus and heat maps

of where the participant fixated, as well as statistics for fixation counts (amongst many others) become available.
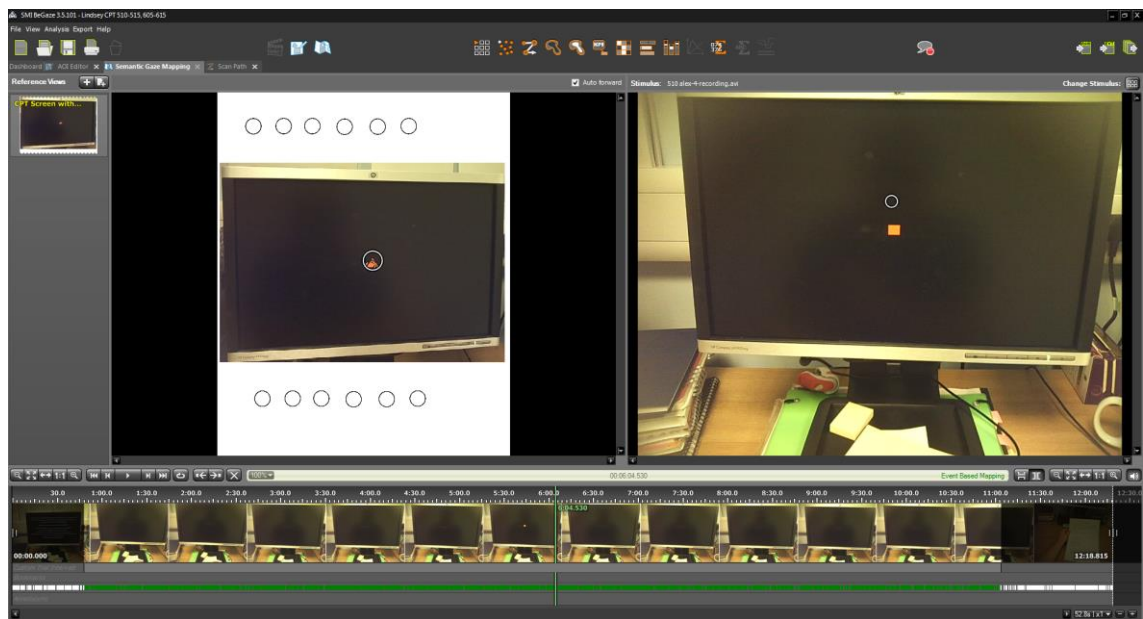
Figure 10: An example of the BeGaze analysis software. The participant's video and fixations are on the right, the fixation mapping template is on the left.

The inferential statistics procedures used follow the recommendations from Field (2013), given the type of data and the research aims. Independent samples *t*-tests (or Mann-Whitney *U* tests when the data were nonparametric) were conducted for each task to look for differences between the groups in fixation count and the percentage of fixations on-target. These were also carried out to look for performance differences within each group but between the original studies of this thesis investigating the relationship between creativity and attention, to test for an effect of the visually stimulating environment. Paired-sample *t*-tests (or Wilcoxon signed ranks tests with nonparametric data) were calculated to study the differences in eye movement behaviour within each group, across the creativity and attention measures (i.e., to examine if creativity tasks yielded more fixations than attention tasks, or vice versa).

7.4 Results

It should be noted here that the results of this study are low on statistical power given the small sample size. This is further discussed in section 7.5.4 as a limitation.

The results are split in to three sections: between-group performance differences, eye-movement differences, and differences between the two environments. Where the data distributions are not normal (as determined by Shapiro-Wilk test of normality), nonparametric tests were carried out.

7.4.1 Between-Group Differences in Creativity and Attention Tasks

Figure 11 shows the scores from the three self-report questionnaires measuring aspects of attention and focus, ordered by group. The possible score range for the ASRS-v1.1 was from zero to six, for the DDFS it was from zero to 48, and for the MWQ it was from five to 30.
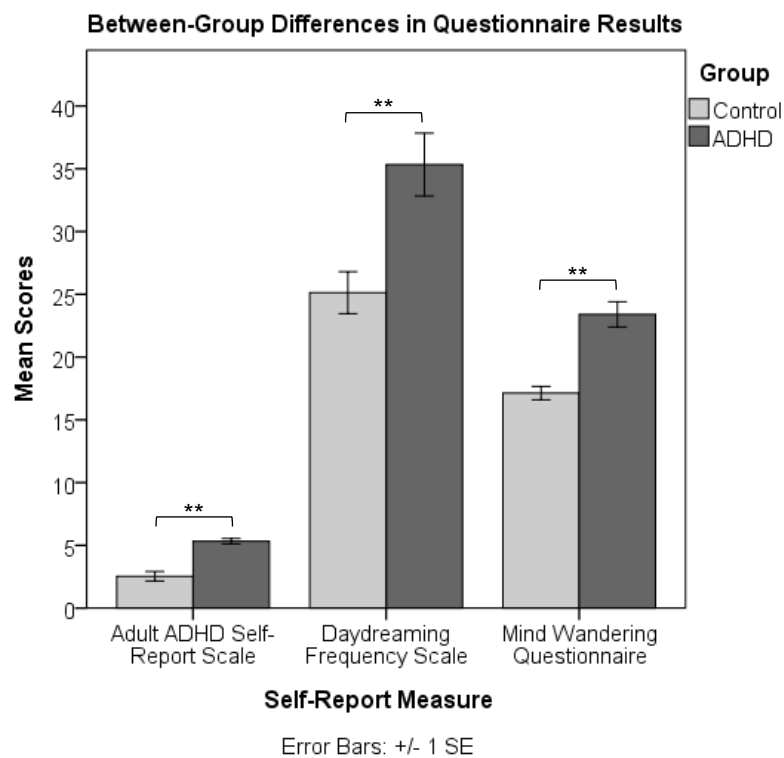
Figure 11: Control and ADHD group scores on self-report measures of attention.
 ** indicates significant difference at the 99% confidence level.

The ADHD group scored consistently higher than the control group on the measures of ADHD symptomology (control mean: 2.53 (SD = 1.46), ADHD mean: 5.33 (SD = .82)), daydreaming frequency (control mean: 25.13 (SD = 6.48), ADHD mean: 35.33 (SD = 9.66)), and mind-wandering (control mean: 17.13 (SD = 2.07), ADHD mean: 23.40 (SD = 3.87)). The differences between the groups were significant for all three: ASRS-v1.1 (U = 7.50, p < .001), DDFS (U = 40.0, p = .003), and the MWQ (t(28) = -5. 534, p < .001, d = 2.242: large effect size), with the ADHD group having poorer scores than the control group.

Figure 12 shows the scores for the creativity tasks, by group. Verbal DT was measured by the unusual uses for a cardboard box task, and figural DT was measured by the Circles task.
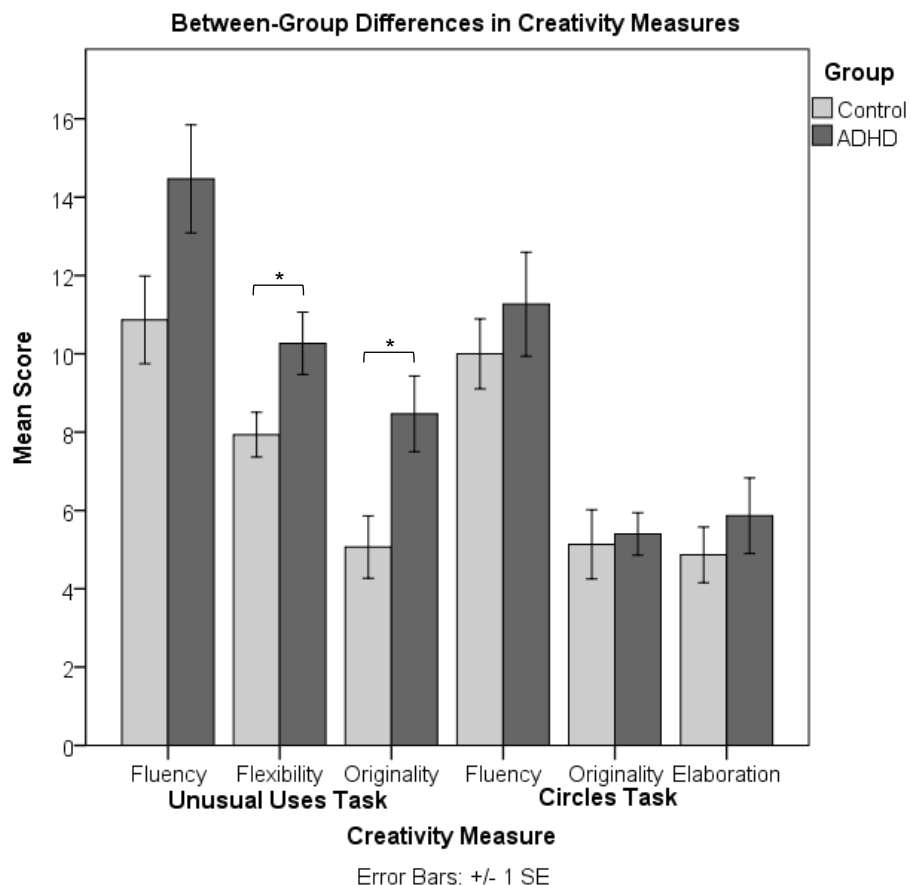
Figure 12: Control and ADHD group scores on verbal and figural divergent thinking measures. * indicates significant difference at the 95% confidence level.

The ADHD group consistently scored better on aspects of DT. The between-group differences were significant for UUT-CB flexibility (t(28) = -2.380, p = .024, d = .872: large effect size), and originality (t(28) = -2.718, p = .011, d = .992: large

effect size), but not for fluency, although it was close: (t(28) = -2.028, p = .052). There were no between-group differences for Circles task fluency (t(28) = -.791, p = .436), originality (t(28) = -.257, p = .799), or elaboration (t(28) = -.835, p = .411).

The mean RTs for the CPT measuring sustained attention demonstrated that the control group (M = 441.35ms, SD = 47.89ms) were slightly faster than the ADHD group (M = 468.39ms, SD = 58.11ms). An independent-samples t-test clarified that this difference was not significant: t(28) = -1.391, p = .175.

The Stroop task measured selective attention. This time, the control group (M = 64.81ms, SD = 139.68ms) were slower to respond in the incongruent condition than the ADHD group (M = 54.46ms, SD = 224.09ms). However the standard deviations here are very high, and an independent-samples t-test confirmed that there not a significant between-group difference in performance: t(28) = .152, p = .880.

7.4.2 Eye Movement Results

Figure 13 illustrates that the ADHD group consistently made more fixations in total over the duration of each of the creativity and attention tasks, when compared to the control group.
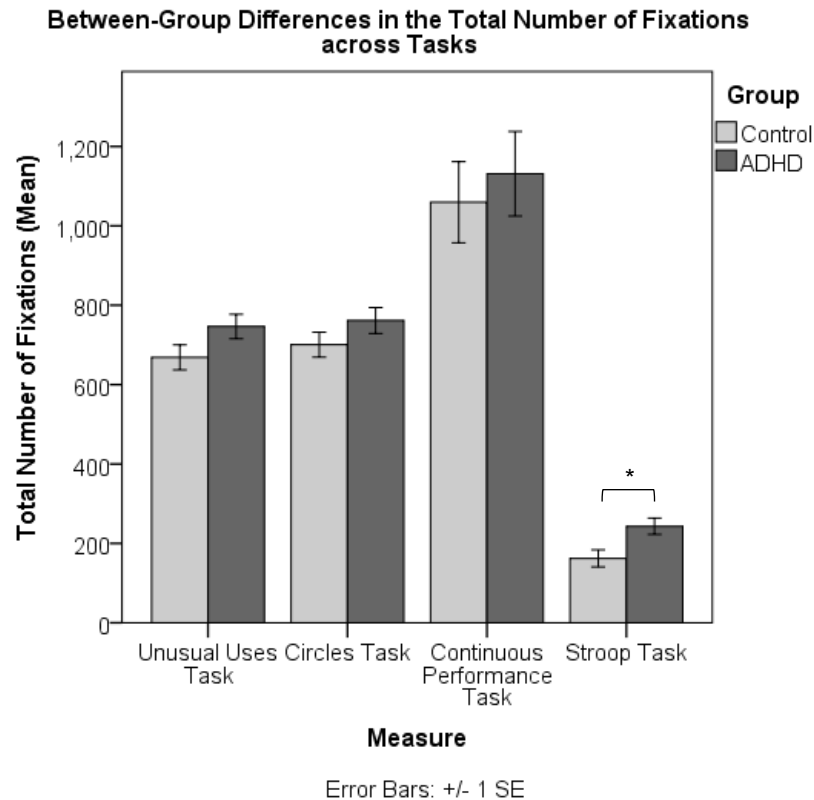
Figure 13: Between-group differences in the total number of fixations over the length of each measure used.
* indicates significant difference at the 95% confidence level.

Independent samples *t*-tests determined that the between-group differences in the total number of fixations were non-significant for the UUT-CB ($t(28) = -1.765$, $p = .089$), Circles task ($t(28) = -1.341$, $p = .191$), and the CPT ($t(28) = -.486$, $p = .630$), but the Stroop task difference was significant ($t(28) = -2.694$, $p = .012$, $d = .984$: large effect size).

The number of each participant's fixations that were on-target in each task was recorded. This was used in conjunction with the total number of fixations, and turned in to a percentage of on-target fixations (i.e., participant one had 884 fixations in total during the UUT-CB, 615 of these were on-target. $(615/884)*100 = 69.57\%$ of their fixations were on-target). The percentages of on-target fixations, per task and between-groups, are shown in figure 14.
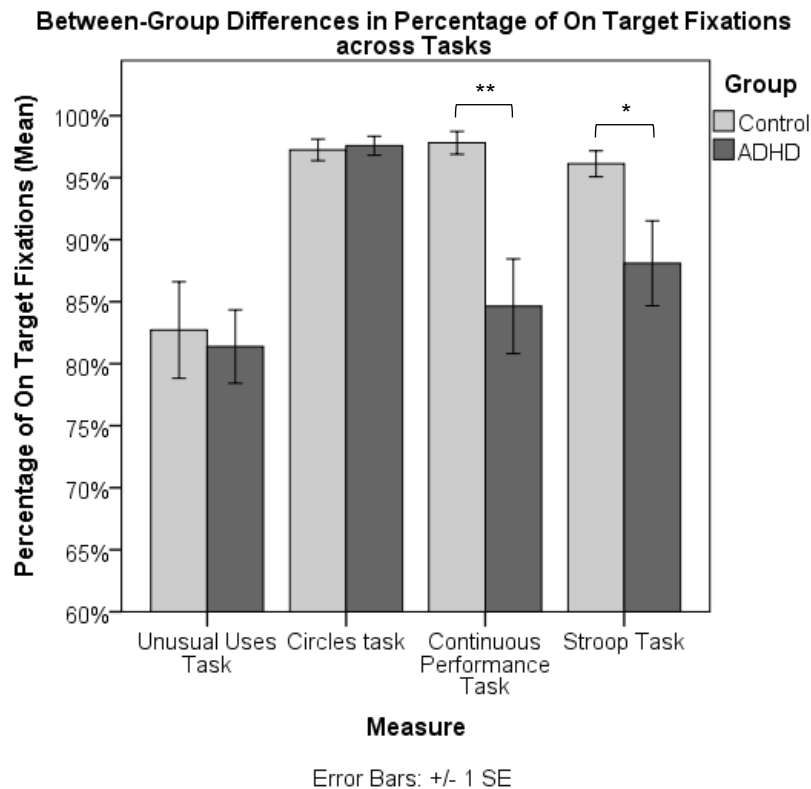
Figure 14: Between-group differences in the percentage of on-target fixations over the length of each measure used.
* indicates significant difference at the 95% confidence level. ** indicates significant difference at the 99% confidence level. Scale starts at 60% in order to clearly illustrate the differences.

Figure 14 shows that the control group spent a higher proportion of their fixations looking at the task target for the attention tasks, than the ADHD group did. Each task yielded non-parametric data in this case. Mann-Whitney U tests determined that there were significant differences between the groups in the percentage of on-target fixations for both the attention tasks: the CPT ($U = 29.0$, $p = .001$), and the Stroop test ($U = 64.0$, $p = .044$). The differences between on-target fixations in the creativity tasks (UUT-CB ($U = 99.0$, $p = .576$) and the Circles task ($U = 101.50$, $p = .648$)) were not significant.

Within the control group, there was a significant difference in percentage of on-target fixations between the tasks, as shown by a Friedman non-parametric test: $X^2(3) = 19.966$, $p < .001$. As required by Wilcoxon Signed Ranks post-hoc tests, the significance level was adjusted to .008 (normal significance level of .05, divided by the number of comparison tests carried out. .05 / 6 = .008): with these parameters, there were significantly fewer on-target fixations between the UUT

and the Circles task, the UUT-CB and the Stroop task, and the UUT-CB and the CPT, as shown in the figure 14 and table 8.

The same analysis was conducted for the ADHD group. Significant differences were found between the tasks in the percentage of fixations that were on-target: $X^2(3) = 17.640$, $p = .001$. Post-hoc comparisons showed that the UUT had significantly fewer on-target fixations than the Circle and Stroop tasks, and the Circles task had significantly more on-target fixations than the CPT and Stroop task, as shown in figure 14 and table 8.

Table 8: Differences in the percentage of on-target fixations across tasks, within groups.

		Control Group		ADHD Group	
		Z	p	Z	p
Unusual Uses Task	Circles Task	- 3.351	.001**	- 3.351	.001**
	Continuous Performance Task	- 3.408	.001**	- 0.795	.427
	Stroop Task	- 2.669	.008**	- 1.761	.005**
Circles Task	Continuous Performance Task	- 0.910	.363	- 2.840	.005**
	Stroop Task	- 1.022	.307	- 2.953	.003**
Continuous Performance Task	Stroop Task	- 1.287	.198	- 1.079	.281

** indicates significance at 99% confidence level.

The table above highlights that the differences in on-target fixations are not consistent between the creativity and attention measures.

7.4.3 The Effect of the Visually Stimulating Environment

To identify any effects the visually stimulating testing environment may have had on the performance on creativity and attention tasks, participant performance on the tasks that were common to both this study (visually stimulating environment) and those described in chapters five and six (visually plain environment) were compared. These tasks were the UUT-CB and the Circles task measuring verbal and figural DT respectively, and the CPT and the Stroop task measuring sustained and selective attention respectively.
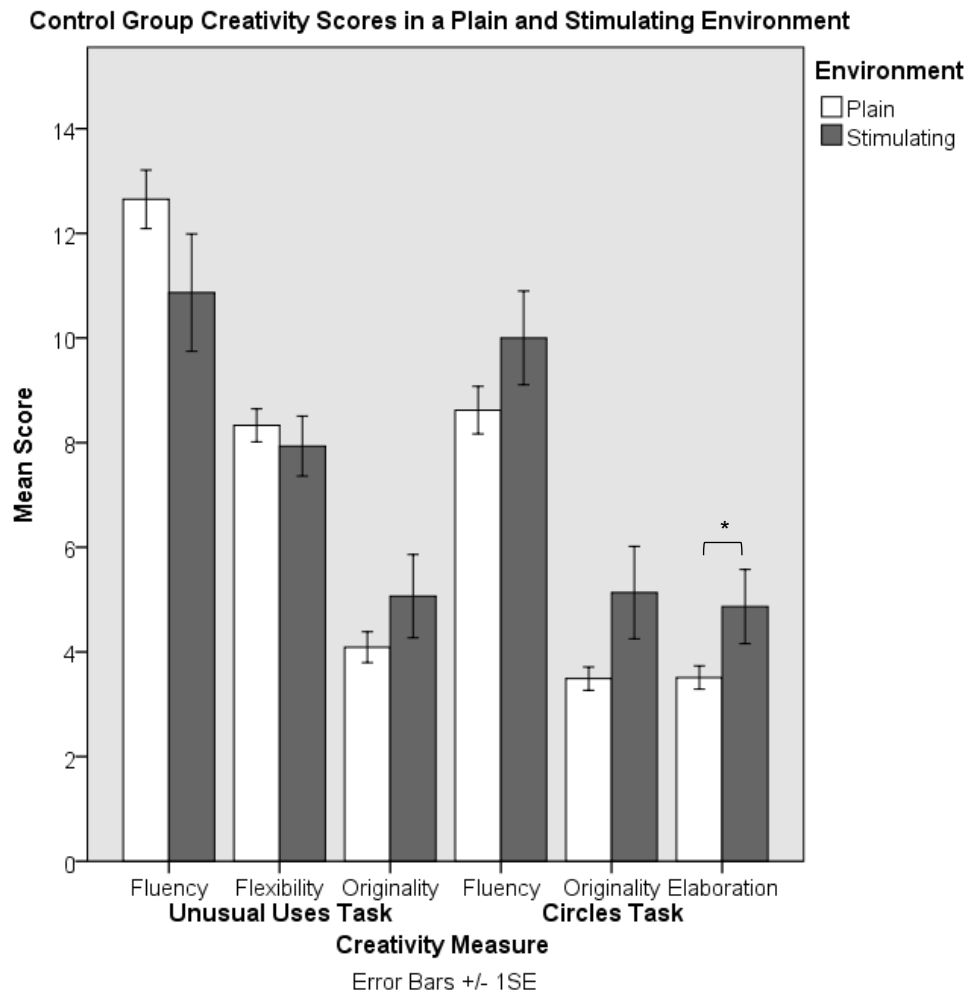
Figure 15: Control group differences in verbal and figural divergent thinking scores in plain vs. stimulating environments.
* indicates significance at 95% confidence level.

Within the control group, the only significant difference was in figural DT elaboration, as shown by independent samples *t*-tests in table 9.
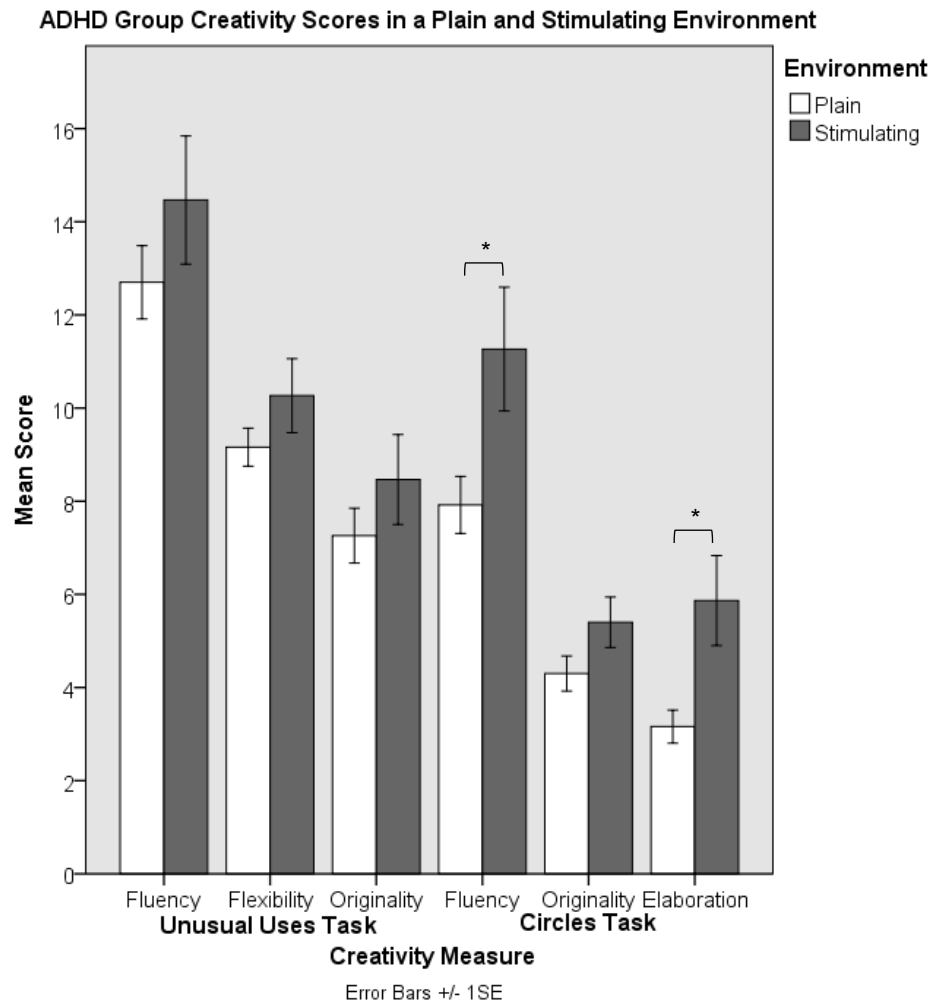
Figure 16: ADHD group differences in verbal and figural divergent thinking scores in plain vs. stimulating environments.
* indicates significance at 95% confidence level.

Figure 16 shows that there were improvements in scores across the creativity measures within the ADHD group, but the only significant differences were in figural DT fluency and elaboration, as shown by independent samples *t*-tests in table 9.
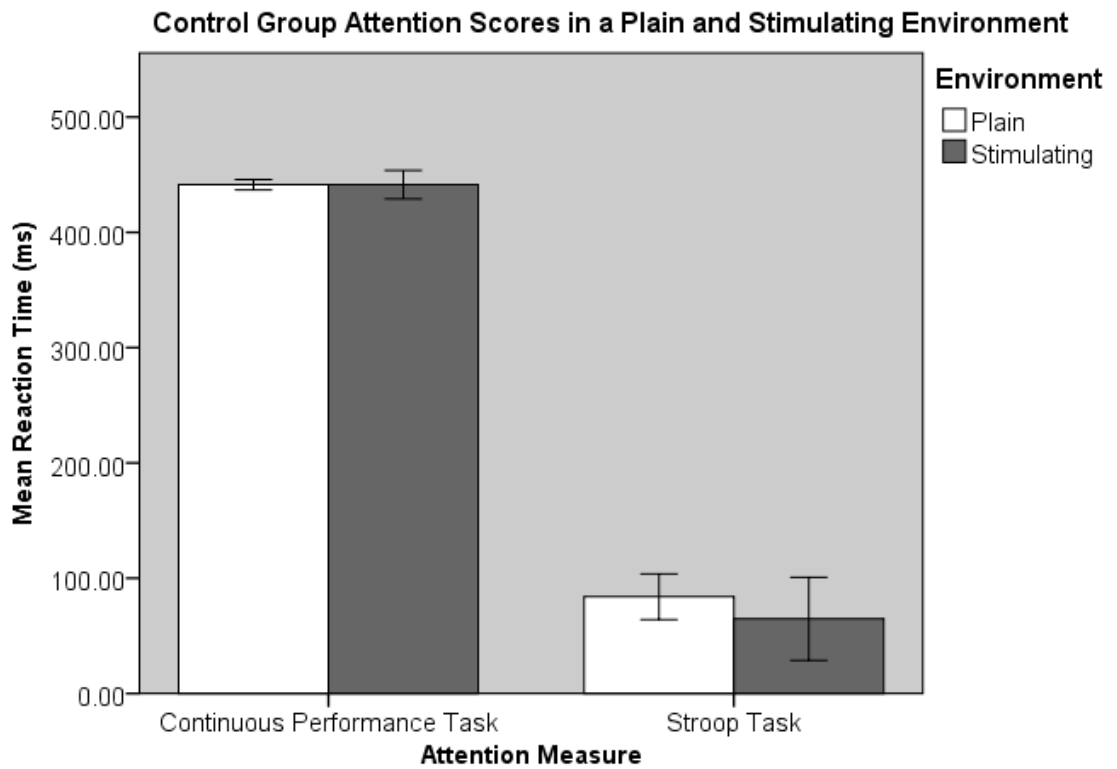
Error Bars: +/- 1 SE

Figure 17: Control group differences in sustained and selective attention scores in plain vs. stimulating environments.

Figure 17 indicates there were only minimal differences in sustained and selective attention performance between the two environments, for the control groups. None of the differences were significant (see table 9).
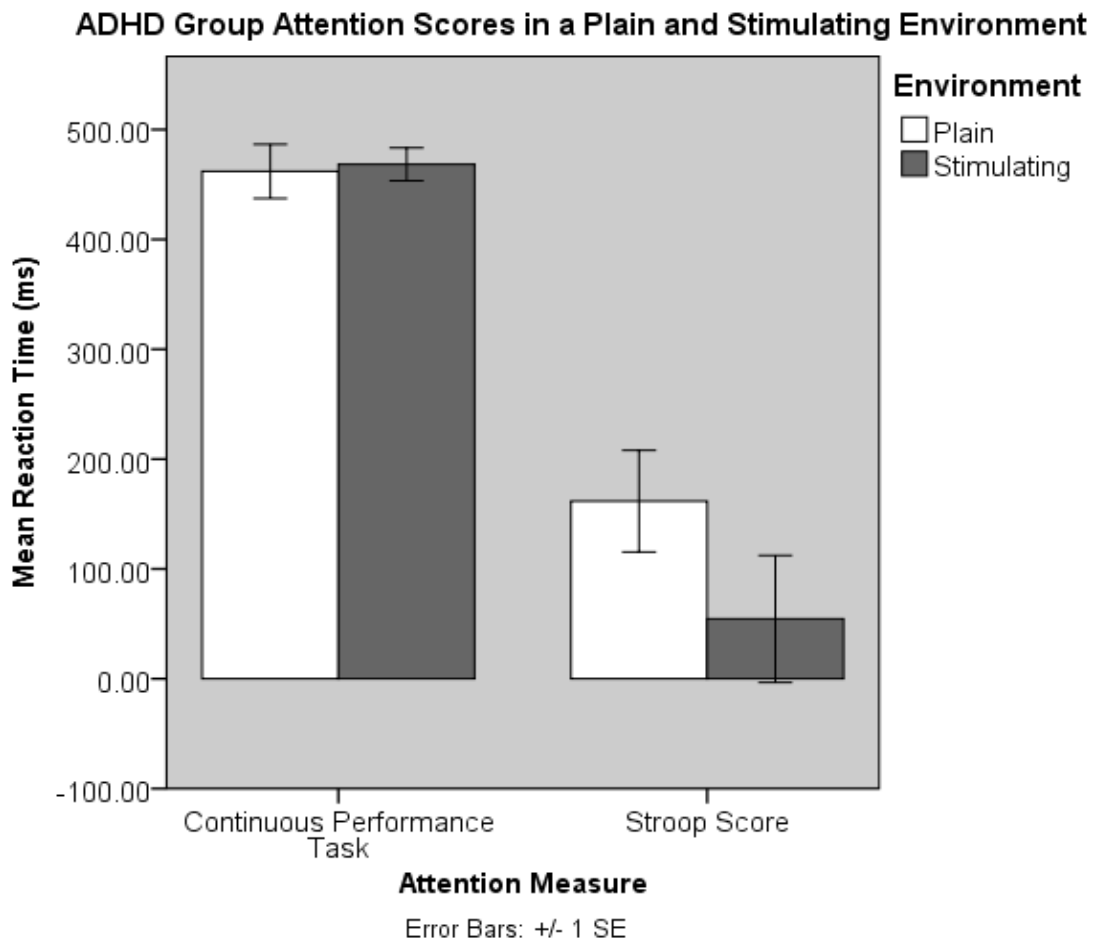
Figure 18: ADHD group differences in sustained and selective attention scores in plain vs. stimulating environments.

Although figure 18 shows that, compared to figure 17, there were slightly larger differences in scores between the environmental conditions for the ADHD groups, these differences were not significant, as shown in table 9.

Table 9: Between-study differences in performance across the tasks.

		Control Group		ADHD Group	
		t	p	t	p
Unusual Uses Task	Fluency	1.179	.241	- 1.088	.281
	Flexibility	0.469	.640	- 1.284	.204
	Originality	- 1.192	.236	- 1.005	.319
Circles Task	Fluency	- 1.127	.262	- 2.508	.015*
	Originality	- 1.805	.090	- 1.465	.148
	Elaboration	- 2.129	.035*	- 3.243	.017*
Continuous Performance Task	RT	- 0.002	.998	- 0.226	.823
Stroop Task	RT Difference	0.360	.720	1.147	.256

* indicates significance at 95% confidence level. *df* = 113.

The *t*-test results in table 9 indicate that both the control and the ADHD groups in this study performed significantly better in figural DT elaboration, meaning that more details were added to their drawings in the visually stimulating environment. The ADHD group also produced significantly more ideas for the Circles task in the visually stimulating setting.

7.5 Discussion

7.5.1 Differences in Eye Movement Behaviour

ADHD has been linked to a naturally under-stimulated state (Nieoullon, 2002), and according to the OST, poor levels of cognitive stimulation leads to inattentiveness, poorer concentration, and stimulation seeking behaviour (Zentall & Zentall, 1983). Consequently, those with ADHD characteristically struggle to focus on tasks. For the creativity tasks in this study, it was thought that the ADHD participants would be more likely to move their eyes away from the target in either an attempt to seek extra stimulation, or to consciously/non-consciously look for ideas. This was not found to be the case.

In terms of the attention tasks, it was predicted that, as the CPT in particular is a long, monotonous task with very little stimulation, those with ADHD would be more likely to move their eyes in order to seek stimulation away from the task itself. Although the Stroop task requires a decision to made, stimulation from the task is still limited, so it was also thought that the ADHD group would move their eyes more during this task too. It was found that those with ADHD had more

fixations across each task, meaning that they moved their eyes more, significantly so over the length of the Stroop task. Yet, the ADHD group looked at the task target significantly less than the control group for the CPT and the Stroop task. Having more fixations but less of them on-target shows that those with ADHD could have struggled to focus on the target, and that they could have been looking elsewhere as an activity aimed at increasing stimulation, as the OST would suggest.

The first hypothesis predicted that the ADHD group would make significantly fewer fixations on-target than the control group, across the tasks. This hypothesis can be partially supported for the attention measures, but cannot be supported for the creativity measures. Furthermore, the second hypothesis stated that there would be a difference in fixation behaviour between the creativity and attention tasks, across both groups. It can therefore be concluded that those with ADHD have less focused fixation behaviour for tasks measuring sustained and selective attention, but are not more or less focused than a control group during divergent thinking tasks. Creativity and attention tasks here are shown to be processed differently in terms of the allocation of visual attention, and show that those with ADHD can maintain their focus on creativity tasks better than they can for attention tasks.

It is possible that the absence of a between-group difference in fixation behaviour during creativity tasks may be because they require the participant to write and draw, which necessitates them to look directly at the page whilst they are doing so. It may also be the case that as the creativity tasks oblige the participants to actively think and produce multiple solutions, and could therefore be inherently more interesting, that this raises cognitive stimulation to a similar level to that of the control group participants.

Interestingly, although the ADHD group spent significantly less time looking at the target in the attention tasks, they did not perform significantly worse. This indicates that their apparent distraction did not detract from their ability to sustain their attention and inhibit irrelevant responses. It could be the case that those with ADHD are generally good at timing their off-target fixations, as they are frequently in the habit of seeking stimulation from other sources, whilst attempting to pay

attention concurrently. It may also be the case that eye-tracking may not reveal functional problems in those with ADHD.

7.5.2 The Effect of the Environment

As the main four measures used within this study had been used previously (chapters five and six, investigating the relationship between creativity and attention in control and ADHD groups) in a plain testing environment, a comparison of the data collected there could be made with the data in this study, which used a visually stimulating office environment.

Within the control group, performance decreased in the stimulating testing environment for verbal DT fluency and flexibility, but increased for verbal DT originality, and figural DT fluency, originality, and significantly increased for elaboration. This means that significantly more details were added to the circle drawings. For the ADHD group, performance increased in the stimulating test environment across each aspect of the divergent thinking tasks, significantly so for figural DT fluency and elaboration. This means that more Circle ideas were drawn, and with more detail, than in the plain environment condition. This shows that the environment seemed to benefit the creativity of those in the ADHD group most, and that a larger sample may lead to more significant differences.

The attention measures were less affected by the change in environment. Within both groups, the differences were very small and non-significant. It can therefore be concluded that the stimulating office environment did not improve or diminish sustained and selective attention performance. The third hypothesis that the visually stimulating testing environment would lead to an improvement in creativity and attention scores across both groups therefore cannot be supported.

According to the OST, the visually stimulating environment may help those with ADHD reach an optimum level of arousal. That is, the added stimuli may help to raise the individual's stimulation level to a more manageable level than it would be in a blank, clear testing room. This would limit stimulation-seeking behaviour, and should help those with the disorder to focus on task. This would be shown by improvements in the attention measures from the plain environment study to the visually stimulating environment study, with a decrease in RTs. Alternatively,

the added stimuli may push stimulation levels above their optimal level, or may simply serve as a distraction, as detailed by the Overflow Theory (Strauss and Lehtinen, 1947, as cited in Zentall & Zentall, 1983), thus occupying cognitive resources and withdrawing attention from the task in hand. This would be shown by an increase in RTs during the attention tasks in the visually stimulating environment compared to the plain setting. Across both groups, it was found that the office environment had no effect, positive or negative, on the overall performance of attention tasks. This may be because the participants are habituated to working in an office, and as most of the participants were students, they may be used to working whilst surrounded by notebooks, folders, and stationery. It may also be because they were obliged to pay attention to the tasks they had volunteered to participate in.

7.5.3 General Discussion

A key finding of this study is that those with ADHD show different eye movement patterns compared to the control group, during tasks of sustained and selective attention. Specifically, they make more fixations but look at the target less. If it is assumed that a move of the eyes indicates a move of attention, then the ADHD group members could have been seeking visual stimulation during these monotonous, lengthy, and boring tasks. This corroborates with the optimal stimulation theory as described in the literature review.

These findings cannot be applied to the creativity tasks however, creating a distinction between the two cognitive processes. It is therefore likely that the creativity tasks provide a suitable level of arousal, removing the necessity for stimulation seeking behaviour. This may be why, in the literature studied in chapter three and in the findings of this thesis, those with ADHD appear to perform well on measures of creativity.

Previous studies have found that extraneous sounds have benefitted the cognitive performance of those with ADHD, and this study aimed to test this with visual stimuli. The visually stimulating testing environment appeared to induce significantly higher scores in aspects of figural DT. However, as these

improvements were inconsistent across the measures, it is unlikely that the environment had an effect on the participants' performance.

The finding that the ADHD group, when compared to the control group, made significantly more fixations during the Stroop task, and significantly fewer on-target fixations for both the Stroop task and the CPT, may be a sign that individuals with ADHD can manage their urge to seek stimulation, by looking away from the target, to an extent that they can look back at it in time to perform successfully. This is in contrast to the control group who looked at the target for longer. Perhaps this is why there was no difference in divided attention performance between the groups in the second study: the ADHD group can manage the extra stimulation of completing two tasks at once. If this was the case, then in the right setting with the appropriate parameters, those with ADHD could actually be more economical with their cognitive resources than a control group. If individuals with an attention disorder can complete a task as successfully as a control group whilst not looking at the target as often, this could point to a difference in attentional strategy between the two groups, the details of which are still unclear.

The literature review of this chapter summarised some research in to the effect of the physical environment on creativity. The presence of windows (Shibata & Suzuki, 2002, 2004) and natural fittings and furnishings (McCoy & Evans, 2002) have been found to be important in perceptions of the environment for creativity. Neither of these items were featured in the testing area for this study. However, the presence of books and a computer (Ceylan et al., 2008), cool coloured décor and complex visual detail (McCoy & Evans, 2002), and bright light (Knez, 1995) are also thought to be important, and all were used in the setting of this study. The findings from this research project do not support or negate any of these ideas, as no effects of the environment were found.

7.5.4 Limitations and Directions for Future Research

As briefly noted in the results section, the statistical power of this study is low due to the small sample size (calculated using G*Power: Faul, Erdfelder, Lang, & Buchner, 2007). Post-hoc power analysis indicated that power ranged from .06

to .99, with mean power across the tests being .52. This is lower than the recommended .80 (Field, 2013). This makes it difficult to find true effects, and for the statistically significant results to show a true effect (e.g., Button et al., 2013). This is a weakness of this study, and adds to the fragility of the results. However, due to the large extent of data extraction analysis required for eye-tracking studies, and the time-consuming nature of this task, studies using this method are typically low on numbers. For example, a search of publications using eye tracking technology across multiple disciplines revealed that sample sizes have been as low as six (Allopenna, Magnuson, & Tanenhaus, 1998), seven (Goldberg, Stimson, Lewenstein, Scott, & Wichansky, 2002), 18 (Cutrell & Guan, 2007), and 26 (Granka, Joachims, & Gay, 2004). Jacob and Karn (2003) summarised sample sizes and key findings from 21 eye-tracking usability papers and found that the mean sample size was just 14.62 participants ($SD = 10.15$), with sample sizes ranging from three to 40 participants. The present study is therefore consistent with others in the field, but this does not counteract the low statistical power, meaning it should be acknowledged, and kept in mind in consideration of the results presented. Unfortunately, it was not possible to include more participants in this study, as it was very difficult to recruit participants with ADHD, and there was limited time available for the data extraction and analysis. Future studies should factor in analysis time to their preliminary plans, so as to collect data from more participants.

Another important limitation of this study is that the participants here wore eye-tracking glasses, but the comparison participants from the two previous studies did not. This is a confounding variable, and meant that not only the environment was changed, but the glasses themselves could also have affected the results. It could be argued that the improvements in figural DT fluency (ADHD group only) and elaboration (both groups) could have been due to the glasses and not the environment. However, the glasses may have made the participants aware of where they were looking, meaning that they focused on-target more than they might normally. It is therefore suggested that the glasses and eye-tracking method could have led to the lack of significant differences between the two environmental conditions. An analysis of eye-movements in a plain environment

would be required to compare the two studies directly, and could contribute to our understanding of sensation seeking behaviour.

The main aim of this study was to examine and compare fixation behaviour in those with and without ADHD during tasks of creativity and attention. Differences were found in sustained and selective attention, but are limited to the types of tasks used in this study. In consideration of sustained and selective attention specifically, future studies could investigate this further by using a variety of tasks at different lengths. It would also be suitable to use 'real-life' measurements of attention, to study how visual attention shifts and the effects on performance in tasks of this type. This would increase ecological validity.

Furthermore, the study reported here measured creativity by verbal and figural DT tasks. However, as previously argued, creativity is a broad and complex construct that can be measured in many different ways. It may have been beneficial to include another measure of creativity, such as a picture completion or collage making task, to track eye movements during these tasks too. It could be that the environment has more of an influence during these free-reign type tasks compared to the DT tasks. Further analysis of exactly where the participants looked could support the theory that diffused attention is useful for creativity.

The environment of the testing sessions of this study was used to determine if visual stimulation could improve creativity, which in this case, it did not. An interesting development of this study would be to use the mobile eye tracker to test the OST in environments outside the laboratory. This could help determine which setting is most suitable for raising low levels of cognitive stimulation for those with ADHD. More comparisons of extraneous visual stimuli in testing environments, and combinations of visual and auditory stimuli, could help the field understand the parameters of the OST, and focus and distractedness in ADHD.

Other methods of improving creativity could be examined in future studies. The environment did not have an effect here, but manipulations of time and break periods may be of benefit to creativity. For example, a period of time spent away from the creativity task (incubation period) has been shown to lead to a more creative solution being produced on return to the task (e.g., Baird et al., 2012;

Gilhooly et al., 2013; Sio & Ormerod, 2009; Sio & Rudowicz, 2007; Snyder et al., 2004; Wallas, 1926). The effect of variations in attention on the benefit of an incubation could be studied. This would be a new direction for the research, and it could help determine the most suitable conditions for creativity.

7.6 Conclusions

To the author's best knowledge, this was the first study to examine eye movements in laboratory-based tasks of creativity. It can be concluded that fixations during a verbal DT task are less often on-target than in the completion of a figural DT task, sustained attention task, and a selective attention task. Further investigation with a variety of creativity measures will help to identify any consistent patterns and differences in fixation behaviour, and therefore the allocation of visual attention, during the act of being creative.

Clear differences in target fixations were found for attention tasks between those with and without ADHD. Again, further analysis is required to fully understand the attentional strategies used by those with an attention disorder, and it is proposed here that these strategies may in fact be more efficient than strategies used by those without ADHD.

A change in the visual stimulation available in the immediate environment did not affect performance across the tasks. Recommendations have been made for developments of this study, and ways to improve ecological validity and real-life application. There are still many questions to be answered in this area, and further study is required to extrapolate the ideas proposed here.

Ultimately, this study has identified differences in the allocation of visual attention between those with and without ADHD, and has interestingly found that fewer target fixations did not lead to a decrease in performance compared to a control group.

Chapter 8 - Attentional Control and the Effectiveness of Incubation on Creative Problem Solving

8.1 Introduction

Sir Paul McCartney has stated that the melody for one of the Beatles' most famous songs, 'Yesterday', came to him not when he was attempting to write music, but when he was dreaming (in Ritter & Dijksterhuis, 2014). Poincaré, a mathematician, and Helmholtz, a scientist with interests in various fields, both reported that the answers to their problems usually came whilst they were not consciously focused on the task, but whilst they were walking or relaxing, having previously become familiar with the problem (in Gilhooly, 2002).

It has been found that periods of time spent away from a problem can be beneficial to formulating the solution (Baird et al., 2012; Gilhooly et al., 2013; Smith & Blankenship, 1991; Wallas, 1926). This break is called incubation, and it is thought to allow non-conscious processing of the problem to continue, whilst conscious processing works on an alternative task (Gilhooly et al., 2013). Laboratory based studies have looked at incubation during a creative problem solving task, with most studies finding that in certain conditions, incubation improves the number and quality of solutions (Baird et al., 2012; Gilhooly et al., 2013; Snyder et al., 2004). For example, it has become clear that the type of incubation task used, the cognitive effort required to complete it, and attentional control are all aspects that could affect the success of incubation (see Ritter & Dijksterhuis (2014) for a review).

The cognitive processes involved in incubation are still unclear (Ritter & Dijksterhuis, 2014). Previous studies (e.g., Baird et al., 2012; Madjar & Shalley, 2008) have alluded to the concept of attention and attentional control in their explanations of how incubation may work, but it has not been thoroughly measured. This study will make a unique contribution to the field as it will determine which aspects of attentional control may be important for incubation during a creative problem solving task. This will be achieved by measuring susceptibility to mind-wandering, self-rated attention, and sustained, selective, and divided attention.

The theory of incubation and the role attention may play will be discussed along with empirical evidence from existing literature.

8.2 Literature Review

8.2.1 What is Incubation?

For problems that are not easily solved, it has been proposed that a period of time spent away from the problem can be beneficial. This is known as an incubation period. One of the first to discuss periods of incubation was Wallas (1926) in his analysis of the creative process. This analysis was developed from anecdotal and introspective information from inventors and problem solvers who stated that solutions often came to them when they were not directly focused on the problem, as was the case for Poincaré and Helmholtz. Wallas (1926) suggested that there were four stages to the creative process: preparation (focusing on and exploring the problem in hand), incubation (the internalisation of the problem by the unconscious mind), illumination (when solutions come into conscious awareness), and revision (the solution is consciously analysed, developed, and made applicable) (Wallas, 1926; see also Gilhooly, 2002; Kristensen, 2004; Lubart, 2000-2001). As previously described in section 3.1.4, this demonstrates a switch between broad and narrow attention.

More recently, incubation has been described as a temporary discontinuation of problem solving effort that allows the solution to surface, apparently without extra effort (e.g., Baird et al., 2012; Gilhooly et al., 2013; Snyder et al., 2004). For incubation to work, an initial period of contemplation or preparation is necessary in order to fully understand the problem in hand (Wallas, 1926). If the solution has not been reached consciously, it is proposed that an incubation period can allow for non-conscious problem solving processes to continue whilst conscious processing is distracted by an alternative, interpolated task (the task that occurs in the incubation period) (Baird et al., 2012; Gilhooly et al., 2013; Sio & Ormerod, 2009; Sio & Rudowicz, 2007; Snyder et al., 2004; Wallas, 1926).

Historically, creativity and incubation research has been focused on single solution problem solving (convergent thinking), and insight (Dijksterhuis & Meurs, 2006; Snyder et al., 2004). This type of task requires the production of one correct answer or solution to a problem, and has been used in studies so often because it replicates the 'Eureka' moment of insight. This is said to arise during naturally occurring problem solving and creativity (as opposed to laboratory based problem solving and creativity), when the solution suddenly becomes clear (Dijksterhuis &

Meurs, 2006). However, the answers to this type of task are usually specific and difficult to find, which may have led to inconsistencies in the literature (Baird et al., 2012; Dijksterhuis, 2004; Dijksterhuis & Meurs, 2006).

There has since been a move in the literature from a focus on convergent thinking tasks to divergent thinking tasks, as these are less restrictive (Baird et al., 2012; Dijksterhuis & Meurs, 2006). As previously discussed, DT involves the production of multiple answers or solutions for one given problem. According to the definition of creativity presented, in order for a solution to be considered creative, it should be deemed original and applicable. Therefore, creativity in this study was the production of original, appropriate, and useful ideas by mode of DT. In order to be in line with the literature, this is frequently referred to as a creative problem solving task (e.g., Gilhooly et al., 2013; Madjar & Shalley, 2008; Schmajuk, Azaz, & Bates, 2009).

There are four main theories apparent in the literature that suggest how incubation may work. These are the relief of fatigue, the relief of mindset/beneficial forgetting, intermittent conscious work, and the non-conscious work theory theories.

8.2.2 Theories of Incubation

The relief of fatigue theory (e.g., Jett & George, 2003; Madjar & Shalley, 2008; Snyder et al., 2004; Wallas, 1926) states that the incubation period allows the mind to refresh, rest, and restore capacity, which in turn creates renewed space for problem solving. However, as testing usually finds that an incubation period spent resting is less effective than when a secondary task is carried out (see Baird et al., 2012), it is unlikely that this is a plausible theory.

The second theory is the relief of mindset (Posner, 1973 in Snyder et al., 2004) or fixation breaking theory (e.g., Smith & Blankenship, 1991). These suggest that time spent in incubation allows for changes in misleading mental sets that may be inhibiting the solving of the problem. It is thought that the incubation period enables the forgetting of unhelpful strategies or assumptions, meaning that when individuals return to the problem, they have a fresh start (also see Segal, 2004,

who calls this theory 'attention withdrawal'). However, paradigms have been used with an immediate incubation procedure, where successful incubation has followed from the presentation of only the instructions of the main problem solving task, eliminating the chance of developing an incorrect mindset in the first place (Dijksterhuis & Meurs, 2006; Gilhooly, Georgiou, Garrison, Reston, & Sirota, 2012).

It was further hypothesised by Gilhooly et al. (2013) that if the relief of mindset theory was accurate, then an incubation period spent completing an interpolated task of a similar modality to the problem solving task (e.g., both tasks requiring verbal processing, or both requiring spatial processing) would promote interference-based forgetting, thus breaking down the dominant response (unhelpful mindset) and enhancing the effect of incubation. This was not found, as when creativity scores were compared, there was a greater benefit of incubation when the interpolated task was dissimilar to the problem solving task (Gilhooly et al., 2013). The relief of mindset/fixation breaking theory was therefore not supported by the authors; however, there may be a more direct way to measure the theory, as discussed in section 8.3.4 in relation to the present study.

The third theory of incubation is the intermittent conscious work theory (Seifert, Meyer, Davidson, Patalano, & Yaniv, 1995) that suggests small periods of conscious problem solving effort are performed by the participant during incubation, which later leads to the successful solution of the problem.

Alternatively, the fourth theory is the non-conscious work theory (for a review, see Gilhooly et al., 2013, as this theory is the result of a collection of studies and is not assigned to one author) and there is empirical research to support it. It proposes that the incubation effect occurs due to the continuous processing of the problem non-consciously (e.g., Dijksterhuis & Meurs, 2006; Gilhooly et al., 2013).

A method of comparing these last two theories is to contrast the performance of those in incubation experimental groups and a control group (i.e., no incubation period), on the interpolated task used during incubation. If conscious work is carried out on the problem solving task, then conscious effort on the interpolated task should be reduced, and thus there should be a poorer performance within

the incubation group (Gilhooly et al., 2012; 2013). This would support the intermittent conscious work theory. If, however, there is no performance deficit by those in the experimental groups, yet there is still a benefit of incubation to creativity task scores, this would support the non-conscious work theory.

A study using this method (Gilhooly et al., 2012) found no difference in performance between-groups, showing that there was no deficit in effort assigned to the interpolated task by the incubation group, meaning that it was unlikely that they were consciously still thinking of solutions for the original task. Similarly, when participants were openly asked if they thought about the original task during their incubation period, there was no relationship between the rating of thoughts and interpolated task performance (Baird et al., 2012). These studies therefore do not support the intermittent conscious work theory, and support the non-conscious work theory, as it implies that conscious efforts were being paid to the incubation task, and not the problem previously presented.

Studies have also found a beneficial effect of incubation even when the participants were not aware that they would return to the original task (see Baird et al., 2012; Snyder et al., 2004). In these studies, the participants were under the impression that they had finished the problem solving task, and had no need to consciously think of further answers. On surprise return to the first task, an improvement in responses was found, consistent with the definition of incubation, and the non-conscious work theory.

Baird and colleagues (2012) appear to have been the only researchers to examine the effect of incubation on new tasks. It is important to note here that incubation effects have only been found when participants return to the same task as before, and not when they have begun a new problem solving task (e.g., Baird et al., 2012). This indicates that incubation works for the task in hand, but is not transferrable and therefore does not improve problem solving ability in general.

The non-conscious work theory is further supported by the investigation of the similarity or dissimilarity of an incubation task compared to the problem solving task, as previously mentioned. In more detail, Gilhooly et al. (2013) tested six groups of participants (two control groups with no incubation period) who were

provided with either a verbal or a spatial problem solving task. During the incubation period, half of those in the verbal task group and half of those in the spatial task group were provided with a verbal interpolated task, and the other half of each group a spatial interpolated task (equalling four experimental groups). Each group carried out the problem solving task for five minutes, followed by five minutes on the interpolated task, before a final five minutes revisiting the original problem solving task. Findings indicated that an incubation task that uses different cognitive resources to the problem solving task is more beneficial (measured by an increase in responses after incubation) than a task that uses the same resources (Gilhooly et al., 2013). It was proposed by the authors that similar tasks would interfere with one another, and that dissimilar tasks allowed for the non-conscious processing of the original task whilst conscious processing was occupied with a different, unrelated, and non-interfering task.

This idea appears to be related to theories of divided attention, dual-tasking, and interference in memory. As previously discussed in section 2.1.4 (Divided Attention), carrying out two tasks simultaneously that use similar cognitive resources is more difficult than if the tasks are different, due to the limits on processing capacity (Bennett et al., 1998; Wickens, 2002). Furthermore, it has been well documented that processing multiple stimuli of a similar nature can lead to interference (Keppel & Underwood, 1962) or decay-based forgetting (Brown, 1958; Peterson & Peterson, 1959). Therefore, it stands that completing a dissimilar task during the incubation period would prevent a cognitive capacity overload, and thus should allow the processing of both tasks to occur at the same time. The distinction between the conscious processing of the incubation task and the non-conscious processing of the original task is supported as previously discussed, as performance on the interpolated activity is equal between those within and outwith incubation (Gilhooly et al., 2012; 2013).

Having presented the leading theories of incubation, it is apparent that although these can help towards the understanding of why incubation may be beneficial, very little is reported on the cognitive processes that may be involved. It is proposed here that attentional control may be an important factor to consider. The existing data relating incubation to attention are therefore discussed next.

8.2.3 Incubation and Attention

In relation to attention, for incubation to be most successful it should allow the individual's attentional focus to be diffused so as to facilitate mind-wandering and unconscious work (Baird et al., 2012; Ritter & Dijksterhuis, 2014).

Mind-wandering occurs when thoughts turn from the current task to become preoccupied with unrelated memories, fantasies, plans, feelings (Killingsworth & Gilbert, 2010; Smallwood & Schooler, 2006) and/or unsolved problems (Baird et al., 2012). It has been suggested that about 30-50% of an adult's waking life is spent mind-wandering (Mrazek, Smallwood, & Schooler, 2012). The relatively high frequency of these shifts of attention from external information to unrelated internal processes has led to the proposal that mind-wandering is beneficial for the cognitive processing of secondary tasks (Smallwood & Schooler, 2006; Stawarczyk, Majerus, Van der Linden & D'Argembeau, 2012). Along these lines, if the primary task is cognitively demanding, it is unlikely that mind-wandering will occur, as there are very few resources available to accommodate it. Therefore, mind-wandering is more likely to take place during a task that does not burden cognitive processes; a simple, undemanding task (Smallwood & Schooler, 2006).

Baird and colleagues (2012) compared the effects of two tasks on the success of incubation during a problem solving task. The first task was deemed to be cognitively undemanding, and the second cognitively demanding and they were carried out during the incubation period. The authors proposed that the undemanding task was less reliant on working memory and would therefore allow for mind-wandering, which in turn would be beneficial for the production of solutions to the problem task set. They also suggested that the cognitively demanding task would not allow for mind-wandering, and would therefore have a detrimental effect on problem solving ability after incubation. In support of this idea, it is established within attention research that if a task is well practised, or is easy, this should occupy less processing capacity than a difficult task (Kahneman, 1973). This would leave processing space for a secondary task, such as the problem needing solved.

It was found that an undemanding task, which was presumed to enable unconscious processing and mind-wandering, better facilitated problem solving

than conditions using a demanding incubation task, a period of rest (conscious work), and no break from problem solving (Baird et al., 2012). However, the authors did not provide an explanation of how the cognitive demand level of each task was determined.

Further evidence has shown that diffused attention, or a tendency towards mind-wandering, is related to enhanced creativity and creative problem solving (see Kasof, 1997). After administering measures of attention and creativity, it has been shown that participants who are generally more distracted and more affected by irrelevant stimuli, performed better on tasks involving creativity than those who were not (e.g., Dykes & McGhie, 1976; Necka, 1999; Rawlings, 1985). In addition, individuals with ADHD have been shown to outperform control groups on self-report measures (White & Shah, 2011) and laboratory based measures (White & Shah, 2006) of creativity.

Within incubation research, Baird and colleagues (2012) and Madjar and Shalley (2008) are the only researchers (to the author's best knowledge) to consider attention and focus explicitly. Baird and colleagues (2012) measured by questionnaire the participants' susceptibility to mind-wandering. They found that those who were more likely to experience mind-wandering had higher uniqueness scores (central to creativity) on the problem solving task they used, compared to those less likely to mind-wander. Alternatively, Madjar and Shalley (2008) measured self-report focused attention in relation to the tasks the participants had just completed, and found that higher levels of attentional focus related to better creativity scores. However, they did stipulate that as this measure came after creative performance, the answers could have been skewed by the participants' perception of how well they did (i.e., if they believed they had performed well, they would rate their attentional focus as higher).

These did not measure attention performance, but used just self-report measures. It was proposed that selective attention or response inhibition could have accounted for the relationship between mind-wandering and creative performance (Baird et al., 2012), and that future research should further consider the effect of attention on incubation in creativity tasks (Madjar & Shalley, 2008). These findings indicate that individual differences in attentional control may be a

contributing factor to the effects of incubation, and this study aimed to develop this idea.

The prominence of nonconscious work in theories explaining incubation could indicate that a core filtering process that controls what information transfers from the unconscious to consciousness could be in place. Csikszentmihalyi and Sawyer (1995) suggested that this was an internal social filter based on learnt assumptions and rules governing the domain or field of the original problem. However, perhaps an attentional filter is more plausible, given the importance of attention and mind-wandering. This is further explored in the present study, as explained in section 8.3.4.

The methods used within the studies discussed have all been similar, in that there is a preferred model for measuring incubation in laboratories, as explained below.

8.3.3 Measuring the Effect of Incubation

Laboratory studies investigating incubation have typically used the same testing paradigm (see Baird et al., 2012; Gilhooly et al., 2013, Olton & Johnson, 1976; Patrick, 1986; Sio & Rudowicz, 2007; Snyder et al., 2004). Firstly, participants in test conditions carry out a problem solving task, followed by an incubation period, before returning to the original task, with each unit lasting for around five minutes. The problem solving tasks are usually scored for accuracy (convergent thinking tasks) or fluency and/or originality of ideas (if DT tasks are used), which become the scores by which pre- and post-incubation effects are measured. Studies featuring a control group who only complete the problem solving task without an incubation period have stronger validity; however, some studies have omitted this (e.g., Snyder et al., 2004). By not including a control group, the researchers cannot make inferences about their findings, as other variables such as the environment, the type of sample, or individual differences may have contributed to the results.

When assessing the effect of incubation in creativity specifically, it is important to ensure that the task used does in fact require the production of creative responses. For a task to involve creativity it should instruct the participant to

produce novel and unique ideas. This appears to be an inconsistency in the literature, as the operational definitions are either different between studies, or not explained at all. For example, Ellwood, Pallier, Snyder, and Gallate (2009), and Snyder et al. (2004) have outlined the creative process by Wallas (1926) in the literature review of their papers, yet their tasks only requested ideas from memory, so the concepts of originality or novelty were not required or encouraged

Within these studies, there was no instruction to think of original, novel, or unique ideas, factors that are central to the concept of creativity. When words such as these are missing from the instructions, they can become recall or memory tests that, by definition, do not contribute to the measurement of creative ability. Although this type of instruction may allow for the identification of participants who are more creative than others (i.e., those who are more willing and able to break the barrier and list unusual uses, rather than realistic or normal uses for the item in question), not having explicit instructions can lead to individual differences in their assumptions of the task requirements. For example, some may believe it is a memory-type task and hence will withhold any creative, unusual responses.

In consideration of the literature, evidence, and paradigms discussed thus far, the research project being presented here is detailed below.

8.3.4 Current Study

As described, periods of incubation can be valuable for problem solving, and it has been suggested but not fully investigated in the existing literature that this could be due to attentional control. With reflection on the theories here discussed, several ideas were incorporated in to the present study.

To test the relief of fatigue hypothesis, a rest period of incubation was included in this study. If there were better improvements in post-incubation problem solving for those in the rest group compared to the experimental groups, support for the theory would be found. However, this has not been the case in the past (e.g., Baird et al., 2012), and is not expected to be the case in this study.

Further, a direct method of testing the relief of mindset theory of incubation was considered in relation to DT, as a UUT was used as the main creative problem solving task. Unhelpful mental sets within a DT UUT would involve the fixation on one type or category of response, for example, the use of a tin can as a container, leading the participant to list all of the things a tin can could contain. Therefore, a direct method of testing this theory was designed by the researcher, and was adopted in the present study. This was to measure the flexibility (type of answer) of the participants' responses to a UUT DT task before and after the incubation period. A change in the types of ideas produced could indicate that the mental set has shifted or broken down. Additionally, by taking a fluency score of the ideas before and after the incubation period and considering this in relation to the flexibility scores, it was also possible to determine if the number of categories of ideas had improved post-incubation. As far as the researcher is aware, this has not been done before.

The intermittent conscious work theory was also tested by openly asking participants if they thought about the original problem during the incubation period. This has been carried out before, and when explicitly asked if they had thought about the problem solving task during incubation, it was found that the rate of intermittent deliberations was not related to the participants' problem solving performance (Baird et al., 2012). It is expected that the present study will support this finding. This method could also indirectly test the non-conscious work hypothesis, as an increase in post-incubation creativity in the absence of reported conscious problem solving during the incubation period may indicate that the problem was processed non-consciously.

Additionally, the present study controlled for and measured potential differences in attentional control. Including a mind-wandering questionnaire (as in Baird et al., 2012), the ASRS-v1.1 (Kessler et al., 2005), as well as tests of sustained, divided, and selective attention, could allude to the individual's attentional control and their propensity to distraction. Investigating individual differences in attentional control and the effect of these on incubation and creativity has not been specifically studied, despite it being mentioned in the literature and discussions of previous research. This has left a gap in the research that this study will fill. Furthermore, if there are correlations between measures of attention

and successful incubation, a case could be made for the role of an attentional filter.

In direct reference to the arguments presented in the previous section, the current experiment had clear instructions (based on those from Torrance, 1990) for the use of creativity in the production of solutions, ensuring that the test measured what it should. As a verbal DT test requires multiple solutions to be produced, this was used as it is optimal for measuring improvement in ideas before and after the incubation period, it is a common measure of creativity, and the present researcher had experience in using it. A convergent thinking task would not be appropriate, as once the solution is found, the task is over, and there is no room for idea improvement.

With regard to the existing literature, the researcher's own past research, and the aims discussed, the research question was: are aspects of attentional control (mind-wandering, response inhibition, sustained, and divided attention) related to incubation success? If so, which aspects and how?

The hypotheses were:

H1. There will be a difference in creativity (fluency, flexibility, originality), between the different incubation conditions. Specifically, those in the undemanding task group will have the best scores post-incubation, in correspondence with the previous research discussed (Baird et al., 2012).

H2. Mind-wandering scores during the incubation periods will correlate positively with scores for fluency, flexibility, and originality.

H3. Incubation will be more successful, based upon better scores in fluency, flexibility, and originality of ideas, for those with lower attention (broad attention) scores.

The IV for this study was incubation type. The experiment therefore consisted of four conditions: 1) rest incubation - participants had an incubation period where they merely rested; 2) undemanding incubation - participants performed an undemanding task during incubation, 3) demanding incubation - participants performed a demanding task during incubation, and 4) control - no incubation.

Before the main study was carried out, a small pilot study was run in order to select cognitively undemanding and demanding tasks for the incubation period. This pilot study is described next.

5.3 Pilot Study: Identifying the Cognitive Demand of Potential Incubation Tasks

The main study on incubation required an undemanding task and a demanding task. Therefore, this pilot study was designed in order to determine the differences in perceived cognitive demand of the tasks used by Baird and others (2012), and a new additional task created by the researcher.

Baird and colleagues provided a brief description of their undemanding and demanding tasks, and the tasks used in the present study were based on this. The stimuli used in the undemanding and demanding tasks were digits from one to nine. In the undemanding task, the targets were coloured digits, and the response was the 'e' key if it was an even number, and the 'o' key if it was an odd number (zero-back task). In the demanding task, the targets were coloured question marks, and the required response was to press the 'e' key if the preceding digit had been an even number, and the 'o' key if it had been an odd number (one-back task).

It was observed that each task may be relatively difficult, as they both required fast reaction times and sustained attention. This led to uncertainty on the cognitive demand distinction between each task. An additional task was consequently created as a comparison, which was intended to be easier than both of the tasks used by Baird and colleagues (2012). This task required only a spacebar press in response to any coloured digit (target) as opposed to a black digit. Further details of these tasks are presented in the methods section below.

For the purpose of this study, the task created by the researcher is named the 'spacebar' task. The undemanding task as described by Baird and others (2012) will be referred to as the 'zero-back' task, and the demanding task will be called the 'one-back' task. The demand of each task increases respectively, and the hypotheses reflect this.

H1: The spacebar task will be rated easier and less demanding than the zero-back and the one-back tasks.

H2: The zero back task will be rated easier and less demanding than the one-back task, in accordance with Baird and colleagues (2012).

H3. The one-back task will be rated as more difficult and demanding than both of the other tasks.

8.4 Methods

8.4.1 Design

A repeated measures design was used as each participant completed all three tasks. The order of task completion was counterbalanced to minimise order and practice effects. The independent variable was task type: the spacebar response, zero-back, and one-back tasks.

The main DV was the demand/difficulty rating given by the participants to each task. Participants were also asked to rate all three tasks in order of cognitive demand. This was a secondary DV that was intended to support the findings from the first DV. Task performance was not considered as a dependent variable for this study, as the aim was only to measure participant's perception on task demand/difficulty.

8.4.2 Participants

Thirty-four participants, 15 male and 19 female, with an age range of 18 to 82 years ($M = 27.4$, $SD = 11.6$; only one over the age of 52), took part in this study. The participants were a collection of students from Edinburgh Napier University, as well as the researcher's colleagues, friends, and family members. Convenience sampling was utilised, and calls for participants were advertised through participant pool emails and posters. The testing session took place in an office at Edinburgh Napier University.

8.4.3 Materials

An information sheet and consent form were provided before the tasks began, and a debrief sheet was provided at the end of the session.

Each incubation task was created using software program E-Prime 2.0 and required a computer and keyboard. All three tasks contained the same non-target stimuli, which were black digits from one to nine, in 'Courier New' font style, size 18. The digits were displayed in a random order and were presented in the centre of a plain white computer screen for 1000ms each, followed by a fixation cross for 1500ms. Each task lasted for 4.5 minutes in total, with target stimuli presented in a random order on 20% of the trials, and non-target stimuli appearing for 80% of trials. It would be possible to record reaction time (in response to targets) and accuracy rates in terms of both omission and commission scores; however this function was not necessary at this stage.

The target stimuli for the spacebar task were red digits, which were presented at the same pace and with the same properties as the non-targets. Participants were instructed to press the spacebar on the keyboard as soon as possible when a target appeared, and not to respond to any black digits (see figure 19). This was designed to be a very easy task that did not require much cognitive effort by the participant other than sustaining attention and distinguishing the colour red from black (the number was irrelevant in this case). Indeed, it is well documented that humans are very efficient at recognising colour, especially identifying one colour in amongst numerous stimuli of another colour, as this is an automatic, pre-attentive process (Ansorge & Horstmann, 2007 (review); Eriksen, 1953) It was proposed that the ease of this task would be optimal for mind-wandering, which was the purpose of using an easy/undemanding task during part two of this study.

Trial Events	**4**		**2**		**7**		**5**		**1**
		+ (1500ms)		+ (1500ms)		+ (1500ms)		+ (1500ms)	
	nontarget (1000ms)		nontarget (1000ms)		target (1000ms)		nontarget (1000ms)		nontarget (1000ms)

Figure 19: Illustration of the spacebar task and the zero-back task.

For the zero-back task, the target stimuli were again red digits, appearing in the same manner as they did in the spacebar task (and also illustrated in figure 19). This time, the participants were required to determine whether the target was an even (by pressing the 'e' key) or odd (by pressing the 'o' key) number. The participants were again requested to respond as quickly as they could. Baird et al. (2012) called this their 'undemanding task' and determined that as it was undemanding, it would be easy for participants to allow their minds to wander. However, the quick decision-making nature of the task may not be undemanding, therefore limiting mind-wandering opportunities. Furthermore, Hines (1990) reported that identifying a number as odd takes more time than even numbers. This indicates that this is not an automatic task, as time and thought are required to make an accurate distinction.

The one-back task followed the example of Baird and colleagues' (2012) 'demanding task', which was designed to be cognitively challenging. The targets were red question marks (?), red digits or black question marks did not appear (see figure 20). When a target was presented, the participants were instructed to determine whether the previously displayed number was even or odd, using the same response keys as described for the zero-back task. This meant that the participant had to pay attention to every number displayed, in case the target followed it. *N*-back tasks are frequently used in the exploration of working memory, attention, and cognitive load, with RT increasing and capacity decreasing as *n* increases (Jaeggi, Buschkuehl, Perrig, & Meier, 2010; Kane, Conway, Miura, & Colflesh, 2007). As this task required continuous thinking and decision making, it was hypothesised that this task would not allow for mind-wandering (as in Baird et al*.,* 2012) and would be rated as difficult by the participants.

Trial Events	4		2		?		5		1
		+ (1500ms)		+ (1500ms)		+ (1500ms)		+ (1500ms)	
	nontarget (1000ms)		nontarget (1000ms)		target (1000ms)		nontarget (1000ms)		nontarget (1000ms)

Figure 20: Illustration of the one-back task.

Following each task, the participants were given a post-task questionnaire in order to measure how difficult they found the task to be, and if they thought mind-wandering would be possible during the completion of the tasks. There were three questions and each had five answer options as shown in figure 21.

1. How difficult would you rate the task that you have just completed?

Very Easy	Easy	Neither Easy or Difficult	Difficult	Very Difficult

2. How much of your concentration do you think was required in order to complete this task correctly?

No concentration was required	A little of my concentration was required	Some of my concentration was required	Most of my concentration was required	All of my concentration was required

3. It would be possible to complete this task whilst allowing my mind to wander/daydream:

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree

Figure 21: Post-Task Questionnaire

Each answer option was scored from one to five, from left to right, and these scores were summed to make a total score per task. A score of three would indicate that a task was very easy, no concentration was required to complete it, and it was possible to mind-wander during completion, and a score of 15 would indicate the opposite result for each question.

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After all of the three tasks and the corresponding post-task questionnaires had been completed, the final questionnaire was issued (see figure 22).

1. **Gender:**   **Male**   **Female**

2. **Age:**

3. **Please rate the tasks in order of cognitive demand, from the least demanding (1) to the most demanding (3):**

           Task A: Spacebar response for red numbers

           Task B: Even ('e') or Odd ('o') response for red numbers

           Task C: Question mark Even ('e') or Odd ('o') response for previous number

4. **Do you have any comments about the demand level of the computer tasks?**

5. **Do you have any further comments about the tasks in general?**

Figure 22: Final Questionnaire

Questions one and two were included to gain demographic information. Question three was important for this study as it explicitly asks participants to compare the cognitive demand for each task to the others. Used in combination with the results from each post-task questionnaire, it was possible to distinguish the easiest task and hardest task according to the opinions of the participants. Questions four and five were asked in order for any comments to be made that might benefit the research in the next stage.

8.4.4 Procedure

The participants were provided with an information sheet, and informed consent was sought prior to the commencement of the experiment. The testing session consisted of a one-to-one format, which allowed the participant to ask the researcher any questions that they may have had. Before each task began, on

screen instructions were presented that explained how the test would work, how long it would last, and how the participant should respond. The instructions stayed on the screen for as long as they were required, which ensured that participants had sufficient time to read and understand them. Each task was followed by a post-task questionnaire in order to determine task difficulty, and to encourage the participants to provide feedback on each task that could be taken forward. When all three tasks were completed, the participants were provided with the final questionnaire and a debrief sheet, and were thanked for their time.

8.5 Results

The results are based on the responses given by the 34 participants. The DVs were the participants' rating of demand/difficulty for the tasks, as determined by post-task questionnaires. Table 10 shows the descriptive statistics for each task.

Table 10: Mean, standard deviations, minimum, and maximum scores for each task as measured by the post-task questionnaires.

	Mean	SD	Min.	Max.
Spacebar task	5.97	1.49	3	9
Zero-back task	9.79	1.30	7	12
One-back task	10.26	1.71	6	13

A repeated measures ANOVA revealed that the differences between the scores were statistically significant: $F(1.64,53.97) = 152.740$, $p < .001$, $\eta^2_p = .822$: large effect size. To ascertain where exactly the differences were, Bonferroni pairwise comparisons were produced, as displayed in figure 23.
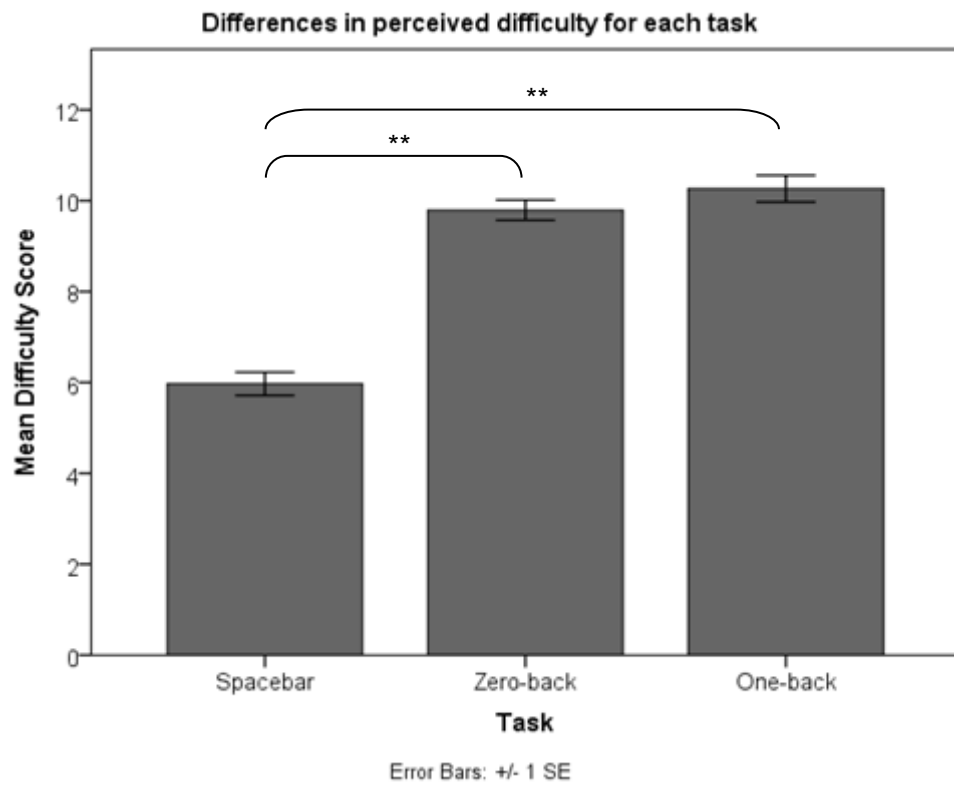
Figure 23: Significant differences in perceived task difficulty.
** indicates significance at 99% confidence level.

There were significant differences between the perceived difficulty scores of the first (spacebar and zero-back: $p < .001$) and second (spacebar and one-back: $p < .001$) comparisons. However, the difference in difficulty scores between the zero-back and the one-back tasks was not significant ($p = .072$).

In reference to the final questionnaire, participants were asked to rank the tasks in order of cognitive demand, with '1' being the least demanding, and '3' being the most demanding.

Table 11: Cognitive demand rankings by number of participants.

	Rank 1	Rank 2	Rank 3
Spacebar task	33	1	0
Zero-back task	1	27	6
One-back task	0	6	28

Rank 1 = least demanding, Rank 3 = most demanding.

Thirty-three participants indicated that they thought the spacebar task was the least demanding task, with one suggesting that this was the case for the zero-back task. Twenty-seven participants thought that the zero-back task came second, meaning they thought it was more demanding than the spacebar task, and six participants rated it as the most demanding task. The one-back task was rated the most demanding task by 28 participants.

A Friedman test determined that there was a statistically significant difference in the rankings of the three tasks: $\chi^2 (2) = 55.824$, $p < .001$. Post hoc analysis with Wilcoxon signed-ranks tests was conducted with a Bonferroni correction applied (Field, 2013), meaning the significance level was set at $p = .017$ (.05 divided by three, as three comparisons are made). The differences in rankings were found to be significant for each pair: the spacebar and zero-back tasks ($Z = -5.202$, $p < .001$), the spacebar and one-back tasks ($Z = -5.427$, $p < .001$), and the zero-back and one-back tasks ($Z = -3.781$, $p < .001$).

There were no relevant extra comments made by any participants.

8.6 Discussion

The results indicate that all of the hypotheses can be supported, as the spacebar task was perceived as significantly easier than the zero-back and one-back tasks, and the one-back task had the highest difficulty score. In support of these mean scores, the spacebar task was ranked as the easiest by all but one of the participants, and the one-back task was rated the most difficult by 82.4% of the participants.

The purpose of this short study was twofold. Firstly, the results would determine which two tasks, the easiest and the hardest, would be used in the larger incubation study. This first point could be answered easily. As the participants' opinions were that the spacebar task was the easiest, and the one-back task was the hardest, they were both carried forward and used as incubation tasks in the next study.

Secondly, the study was conducted to challenge the assumptions made by Baird and colleagues (2012) that their tasks differed in terms of cognitive demand, with

one being 'undemanding' (zero-back), and the other being 'demanding' (one-back). The results show that indeed, the participants found the tasks by Baird and others (2012) to both be relatively difficult, and both were considered cognitively demanding. The difference between the mean difficulty scores for these two tasks was not significant. The argument that the 'undemanding' task allowed for mind-wandering (Baird et al., 2012) is therefore called into question. This means that the differences that the authors reportedly found between the 'demanding' and 'undemanding' incubation conditions may be due to another factor or variable that was not measured or considered.

The results from the pilot study inform the main study. The spacebar and one-back tasks were taken forward and used as the 'undemanding' and 'demanding' tasks respectively.

8.7 The Role of Attentional Control in Incubation

Following the successful completion of the pilot study, the main incubation study was carried out in consideration of the aims, hypotheses, and justifications discussed in the literature review of this chapter.

8.8 Methods

8.8.1 Design

The study had a between-subjects design. The dependent variables were the fluency, flexibility, and originality scores of the ideas produced by the participants during an UUT-TC, according to the scoring guidelines provided by Torrance (1990). The independent variable was incubation type, which had four levels: 1. Rest, 2. Undemanding task, 3. Demanding task, and 4. No incubation. This allowed for the use of a between-subjects ANOVA in the statistical investigation. Correlational analyses and ANCOVAs were also performed to determine which measures of attention related to creative problem solving and incubation success.

8.8.2 Participants

There were 101 participants in this study, who were students at Edinburgh Napier University or members of the general public. Eleven participants did not provide their gender and age information. Of the other 90 participants, there were 19 males, 71 females, and the mean age of the sample was 27.4 years (min. = 18, max. = 82, *SD* = 11.08). The control group consisted of 26 participants, and each of the three other groups contained 25 participants.

The participants were recruited with the use of posters, internet advertising on social media and Gumtree, and opportunity sampling. The Psychology department participant pool was also used during recruitment, which involved emailing students who had previously indicated their interest in taking part in psychological research.

8.8.3 Materials

An information sheet (appendix 16.3) and consent form (appendix 17) were provided before the test session, and a debrief sheet (appendix19.3) was provided afterwards. Overall, there were ten tasks for participants to complete.

Questionnaires. Three questionnaires featured within the testing session as measures of self-report attentional control: the Adult ADHD Self-Report Scale (ASRS-v1.1: Kessler et al., 2005), the Mind-Wandering Questionnaire (MWQ: Mrazek et al., 2013), and the Daydreaming Frequency Scale (DDFS: Giambria, 1993), as described in section 4.3.1. The responses to the MWQ and DDFS were analysed for reliability[3]. The MWQ returned a Cronbach's alpha of .738, and the DDFS had a Cronbach's alpha score of .928. These scores indicate strong inter-item reliability.

Attention Measures. There were three further tests of attention. The CPT measured sustained attention by recording spacebar responses to a red square target amongst distractors over a 12-minute period. Using a measure of sustained attention should indicate how well individuals remain focused by extracting

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[3] The scoring of the ASRS does not allow for reliability analysis in this study, but this has been previously researched by others. See section 4.3.1 for details.

reaction times, and omission and commission rates. The Stroop task measured selective attention and response inhibition over congruent and incongruent word/colour trials. Measuring selective attention in an incubation study was suggested (but not carried out) by Baird and colleagues (2012) and should indicate the strength of an individual's response inhibition and attentional control. Those with strong attentional control and who can focus well should have quicker reaction times, and a smaller difference between congruent and incongruent conditions than those who have less control and are more distracted in nature. The dual-task measured divided attention by comparing single and dual task performance on number list repetition and maze tracking. Divided attention is one of the most difficult cognitive processes (Bennett et al., 1998), and measuring dual-tasking ability allows further inferences to be made about how well individuals can control and manage their attentional resources. Each of these measures are described in full in section 4.3.3.

Creativity Measure. To measure creative problem solving, the tin can version of the UUT (UUT-TC; section 4.3.2) was used. This was scored for fluency, flexibility, and originality according to the guidelines provided by Torrance (1990). A test of DT such as this has been found to be more suited to incubation than convergent thinking tasks as it allows for further responses to be added, and does not end with one correct answer (Baird et al., 2012; Dijksterhuis & Meurs, 2006; Snyder et al., 2004). This would cut short or prolong a testing session, depending on the participant's ability to solve the problem. The UUT-TC was carried out for five minutes in total. Snyder and colleagues (2004) found that five minutes was an optimal time for a UUT-TC, and that there was no benefit to having more time. Additionally, by keeping to a five-minute completion time, comparisons could be made to the results of the same task in the researcher's first study, which also lasted for five minutes, if required.

Immediately after their incubation period, participants in the experimental conditions (rest, undemanding, and demanding task groups) were provided with a post-incubation questionnaire (PIQ) to complete (see figure 24). Those in the rest condition were presented with questions one and two only, with the words 'completing this task' changed to 'resting'. The completion of the PIQ took approximately 30 seconds (15 seconds for post-rest questionnaire). In reference

to the results of the pilot study, the spacebar task was used as the undemanding incubation task, and the one-back task was the demanding task, each lasting 4 minutes and 30 seconds. The rest period lasted for 4 minutes and 45 seconds, meaning that each incubation period lasted for five minutes.

Think about the computer task you have just completed.
Please answer the following questions honestly. Indicate your response to each statement by ticking the one box that best describes your answer.

1. **Did you day-dream/mind-wander whilst you were completing the task?**

I don't know	No, not at all	Yes, but only a little	Yes, for about half of the time	Yes, throughout most of the task

2. **Did you try to think of more ideas for the Tin Can task whilst you were completing the task?**

I don't know	No, not at all	Yes, but only a little	Yes, for about half of the time	Yes, throughout most of the task

3. **How difficult would you rate the task that you have just completed?**

Very Easy	Easy	Neither Easy or Difficult	Difficult	Very Difficult

4. **How much of your concentration do you think was required in order to complete this task correctly?**

No concentration was required	A little of my concentration was required	Some of my concentration was required	Most of my concentration was required	All of my concentration was required

5. **It would be possible to complete this task whilst allowing my mind to wander/daydream:**

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree

Figure 24: Post-Incubation Questionnaire

These questions were asked in order to test the intermittent conscious work theory, and to look for relationships between the answers to the questions and idea originality. This questionnaire was presented after every completion of the undemanding/demanding tasks, even when they were not used in the incubation period (i.e., as part of the additional tasks, post-UUT-TC). This information was used to check if there were between-group differences in perceived task demand.

8.8.4 Procedure

Below (table 12) is a summary of the tasks the participants took part in, according to condition.

Table 12: Illustration of experimental procedure.

Group	Time				
	≈ 5mins	2.5mins	5mins	2.5mins	≈ 35mins
Rest	Questionnaires	UUT	Rest + PIQ	UUT	Undemanding task, demanding task, CPT, Stroop, dual-task.
Undemanding Task	Questionnaires	UUT	Spacebar Task + PIQ	UUT	Demanding task, CPT, Stroop, dual-task.
Demanding Task	Questionnaires	UUT	One-back Task + PIQ	UUT	Undemanding task, CPT, Stroop, dual-task.
	≈ 5mins	5mins	≈ 35mins		
Control	Questionnaires	UUT	Undemanding task, demanding task, CPT, Stroop, dual-task.		

Each testing session lasted around 50 minutes, and took place in a computer laboratory at Edinburgh Napier University. The participants read an information sheet and signed their informed consent to take part in the study. Each session across all four conditions began with the completion of the ASRS-v1.1, DDFS, and MWQ.

Instructions for the UUT-TC were given following the questionnaires and any questions the participants may have had about the task were answered.

After 2.5 minutes on the UUT-TC, those in the experimental groups all had a five minute incubation period, before they returned to the task again for a further 2.5 minutes. Incubation periods of three (Dijksterhuis & Meurs, 2006), four (Gilhooly et al., 2012), five (Gilhooly et al., 2013), and 12 (Baird et al., 2012) minutes have featured in the studies that influenced this one, and it appears that there is little general consensus on how long an incubation period should be (Sio & Ormerod, 2009). Responses pre-incubation were written on side one of the UUT-TC sheet, and responses post-incubation were written on side two: the instructions were displayed on both sides of the task sheet.

The participants were aware from the instructions that there would be a break before they returned to the original task again. It has been argued that allowing participants this knowledge of return increases ecological validity, as in normal problem solving situations, individuals would be aware that they had not completed the task yet. Furthermore, if this instruction is not given overtly, it may lead to individual differences in expectation, as some may believe the task is over and some may not (Gilhooly et al., 2013).

Those in the rest condition sat in silence, doing nothing, for the length of their 4.75-minute incubation period, followed by the PIQ (15 seconds). The undemanding, demanding, CPT, Stroop, and dual tasks were provided to those in the rest and control groups after the UUT-TC, in a semi-random order, to study performance on these measures by all participants involved. These participants were explicitly told that they would not be returning to the UUT-TC.

Individuals in the demanding and undemanding conditions followed the same pattern of events as those in the rest condition; however, the incubation periods were spent carrying out the undemanding task or the demanding task (4.5

minutes), followed by the PIQ (30 seconds), before returning to the UUT-TC. The task that was not used in their incubation period (i.e., the demanding task for the undemanding condition) was provided after the second phase of creative problem solving was complete, along with the Stroop task, the CPT, and the dual task, meaning that all of the participants completed every measure used. This allowed the researcher to ensure that performance on each task was consistent regardless of condition and to measure differences in attentional control across the sample. After the full completion of the UUT-TC, and before participants carried out any remaining attention measures, they were clearly informed that the creative problem solving task was finished and would not be returned to.

The control group had no incubation break, meaning participants continued work on the UUT-TC for five minutes. They were however, asked to turn the page after 2.5 minutes, and to continue the task on the opposite side.

The raw data were scored according to the details provided in section 4.3.

8.9 Results

The results of this study are relatively high on statistical power given the small sample size of each experimental group. Post-hoc power analysis produced values ranging from .85 to .99 for the tests involving fluency, ($M = .95$, $SD = .07$), .60 to .99 for flexibility ($M = .85$, $SD = .18$), .05 to .16 for originality ($M = .10$, $SD = .06$), and .39 to .94 for the percentage original ideas tests ($M = .73$, $SD = .26$). With the exception of originality where the power values are particularly low, these values meet, or a very close to, the recommendation of .8 from Field (2013). This means that the chances of finding true significant results given the effect size are high (e.g., Button et al., 2013). However, there is still variability in the power scores, and the results for the dependent variable of originality in particular should be treated with caution.

8.9.1 The Incubation Effect: Results

Hypothesis one was: there will be a difference in creativity (fluency, flexibility, originality), between the different incubation conditions. Specifically, those completing the undemanding task will have the best scores post-incubation.

The means and *SD*s of the creativity scores, by group, are shown in table 13.

Table 13: Mean scores with standard deviations for the creative problem solving task.

		Pre-incubation		Post-incubation	
		M	*SD*	*M*	*SD*
Fluency	Rest	9.64	2.87	6.84	2.44
	Undemanding	9.76	4.75	6.48	3.07
	Demanding	9.56	4.10	7.08	3.79
	Control	9.96	3.50	6.19	3.11
Flexibility	Rest	6.88	2.09	4.69	2.05
	Undemanding	6.92	2.86	5.36	1.89
	Demanding	7.40	3.03	5.04	2.32
	Control	6.81	2.45	5.44	2.02
Originality	Rest	3.60	2.50	3.48	2.02
	Undemanding	3.56	2.86	3.44	2.69
	Demanding	3.56	2.20	3.12	2.09
	Control	3.15	2.26	2.81	1.63
Percentage of Original Ideas	Rest	35.09	18.14	50.56	22.64
	Undemanding	32.56	18.61	50.41	29.33
	Demanding	36.88	14.68	45.23	18.55
	Control	31.95	17.33	47.27	23.27

In order to identify any effects of incubation, the experimental condition, and for any interactions, mixed ANOVAs were run, where the within-subjects variables were the pre- and post-incubation scores and the between subjects variable was the experimental group. There was one ANOVA per dependent variable (fluency, flexibility, originality, and percentage of original ideas). There were significant differences found pre- and post-incubation on total scores for fluency, flexibility, and percentage of original ideas, although not for originality alone.

From pre- to post-incubation, there were significant decreases in fluency scores ($F (1,97) = 125.732$, $p < .001$, $\eta^2_p = .565$: large effect size) and flexibility scores ($F (1,97) = 75.932$, $p < .001$, $\eta^2_p = .439$: large effect size). There was a significant increase in percentage of original ideas, as proportionally more ideas were original at post-incubation measurement: ($F (1,74) = 24.231$, $p < .001$, $\eta^2_p = .247$: large effect size). However, there were no significant differences in originality scores pre- and post-incubation ($F (1,97) = 1.567$, $p = .214$). Across all of these creativity variables, there were no significant main effects for experimental condition (all Fs $< .448$, $p > .05$), and there were no significant interactions between incubation scores and experimental condition (all Fs < 1.062, $p > .05$).

Additionally, across the experimental groups, of the ideas produced post-incubation, 62.3% ($SD = 21.76\%$) belonged to additional, new flexibility categories not used pre-incubation.

As reported, there were no pre- and post-incubation between-group differences in fluency, flexibility, originality, or in added flexibility scores or the percentage of original ideas. There were also no differences in UUT-TC performance between the control group and the experimental group as a whole.

8.9.2 Mind-Wandering During Incubation and the Effect on Creativity: Results
The second hypothesis was: levels of mind-wandering during the incubation periods will correlate with better scores for fluency, flexibility, and originality.

Participants in the experimental groups were explicitly asked if they allowed their minds to wander during their incubation period, 67 (89.33%) stated that they did, and six (8%) did not (the remaining 2 (3.67%) were unsure). The maximum score possible was three, the means are shown in table 14.

Table 14: Table of means for mind-wandering rates during incubation.

Group	Mean	SD
Rest	2.20	0.91
Undemanding	1.64	0.76
Demanding	1.00	0.58

Using a one-way ANOVA (mind-wandering during incubation score X condition), it was found that the amount of self-report mind-wandering was significantly different between-groups (F (2,72) = 15.540, $p <$ .001, η^2_p = .302: large effect size), with the rest group allowing their minds to wander the most, and the demanding task group the least. Bonferroni pairwise comparisons indicated that there were significant differences between each condition, as shown in figure 25.
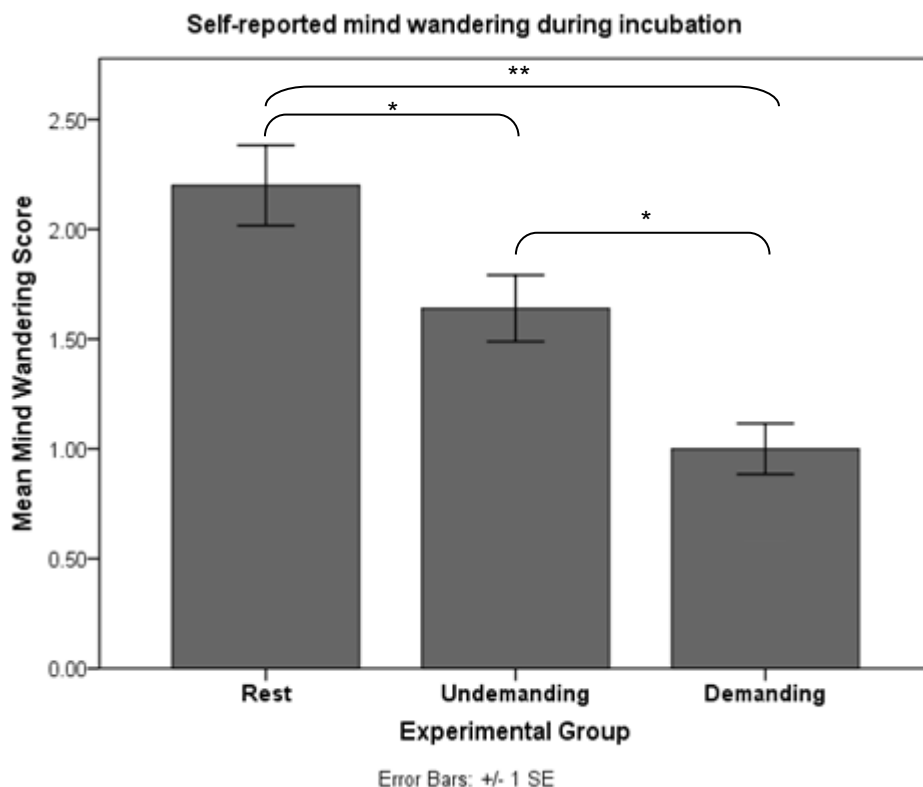
Figure 25: Pairwise comparisons of within incubation mind-wandering.
* indicates significance at 95% confidence level. ** indicates significance at 99% confidence level.

Pearson correlational analyses indicated that self-reported mind-wandering during incubation was related to an increase in new categories of ideas post-incubation (i.e., additional flexibility categories that did not appear pre-incubation): $r =$ .250, $p =$ .030, but was unrelated to the other measures of creative problem-solving.

Participants were also asked if they consciously attempted to generate further solutions to the UUT-TC during their incubation period, with 46 (61%) stating that they did consider the UUT-TC, and 29 (39%) saying they did not. Once again, the maximum score was three, and the means are shown below in table 15.

Table 15: Table of means for UUT-TC consideration rates during incubation.

Group	Mean	SD
Rest	2.16	0.94
Undemanding	1.32	1.22
Demanding	0.36	0.64

Between-group differences, determined by one-way ANOVA ('task consideration' X condition), were also found for this measure ($F_{(2,72)} = 21.937$, $p < .001$, $\eta^2_p = .379$: large effect size). The pairwise comparisons are illustrated in figure 26, and show that there were significant differences between each comparison, with the rest group thinking of the UUT-TC the most, and the demanding group the least.
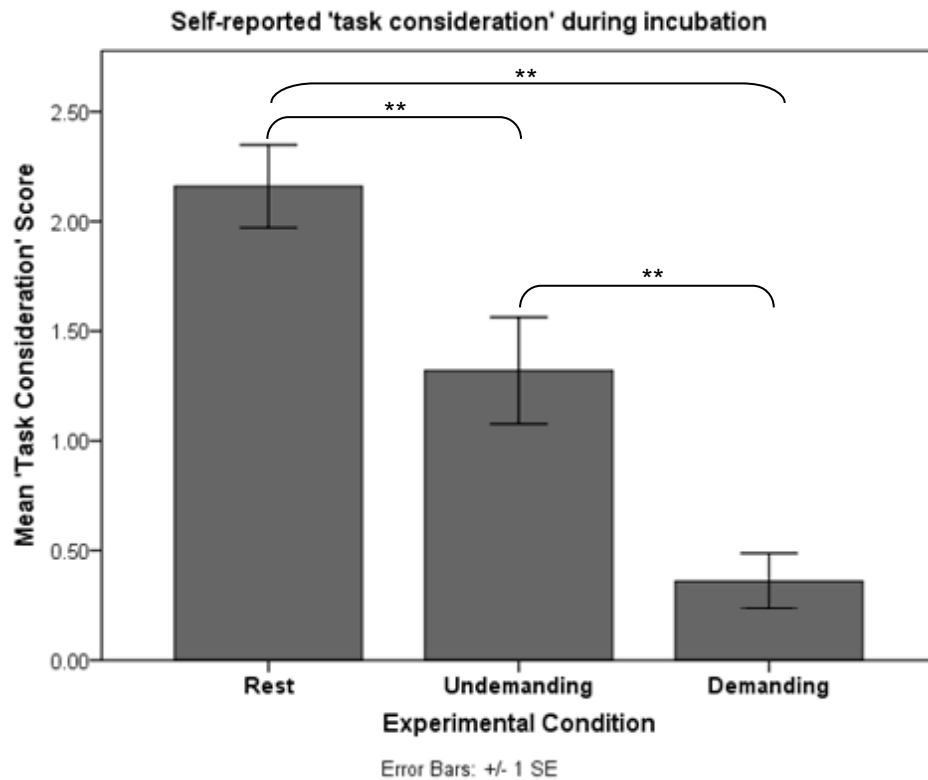
Figure 26: Pairwise comparisons of within incubation UUT-TC consideration scores.
** indicates significance at 99% confidence level.

This continued task deliberation was also significantly related to the number of added flexibility categories post-incubation ($r = .261$, $p = .024$), but was unrelated to fluency and originality ($p > .05$).

Self-reported mind-wandering (from the incubation task) and UUT-TC consideration during incubation were predictably related to each other ($r = .451$, $p < .001$), but they did not relate to any other measure of attention (i.e., self-report, selective, sustained, and divided attention; all $p > .05$).

As with the pilot study, a paired-sample t-test determined that the demanding task ($M = 6.23$, $SD = 2.37$) was rated as significantly more difficult than the undemanding task ($M = 4.19$, $SD = 1.41$): $t(100) = -9.643$, $p < .001$, $d = 1.046$: large effect size. There were no significant differences in performance on the incubation tasks (undemanding task $t(74) = -.520$, $p = .605$, demanding task: $t(74) = 1.933$, $p = .057$) between those completing the tasks during incubation and those not.

8.9.3 Incubation and Attention: Analysis of Covariance

For the following regressions and ANCOVA analysis, guidance from Field (2013) was used. When each of the attentional factors (i.e., scores on the ASRS-v1.1, DDFS, MWQ, CPT, Stroop test, Dual-task, mind-wandering during incubation, and tin-can consideration during incubation) were entered in to a multiple linear regression, it was found that altogether, they accounted for 8.3% of the variance in overall fluency (adjusted $R^2 = .083$, $F(8, 47) = 1.620$, $p = .145$, $beta = -.244$ to .277), 1.7% of the variance in overall flexibility (adjusted $R^2 = .017$, $F(8, 47) = 1.117$, $p = .370$, $beta = -.176$ to .224), and 2.8% of the variance in overall originality (adjusted $R^2 = .028$, $F(8, 47) = 1.200$, $p = .320$, $beta = -.146$ to .206). As each produced a non-significant result, the attention measures collectively do not predict creativity scores.

In order to investigate the effect that attention measures play in explaining incubation effects, factorial Analysis of Covariance (ANCOVA) was carried out to test if any of the attention measures could predict creativity when they were controlled for.[4] A significant ANCOVA would suggest that there could be an effect

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[4] ANCOVAs were not carried out in the study investigating the relationship between creativity and attention (chapter six), as to control for attention would remove the benefit of including an ADHD comparison group.

of the attention variable covariate on the creativity scores. For those that were significant, the contribution that the attention variable made to the creativity score is specified (R^2), as determined through the calculation of simple univariate linear regression (as recommended by Field, 2013).

The ANCOVA results are presented in table 16. The significant results are indicated by accompanying effect sizes and R^2 value.

In summary of the significant findings, performance on the ASRS-v1.1, the Stroop task, and the dual-task separately and significantly predicted fluency, flexibility, and originality scores overall. These were the only cases of attention scores predicting an originality score. UUT-TC consideration during the incubation period could also significantly predict fluency and flexibility scores overall, but not originality scores.

Each measure (with the exception of the CPT and dual-task) significantly predicted pre- and post-incubation scores for fluency and flexibility. The dual-task was found to predict pre- and post-incubation scores for fluency only. The CPT had no significant ANCOVA results.

Controlling for each aspect of attention did not lead to between-group differences in creativity, showing that there truly was no effect of the experimental condition. Furthermore, there were no significant interactions between pre- and post-incubation scores and condition, when the attention variables were controlled for.

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Table 16: ANCOVA results using attention measures as covariates.

Covariate	DT Aspect	ANCOVA Test of Effects	F	df	p	η^2_p	Effect Size	R^2
Adult ADHD Self-Report Scale - v1.1	Fluency	ASRS	5.010	1, 96	.028	0.050	small/medium	.022
		Pre/Post Incubation	38.039	1, 96	.001	0.284	large	Pre: .014, Post: .054
		Condition	0.016	3, 96	.997			
		Interaction	1.052	3, 96	.373			
	Flexibility	ASRS	4.984	1, 96	.028	0.049	small/medium	.031
		Pre/Post Incubation	9.686	1, 96	.002	0.092	medium/large	Pre: .000, Post: .014
		Condition	0.354	3, 96	.786			
		Interaction	0.436	3, 96	.727			
	Originality	ASRS	7.563	1, 96	.007	0.073	medium	.036
		Pre/Post Incubation	3.881	1, 96	.052			
		Condition	0.283	3, 96	.838			
		Interaction	0.151	3, 96	.929			
Daydreaming Frequency Scale	Fluency	DDFS	0.616	1, 96	.435			
		Pre/Post Incubation	30.014	1, 96	.001	0.238	large	Pre: .074, Post: .032
		Condition	0.029	3, 96	.993			
		Interaction	0.899	3, 96	.444			
	Flexibility	DDFS	1.029	1, 96	.313			
		Pre/Post Incubation	8.855	1, 96	.004	0.084	medium/large	Pre: .005, Post: .019
		Condition	0.399	3, 96	.754			
		Interaction	0.303	3, 96	.823			
	Originality	DDFS	0.349	1, 96	.556			
		Pre/Post Incubation	1.328	1, 96	.252			
		Condition	0.106	3, 96	.956			
		Interaction	0.656	3, 96	.420			
Mind Wandering Questionnaire	Fluency	MWQ	0.244	1, 96	.623			
		Pre/Post Incubation	15.147	1, 96	.001	0.138	large	Pre: .000, Post: .018
		Condition	0.018	3, 96	.997			
		Interaction	0.794	3, 96	.500			
	Flexibility	MWQ	0.849	1, 96	.359			
		Pre/Post Incubation	4.351	1, 96	.040	0.044	small/medium	Pre: .006, Post: .015
		Condition	0.340	3, 96	.797			
		Interaction	0.257	3, 96	.856			
	Originality	MWQ	1.274	1, 96	.262			
		Pre/Post Incubation	3.312	1, 96	.072			
		Condition	0.301	3, 96	.824			
		Interaction	0.171	3, 96	.909			
Sustained Attention: Continuous Perfromance Task	Fluency	CPT	0.230	1, 96	.633			
		Pre/Post Incubation	0.006	1, 96	.939			
		Condition	0.168	3, 96	.918			
		Interaction	0.807	3, 96	.494			
	Flexibility	CPT	0.091	1, 96	.764			
		Pre/Post Incubation	0.772	1, 96	.382			
		Condition	0.298	3, 96	.827			
		Interaction	0.404	3, 96	.750			
	Originality	CPT	0.109	1, 96	.742			
		Pre/Post Incubation	0.006	1, 96	.941			
		Condition	0.774	3, 96	.512			
		Interaction	0.156	3, 96	.926			
Selective Attention: Stroop Task	Fluency	Stroop Task	4.129	1, 96	.045	0.043	small/medium	.020
		Pre/Post Incubation	126.988	1, 96	.001	0.580	large	Pre: .040, Post: .029
		Condition	0.158	3, 96	.924			
		Interaction	0.674	3, 96	.570			
	Flexibility	Stroop Task	4.003	1, 96	.048	0.042	small/medium	.060
		Pre/Post Incubation	74.171	1, 96	.001	0.446	large	Pre: .036, Post: .016
		Condition	0.590	3, 96	.623			
		Interaction	0.302	3, 96	.824			
	Originality	Stroop Task	7.062	1, 96	.001	0.736	large	.039
		Pre/Post Incubation	1.732	1, 96	.191			
		Condition	0.850	3, 96	.470			
		Interaction	0.140	3, 96	.936			

Covariate	DT Aspect	ANCOVA Test of Effects	F	df	p	η^2_p	Effect Size	R^2
Divided Attention: Dual-Task	Fluency	Dual-task	4.799	1, 96	.031	0.048	small/medium	.048
		Pre/Post Incubation	6.022	1, 96	.016	0.059	medium	Pre: .050 Post: .030
		Condition	0.032	3, 96	.992			
		Interaction	1.067	3, 96	.367			
	Flexibility	Dual-task	5.540	1, 96	.000	0.257	large	.053
		Pre/Post Incubation	0.587	1, 96	.445			
		Condition	0.470	3, 96	.704			
		Interaction	0.348	3, 96	.791			
	Originality	Dual-task	8.469	1, 96	.004	0.081	medium	.077
		Pre/Post Incubation	0.002	1, 96	.965			
		Condition	0.542	3, 96	.655			
		Interaction	0.159	3, 96	.924			
Mind Wandering during Incubation	Fluency	MW during Incubation	1.856	1, 71	.177			
		Pre/Post Incubation	16.554	1, 71	.001	0.189	large	Pre: .010, Post: .020
		Condition	0.361	2, 71	.699			
		Interaction	0.597	2, 71	.553			
	Flexibility	MW during Incubation	1.520	1, 71	.222			
		Pre/Post Incubation	13.629	1, 71	.001	0.161	large	Pre: .001, Post: .021
		Condition	0.750	2, 71	.476			
		Interaction	0.079	2, 71	.924			
	Originality	MW during Incubation	0.377	1, 71	.541			
		Pre/Post Incubation	0.449	1, 71	.505			
		Condition	0.007	2, 71	.993			
		Interaction	0.105	2, 71	.900			
Consideration of the Unusual Uses Task during Incubation	Fluency	UUT during Incubation	4.152	1, 71	.045	0.055	medium	.008
		Pre/Post Incubation	28.98	1, 71	.001	0.290	large	Pre: .022, Post: .034
		Condition	0.903	2, 71	.410			
		Interaction	0.543	2, 71	.584			
	Flexibility	UUT during Incubation	7.319	1, 71	.009	0.093	medium/large	.035
		Pre/Post Incubation	17.849	1, 71	.001	0.201	large	Pre: .023, Post: .053
		Condition	2.322	2, 71	.106			
		Interaction	0.286	2, 71	.752			
	Originality	UUT during Incubation	2.803	1, 71	.098			
		Pre/Post Incubation	0.314	1, 71	.577			
		Condition	0.302	2, 71	.740			
		Interaction	0.166	2, 71	.848			

8.10 Discussion

The aim of this study was to determine which aspects of attentional control (ADHD symptoms, daydreaming, mind-wandering, selective, sustained, and divided attention) were related to incubation success. Furthermore, the experimental manipulation was designed to improve incubation by using an undemanding interpolated task, and diminish it using a cognitively demanding task.

8.10.1 The Incubation Effect

The results indicate that the first hypothesis cannot be supported, as there were no significant differences in creative problem solving scores between any of the groups. In every group, mean scores on fluency, flexibility, and originality reduced

after incubation, or after the first 2.5 minutes in the case of the control group. This does not corroborate with previous research that has found an improvement in creativity post-incubation.

However, in contrast, one of the main findings is that of the ideas produced post-incubation, a significantly higher percentage of them were original compared to those listed in part one, highlighting a benefit of taking a break from the problem-solving task. This is not an improvement of pure originality, meaning there was not a quantitative increase in the number of original ideas, as fluency also decreased. So, there were fewer UUT-TC solutions, but a significantly higher proportion of them were original compared to those produced pre-incubation.

This could illustrate that the ability to think of original responses comes after the unoriginal ideas have been written down and cleared from processing, and/or after the task has become familiar. Firstly, the ideas that immediately come to mind when the task is set may fill the available cognitive capacity, meaning there is no processing space to allow the exploration of new ideas. The proposal that it is necessary to clear the immediate responses from processing in order to generate more unusual ideas corroborates with the relief of mindset theory (Posner, 1973 in Snyder et al., 2004), as well as with theories of limited capacity in both attention (see Broadbent, 1958; Chun et al., 2011; Lachter et al., 2004; Treisman, 1969) and working memory (Baddeley, 2000). Secondly, it is commonly reported that familiarisation of the problem must take place in order for solutions to be generated (Kristensen, 2004; Lubart, 2000-2001; Wallas, 1926), so the participants may be spending the first half of the task becoming accustomed to the task requirements.

With consideration of the participant group as a whole, there were significant differences in fluency and flexibility, with scores lowering in the second half of the UUT-TC task. As fluency decreases, there is an expectation that flexibility and originality will decrease too, as they can only increase with the number of ideas produced (i.e., fluency). As originality did not decrease significantly, more ideas post-incubation must have been original, which was found to be the case as presented.

As an undemanding incubation condition had previously been found to benefit problem solving (Baird et al*.,* 2012), it was expected that those in the undemanding group would show the greatest improvement, or smallest decrease, in creativity scores in this study. An explanation for the lack of a significant incubation effect in this case may be explained by the results related to hypothesis two.

8.10.2 Mind-Wandering During Incubation and the Effect on Creativity

The amount of mind-wandering during incubation reported by the participants differed significantly between the experimental groups. Those in the rest condition mind-wandered the most, followed by those in the undemanding group, and those in the demanding task the least. This supports the expectation that a cognitively easy task allows for more mind-wandering than a difficult task, and according to previous studies, should have led to successful incubation. Although mind-wandering was related to additional flexibility post-incubation, a similar effect was not found for fluency or originality.

Further, there were significant between-group differences in the amount of UUT-TC consideration during incubation reported by the participants, with the rest group carrying this out the most, and the demanding group the least.

What is noteworthy is that participants in each experimental group appear to have behaved differently during the incubation period in terms of self-reported mind-wandering and UUT-TC processing, but this had no effect on subsequent creative performance. This means that there was no benefit to mind-wandering, and that actively thinking of solutions may not lead to the production of more creative ones.

Across the experimental group, self-reported mind-wandering and UUT-TC consideration during incubation were related to each other, as well as each being correlated to a significant increase in the number of additional idea categories (flexibility) post-incubation, but there were no significant between-group differences in this. This could show support for the relief of mindset theory (Posner, 1973 in Snyder et al., 2004), as there has been an increase in the number of types of ideas explored, indicating that unhelpful mental sets could have been broken. Support is also provided for the intermittent conscious work

theory (Seifert et al., 1995), as time spent considering the task has led to an improvement in the variety and percentage of original ideas.

However, to revisit the description of incubation, periods of time spent away from a problem are thought to be beneficial to formulating the solution (Baird et al., 2012; Gilhooly et al., 2013; Wallas, 1926). In the present study, it was found that although participants reported that they allowed their minds to wander from the incubation task, they were not distracted by irrelevant thoughts, but instead were consciously considering additional uses for a tin can. This reveals that they were not engaged in an incubation period at all, but were still actively and consciously working on the problem solving task, which could account for the lack of an effect on creativity. Further reasons for the lack of incubation findings replicating previous work are discussed in section 8.10.4.

8.10.3 Incubation and Attention

By using ANCOVAs, it was possible to control each attentional measure, in order to test their impact on the creativity scores. In union with this, regression analysis enabled the calculation of the contribution of each significant attention covariate, to the variance in each creativity score. The attention measures as a whole (ADHD symptoms, daydreaming, and mind-wandering scores; sustained, selective, and divided attention performance; and mind-wandering and UUT consideration during the incubation period) explained 8.3% of the variance in fluency scores, 1.7% of the variance in flexibility scores, and 2.8% of the variance in originality scores (shown by a multiple regression). However, as there were eight attention measures considered in this analysis, it was necessary to break this down to determine the possible contribution of each attention measure to the three aspects of creativity measured: fluency, flexibility, and originality.

It was found that scores on the adult ADHD self-report scale (ASRS-v1.1), performance on the Stroop task measuring selective attention, and performance on the dual-task measuring divided attention could all significantly predict overall fluency, flexibility, and originality scores separately. The contribution of each attention measure to the creativity scores was fairly low, ranging from 2% to 7.7%. Although an interesting finding, these contribution percentages are weak.

Additionally, the consideration of solutions for the problem solving task during the incubation period (measured by self-report) was also found to significantly predict fluency scores (0.8%) and flexibility (3.5%) scores, but again the contributions are small. Every attention measure (except sustained and divided attention) was found to significantly predict fluency and flexibility scores pre- and post-incubation. It could be that all of these findings described here exist because similar EFs or cognitive processes are used in both attention and DT tasks (e.g., Zabelina et al., 2015), as was proposed in section 6.4.3. Fluency and flexibility could arguably require the use of working memory, organisation, and selective attention/response inhibition in order to score highly. On the other hand, originality may be less affected by EF processes.

Overall, the ANCOVAs did not reveal any effects of the incubation condition when the attention measures were controlled for, as all of the between-group tests were non-significant. This means that differences in attention performance cannot explain the lack of a significant effect of incubation and incubation type.

Controlling for the attention measures in this study highlighted the effect that attention could have on creativity as measured by verbal DT. The contribution percentages were all small when divided up in to single attention measures, and overall they only explained 1.7 to 8.3% of the variance in fluency, flexibility, and originality. Performance on the Stroop task measuring selective attention, and the dual-task measuring divided attention seemed to have the largest effects on the creativity scores. Future research could therefore investigate this further, by isolating each attention type, measuring it in numerous forms to test reliability, and using different types of creativity tasks. This would determine if these results are consistent, and further analysis could help to clarify the influence of selective and divided attention on creativity.

8.10.4 General Discussion

This study has shown that incubation can lead to an increase in the percentage of original ideas. Thinking broadly and beyond this study, an expansion of this idea could relate to many fields, such as brainstorming, and individual or group decision making. If individuals were aware that taking a break from a problem

could lead to a more creative solution, then this could be more widely implemented. Specifically, this could be of benefit in business or politics where solutions are produced and decisions are made every day, some more hastily than others. For example, if methods of saving money were being deliberated within a cabinet meeting, a discussion of possible solutions could take place (as required in the preparation stage of problem solving), followed by a break for the cabinet members to consolidate their ideas, and then to incubate the problem. If the meeting was recalled some time later, each member may have a more creative, useful, and appropriate proposed solution. A period of incubation in problem solving and decision making processes could limit phenomena such as groupthink, and could perhaps result in more successful, and less risky outcomes.

The results of this study do not demonstrate a significant benefit of a cognitively undemanding incubation period on creative problem solving, as was predicted. In contrast to Baird and colleagues (2012) who demonstrated that a cognitively undemanding task was beneficial for incubation, Segal (2004) has shown that a demanding task requiring full attention is more suitable. Contrary to both of these studies, this research has not shown a benefit of either task. Yet, those in the undemanding task group allowed their minds to wander and consciously thought of UUT-TC solutions significantly more than those in the demanding group. This did not lead to more creative solutions however, meaning that the importance of mind-wandering in incubation, as suggested by Baird and colleagues (2012), is not supported.

The incubation period did allow for the mind to wander, but participants used this time to think consciously of more solutions to the problem solving task. Technically, this demonstrates mind-wandering from the incubation task, but does not show that the participants' minds wandered away from the original problem solving task. Therefore, it is argued that the participants did not partake in incubation at all, at least not in the manner it was intended to occur. This may be because they were told that they would be returning to the task. Although this was thought to improve ecological validity and minimise individual differences in task expectations (e.g., Gilhooly et al., 2013), it may have had an adverse effect in this particular study.

Furthermore, this finding shows that although those completing the cognitively demanding task reported significantly less mind-wandering during the incubation period, the task was not so demanding that it inhibited mind-wandering altogether. This highlights a potential problem with previous studies that have not controlled for the lack of incubation during a supposed incubation period, as results could be false positives. To control this, the incubation period would either need to be so long that the participant naturally stops consciously thinking of solutions for the problem, or the interpolated task would have to be more cognitively demanding. Alternatively, Madjar and Shalley (2008) have found that setting a goal for the creativity and the interpolated task improves creative responses. It was proposed that this encouraged the participants to maintain full focus and concentration on the task in hand, thus they committed to the incubation activity as well as the creativity task. Goal-setting could be further researched in relation to focused and selective attention in future incubation studies.

As the hypotheses were not fully met, the applicability and support of theories discussed in the literature review is limited, but are summarised below.

The relief of fatigue theory (Posner, 1973 in Snyder et al., 2004; Wallas, 1926) for successful incubation had previously been dismissed, as a period of rest was thought to be less effective than the completion of a secondary task. In this study, resting was not significantly worse than either of the other incubation tasks, so this theory may have been too eagerly rejected by others.

Within the present study, the relief of mindset theory (Posner, 1973 in Snyder et al., 2004) has been related to an increase in the percentage of original ideas post-incubation, but it was also specifically tested. This was done by calculating the percentage of post-incubation ideas that belonged to new categories. Across the experimental groups, a mean of 62.3% (SD = 21.76%) of post-incubation ideas belonged to new categories. Although there were no between-group differences, this is still a moderate percentage, which supports the theory that an interruption from actively solving the problem can break down limited mindsets, or enhance the use of/engage further mindsets.

The intermittent conscious work theory states that short amounts of conscious problem solving continues during incubation (see Gilhooly et al., 2013; Seifert et al., 1995). Unfortunately, in this study, the conscious work carried out by the participants appeared to be prolonged rather than intermittent, given the high scores on reported mind-wandering and UUT-TC consideration. Still, as this was related to increases in the production of idea categories and a higher percentage of original ideas, there may be merit to this theory.

Finally, the non-conscious work theory cannot be supported by this study, as the participants did not disengage from the problem-solving task.

Olton and Johnson (1976) also failed to replicate the incubation results from previous research, and illustrated that they were not the first to do so, suggesting that at the time, no study with positive findings had been replicated. They proposed that such difficulties could be due to differences in ability amongst participants and time limitations on initial problem solving being too short, yet they controlled for these aspects. Alternatively, it was suggested that real life incubation as reported by scientists and inventors, occurs in those who are highly motivated, over long periods of time possibly lasting days or months, and in those with an in-depth knowledge of the field in which their problem belongs (Olton & Johnson, 1976). Subsequently, it is possible that experimental laboratory studies may not reflect the conditions required for the consistent measurement of truly and significantly effective incubation.

The limitations of this study and directions for the development of incubation research are presented below.

8.10.5 Limitations and Directions for Future Research
The main limitation of this study could be the time limit imposed on the incubation period. There is little consensus on how long an incubation period should be (Sio & Ormerod, 2009). This study followed examples of previous research by being five minutes in length, and support has been reported for reducing task time periods to benefit creativity (Madjar & Shalley, 2008). Madjar and Shalley (2008) stipulated that short periods of time on creativity tasks should be combined with a high attentional focus, something that may not have been apparent within the

participants. Furthermore, it is proposed here that this was not long enough for the task to move from conscious to non-conscious processing, as is required for incubation to be successful. This was evidenced as participants admitted using this period to think of extra solutions. This may be inhibited by telling them that the task was over before it was, but as previously discussed, this is not ecologically valid. Other methods of encouraging the participants to stop consciously thinking of solutions to the UUT-TC could be considered. For example, perhaps a distraction would be beneficial, such as a conversation or the viewing of a short film, rather than just a computer task. Alternatively, as previously mentioned, setting a goal for performance could also lead the participant to concentrate fully on the incubation task, in order to meet the goal.

Another potential timing issue that could explain the lack of incubation success in the core creativity scores could be due to the length of part one of the problem-solving task, and/or the timing of the incubation period. Breaking from the problem-solving task could be beneficial (as explained in the literature review) to the preparation and the working process of problem solving, or detrimental if the break comes at a time that is not optimal. For example, the break could lead to a lack of engagement with the problem-solving task, or to the forgetting of important details, meaning that a longer period of time is required on return to the task in order to re-engage with its requirements (Jett & George, 2003; Madjar & Shalley, 2008). It is possible that with longer task durations, and a longer incubation period, there may have been significant improvements in fluency, flexibility, and originality from pre- to post-incubation.

It has been suggested that the ideal timing for an incubation period would be at the discretion of the individual (Madjar & Shalley, 2008). Outwith experimental conditions, an incubation period only occurs when the problem-solver has completed the preparation stage, and when they choose to take a break from actively trying to find the solution. The incubation period could take place when the individual feels that they have run out of ideas, or if they need a break to rest their minds. Conversely, the incubation period need not take place if the individual is working productively and successfully on the problem (Madjar & Shalley, 2008), or if they are motivated to continue with the task. By enforcing an incubation period on participants in this study, the natural problem solving process could

have been interrupted, thus leading to the lack of results supporting the benefit of an incubation period (although this testing paradigm has been used successfully in studies finding a positive effect of incubation). Future studies could allow the participant the freedom to take their incubation break when they felt it was necessary, although this would be difficult to control experimentally. Furthermore, positive or negative priming could be used in a design such as this to ascertain if a 'belief' in the effects of incubation could in fact enhance it.

Ecological validity could be improved upon by using incubation tasks that involve real-life activities, such as exercise, driving, or chores. These suggestions contain a physical aspect that may produce different results compared to completing a computer task during incubation. Driving in particular is known to utilise procedural memory, meaning it is an automatic, non-conscious skill that maintains an aspect of conscious processing in the decisions that must be made when negotiating a roundabout, for example. It may be that tasks of this nature could be the optimal undemanding task that could facilitate mind-wandering, and therefore incubation. This would relate to the anecdotal evidence provided by Poincaré and Helmholtz for example, as they stipulated that illumination occurred when they were physically relaxing or walking.

In relation to these ideas of changing the modality of the incubation task, researchers have found that rapid eye movement (REM) sleep can be more effective than a period of rest and non-REM sleep for the production of remote associations (Cai, Mednick, Harrison, Kanady, & Mednick, 2009). It would be interesting to investigate the effect of REM sleep incubation on creative responses to a divergent thinking task such as a UUT.

The most recent incubation research, as reviewed, has focused on DT. However, there is a large quantity of studies that have explored incubation in relation to CT. Future studies should consider attentional control and incubation success in relation to convergent thinking and insight tasks, in order to include these other aspects of creativity, and cover all of the bases.

Future research could also investigate incubation success and mind-wandering behaviour comparing those with medicated and non-medicated ADHD. It would be valuable to know if medication enhances or inhibits mind-wandering, and if the

result was conducive to creative problem solving or not. This knowledge could be of benefit to those with the disorder, who could utilise it in consideration of their learning and working behaviour.

8.11 Conclusions

Some positive findings have become apparent. For example, in the second half of the UUT-TC, although the raw scores of fluency, flexibility, and originality decreased, a high percentage of these ideas were from new categories, and the concentration of original ideas was significantly higher. This shows that a break from writing down solutions could be beneficial, and when faced with a problem, the first solutions may not always be the most useful, appropriate, and novel.

This study of attentional control and the effect of incubation on creative problem solving has not produced the results expected with consideration of the literature. All but one of the attention measures predicted fluency and flexibility scores pre- and post-incubation. This is a broad finding though, and was thought to be down to the functional similarities in the EFs required to complete both an attention task and a DT task. The incubation paradigm was not replicated, as participants did not engage in incubation in the intended manner, and this is thought to be due to the timing of the incubation period, as discussed. Propositions have been made on how to improve on the study, and directions for future research have been offered.

Chapter 9 – General Discussion

9.1 Overview

E. B. White, Marie Curie, and Leonardo da Vinci, were three examples used here to illustrate that focused attention, and the ability to maintain concentration even in distracting environments, may be important for the production of creative ideas. Richard Wagner, Arthur Schopenhauer, Marcel Proust, Thomas Carlyle, and Franz Kafka, were all described as being unable to do just that, and complained that they were distracted by nature, with many using relatively extreme methods to soundproof their working environment in order limit distractions and to obtain any level of productivity. The empirical evidence presented in the literature supported this second example, with numerous findings indicating that both broad and narrow attention were beneficial for creativity. Details of a distinction between broad and narrow attentional sets or traits were published, along with corroborating evidence of the link between broad, unfocused attention, and higher creativity scores.

After reviewing the literature in the fields of creativity, attention, ADHD, and the links between these concepts, it was concluded that aspects of attention were integral to theories explaining the construct of creativity. Focus and concentration must at some point be diffused to allow original solutions to be formed, for creative associations to be constructed, or to allow the unoriginal and unhelpful mindset limitations to be forgotten. The evidence, however, was mainly based on the results of one creativity and one attention measure being used to illustrate the relationship between the two processes. Reducing the extent of both creativity and attention, by representing them with one measure each, undermines the complexity and multifaceted nature of each entity, and has arguably led to an overgeneralisation.

The research presented in this thesis was designed to determine whether or not a general relationship exists between creativity and attention, if those with ADHD are more creative and less attentive than those without, and if creativity could be improved. Evidence for each of these will be summarised in turn.

9.1 Is there a Relationship between Creativity and Attention?

The findings advocated that there is no link between creativity and attention, and is not as clear as previously theorised. When separately controlling for self-reported ADHD symptomology, selective attention, and divided attention scores, each was found to predict performance on a verbal DT task. These findings were very low on impact, but did show a connection between creativity and attention.

As those with ADHD have problems with their attention, it was thought that any correlations between the constructs of creativity and attention would be larger, however no such relationships was found (chapter 6). This indicates that perhaps the deficits observed in ADHD are not conducive to creativity after all.

Overall, it is therefore argued here that there is not a broad, inclusive relationship between creativity and attention.

9.2 Are those with ADHD More Creative and Less Attentive than those without?

While there was no statistical evidence of a relationship between scores on creativity and attention tasks, the ADHD groups consistently had higher mean scores (not always significantly) than the control groups on each measure and aspect of creativity, across the studies. This suggests that there could be something fundamentally different between the samples, but as attention was not related to creativity, it could be something else.

It may be a creative strategy that is different between the groups, in that those with ADHD may be more inclined to think outside of the perceived boundaries, or are more open-minded. It may also be that those with the disorder are less likely to heed rules and limitations, thus leading to more unusual and creative responses. Or, a creativity task may provide cognitive stimulation that engages their interest and allows them to perform at a greater potential, as would fit with the cognitive energetic model (Sergeant, 2005) of ADHD, and the optimal stimulation theory (Zentall & Zentall, 1983). Another possibility is that those with ADHD are typically less inhibited and more impulsive than those without. For example, numerous control group participants stated that they were not very creative and had 'mind-blocks' when carrying out the creativity tasks, whereas

this was less frequent within the ADHD group. Although this was not specifically measured, a general trait of caring less about what others may think of their responses could have been present in the ADHD group. This research cannot stipulate exactly what the difference between the groups is.

Another key finding was that compared to the control group, those with ADHD had significantly fewer on-target fixations during attention tasks (CPT and Stroop), which did not reflect in a drop in performance. Cognitive arousal from the visually stimulating environment was unlikely to have had an effect here. So again, this points to a potential difference in cognitive strategy and tactics for sufficiently allocating attention, as to complete the task successfully and to maintain cognitive stimulation. It could be argued that this is a form of multitasking: completing the task whilst moving the eyes to seek stimulation. This could be related to performance on the divided attention task (chapter six), where the ADHD group were as strong as the control group. This strategy could stem from differences in EF, rather than differences in attention specifically, in those with ADHD (as discussed in section 2.6). Those with ADHD are known to have EF differences compared to those without. Furthermore, creativity has been related to higher EFs and EF capacity (e.g., Benedek et al., 2012; Bott et al., 2014; Gilhooly, Fioratou, Anthony, & Wynn, 2007; Van Stockum & Decaro, 2014). It is therefore concluded here, that those with ADHD could have cognitive multitasking as a strength, as they repeatedly perform tasks whilst concurrently attempting to increase their levels of cognitive stimulation. Unfortunately it is not possible based on the results of this thesis to provide further detail of this assertion, but further research as described in previous chapters could help with this.

The self-report measures of attention consistently yielded significant differences between the control group and the ADHD group, with the latter having higher scores in distractibility, ADHD symptoms, daydreaming, and mind-wandering. These show that there is a core difference in how individuals within each group analyse their own attentional abilities. If these results are taken at face value, they reflect the daily problems that individuals have with maintaining their focus and concentration, and minimising daydreaming and mind-wandering. This can be tiresome and frustrating, and could lead to the work, life, and social difficulties reviewed in chapter two. What is worth considering though, is that the participants

with ADHD knew or strongly believed that they had the disorder, and only took part in this research because of that. This could have led to a participant bias in the scores on these self-report measures. Accordingly, deficits in attention as reported by the participants did not always corroborate with their performance on tasks measuring attention.

9.3 Can Creativity be Improved?

This thesis tested just two of the many methods that have been described that could potentially improve creativity: a visually stimulating environment and an incubation period. These methods were very different, and neither appeared to significantly increase creative performance.

The decision to carry out research comparing the effects of a plain laboratory environment and a colourful, visually busy office environment was made in order to improve ecological validity in the testing setting, and to further investigate previous findings that have found an environmental effect on creativity (as reported in section 7.2.4). Furthermore, an examination of the cognitive arousal and stimulation theories indicated that a stimulating environment could be beneficial to the concentration and productivity of those with ADHD (section 7.2).

One of the main findings was that both a control and an ADHD group had significantly higher elaboration scores for figural DT in a visually stimulating environment compared to the plain environment, meaning that more details were added to their designs. The ADHD group also produced significantly more drawings in this task in the stimulating environment. Whilst interesting, this was not found for the verbal DT, and was not found for figural DT originality, which is arguably the most important measurement of creativity. The findings may have been down to individual differences between the plain environment group and the stimulating environment group. As this was the only effect to be found, it is concluded that the office-like environment in particular does not improve creativity in either a control group or an ADHD group. The testing environment should be an important consideration for creativity researchers, as past studies have found an effect. Future research could manipulate the environment, and use other creativity tasks (such as the construction of a creative product) to test this further.

The other method for improving creativity that has been reported is the use of an incubation period. Both anecdotal and empirical evidence has pointed to a benefit of spending time away from actively attempting to produce solutions, and doing a different but easy task instead (section 8.2).

This research found that there was no positive effect of taking a break from the task to the aspects of fluency, flexibility, or originality. However, the key finding here was that a break from the task did lead to a higher proportion of original ideas on return to the task, meaning that more of the ideas produced were creative than before the incubation period. What was also found though, was that the participants reported that they consciously thought of more responses for the creative problem solving task when they should have been incubating from the task. This could explain the increase in the proportion of original ideas: the participants had time to think of more creative responses. Therefore, it was concluded that the incubation paradigm was not replicated here, and that other studies could perhaps consider whether incubation genuinely took/takes place in their studies too.

It could be that this contemplation time (what should have been an incubation period) was beneficial to the production of original ideas, or the elimination of non-original ideas, in the verbal DT task. This should be further investigated, with manipulations of 'thinking time' and 'writing time'. Furthermore, suggestions have been made for the application of 'real-life' incubation periods, as per the anecdotal evidence.

9.4 Limitations and Directions for Future Research

It can be established from the literature that replicating the deficits associated with ADHD in laboratory conditions is difficult, and results from experiments using those with ADHD as participants yield inconsistent and disparate results. This body of work is perhaps the most comprehensive investigation of attention and creativity in ADHD and control adults, yet the results are not supportive of the literature. It is proposed here that attention tasks used in experimental research, such as those used in the present study, may not 'induce' ADHD symptoms as they are goal-directed, achievable, and easy. It is for this reason that the suggestion for ecologically valid, 'real-life' measurements of attention have been

repeated throughout this thesis. It may therefore be worth replicating parts of this research whilst measuring attention paid to an individual's day to day work, rather than specific, laboratory based tasks, with a focus on selective attention. The symptoms of ADHD may be more apparent when an individual is completing a school or work assignment, as these tasks are less novel and longer in duration.

As well as the previous recommendations that have been made, future research should consider the finding that those with ADHD consistently have higher scores across creativity tasks, but should measure this with respect to executive function and dysfunction, rather than attention specifically. This would help to relate the results to the cognitive theories of ADHD, and may help to pinpoint the characteristic of ADHD that sets this group apart in creativity.

The OST (Zentall & Zentall, 1983) and MBAM (Söderlund et al., 2007) theories have been prominent in the literature in the explanation of the behaviour of those with ADHD, and the lack of supporting evidence here should not be a sign that these valuable theories are dismissed. Conversely, it is suggested that they should be studied further, and especially with the consideration of creativity, where there has been very little research. It is clear that the ADHD group tend to be more creative, but this pattern may not remain in settings where cognitive stimulation is very low or very high.

Within this thesis, the individuals with ADHD were not monitored for medication use. It was deemed to be outwith the researcher's expertise and justification to ask individuals to withhold their medication for the purposes of this study. As ADHD medication controls impulses, it may be the case the results would have been different, especially in the eye-tracking study, if medication had not been taken by the individuals. However, this is only conjecture, as conversations with some of the participants revealed that there was a mixture of people on medication and those not. Future studies should consider this as a covariate, and could study medication use alongside measures of both creativity and attention, to examine its effects.

In a similar issue, a distinction was not made between participants who had ADHD-inattentive type, ADHD-impulsive type, and ADHD-combined type. It has been suggested recently that it is the combination of inattention and impulsivity

that benefits creativity (Fugate et al., 2013), so future research should control for the distinction.

It is important to consider other factors that may influence the results in studies such as these. For example, personality was not directly measured within this thesis, and numerous studies highlight the influence that personality can have on creative performance (e.g., Baas, Roskes, Sligte, Nijstad, & De Dreu, 2013; Dul, Ceylan, & Jaspers, 2011; Eysenck, 1993). Furthermore, the ability to produce, and the quality of, internal representations and imagery are also thought to contribute to creative problem solving (Goldschmidt & Smolkov, 2006), and were not measured here. Much of the early work investigating creative thought focused on mental imagery, and was driven by anecdotal evidence, such as Kekule's dream that led to his discovery of the benzene molecules' structure (Rudofsky & Wotiz, 1988), and Einstein's imagery of travelling alongside a light wave (Malaga, 2000). In experiments, relationships have been found between mental imagery and the use of image cues and creative thinking (e.g., Bogart, Pasquier, & Barnes, 2013; Finke, 2014; Kozhevnikov, Kozhevnikov, Yu, & Blazhenkova, 2013). As creativity is a very complex construct, it would be unmanageable to measure and control for every possible influencing variable.

Lastly, there is likely to be a sample bias present within these studies. Each participant volunteered to take part in the research in their own time, and the study was advertised as involving creativity and attention. It is therefore probable that the participants had a particular interest in psychology research, creativity, and/or attention before taking part. For example, participants may have had prior knowledge of research methods, or they may have been particularly creative or attentive/inattentive. The recruitment posters did state that participants did not need to be creative or attentive, yet this is not a safe-guard against group characteristics such as these. It could be the case that the control group had a particular interest in creativity, which could have raised their scores on the tasks, thus closing the gap between their scores and that of the ADHD group. Furthermore, the ADHD group participants may have taken part due to their interest in the disorder, and not because of an interest in creativity. These factors could explain the limited significant between group differences in creative performance, and may have offset the chances of finding a relationship between the two constructs. The scores collected and results obtained may therefore only

be applicable to others with the same mind-set or interest as the present sample. This is another key limitation of this research, which affects generalisability, but this is common to all psychology studies that recruit volunteers as participants.

9.5 Conclusions

This thesis has presented four large studies that comprehensively and rigorously investigated the relationship between creativity and attention, the effect that variances in attention can have on creativity, the differences between those with and without ADHD, and methods to improve creativity. Creativity was measured by self-report self-efficacy and past creative achievement, verbal and figural divergent thinking, and collage production. To measure attention, self-report distractibility, ADHD symptoms, mind-wandering and daydreaming were recorded, as well as tasks measuring attentional control, and sustained, selective, and divided attention.

The five key findings were:

1. There was no relationship between the constructs of creativity and attention.
2. Those with ADHD had higher scores on all measures of creativity, significantly for the percentage of original ideas in verbal and figural divergent thinking, compared to those without, though these differences were not always significant.
3. The performance of those with ADHD on attention tasks was not compromised when the participants spent less time looking at the target compared to a control group.
4. A 'busy' visual environment does not improve creativity or attention.
5. A break from writing down responses for a UUT can lead to a higher proportion of original ideas being produced.

It has been made clear that there is not a demonstrable, overarching relationship between creativity and attention in the measures here used, and the participants tested. However, many directions for future research have been proposed, with an examination of cognitive strategies and executive function being held as the most important.

The examples of famous creative individuals highlighted throughout the chapters inspired this research as well as many other studies before it. However, and unfortunately, no grand conclusions can be drawn about their incredible talents and a link with their attentional problems. It is perhaps likely that if a historical analysis took place of a representative sample of notable creators, that attentional traits would be normally distributed.

Russell Barkley (e.g., 2011), one of the world's leading experts in ADHD, has frequently and repeatedly stated that ADHD is not a gift, and that there is no research evidencing a benefit to having the disorder. Whilst it is not the intention here to undermine the severe difficulties that those with ADHD face, and with the understanding that further research is required, it is concluded here that creativity and the production of original ideas could potentially be a small silver lining to the debilitating disorder.

References

Abikoff, H., Courtney, M. E., Szeibel, P. J., & Koplewicz, H. S. (1996). The effects of auditory stimulation on the arithmetic performance of children with ADHD and nondisabled children. *Journal of Learning Disabilities*, *29*(3), 238-246.

Abraham, A. & Windmann, S. (2007). Creative cognition: The diverse operations and the prospect of applying a cognitive neuroscience perspective. *Methods, 42*, 38-48.

Abraham, A., Windmann, S., Siefen, R., Daum, I., & Gunturkun, O. (2006). Creative thinking in adolescents with Attention-Deficit Hyperactivity Disorder (ADHD). *Child Neuropsychology, 12*, 111-123.

Adler, L. A., Spencer, T., Faraone, S. V., Kessler, R. C., Howes, M. J. Biederman, J. & Secnik, K. (2006). Validity of Pilot Adult ADHD Self-Report Scale (ASRS) to Rate Adult ADHD Symptoms. *Annals of Clinical Psychiatry, 18*(3), 145-148.

Advokat, C., Lane, S. M. & Luo, C. (2011). College students with and without ADHD: Comparison of self-report of medication usage, study habits, and academic achievement. *Journal of Attention Disorders, 15*(8), 656-666.

Advokat, C., Martino, L., Hill, B. D., & Gouvier, W. (2007). Continuous Performance Test (CPT) of college students with ADHD, psychiatric disorders, cognitive deficits, or no diagnosis. *Journal of Attention Disorders*, *10*(3), 253-256.

Allopenna, P. D., Magnuson, J. S., & Tanenhaus, M. K. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. *Journal of Memory and Language*, *38*(4), 419-439.

Amabile, T. M. (1982). Social psychology of creativity: A consensual assessment technique. *Journal of Personality and Social Psychology, 43*(5), 997-1013.

Amabile, T. M. (1983). *The social psychology of creativity*. New York: Springer-Verlag.

Amabile, T. M. (1985). Motivation and creativity: Effects of motivational orientation on creative writers. *Journal of Personality and Social Psychology, 48*(2), 393-399.

Amabile, T. M. (1996). Creativity in context. Colorado: Westview Press.

Amabile, T. (2012). *Componential Theory of Creativity*. Harvard Business School.

Amabile, T. M., Hennessey, B. A., & Grossman, B. S. (1986). Social influences on creativity: the effects of contracted-for reward. *Journal of Personality and Social Psychology*, *50*(1), 14.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Anderson, V., Northam, E., Hendy, J. & Wrennall, J. (2001). *Developmental Neuropsychology: A Clinical Approach*. London: Psychology Press.

Andreasen, N. C. (1987). Creativity and mental illness: Prevalence rates in writers and their first-degree relatives. *American Journal of Psychiatry*, *144*(10), 1288-1292.

Ansburg, P. I. & Hill, K. (2003). Creative and analytic thinkers differ in their use of attentional resources. *Personality and Individual Differences, 34,* 1141-1152.

Ansorge, U., & Horstmann, G. (2007). Preemptive control of attentional capture by colour: Evidence from trial-by-trial analyses and orderings of onsets of capture effects in reaction time distributions. *The Quarterly Journal of Experimental Psychology, 60*(7), 952-975.

Antrop, I., Roeyers, H., Oost, P. V., & Buysse, A. (2000). Stimulation seeking and hyperactivity in children with ADHD. *Journal of Child Psychology and Psychiatry, 41*(2), 225-231.

Armstrong, I. T., & Munoz, D. P. (2003a). Attentional blink in adults with attention-deficit hyperactivity disorder. *Experimental Brain Research, 152*(2), 243-250.

Armstrong, I. T., & Munoz, D. P. (2003b). Inhibitory control of eye movements during oculomotor countermanding in adults with attention-deficit hyperactivity disorder. *Experimental Brain Research, 152*(4), 444-452.

Armstrong, T. (2012). Neurodiversity in the Classroom: Strength-Based Strategies to Help Students with Special Needs Succeed in School and Life. *Association for Supervision and Curriculum Development.* Vancouver: ASCD Publications.

Asherson, P., Akehurst, R., Kooij, J. S., Huss, M., Beusterien, K., Sasané, R., ... & Hodgkins, P. (2012). Under Diagnosis of Adult ADHD Cultural Influences and Societal Burden. *Journal of Attention Disorders, 16*(5 suppl), 20S-38S.

Asplund, C. L., Todd, J. J., Snyder, A. P., & Marois, R. (2010). A central role for the lateral prefrontal cortex in goal-directed and stimulus-driven attention. *Nature Neuroscience, 13*(4), 507-512.

Baas, M., Roskes, M., Sligte, D., Nijstad, B. A., & De Dreu, C. K. (2013). Personality and creativity: the dual pathway to creativity model and a research agenda. *Social and Personality Psychology Compass, 7*(10), 732-748.

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Science, 4*(11), 417-423.

Baddeley, A. (2007). *Working Memory, Thought and Action.* Oxford: Oxford University Press.

Baer, J. (1996). Does artistic creativity decline during elementary school? *Psychological Reports, 78*, 927-930.

Baer, J. (2014). *Creativity and divergent thinking: A task-specific approach.* Hove: Psychology Press.

Baird, B., Smallwood, J., Mrazek, M. D., Kam, J. W. Y., Franklin, M. S. & Schooler, J. W. (2012). Inspired by distraction: Mind-wandering facilitates creative incubation. *Psychological Science, 23*(10), 1117-1122.

Bajaj, J. S., Hafeezullah, M., Franco, J., Varma, R. R., Hoffmann, R. G., Knox, J. F., ... & Saeian, K. (2008). Inhibitory control test for the diagnosis of minimal hepatic encephalopathy. *Gastroenterology, 135*(5), 1591-1600.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman.

Barkley, R. A. (1991). The ecological validity of laboratory and analogue assessment methods of ADHD symptoms. *Journal of Abnormal Child Psychology*, *19*(2), 149-178.

Barkley, R. A. (1997). Behavioural inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*(1), 65-94.

Barkley, R. A. (2011). In adhdlifeproject1, *ADHD is not a Gift* [video file]. Retrieved from https://www.youtube.com/watch?v=68W2fzN3ZiU

Barkley, R. A. (2008). Classroom accommodations for children with ADHD. *The ADHD Report,* 16(4), 7-10.

Barron, F. & Harrington, D. M. (1981). Creativity, intelligence, and personality. *Annual Review of Psychology, 32,* 439-476.

Batey, M. & Furnham, A. (2006). Creativity, intelligence, and personality: A critical review of the scattered literature. *Genetic, Social, and General Psychology Monographs, 132*(40), 355-429.

Beaman, C. P., Bridges, A. M., & Scott, S. K. (2007). From dichotic listening to the irrelevant sound effect: A behavioural and neuroimaging analysis of the processing of unattended speech. *Cortex*, *43*(1), 124-134.

Beghetto, R. A. (2006). Creative self efficacy: Correlates in middle and secondary students. *Creativity Research Journal, 18*(4), 447-457.

Ben-David, B. M., Tewari, A., Shakuf, V., & Van Lieshout, P. H. (2014). Stroop effects in Alzheimer's disease: Selective attention speed of processing, or color-naming? A meta-analysis. *Journal of Alzheimer's Disease*, *38*(4), 923-938.

Benedek, M., Franz, F., Heene, M., & Neubauer, A. C. (2012). Differential effects of cognitive inhibition and intelligence on creativity. *Personality and Individual Differences*, *53*(4), 480-485.

Bennett, T., Raymond, M., Malia, K., Bewick, K. & Linton, B. (1998). Rehabilitation of attention and concentration deficits following brain injury. *The Journal of Cognitive Rehabilitation,* 8-13.

Berlin, L., & Bohlin, G. (2002). Response inhibition, hyperactivity, and conduct problems among preschool children. *Journal of Clinical Child and Adolescent Psychology*, *31*(2), 242-251.

Blanchot, M. (1997). *Friendship*, trans. E. Rottenburg. California, USA: Stanford University Press.

Bogart, B. D., Pasquier, P., & Barnes, S. J. (2013, June). An integrative theory of visual mentation and spontaneous creativity. In *Proceedings of the 9th ACM Conference on Creativity & Cognition* (pp. 264-273). ACM.

Börger, N., van Der Meere, J., Ronner, A., Alberts, E., Geuze, R., & Bogte, H. (1999). Heart rate variability and sustained attention in ADHD children. *Journal of Abnormal Child Psychology, 27*(1), 25-33.

Bott, N., Quintin, E. M., Saggar, M., Kienitz, E., Royalty, A., Hong, D. W. C., ... & Reiss, A. L. (2014). Creativity training enhances goal-directed attention and information processing. *Thinking Skills and Creativity*, *13*, 120-128.

Bowden, E. M., & Jung-Beeman, M. (2003). Normative data for 144 compound remote associate problems. *Behavior Research Methods, Instruments, & Computers*, *35*(4), 634-639.

Broadbent, D. E. (1958). *Perception and communication*. New York: Oxford University Press.

Brodeur, D. A., & Pond, M. (2001). The development of selective attention in children with attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology*, *29*(3), 229-239.

Brown, J. (1958). Some tests of the decay theory of immediate memory. *Quarterly Journal of Experimental Psychology*, *10*(1), 12-21.

Brown, T. E. (2013). *A new understanding of ADHD in children and adults: Executive function impairments.* Hove, UK: Routledge.

Bunford, N., Brandt, N. E., Golden, C., Dykstra, J. B., Suhr, J. A., & Owens, J. S. (2014). Attention-deficit/hyperactivity disorder symptoms mediate the association between deficits in executive functioning and social impairment in children. *Journal of Abnormal Child Psychology*, *43*(1), 133-147.

Bush, G. (2010). Attention-deficit/hyperactivity disorder and attention networks. *Neuropsychopharmacology*, *35*(1), 278-300.

Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, *14*(5), 365-376.

Cai, D. J., Mednick, S. A., Harrison, E. M., Kanady, J. C., & Mednick, S. C. (2009). REM, not incubation, improves creativity by priming associative networks. *Proceedings of the National Academy of Sciences*, *106*(25), 10130-10134.

Care Quality Commission. (2015). The safer management of control drugs: Annual report 2014. Retrieved November 6, 2015, from http://www.cqc.org.uk/content/safer-management-controlled-drugs-2014

Carlson, C. L., Booth, J. E., Shin, M., & Canu, W. H. (2002). Parent-, teacher-, and self-rated motivational styles in ADHD subtypes. *Journal of Learning Disabilities*, *35*(2), 104-113.

Carson, S. H., Peterson, J. B. & Higgins, D. M. (2003). Decreased latent inhibition is associated with increased creative achievement in high-functioning individuals. *Journal of Personality and Social Psychology, 85*(3), 499-506.

Carson, S. H., Peterson, J. B. & Higgins, D. M. (2005). Reliability, validity and factor structure of the creative achievement questionnaire. *Creativity Research Journal, 17*(1), 37-50.

Castellanos, F. X., & Tannock, R. (2002). Neuroscience of attention-deficit/hyperactivity disorder: the search for endophenotypes. *Nature Reviews Neuroscience*, *3*(8), 617-628.

Castle, L., Aubert, R. E., Verbrugge, R. R., Khalid, M., & Epstein, R. S. (2007). Trends in medication treatment for ADHD. *Journal of Attention Disorders*, *10*(4), 335-342.

Cattell, R. B. (1971). Abilities: their structure, growth and action. Boston: Houghton Mifflin.

Centres for Disease Control and Prevention, USA Government. (2013). *Attention-Deficit/Hyperactivity Disorder (ADHD): Data and Statistics.* Available at http://www.cdc.gov/ncbddd/adhd/data.html, retrieved March 25th, 2014.

Ceylan, C., Dul, J., & Aytac, S. (2008). Can the office environment stimulate a manager's creativity?. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *18*(6), 589-602.

Cherry, E. C. (1953). Some experiments on the recognition of speech with one and two ears. *Journal of the Acoustical Society of America, 25,* 975-979.

Choi, H. H., Van Merriënboer, J. J., & Paas, F. (2014). Effects of the physical environment on cognitive load and learning: towards a new model of cognitive load. *Educational Psychology Review*, 26(2), 225-244.

Christakou, A., Murphy, C. M., Chantiluke, K., Cubillo, A. I., Smith, A. B., Giampietro, V., ... & Rubia, K. (2013). Disorder-specific functional abnormalities during sustained attention in youth with attention deficit hyperactivity disorder (ADHD) and with autism. *Molecular Psychiatry*, 18(2), 236-244.

Chun, M. M., Golomb, J. D. & Turk-Browne, N. B. (2011). A taxonomy of external and internal attention. *The Annual Review of Psychology, 62*, 73-101.

Chun, M. M., & Potter, M. C. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental psychology: Human perception and performance*, 21(1), 109-127.

Claesdotter-Hybbinette, E., Safdarzadeh-Haghighi, M., Råstam, M., & Lindvall, M. (2015). Abnormal brainstem auditory response in young females with ADHD. *Psychiatry research*, 229(3), 750-754.

Clapham, M. M. (2001). The effects of affect manipulation and information exposure on divergent thinking. *Creativity Research Journal, 13*(3-4), 335-350.

Clark, J. M. (1996). Contributions of inhibitory mechanisms to unified theory in neuroscience and psychology. *Brain and cognition*, 30(1), 127-152.

Clarke, P. J., Hart, S., & MacLeod, C. (2014). Is selective attention in anxiety characterised by biased attentional engagement with or disengagement from threat: Evidence from a colour-naming paradigm. *Journal of Experimental Psychopathology*, 5(1), 38-51.

Cohen Kadosh, R., Gevers, W., & Notebaert, W. (2011). Sequential analysis of the numerical Stroop effect reveals response suppression. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 37(5), 1243.

Comrey, A. L., & Lee, H. B. (1992). *A first course in factor analysis*. Hillsdale, New Jersey: Erlbaum.

Cooley, E. L., & Morris, R. D. (1990). Attention in children: A neuropsychologically based model for assessment. *Developmental Neuropsychology, 6*(3), 239-274.

Corbetta, M. & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews: Neuroscience, 3,* 201-215.

Corkum, P. V., & Siegel, L. S. (1993). Is the continuous performance task a valuable research tool for use with children with Attention-Deficit-Hyperactivity Disorder? *Journal of Child Psychology and Psychiatry*, 34(7), 1217-1239.

Corteen, R. S. & Dunn, D. (1974). Shock-associated words in a nonattended message: A test for momentary awareness. *Journal of Experimental Psychology, 102,* 1143-1144.

Cramond, B. (1994a). *The relationship between Attention-Deficit Hyperactivity Disorder and creativity*. Paper presented at the meeting of the American Educational Research Association, New Orleans, Louisiana.

Cramond, B. (1994b). Attention-Deficit Hyperactivity Disorder and creativity – What is the connection? *The Journal of Creative Behaviour, 28*(3), 193-210.

Cramond, B. (1995). The coincidence of attention deficit hyperactivity disorder and creativity. *Attention Deficit Disorder Research-Based Decision Making Series 9508.*

Cruickshank, W. M., Bentzen, F. A., Ratzeburg, F. H., & Tannhauser, M. T. (1961). *A teaching method for brain injured and hyperactive children: A demonstration pilot study.* New York, USA: Syracuse University Press.

Csikszentmihalyi, M., & Sawyer, K. (1995). Creative insight: The social dimension of a solitary moment. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight.* Massachusetts: MIT Press.

Cutrell, E., & Guan, Z. (2007, April). What are you looking for?: an eye-tracking study of information usage in web search. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 407-416). ACM.

De Dreu, C. K., Nijstad, B. A., Baas, M., Wolsink, I., & Roskes, M. (2012). Working memory benefits creative insight, musical improvisation, and original ideation through maintained task-focused attention. *Personality and Social Psychology Bulletin*, *38*(5), 656-669.

de Souza Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review*, *22*(3), 148-153.

Dellas, M., & Gaier, E. L. (1970). Identification of creativity: The individual. *Psychological Bulletin*, *73*(1), 55.

Della Sala, S. D., Foley, J. A., Beschin, N., Allerhand, M. & Logie, R. H. (2010). Assessing dual-task performance using a paper-and-pencil test: Normative data. *Archives of Clinical Neuropsychology, 25*, 410-419.

Deutsch, J. A., & Deutsch, D. (1963). Attention: some theoretical considerations. *Psychological review*, *70*(1), 80.

Dewing, K. & Battye, G. (1971). Attention deployment and nonverbal fluency. *Journal of Personality and Social Psychology, 17*(2), 214-218.

De Wit, H. (2009). Impulsivity as a determinant and consequence of drug use: a review of underlying processes. *Addiction Biology*, *14*(1), 22-31.

Dige, N., Maahr, E., & Backenroth-Ohsako, G. (2010). Reduced Capacity in a Dichotic Memory Test for Adult Patients With ADHD. *Journal of Attention Disorders*, *13*(6), 677-683.

Di Lollo, V., Kawahara, J., Shahab Ghorashi, S. M. & Enns, J. T. (2005). The attentional blink: Resource depletion or temporary loss of control? *Psychological Research, 69*, 191-200.

Dijksterhuis, A. (2004). Think Different: the merits of unconscious thought in preference development and decision making. *Journal of Personality and Social Psychology, 87*(5), 586-598.

Dijksterhuis, A. & Meurs, T. (2006). Where creativity resides: The generative power of unconscious thought. *Consciousness and Cognition, 15,* 135-146.

Dobbs, S., Furnham, A., & McClelland, A. (2011). The effect of background music and noise on the cognitive test performance of introverts and extraverts. *Applied Cognitive Psychology*, *25*(2), 307-313.

Dopheide, J. A., & Pliszka, S. R. (2009). Attention-Deficit-Hyperactivity Disorder: An Update. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*, *29*(6), 656-679.

Dorfman, L., Martindale, C., Gassimova, V., & Vartanian, O. (2008). Creativity and speed of information processing: A double dissociation involving elementary versus inhibitory cognitive tasks. *Personality and Individual Differences, 44*(6), 1382-1390.

Dosaj, A., Overlin, J., & Turnage, C. (2015). A device for the objective assessment of ADHD using eye movements. *Capstone Design Expo: Posters.* Retrieved January 8th, 2016, available from: http://scholarscompass.vcu.edu/capstone/28/?utm_source=scholarscompass.vcu.edu%2Fcapstone%2F28&utm_medium=PDF&utm_campaign=PDFCoverPages

Douglas, M. (1995). Forgotten knowledge. In: Strathern, M. (ed.) *Shifting Contexts: Transformations in Anthropological Knowledge.* London: Routledge, pp 13-29.

Driver, J. (2001). A selective review of selective attention research from the past century. *British Journal of Psychology, 92,* 53-78.

Duchowski, A. (2007). *Eye tracking methodology: Theory and practice* (Vol. 373). Springer Science & Business Media.

Dudek, S. Z., Strobel, M. G., & Runco, M. A. (1993). Cumulative and proximal influences on the social environment and children's creative potential. *The Journal of Genetic Psychology, 154*(4), 487-499.

Dul, J., Ceylan, C., & Jaspers, F. (2011). Knowledge workers' creativity and the role of the physical work environment. *Human Resource Management, 50*(6), 715-734.

Duncan, J. (1980). The locus of interference in the perception of simultaneous stimuli. *Psychological review, 87*(3), 272.

DuPaul, G. J., & Eckert, T. (1998). Academic interventions for students with attention-deficit-hyperactivity disorder: A review of the literature. *Reading and Writing Quarter 14*(1),59-82.

Dux, P. E., & Marois, R. (2009). The attentional blink: A review of data and theory. *Attention, Perception, & Psychophysics, 71*(8), 1683-1700.

Dykes, M., & McGhie, A. (1976). A comparative study of attentional strategies of Schizophrenic and highly creative normal subjects. British Journal of Psychiatry, 128, 50–56.

Egeland, J., & Kovalik-Gran, I. (2010). Validity of the factor structure of Conners' CPT. *Journal of attention disorders, 13*(4), 347-357.

Egeland, J., Nordby Johansen, S. & Ueland, T. (2010). Do low-effort learning strategies mediate impaired memory in ADHD? *Journal of Learning Disabilities, 43*(5), 430-440.

Eindhoven, J. E., & Vinacke, W. E. (1952). Creative processes in painting. *Journal of General Psychology, 47,* 165–179.

Ellwood, S., Pallier, G., Snyder, A., & Gallate, J. (2009). The incubation effect: Hatching a solution?. *Creativity Research Journal, 21*(1), 6-14.

Epstein, J. N., Erkanli, A., Conners, C. K., Klaric, J., Costello, J. E., & Angold, A. (2003). Relations between continuous performance test performance measures and ADHD behaviours. *Journal of Abnormal Child Psychology, 31*(5), 543-554.

Eriksen, C. W. (1953). Object location in a complex perceptual field. *Journal of Experimental Psychology, 45*(2), 126.

Eysenck, H. J. (1976). *The Measurement of Personality.* Baltimore: University Park Press.

Eysenck, H. J. (1993). Creativity and personality: Suggestions for a theory. *Psychological Inquiry*, *4*(3), 147-178.

Eysenck, H. J. (1995). *Genius: The natural history of creativity*. New York: Cambridge University Press.

Eysenck, H. J., & Eysenck, M. W. (1985). *Personality and individual differences: A natural science approach.* New York: Plenum Press.

Faraone, S. V., Biederman, J., & Mick, E. (2006). The age-dependent decline of attention deficit hyperactivity disorder: A meta-analysis of follow-up studies. *Psychological Medicine, 36,* 159-165.

Faraone, S. V., Perlis, R. H., Doyle, A. E., Smoller, J. W., Goralnick, J. J., Holmgren, M. A., & Sklar, P. (2005). Molecular genetics of attention-deficit/hyperactivity disorder. *Biological Psychiatry*, *57*(11), 1313-1323.

Faraone, S. V., Sergeant, J., Gillberg, C., & Biederman, J. (2003). The worldwide prevalence of ADHD: is it an American condition? W*orld Psychiatry, 2*(2), 104.113.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175-191.

Feist, G. J. (1998). A meta-analysis of personality in scientific and artistic creativity. *Personality and Social Psychology Review*, *2*(4), 290-309.

Field, A. P. (2013). Discovering statistics using IBM SPSS Statistics (4th edition). London: Sage publications.

Filley, C. M. (2002). The neuroanatomy of attention. *Seminars in Speech and Language, 23*(2), 89-98.

Fink, A., Grabner, R. H., Benedek, M., Reishofer, G., Hauswirth, V., Fally, M., … & Neubauer, A. C. (2009). The creative brain: Investigation of brain activity during creative problem solving by means of EEG and fMRI. *Human Brain Mapping, 30*, 734-748.

Finke, R. A. (1996). Imagery, creativity, and emergent structure. *Consciousness and Cognition, 5*(3), 381-393.

Finke, R. A. (2014). *Creative imagery: Discoveries and inventions in visualization*. Psychology Press.

Finke, R. A., Ward, T. B. & Smith, S. M. (1992). *Creative cognition: Theory, research, and applications.* Massachusetts: MIT Press.

Fischer, R. & Hommel, B. (2012). Deep thinking increases task-set shielding and reduces shifting flexibility in dual-task performance. *Cognition, 123,* 303-307.

Fodor, E. M. (1999). Subclinical inclination toward manic-depression and creative performance on the Remote Associates Test. *Personality and Individual Differences*, *27*(6), 1273-1283.

Fox, M. D., Corbetta, M., Snyder, A. Z., Vincent, J. L., & Raichle, M. E. (2006). Spontaneous neuronal activity distinguishes human dorsal and ventral attention systems. *Proceedings of the National Academy of Sciences*, *103*(26), 10046-10051.

Freitag, C. M., Rohde, L. A., Lempp, T., & Romanos, M. (2010). Phenotypic and measurement influences on heritability estimates in childhood ADHD. *European Child & Adolescent Psychiatry*, *19*(3), 311-323.

Frey, J. N., Ruhnau, P., & Weisz, N. (2015). Not so different after all: The same oscillatory processes support different types of attention. *Brain Research*. Available online:

http://www.sciencedirect.com/science/article/pii/S0006899315001171, retrieved October 30, 2015.

Friedman, F., Raymond, B. A., & Feldhusen, J. F. (1978). The effects of environmental scanning on creativity. *Gifted Child Quarterly, 22*(2), 248-251.

Friedman, R. S., Fishbach, A., Forster, J. & Werth, L. (2003). Attentional priming effects on creativity. *Creativity Research Journal, 15*(2 & 3), 277-286.

Fugate, C. M., Zentall, S. S., & Gentry, M. (2013). Creativity and Working Memory in Gifted Students With and Without Characteristics of Attention Deficit Hyperactive Disorder Lifting the Mask. *Gifted Child Quarterly, 57*(4), 234-246.

Furnham, A., Zhang, J. & Chamorro-Premuzic, T. (2005-2006). The relationship between psychometric and self-estimated intelligence, creativity, personality and academic achievement. *Imagination, Cognition and Personality, 25*(2), 119-145.

Gamble, K. R., & Kellner, H. (1968). Creative functioning and cognitive regression. *Journal of Personality and Social Psychology, 9*(3), 266–271.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences.* New York: Basic.

Gardner, H. (1993). *Creating Minds.* New York: Basic.

Getzels, J. W. & Jackson, P. W. (1962). *Creativity and intelligence: Explorations with gifted students.* New York: Wiley.

Ghiselin, B. (Ed.). (1985). *The creative process: A symposium.* Berkeley: University of California Press. (Original work published 1952).

Giambra, L. M. (1993). The influence of aging on spontaneous shifts of attention from external stimuli to the contents of consciousness. *Experimental Gerontology, 28,* 485-492.

Giambra, L. M., & Quilter, R. E. (1989). Sex differences in sustained attention across the adult life span. *Journal of Applied Psychology, 74*(1), 91-95.

Giesbrecht, B. L., & Di Lollo, V. (1998). Beyond the attentional blink: Visual masking by object substitution. *Journal of Experimental Psychology: Human Perception & Performance, 24,* 1454-1466.

Giesbrecht, B., Woldorff, M. G., Song, A. W., & Mangun, G. R. (2003). Neural mechanisms of top-down control during spatial and feature attention. *Neuroimage, 19*(3), 496-512.

Gilhooly, K. J. (2002). *Thinking. Directed, Undirected, and Creative* (Third Ed.). London, UK: Academic Press.

Gilhooly, K. J., Fioratou, E., Anthony, S. H., & Wynn, V. (2007). Divergent thinking: Strategies and executive involvement in generating novel uses for familiar objects. *British Journal of Psychology, 98*(4), 611-625.

Gilhooly, K. J., Georgiou, G. & Devery, U. (2013). Incubation and creativity: Do something different. *Thinking and Reasoning, 19*(2), 137-149.

Gilhooly, K. J., Georgiou, G. J., Garrison, J. Reston, J. D. & Sirota, M. (2012). Don't wait to incubate: Immediate versus delayed incubation in divergent thinking. *Memory & Cognition, 40,* 966-975.

Gizer, I. R., Ficks, C., & Waldman, I. D. (2009). Candidate gene studies of ADHD: a meta-analytic review. *Human Genetics, 126*(1), 51-90.

Goldberg, J. H., Stimson, M. J., Lewenstein, M., Scott, N., & Wichansky, A. M. (2002, March). Eye tracking in web search tasks: design implications. In

Proceedings of the 2002 Symposium on Eye Tracking Research & Applications (pp. 51-58). ACM.

Golden, C. J. (1975). The measurement of creativity by the Stroop color and word test. *Journal of Personality Assessment, 39*(5), 502–506.

Goldschmidt, G., & Smolkov, M. (2006). Variances in the impact of visual stimuli on design problem solving performance. *Design Studies*, *27*(5), 549-569.

Gomez, R. & Condon, M. (1999). Central auditory processing ability in children with ADHD with and without learning disabilities. *Journal of Learning Difficulties*, *32*(2), 150-158.

Gould, T. D., Bastain, T. M., Israel, M. E., Hommer, D. W., & Castellanos, F. X. (2001). Altered performance on an ocular fixation task in attention-deficit/hyperactivity disorder. *Biological psychiatry, 50*(8), 633-635.

Granka, L. A., Joachims, T., & Gay, G. (2004, July). Eye-tracking analysis of user behavior in WWW search. In *Proceedings of the 27th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval* (pp. 478-479). ACM.

Green, M. J. & Williams, L. M. (1999). Schizotypy and creativity as effects of reduced cognitive inhibition. *Personality and Individual Differences, 27*, 263–276.

Groman, S. M., James, A. S., & Jentsch, J. D. (2009). Poor response inhibition: at the nexus between substance abuse and attention deficit/hyperactivity disorder. *Neuroscience & Biobehavioral Reviews*, *33*(5), 690-698.

Gualtieri, C. T., & Johnson, L. G. (2008). Medications do not necessarily normalize cognition in ADHD patients. *Journal of attention disorders*, *11*(4), 459-469.

Guenther, A. (1995). What Educators and Parents Need To Know about ADHD, Creativity, and Gifted Students. *Practitioners' Guide A9814*.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5,* 444-454.

Guilford, J. P. (1956). The structure of intellect. *Psychological Bulletin, 53*(4), 267-293.

Guilford, J. P. (1967). *The nature of human intelligence.* New York: McGraw-Hill.

Guilford, J. P. (1987). Creativity Research: Past, Present and Future. In Isaksen, S. G. (Ed.), Frontiers of Creativity Research: Beyond the Basics (pp. 33-65). New York: Bearly Limited.

Guilford, J. P. & Christensen, P. R. (1973). The one-way relation between creative potential and IQ. *The Journal of Creative Behaviour, 7*(4), 247-252.

Guilford, J. P. & Hoepfner, R. (1966). Creative potential as related to measures of IQ and verbal comprehension. In Sternberg, R. J., & O'Hara, L. A. (1999). Creativity and intelligence. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 251-272). Cambridge, UK: Cambridge University Press.

Haenlein, M., & Caul, W. F. (1987). Attention deficit disorder with hyperactivity: a specific hypothesis of reward dysfunction. *Journal of the American Academy of Child & Adolescent Psychiatry*, *26*(3), 356-362.

Haensly, P. A. & Reynolds, C. R. (1989). Creativity and intelligence. In J. A. Glover, R. R. Ronning, & C. R. Reynolds (Eds.), *Handbook of Creativity* (pp.111-132). New York: Plenum.

Hahn, B., Ross, T. J., & Stein, E. A. (2006). Neuroanatomical dissociation between bottom–up and top–down processes of visuospatial selective attention. *Neuroimage, 32*(2), 842-853.

Halperin, J. M., Sharma, V., Greenblatt, E., & Schwartz, S. T. (1991). Assessment of the continuous performance test: reliability and validity in a nonreferred sample. *Psychological Assessment: A Journal of Consulting and Clinical Psychology, 3*(4), 603-608.

Halpern, D. F. (2013). *Sex Differences in Cognitive Abilities* (4th ed.). Hove: Psychology press.

Happé, F., Booth, R., Charlton, R., & Hughes, C. (2006). Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: examining profiles across domains and ages. *Brain and Cognition, 61*(1), 25-39.

Harper, G. W., & Ottinger, D. R. (1992). The performance of hyperactive and control preschoolers on a new computerized measure of visual vigilance: The Preschool Vigilance Task. *Journal of Child Psychology and Psychiatry, 33*(8), 1365-1372.

Harpin, V. A. (2005). The effect of ADHD on the life of an individual, their family, and community from preschool to adult life. *Archives of Disease in Childhood, 90*, i2-i7.

Hartmann, T. (1993). *Attention Deficit Disorder: A Different Perception.* California: Underwood-Miller.

Hasan, P. & Butcher, H. J. (1966). Creativity and intelligence: A partial replication with Scottish children of Getzels' and Jackson's study. *British Journal of Psychology, 57*(1-2), 129-235.

Hawthorne, G., Quintin, E. M., Saggar, M., Bott, N., Keinitz, E., Liu, N., ... & Reiss, A. L. (2014). Impact and sustainability of creative capacity building: the cognitive, behavioral, and neural correlates of increasing creative capacity. In *Design Thinking Research* (pp. 65-77). Springer International Publishing.

Healey, C. G., & Enns, J. T. (2012). Attention and visual memory in visualization and computer graphics. *IEEE Transactions on Visualization and Computer Graphics, 18*(7), 1170-1188.

Healey, D. (2014). Attention-deficit/hyperactivity disorder and creativity: ever the twain shall meet?. *Creativity and Mental Illness*, 236-249.

Healey, D. & Rucklidge, J.J. (2006). An investigation into the relationship among ADHD symptomatology, creativity, and neuropsychological functioning in children. *Child Neuropsychology, 12,* 421-483.

Helton, W. S., & Warm, J. S. (2008). Signal salience and the mindlessness theory of vigilance. *Acta Psychologica, 129*(1), 18-25.

Helton, W. S., Weil, L., Middlemiss, A., & Sawers, A. (2010). Global interference and spatial uncertainty in the Sustained Attention to Response Task (SART). *Consciousness and cognition, 19*(1), 77-85.

Henderson, J., & Ferreira, F. (2012). *The interface of language, vision, and action: Eye movements and the visual world*. Hove: Psychology Press.

Hennessey, B. A., & Amabile, T. M. (2010). Creativity. *The Annual Review of Psychology, 61*, 569-598.

Hermer-Vazquez, L., Spelke, E. S., & Katsnelson, A. S. (1999). Sources of flexibility in human cognition: Dual-task studies of space and language. *Cognitive Psychology, 39*(1), 3-36.

Hines, T. M. (1990). An odd effect: Lengthened reaction times for judgments about odd digits. *Memory & Cognition, 18*(1), 40-46.

Hocevar, D., & Bachelor, P. (1989). A taxonomy and critique of measurements used in the study of creativity. In *Handbook of Creativity* (pp. 53-75). USA: Springer US.

Hoffman, J. E., & Subramaniam, B. (1995). The role of visual attention in saccadic eye movements. *Perception & Psychophysics, 57*(6), 787-795.

Hollingsworth, D. E., McAuliffe, S. P., & Knowlton, B. J. (2001). Temporal allocation of visual attention in adult attention deficit hyperactivity disorder. *Journal of Cognitive Neuroscience, 13*(3), 298-305.

Houghton, S., Douglas, G., West, J., Whiting, K., Wall, M., Langsford, S., … & Carroll, A. (1999). Differential patterns of executive function in children with attention-deficit hyperactivity disorder according to gender and subtype. *Journal of Child Neurology, 14*(12), 801-805.

Howell, D. C. (2007). *Statistical Methods for Psychology* (6th edition). California: Thomson Wadsworth.

Huang-Pollock, C. L., Nigg, J. T., & Carr, T. H. (2005). Deficient attention is hard to find: applying the perceptual load model of selective attention to attention deficit hyperactivity disorder subtypes. *Journal of Child Psychology and Psychiatry, 46*(11), 1211-1218.

Hughson, N. I. & Hughson, R. T. (2004). *Psychology of Creativity.* Arizona: Amazing Books.

Iaria, G., Fox, C. J., Chen, J. K., Petrides, M., & Barton, J. J. (2008). Detection of unexpected events during spatial navigation in humans: Bottom-up attentional system and neural mechanisms. *European Journal of Neuroscience, 27*(4), 1017-1025.

Irwin, D. E. (1992). Visual Memory Within and Across Fixations. In K. Rayner (Ed.), *Eye movements and visual cognition: Scene perception and reading*. New York: Springer-Verlag.

Iseman, J. S. & Naglieri, J. A. (2011). A cognitive strategy instruction to improve math calculation for children with ADHD and LD: A randomized controlled study. *Journal of Learning Disabilities, 44*(2), 184-195.

Isen, A. M., Daubman, K. A., & Nowicki, G. P. (1987). Positive affect facilitates creative problem solving. *Journal of Personality and Social psychology, 52*(6), 1122-1131.

Jacob, R. J., & Karn, K. S. (2003). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. *Mind, 2*(3), 573-605.

Jacobsen, L. K., Hong, W. L., Hommer, D. W., Hamburger, S. D., Castellanos, F. X., Frazier, J. A., et al. (1996). Smooth pursuit eye movements in childhood-onset schizophrenia: Comparison with attention-deficit hyperactivity disorder and normal controls. *Biological Psychiatry, 40*(11), 1144-1154.

Jaeggi, S. M., Buschkuehl, M., Perrig, W. J., & Meier, B. (2010). The concurrent validity of the N-back task as a working memory measure. *Memory,18*(4), 394-412.

Jauk, E., Benedek, M., Dunst, B., & Neubauer, A. C. (2013). The relationship between intelligence and creativity: New support for the threshold hypothesis by means of empirical breakpoint detection. *Intelligence, 41*(4), 212-221.

Jaussi, K. S., Randel, A. E. & Dionne, S. D. (2007). I am, I think I can, and I do: The role of personal identity, self-efficacy, and cross-application of experiences in creativity at work. *Creativity Research Journal, 19*(2-3), 247-258.

Jensen, P. S., Arnold, L. E., Swanson, J. M., Vitiello, B., Abikoff, H. B., Greenhill, L. L., ... & Hur, K. (2007). 3-year follow-up of the NIMH MTA study. *Journal of the American Academy of Child & Adolescent Psychiatry, 46*(8), 989-1002

Jett, Q. R., & George, J. M. (2003). Work interrupted: A closer look at the role of interruptions in organizational life. *Academy of Management Review, 28*(3), 494-507.

Johnson, J. A., Strafella, A. P., & Zatorre, R. J. (2007). The role of the dorsolateral prefrontal cortex in bimodal divided attention: two transcranial magnetic stimulation studies. *Journal of Cognitive Neuroscience, 19*(6), 907-920.

Johnson, J. A., & Zatorre, R. J. (2006). Neural substrates for dividing and focusing attention between simultaneous auditory and visual events. *Neuroimage, 31*(4), 1673-1681.

Johnson, K. A., Robertson, I. H., Kelly, S. P., Silk, T. J., Barry, E., Dáibhis, A., ... & Bellgrove, M. A. (2007). Dissociation in performance of children with ADHD and high-functioning autism on a task of sustained attention. *Neuropsychologia, 45*(10), 2234-2245.

Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: a review of our current understanding. *Neuropsychology Review, 17*(3), 213-233.

Kahneman, D. (1973). *Attention and effort.* New Jersey: Prentice-Hall.

Kane, M. J., Conway, A. R., Miura, T. K., & Colflesh, G. J. (2007). Working memory, attention control, and the N-back task: a question of construct validity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(3), 615.

Kane, M. J. & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*(1), 47-70.

Karatekin, C. (2004). A test of the integrity of the components of Baddeley's model of working memory in attention-deficit/hyperactivity disorder (ADHD). *Journal of Child Psychology and Psychiatry, 45*(5), 912-926.

Karatekin, C. (2005). A comprehensive and developmental theory of ADHD is tantalizing, but premature. *Behavioural and Brain Sciences, 28*(3), 430-431.

Karatekin, C. (2007). Eye tracking studies of normative and atypical development. *Developmental Review, 27*(3), 283-348.

Kasof, J. (1997). Creativity and breadth of attention. *Creativity Research Journal, 10*(4), 303-315.

Kaufman, J. C., Plucker, J. A. & Baer, J. (2008). *Essentials of Creativity Assessment.* New Jersey: John Wiley & Sons, Inc.

Keating, D. P. (1978). A search for social intelligence. *Journal of Educational Psychology, 70*(2), 218.

Keppel, G., & Underwood, B. J. (1962). Proactive inhibition in short-term retention of single items. *Journal of Verbal Learning and Verbal Behavior, 1*(3), 153-161.

Kessler, R. C., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E., … & Walters, E. E. (2005). The World Health Organisation Adult ADHD Self-Report Scale (ASRS): a short screening scale for use in the general population. *Psychological Medicine, 35*(2), 245-256.

Kessler, R. C., Adler, L., Gruber, M. J., Sarawate, C. A., Spencer, T. & Van Brunt, D. L. (2007). Validity of the World Health Organization Adult ADHD Self-Report Scale (ASRS) Screener in a representative sample of health plan members. *International Journal of Methods in Psychiatric Research, 16*(2), 52-65.

Kharkhurin, A. V. (2011). The role of selective attention in bilingual creativity. *Creativity Research Journal, 23*(3), 239-254.

Killingsworth, M. A. & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science, 330*, 932.

Kim, K. H. (2005). Can only intelligent people be creative? A meta-analysis. *Prufrock Journal, 16*(2-3), 57-66.

Kim, K. H. (2006). Can we trust creativity tests? A review of the Torrance tests of creative thinking (TTCT). *Creativity Research Journal, 18*(1), 3-14.

Knez, I. (1995). Effects of indoor lighting on mood and cognition. *Journal of Environmental Psychology, 15*(1), 39-51.

Kozhevnikov, M., Kozhevnikov, M., Yu, C. J., & Blazhenkova, O. (2013). Creativity, visualization abilities, and visual cognitive style. *British Journal of Educational Psychology, 83*(2), 196-209.

Kristensen, T. (2004). The physical context of creativity. *Creativity and Innovation Management, 13*(2), 89-96.

Kuhn, J-T. & Holling, H. (2009). Exploring the nature of divergent thinking: A multilevel analysis. *Thinking Skills and Creativity, 4*, 116-123.

Kwiatkowski, J., Vartanian, O., & Martindale, C. (1999). Creativity and speed of mental processing. *Empirical Studies of the Arts, 17*(2), 187-196.

Lachter, J., Forster, K. I., & Ruthruff, E. (2004). Forty-five years after Broadbent (1958): Still no identification without attention. *Psychological Review, 111*(4), 880-913.

Land, M., Mennie, N., & Rusted, J. (1999). The roles of vision and eye movements in the control of activities of daily living. *Perception, 28*(11), 1311-1328.

Lansbergen, M. M., Kenemans, J. L., & van Engeland, H. (2007). Stroop interference and attention-deficit/hyperactivity disorder: a review and meta-analysis. *Neuropsychology, 21*(2), 251.

Lee, C. S., Huggins, A. C., & Therriault, D. J. (2014). A measure of creativity or intelligence? Examining internal and external structure validity evidence of the Remote Associates Test. *Psychology of Aesthetics, Creativity, and the Arts, 8*(4), 446-460.

Lee, K. M., & Olenchak, F. R. (2014). Individuals with a gifted/attention deficit/hyperactivity disorder diagnosis Identification, performance, outcomes, and interventions. *Gifted Education International*, 1-15.

Leigh, R. J., & Zee, D. S. (2015). *The Neurology of Eye Movements*. Oxford: Oxford University Press.

Levy, F., Hay, D. A., McStephen, M., Wood, C., & Waldman, I. (1997). Attention-deficit hyperactivity disorder: a category or a continuum? Genetic analysis of a large-scale twin study. *Journal of the American Academy of Child & Adolescent Psychiatry, 36*(6), 737-744.

Lezak, M. D. (1983). *Neuropsychological Assessment* (2nd ed.). New York: Oxford University Press.

Li, C. S. R., Chen, S. H., Lin, W. H., & Yang, Y. Y. (2005). Attentional blink in adolescents with varying levels of impulsivity. *Journal of Psychiatric Research*, *39*(2), 197-205.

Liu, L., Cheng, J., Su, Y., Ji, N., Gao, Q., Li, H., ... & Wang, Y. (2015). Deficiency of Sustained Attention in ADHD and Its Potential Genetic Contributor MAOA. *Journal of Attention Disorders*, 1-8.

Loose, R., Kaufmann, C., Auer, D. P., & Lange, K. W. (2003). Human prefrontal and sensory cortical activity during divided attention tasks. *Human Brain Mapping*, *18*(4), 249-259.

López, V., Pavez, F., López-Calderón, J., Ortega, R., Sáez, N., Carrasco, X., ... & Aboitiz, F. (2008). Electrophysiological evidences of inhibition deficit in Attention-Deficit/Hyperactivity Disorder during the attentional blink. *Open Behavioral Science Journal*, *2*, 23-31.

Lubart, T. I. (2000-2001). Models of the creative process: Past, present and future. *Creativity Research Journal, 13*(3&4), 295-308.

MacLean, K. A., Ferrer, E., Aichele, S. R., Bridwell, D. A., Zanesco, A. P., Jacobs, T. L., ... & Saron, C. D. (2010). Intensive meditation training improves perceptual discrimination and sustained attention. *Psychological Science*, *21*(6), 829-839.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin*, *109*(2), 163-203.

Madjar, N., & Shalley, C. E. (2008). Multiple tasks' and multiple goals' effect on creativity: Forced incubation or just a distraction?. *Journal of Management*, *34*(4), 786-805.

Malaga, R. A. (2000). The effect of stimulus modes and associative distance in individual creativity support systems. *Decision Support Systems*, *29*(2), 125-141.

Marchetta, N. D., Hurks, P. P., De Sonneville, L. M., Krabbendam, L., & Jolles, J. (2007). Sustained and focused attention deficits in adult ADHD. *Journal of Attentional Disorders, 11*(6), 664–676.

Marco, R., Miranda, A., Schlotz, W., Melia, A., Mulligan, A., Müller, U., ... & Sonuga-Barke, E. J. (2009). Delay and reward choice in ADHD: an experimental test of the role of delay aversion. *Neuropsychology*, *23*(3), 367.

Marije Boonstra, A., Oosterlaan, J., Sergeant, J. A., & Buitelaar, J. K. (2005). Executive functioning in adult ADHD: a meta-analytic review. *Psychological Medicine*, *35*(08), 1097-1108.

Martens, Y. (2008, June). Unlocking creativity with the physical workspace. In *CIB W70 International conference in Facilities Management, Edinburgh, GB, June 16-June 18, 2008. CIB report 135, 579-588. Author's version*. Heriot Watt University.

Martindale, C. (1999). Biological bases of creativity. In R. J. Sternberg (Ed.), Handbook of creativity (pp. 137–152). Cambridge, UK: Cambridge University Press.

Martindale, C. & Hines, D. (1975). Creativity and cortical activation during creative, intellectual, and EEG feedback tasks. *Biological Psychology, 3*(2), 91-100.

Mason, D. J., Humphreys, G. W., & Kent, L. S. (2003). Exploring selective attention in ADHD: visual search through space and time. *Journal of Child Psychology and Psychiatry*, *44*(8), 1158-1176.

Mason, D. J., Humphreys, G. W., & Kent, L. (2005). Insights into the control of attentional set in ADHD using the attentional blink paradigm. *Journal of Child Psychology and Psychiatry*, *46*(12), 1345-1353.

Matsuo, Y., Watanabe, M., Taniike, M., Mohri, I., Kobashi, S., Tachibana, M., ... & Kitamura, Y. (2015). Gap Effect Abnormalities during a Visually Guided Pro-Saccade Task in Children with Attention Deficit Hyperactivity Disorder. *PloS one*, *10*(5), e0125573-e0125573.

McAvinue, L., Vangkilde, S. A., Johnson, K., Habekost, T., Kyllingsbæk, S., Robertson, I., & Bundesen, C. (2012). A Componential Analysis of Visual Attention in Children with ADHD. *Journal of Attention Disorders, 19*(10), 882-894.

McCoy, J. M., & Evans, G. W. (2002). The potential role of the physical environment in fostering creativity. *Creativity Research Journal*, *14*(3-4), 409-426.

McCutcheon, L. E., Ashe, D. D., Houran, J., & Maltby, J. (2003). A cognitive profile of individuals who tend to worship celebrities. *The Journal of Psychology*, *137*(4), 309-322.

McFarlin, D. B., & Blascovich, J. (1984). On the Remote Associates Test (RAT) as an alternative to illusory performance feedback: A methodological note. *Basic and Applied Social Psychology*, *5*(3), 223-229.

Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review, 69*(3), 220-232.

Mednick, S. A. & Mednick, M. T. (1967). *Examiner's manual: Remote Associates Test.* Boston: Houghton Mifflin.

Memmert, D. (2007). Can creativity be improved by an attention-broadening training program? An exploratory study focusing on team sports. *Creativity Research Journal*, *19*(2-3), 281-291.

Memmert, D. (2009). Noticing unexpected objects improves the creation of creative solutions – Inattentional blindness by children influences divergent thinking negatively. *Creativity Research Journal, 21*(2-3), 302-304.

Memmert, D. (2011). Creativity, expertise, and attention: Exploring their development and their relationships. *Journal of Sports Sciences, 29*(1), 93-102.

Mendelsohn, G. A. (1976). Associative and attentional processes in creative performance. *Journal of Personality, 44*, 341–369.

Mendelsohn, G. A. & Griswold, B. B. (1964). The differential use of incidental stimuli in problem solving as a function of creativity. *Journal of Abnormal Psychology, 68*(4), 431-436.

Merkt, J., Beck, L., Ernsthaus, J., Huschka, S., Kremer, S., Mikles, B., ... & Gawrilow, C. (2013, June). "Uninhibited Imaginations" - Relation of Impulsivity and Creativity in College Students. *Poster presented at the 4th World Congress on ADHD.* Milan, Italy.

Merritt, P., Hirshman, E., Wharton, W., Stangl, B., Devlin, J., & Lenz, A. (2007). Evidence for gender differences in visual selective attention. *Personality and Individual Differences*, *43*(3), 597-609.

Miyahara, M., Piek, J., & Barrett, N. (2006). Accuracy of drawing in a dual-task and resistance-to-distraction study: Motor or attention deficit?. *Human Movement Science, 25*(1), 100-109.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive psychology, 41*(1), 49-100.

Moffitt, T. E., Houts, R., Asherson, P., Belsky, D. W., Corcoran, D. L., Hammerle, M., ... & Poulton, R. (2015). Is Adult ADHD a Childhood-Onset Neurodevelopmental Disorder? Evidence from a Four-Decade Longitudinal Cohort Study. *American Journal of Psychiatry* (ajp in Advance).

Moisala, M., Salmela, V., Salo, E., Carlson, S., Vuontela, V., Salonen, O., & Alho, K. (2015). Brain activity during divided and selective attention to auditory and visual sentence comprehension tasks. *Frontiers in Human Neuroscience, 9*(86), 1-15.

Molina, B. S., Hinshaw, S. P., Swanson, J. M., Arnold, L. E., Vitiello, B., Jensen, P. S., ... & MTA Cooperative Group. (2009). The MTA at 8 years: prospective follow-up of children treated for combined-type ADHD in a multisite study. *Journal of the American Academy of Child & Adolescent Psychiatry, 48*(5), 484-500.

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology, 30*(3), 791-800.

Mrazek, M. D., Phillips, D. T., Franklin, M. S., Broadway, J. M., & Schooler, J. W. (2013). Young and restless: validation of the Mind-Wandering Questionnaire (MWQ) reveals disruptive impact of mind-wandering for youth. *Frontiers in Psychology, 4*(560), 1-7.

Mrazek, M. D., Smallwood, J. and Schooler, J. W. (2012). Mindfulness and mind-wandering: Finding convergence through opposing constructs. *Emotion, 12*, 442-448.

MTA Cooperative Group. (1999). A 14-month randomized clinical trial of treatment strategies for attention-deficit/hyperactivity disorder. *Archives of General Psychiatry, 56*(12), 1073-1086.

Müller, H. J., & Krummenacher, J. (2006). Visual search and selective attention. *Visual Cognition, 14*(4-8), 389-410.

Mullet, D. R., & Rinn, A. N. (2015). Giftedness and ADHD: Identification, Misdiagnosis, and Dual Diagnosis. *Roeper Review, 37*(4), 195-207.

Munoz, D. P., Armstrong, I. T., Hampton, K. A., & Moore, K. D. (2003). Altered control of visual fixation and saccadic eye movements in attention-deficit hyperactivity disorder. *Journal of Neurophysiology, 90*(1), 503-514.

Munoz, D. P., Hampton, K. A., Moore, K. D., & Goldring, J. E. (1999). Control of purposive saccadic eye movements and visual fixation in children with attention-deficit. In W. Becker, H. Deubel, & T. Mergner (Eds.), *Current Oculomotor Research: Physiological and Psychological Aspects*, (pp 415-424). New York: Springer Science+Business Media.

Murphy, K., & Barkley, R. A. (1996). Prevalence of DSM-IV symptoms of ADHD in adult licensed drivers: implications for clinical diagnosis. *Journal of Attention Disorders, 1*(3), 147-161.

Necka, E. (1999). Creativity and Attention. *Polish Psychological Bulletin, 30*(2), 85-97.

NHS. (2014). Attention deficit hyperactivity disorder (ADHD) - Treatment. (2015, May 15). Retrieved November 6, 2015, from http://www.nhs.uk/Conditions/Attention-deficit-hyperactivity-disorder/Pages/Treatment.aspx

Nichols, S. L., & Waschbusch, D. A. (2004). A review of the validity of laboratory cognitive tasks used to assess symptoms of ADHD. *Child Psychiatry and Human Development, 34*(4), 297-315.

Nieoullon, A. (2002). Dopamine and the regulation of cognition and attention. *Progress in Neurobiology, 67*(1), 53-83.

Nieuwenstein, M. R. (2006). Top-down controlled, delayed selection in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 32*(4), 973-985.

Nigg, J. T. (1999). The ADHD response-inhibition deficit as measured by the stop task: Replication with DSM–IV combined type, extension, and qualification. *Journal of abnormal child psychology, 27*(5), 393-402.

Nigg, J. T., John, O. P., Blaskey, L. G., Huang-Pollock, C. L., Willicut, E. G., Hinshaw, S. P., & Pennington, B. (2002). Big five dimensions and ADHD symptoms: links between personality traits and clinical symptoms. *Journal of Personality and Social Psychology, 83*(2), 451.

Ohly, S., Sonnentag, S., & Pluntke, F. (2006). Routinization, work characteristics and their relationships with creative and proactive behaviors. *Journal of Organizational Behavior, 27*(3), 257-279.

Oja, L., Huotilainen, M., Nikkanen, E., Oksanen-Hennah, H., Laasonen, M., Voutilainen, A., ... & Alho, K. (2015). Behavioural and electrophysiological indicators of auditory distractibility in children with ADHD and comorbid ODD. *Brain Research*, 1632, 42-50.

Olton, R. M., & Johnson, D. M. (1976). Mechanisms of Incubation in Creative Problem Solving. *American Journal of Psychology, 89*(4), 617-630.

Paloyelis, Y., Asherson, P., & Kuntsi, J. (2009). Are ADHD symptoms associated with delay aversion or choice impulsivity? A general population study. *Journal of the American Academy of Child & Adolescent Psychiatry, 48*(8), 837-846.

Pashler, H. E. (1994). Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin, 116*(2), 220-244.

Pashler, H. E. (1999). *The Psychology of Attention.* Massachusetts, USA: MIT Press.

Patrick, A. S. (1986). The role of ability in creative 'incubation'. *Personality and Individual differences, 7*(2), 169-174.

Pelham Jr, W. E., & Fabiano, G. A. (2008). Evidence-based psychosocial treatments for attention-deficit/hyperactivity disorder. *Journal of Clinical Child & Adolescent Psychology, 37*(1), 184-214.

Pelham Jr, W. E., Waschbusch, D. A., Hoza, B., Gnagy, E. M., Greiner, A. R., Sams, S. E., ... & Carter, R. L. (2011). Music and video as distractors for boys with ADHD in the classroom: Comparison with controls, individual differences, and medication effects. *Journal of Abnormal Child Psychology, 39*(8), 1085-1098.

Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology, 58*(3), 193.

Plucker, J. A. (1999). Is the proof in the pudding? Reanalyses of Torrance's (1958 to present) longitudinal data. *Creativity Research Journal, 12*(2), 103-114.

Plucker, J. A. & Renzulli, J. S. (1999). Psychometric approaches to the study of human creativity. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 35-61). Cambridge, UK: Cambridge University Press.

Polanczyk, G., de Lima, M., Horta, B., Biederman, J. & Rohde, L. (2007). The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *The American Journal of Psychiatry, 164*(6), 942-948.

Post, F. (1994). Creativity and psychopathology: A study of 291 world-famous men. *British Journal of Psychiatry, 165,* 22-34.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, *32*(1), 3-25.

Preckel, F., Holling, H., & Wiese, M. (2006). Relationship of intelligence and creativity in gifted and non-gifted students: An investigation of threshold theory. *Personality and Individual Differences*, *40*(1), 159-170.

Radcliff, M. (2008). Absentminded professor or Romantic artist? The depiction of creativity in documentary biographies of Albert Einstein. *Journal of Popular Film and Television, 36*(2), 62-72.

Radosh, A., & Gittleman, R. (1981). The effect of appealing distractors on the performance of hyperactive children. *Journal of Abnormal Child Psychology, 9*, 179–189.

Rapport, M. D., Chung, K. M., Shore, G., & Isaacs, P. (2001). A conceptual model of child psychopathology: Implications for understanding attention deficit hyperactivity disorder and treatment efficacy. *Journal of Clinical Child Psychology*, *30*(1), 48-58.

Rawlings, D. (1985). Psychoticism, creativity and dichotic shadowing. *Personality and Individual Differences, 6*(6), 737-742.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink?. *Journal of Experimental Psychology: Human Perception and Performance*, *18*(3), 849-860.

Rego, A., Sousa, F., Marques, C., & e Cunha, M. P. (2012). Authentic leadership promoting employees' psychological capital and creativity. *Journal of Business Research*, *65*(3), 429-437.

Reid, R., Vasa, S. F., Maag, J. W., & Wright, G. (1994). An analysis of teacher's perceptions of attention deficit-hyperactivity disorder. *Journal of Research and Development in Education, 27,* 195-195.

Remington, R. W. (1980). Attention and saccadic eye movements. *Journal of Experimental Psychology: Human Perception and Performance*, *6*(4), 726.

Reuter, M., Kirsch, P. & Hennig, J. (2006). Inferring candidate genes for Attention Deficit Hyperactivity Disorder (ADHD) assessed by the World Health Organization Adult ADHD Self-Report Scale (ASRS). *Journal of Neural Transmission, 113,* 929-938.

Riccio, C. A., & Reynolds, C. R. (2001). Continuous Performance Tests are sensitive to ADHD in adults but lack specificity. *Annals of the New York Academy of Sciences*, *931*, 113-139.

Riccio, C. A., Reynolds, C. R., Lowe, P., & Moore, J. J. (2002). The continuous performance test: a window on the neural substrates for attention?. *Archives of Clinical Neuropsychology*, *17*(3), 235-272.

Rindermann, H., & Neubauer, A. C. (2004). Processing speed, intelligence, creativity, and school performance: Testing of causal hypotheses using structural equation models. *Intelligence*, *32*(6), 573-589.

Ritter, S. M., & Dijksterhuis, A. (2014). Creativity—the unconscious foundations of the incubation period. *Frontiers in Human Neuroscience*, *8*, 215.

Robbins, T. W. (2000). Chemical neuromodulation of frontal-executive functions in humans and other animals. *Experimental Brain Research*, *133*(1), 130-138.

Robinson, D. L., & Kertzman, C. (1990). Visuospatial attention: Effects of age, gender, and spatial reference. *Neuropsychologia*, *28*(3), 291-301.

Robinson-Morral, E. J., Reiter-Palmon, R., & Kaufman, J. C. (2013). The Interactive Effects of Self-Perceptions and Job Requirements on Creative Problem Solving. *The Journal of Creative Behavior*, *47*(3), 200-214.

Rodriguez-Jimenez, R., Avila, C., Jimenez-Arriero, M. A., Ponce, G., Monasor, R., Jimenez, M. E. E. A., ... & Palomo, T. (2006). Impulsivity and sustained attention in pathological gamblers: influence of childhood ADHD history. *Journal of Gambling Studies*, *22*(4), 451-461.

Rosa, P. J., Gamito, P., Oliveira, J., Morais, D., Pavlovic, M., & Smyth, O. (2015, October). Show me your eyes! The combined use of eye tracking and virtual reality applications for cognitive assessment. In *Proceedings of the 3rd 2015 Workshop on ICTs for improving Patients Rehabilitation Research Techniques* (pp. 135-138). ACM.

Rosenthal, R. H., & Allen, T. W. (1980). Intratask distractibility in hyperkinetic and nonhyperkinetic children. *Journal of Abnormal Child Psychology*, *8*(2), 175-187.

Ross, R. G., Harris, J. G., Olincy, A., & Radant, A. (2000a). Eye movement task measures inhibition and spatial working memory in adults with schizophrenia, ADHD, and a normal comparison group. *Psychiatry Research*, *95*(1), 35-42.

Ross, R. G., Hommer, D., Breiger, D., Varley, C., & Radant, A. (1994). Eye movement task related to frontal lobe functioning in children with attention deficit disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *33*(6), 869-874.

Ross, R. G., Olincy, A., Harris, J. G., Sullivan, B., & Radant, A. (2000b) Smooth Pursuit Eye Movements in Schizophrenia and Attentional Dysfunction: Adults with Schizophrenia, ADHD, and a Normal Comparison Group. *Biological Psychiatry, 48,* 197-203.

Rossman, B. B. & Horn, J. L. (1972). Cognitive, motivational and temperamental indicants of creativity and intelligence. *Journal of Educational Measurement, 9*(4), 265-286.

Rowe, G., Hirsh, J. B., & Anderson, A. K. (2007). Positive affect increases the breadth of attentional selection. *PNAS*, *104*(1), 383-388.

Rudofsky, S. F. & Wotiz, J. H. (1988). Psychologists and the dream accounts of August Kekulé. *Ambix*, *35*(1), 31-38.

Runco, M. A. (2004). Creativity. *Annual Review of Psychology, 55,* 657-687.

Runco, M. A. (2007) *Creativity. Theories and Themes: Research, Development and Practice.* London: Elsevier Academic Press.

Runco, M. A. (2008). Commentary: Divergent Thinking Is Not Synonymous With Creativity. *Psychology of Aesthetics, Creativity, and the Arts, 2*(2), 93-96.

Runco, M. A., & Albert, R. S. (1986). The threshold theory regarding creativity and intelligence: An empirical test with gifted and nongifted children. *Creative Child and Adult Quarterly*, *11*(4), 212-218.

Sacramento, C. A., Fay, D., & West, M. A. (2013). Workplace duties or opportunities? Challenge stressors, regulatory focus, and creativity. *Organizational behavior and Human Decision Processes*, *121*(2), 141-157.

Sagvolden, T., Johansen, E. B., Aase, H., & Russell, V. A. (2005). A dynamic developmental theory of attention-deficit/hyperactivity disorder (ADHD) predominantly hyperactive/impulsive and combined subtypes. *Behavioural and Brain Sciences*, *28*(3), 397-418.

Sarver, D. E., Rapport, M. D., Kofler, M. J., Raiker, J. S., & Friedman, L. M. (2015). Hyperactivity in attention-deficit/hyperactivity disorder (ADHD): Impairing deficit or compensatory behavior?. *Journal of abnormal child psychology*, 1-14.

Savage, R., Cornish, K., Manly, T., & Hollis, C. (2006). Cognitive processes in children's reading and attention: The role of working memory, divided attention, and response inhibition. *British Journal of Psychology*, *97*(3), 365-385.

Schmajuk, N., Aziz, D. R. & Bates, M. J. B. (2009). Attentional-Associative Interactions in Creativity. *Creativity Research Journal*, *21*(1), 92-103.

Schmidt, M. H., Möcks, P., Lay, B., Eisert, H. G., Fojkar, R., Fritz-Sigmund, D., ... & Musaeus, B. (1997). Does oligoantigenic diet influence hyperactive/conduct-disordered children—a controlled trial. *European Child & Adolescent Psychiatry*, *6*(2), 88-95.

Schwartz, K., & Verhaeghen, P. (2008). ADHD and Stroop interference from age 9 to age 41 years: a meta-analysis of developmental effects. *Psychological Medicine*, *38*(11), 1607-1616.

Segal, E. (2004). Incubation in insight problem solving. *Creativity Research Journal, 16,* 141-148.

Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., & Yaniv, I. (1995). Demystification of cognitive insight: Opportunistic assimilation and the prepared-mind perspective. In R. J. Sternberg & J. E. Davidson (Eds.). *The nature of insight*, pp. 65–124. Cambridge, MA: MIT Press.

Sen, A. K. & Hagtvet, K. (1993). Correlations among creativity, intelligence, personality, and academic achievement. *Perceptual and Motor Skills, 77*(2), 197-198.

Sergeant, J. A. (2005). Modelling attention-deficit/hyperactivity disorder: a critical appraisal of the cognitive-energetic model. *Biological Psychiatry*, *57*(11), 1248-1255.

Sergeant, J. A., Oosterlaan, J., & van der Meere, J. (1999). Information processing and energetic factors in attention-deficit/hyperactivity disorder. In *Handbook of Disruptive Behavior Disorders* (pp. 75-104). Springer US.

Shalev, L., Ben-Simon, A., Mevorach, C., Cohen, Y. & Tsal, Y. (2011). Conjunctive Continuous Performance Task (CCPT) - A pure measure of sustained attention. *Neuropsychologia, 49*, 2584-2591.

Shapiro, K. L., Arnell, K. M. & Raymond, J. E. (1997). The attentional blink. *Trends in Cognitive Sciences, 1*(8), 291-296.

Shapiro, K. L., Raymond, J. E., & Arnell, K. M. (1994). Attention to visual pattern information produces the attentional blink in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception & Performance*, 20, 357-371.

Shaw, K., Wagner, I., Eastwood, H., & Mitchell, G. (2003). A qualitative study of Australian GPs' attitudes and practices in the diagnosis and management of attention-deficit/hyperactivity disorder (ADHD). *Family Practice*, *20*(2), 129-134.

Shaw, P., Eckstrand, K., Sharp, W., Blumenthal, J., Lerch, J. P., Greenstein, D., ... & Rapoport, J. L. (2007). Attention-deficit/hyperactivity disorder is characterized by a delay in cortical maturation. *Proceedings of the National Academy of Sciences*, *104*(49), 19649-19654.

Shaw, P., Malek, M., Watson, B., Sharp, W., Evans, A., & Greenstein, D. (2012). Development of cortical surface area and gyrification in attention-deficit/hyperactivity disorder. *Biological Psychiatry*, *72*(3), 191-197.

Shepherd, M., Findlay, J. M., & Hockey, R. J. (1986). The relationship between eye movements and spatial attention. *The Quarterly Journal of Experimental Psychology*, *38*(3), 475-491.

Shibata, S., & Suzuki, N. (2002). Effects of the foliage plant on task performance and mood. *Journal of Environmental Psychology, 22*, 265-272.

Shibata, S., & Suzuki, N. (2004). Effects of an indoor plant on creative task performance and mood. *Scandinavian Journal of Psychology, 45*, 373-381.

Shulman, G. L., Astafiev, S. V., Franke, D., Pope, D. L., Snyder, A. Z., McAvoy, M. P., & Corbetta, M. (2009). Interaction of stimulus-driven reorienting and expectation in ventral and dorsal frontoparietal and basal ganglia-cortical networks. *The Journal of Neuroscience*, *29*(14), 4392-4407.

Simon, V., Czobor, P., Bálint, S., Mészáros, Á., & Bitter, I. (2009). Prevalence and correlates of adult attention-deficit hyperactivity disorder: meta-analysis. *The British Journal of Psychiatry*, *194*(3), 204-211.

Simonton, D. K. (1990) Creativity and wisdom in aging. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (3rd ed., pp. 320–329). San Diego, California: Academic.

Simonton, D. K. (2014). Can creative productivity be both positively and negatively correlated with psychopathology? Yes!. *Frontiers in Psychology, 5,* 455.

Singer, J. L. & Antrobus, J. S. (1970). *Manual for the Imaginal Processes Inventory.* New Jersey: Educational Testing Service.

Sio, U. N. & Ormerod, T. C. (2009). Does incubation enhance problem solving? A meta-analytic review. *Psychological Bulletin, 135*(1), 94-120.

Sio, U. N. & Rudowicz, E. (2007). The role of an incubation period in creative problem solving. *Creativity Research Journal,* 19(2-3), 307-318.

Slaats-Willemse, D., Swaab-Barneveld, H., De Sonneville, L., Van Der Meulen, E., & Buitelaar, J. A. N. (2003). Deficient response inhibition as a cognitive endophenotype of ADHD. *Journal of the American Academy of Child & Adolescent Psychiatry*, *42*(10), 1242-1248.

Smallwood, J. & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin, 132*(6), 946-958.

Smith, K. A., Huber, D. E., & Vul, E. (2013). Multiply-constrained semantic search in the Remote Associates Test. *Cognition, 128*(1), 64-75.

Smith, S. M., & Blankenship, S. E. (1991). Incubation and the persistence of fixation in problem solving. *American Journal of Psychology, 104*(1), 61-87.

Snyder, A., Mitchell, J., Ellwood, S., Yates, A., & Pallier, G. (2004). Nonconscious idea generation. *Psychological Reports, 94*(3c), 1325-1330.

Söderlund, G. B., Sikström, S., Loftesnes, J. M., & Sonuga-Barke, E. J. (2010). The effects of background white noise on memory performance in inattentive school children. *Behavioral and Brain Functions, 6*(1), 55-65

Söderlund, G., Sikström, S., & Smart, A. (2007). Listen to the noise: noise is beneficial for cognitive performance in ADHD. *Journal of Child Psychology and Psychiatry, 48*(8), 840-847.

Solanto, M. V., Abikoff, H., Sonuga-Barke, E., Schachar, R., Logan, G. D., Wigal, T., ... & Turkel, E. (2001). The ecological validity of delay aversion and response inhibition as measures of impulsivity in AD/HD: a supplement to the NIMH multimodal treatment study of AD/HD. *Journal of Abnormal Child Psychology, 29*(3), 215-228.

Sonuga-Barke, E. J. (2002). Psychological heterogeneity in AD/HD—a dual pathway model of behaviour and cognition. *Behavioural Brain Research, 130*(1), 29-36.

Sonuga-Barke, E. J. (2003). The dual pathway model of AD/HD: an elaboration of neuro-developmental characteristics. *Neuroscience & Biobehavioral Reviews, 27*(7), 593-604.

Spelke, E. S. (2005). Sex differences in intrinsic aptitude for mathematics and science?: A critical review. *American Psychologist, 60*(9), 950-958.

Spence, C., & Driver, J. (1997). On measuring selective attention to an expected sensory modality. *Perception & Psychophysics, 59*, 389–403.

Spencer, T. J., Biederman, J., Madras, B. K., Dougherty, D. D., Bonab, A. A., Livni, E., ... & Fischman, A. J. (2007). Further evidence of dopamine transporter dysregulation in ADHD: a controlled PET imaging study using altropane. *Biological psychiatry, 62*(9), 1059-1061.

Starko, A. J. (1995). *Creativity in the Classroom.* New York: Longman.

Stavridou, A., & Furnham, A. (1996). The relationship between psychoticism, trait-creativity and the attentional mechanism of cognitive inhibition. *Personality and Individual Differences, 21*(1), 143–153.

Stawarczyk, D., Majerus, S., Van der Linden, M. & D'Argembeau, A. (2012). Using the daydreaming frequency scale to investigate the relationships between mind-wandering, psychological well-being, and present-moment awareness. *Frontiers in Psychology: Personality Science and Individual Differences, 3*(363), 1-15.

Stern, P., & Shalev, L. (2013). The role of sustained attention and display medium in reading comprehension among adolescents with ADHD and without it. Research in Developmental Disabilities, 34(1), 431-439.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: Prospects and paradigms. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 3-15). Cambridge, UK: Cambridge University Press.

Sternberg, R. J., & O'Hara, L. A. (1999). Creativity and intelligence. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 251-272). Cambridge, UK: Cambridge University Press.

Sternberg, R.J. & Willams, W. M. (1996). *How to Develop Student Creativity.* Alexandria: Association for Supervision and Curriculum Development.

Stone, N. J., & English, A. J. (1998). Task type, posters, and workspace colour on mood, satisfaction, and performance. *Journal of Environmental Psychology, 18,* 175–185.

Strayer, D. L., & Johnston, W. A. (2001). Driven to distraction: Dual-task studies of simulated driving and conversing on a cellular telephone. *Psychological Science*, *12*(6), 462-466.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662.

Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: a conceptual view. *Psychological Research*, *63*(3-4), 289-298.

Styles, E. A. (2006). *The Psychology of Attention,* (2nd ed.). Hove, UK: Psychology Press.

Tabachnick, B. G., & Fidell, L. S. (2012). *Using Multivariate Statistics*, 5th ed. Boston: Pearson.

Taft, R. & Rossiter, J. R. (1966). The Remote Associates Test: Divergent or Convergent Thinking? *Psychological Reports, 19,* 1313-1314.

Thapar, A., Cooper, M., Eyre, O., & Langley, K. (2013). Practitioner review: what have we learnt about the causes of ADHD? *Journal of Child Psychology and Psychiatry*, *54*(1), 3-16.

Tierney, P. & Farmer, S. M. (2002). Creative self-efficacy: Its potential, antecedents and relationship to creative performance. *Academy of Management Journal, 45*(6), 1137-1148.

Torrance, E. P. (1966). *The Torrance Tests of Creative Thinking: Norms-Technical Manual Research Edition. Verbal Tests, Forms A and B, Figural Tests, Forms A and B.* New Jersey: Personnel Press.

Torrance, E. P. (1972). Predictive validity of the Torrance Tests of Creative Thinking. Journal of Creative Behavior, 6(4), 236–252.

Torrance, E. P. (1974). *The Torrance Tests of Creative Thinking-Norms-Technical Manual Research Edition-Verbal Tests, Forms A and B-Figural Tests, Forms A and B.* Princeton, New Jersey: Personnel Press.

Torrance, E. P. (1975). Creativity research in education: Still alive. In Sternberg, R. J., & O'Hara, L. A. (1999). Creativity and intelligence. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 251-272). Cambridge, UK: Cambridge University Press.

Torrance, E. P. (1990). *Torrance Tests of Creative Thinking: Manual for scoring and interpreting results.* Illinois: Scholastic Testing Service, Inc.

Torrance, E. P. (1998). *The Torrance tests of creative thinking norms—Technical manual figural (streamlined) forms A & B.* Illinois: Scholastic Testing Service.

Torrance, E. P., Ball, O. E. & Safter, H. T. (1992). *Torrance Tests of Creative Thinking: Streamlined scoring guide, figural A and B.* Illinois: Scholastic Testing Service, Inc.

Torrance, E. P., & Safter, H. T. (1999). Making the creative leap beyond. Buffalo, NY: Creative Education Foundation Press.

Treisman, A. M. (1960). Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology, 12,* 242-248.

Treisman, A. M. (1969). Strategies and models of selective attention. *Psychological Review, 76*, 282–299.

Treisman, A. (1985). Preattentive processing in vision. *Computer Vision, Graphics, and Image Processing*, *31*(2), 156-177.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology*, *12*(1), 97-136.

Tseng, P. H., Cameron, I. G., Munoz, D. P., & Itti, L. (2014). *U.S. Patent No. 8,808,195*. Washington, DC: U.S. Patent and Trademark Office.

Tucha, L. I., Tucha, O., Walitza, S., Sontag, T. A., Laufkötter, R., Linder, M., & Lange, K. W. (2009). Vigilance and sustained attention in children and adults with ADHD. *Journal of Attention Disorders*, *12*, 410-421.

Türkan, B. N., Amado, S., Ercan, E. S., & Perçinel, I. (2016). Comparison of change detection performance and visual search patterns among children with/without ADHD: Evidence from eye movements. *Research in Developmental Disabilities*, *49*, 205-215.

Unsworth, N., Redick, T. S., Lakey, C. E., & Young, D. L. (2010). Lapses in sustained attention and their relation to executive control and fluid abilities: An individual differences investigation. *Intelligence*, *38*(1), 111-122.

van der Meere, J. (2002). The role of attention. In S. Sandberg (ed). *Hyperactivity and Attention Disorders of Childhood*, pp. 162-213.

van der Meere, J., & Sergeant, J. (1988). Controlled processing and vigilance in hyperactivity: Time will tell. *Journal of Abnormal Child Psychology*, *16*(6), 641-655.

van der Meere, J., Shalev, R., Börger, N., & Gross-Tsur, V. (1995). Sustained attention, activation and MPH in ADHD: a research note. *Journal of Child Psychology and Psychiatry*, *36*(4), 697-703.

van Mourik, R., Oosterlaan, J., Heslenfeld, D. J., Konig, C. E., & Sergeant, J. A. (2007). When distraction is not distracting: A behavioral and ERP study on distraction in ADHD. *Clinical Neurophysiology*, *118*(8), 1855-1865.

Van Stockum, C. A., & DeCaro, M. S. (2014). Enclothed Cognition and Controlled Attention during Insight Problem-Solving. *Journal of Problem Solving*, *7*(1), 73-83.

Vartanian, O. (2009). Variable attention facilitates creative problem solving. *Psychology of Aesthetics, Creativity, and the Arts*, *3*(1), 57-59.

Vartanian, O., Martindale, C., & Kwiatkowski, J. (2007). Creative potential, attention, and speed of information processing. *Personality and Individual Differences, 43*, 1470-1480.

Vendrell, P., Junque, C., Pujol, J., Jurado, M. A., Molet, J., & Grafman, J. (1995). The role of prefrontal regions in the Stroop task. *Neuropsychologia, 33*(3), 341-352.

Vogel, E. K. & Luck, S. J. (2002). Delayed working memory consolidation during the attentional blink. *Psychonomic Bulletin and Review, 9*(4), 739-743.

Volkow, N. D., Wang, G. J., Kollins, S. H., Wigal, T. L., Newcorn, J. H., Telang, F., ... & Swanson, J. M. (2009). Evaluating dopamine reward pathway in ADHD: clinical implications. *JAMA, 302*(10), 1084-1091.

Waddell, C. (1998). Creativity and mental illness: is there a link?. *Canadian Journal of Psychiatry*, *43*(2), 166-172.

Wallach, M. A. & Kogan, N. (1965). *Modes of Thinking in Young Children.* New York: Holt, Rinehart & Winston.

Wallas, G. (1926). *The art of thought.* New York: Harcourt, Brace and Company.

Ward, T. B., Smith, S. M., & Finke, R. (1999). Creative cognition. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 189-212). Cambridge, UK: Cambridge University Press.

Warm, J. S., Parasuraman, R., & Matthews, G. (2008). Vigilance requires hard mental work and is stressful. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 50*(3), 433-441.

Wegbreit, E., Suzuki, S., Grabowecky, M., Kounios, J., & Beeman, M. (2012). Visual attention modulates insight versus analytic solving of verbal problems. *The Journal of Problem Solving, 4*(2), 94-115.

White, E. B. (1969). The Art of Essay, No.1/Interviewers: G. Plimpton & F. H. Crowther. *The Paris Review.* Retrieved from http://www.theparisreview.org/interviews/4155/the-art-of-the-essay-no-1-e-b-white

White, H. A. & Shah, P. (2006). Uninhibited imaginations: Creativity in adults with Attention-Deficit/Hyperactivity Disorder. *Personality and Individual Differences, 40*, 1121-1131.

White, H. A. & Shah, P. (2011). Creative style and achievement in adults with attention-deficit/hyperactivity disorder. *Personality and Individual Differences, 50*, 673-677.

Wickens, C. D. (2002). Multiple resources and performance prediction. *Theoretical Issues in Ergonomics Science, 3*(2), 159-177.

Wiley, J., & Jarosz, A. F. (2012). Working memory capacity, attentional focus, and problem solving. *Current Directions in Psychological Science, 21*(4), 258-262.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biological psychiatry, 57*(11), 1336-1346.

Wolf, P. (2001). Creativity and chronic disease Vincent van Gogh (1853-1890). *Western Journal of Medicine, 175*(5), 348.

Wolfradt, U. & Pretz, J. E. (2001). Individual differences in creativity: Personality, story writing, and hobbies. *European Journal of Personality, 15,* 297-310.

Wood, E., Zivcakova, L., Gentile, P., Archer, K., De Pasquale, D., & Nosko, A. (2011). Examining the impact of off-task multi-tasking with technology on real-time classroom learning. *Computers & Education, 58*(1), 365-374.

Yamada, M., Aoyama, T., Okamoto, K., Nagai, K., Tanaka, B., & Takemura, T. (2011). Using a Smartphone while walking: a measure of dual-tasking ability as a falls risk assessment tool. *Age and Ageing*, afr039.

Zabelina, D. L., Condon, D., & Beeman, M. (2014). Do dimensional psychopathology measures relate to creative achievement or divergent thinking?. *Frontiers in psychology, 5*, article 1029, 1-11.

Zabelina, D. L., O'Leary, D., Pornpattananangkul, N., Nusslock, R., & Beeman, M. (2015). Creativity and sensory gating indexed by the P50: Selective versus leaky sensory gating in divergent thinkers and creative achievers. *Neuropsychologia, 69*, 77-84.

Zabelina, D. L., & Robinson, M. D. (2010). Creativity as flexible cognitive control. *Psychology of Aesthetics, Creativity, and the Arts*, *4*(3), 136-143.

Zentall, S. S. & Zentall, T. R. (1983). Optimal stimulation: A model of disordered activity and performance in normal and deviant children. *Psychological Bulletin, 94*(3), 446-471.

Zhou, J., & Hoever, I. J. (2014). Research on workplace creativity: A review and redirection. *Annual Review of Organizational Psychology and Organizational Behavior, 1*(1), 333-359.

Appendices

Appendix 1: Preliminary Questionnaire

Participant Information Questionnaire

Gender: (tick)
Male
Female

Age:

1. I am easily distracted:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

2. I am good at focussing my attention on one thing at a time:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

3. Being creative is important to me:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

4. In general, my creativity is an important part of my self-image:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

5. I am good at coming up with new ideas:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

6. Being creative is important in my occupation:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

7. My creativity is an important part of who I am:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

8. I have a lot of good ideas:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

9. I believe that being creative is a valuable trait:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

10. Overall, my creativity has little to do with who I am:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

11. I have a good imagination:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

12. I can easily concentrate on one task until it is finished:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

13. I struggle to fully focus my attention on one task:

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

Appendix 2: Creative Achievement Questionnaire (CAQ)

Creative Achievement Questionnaire.

1. *Place a tick beside the areas in which you feel you have more talent, ability, or training than the average person.*

(tick)

	visual arts (painting, sculpture)
	music
	dance
	individual sports (tennis, golf)
	team sports
	architectural design
	entrepreneurial ventures
	creative writing
	humour
	inventions
	scientific inquiry
	theatre and film
	culinary arts

2. Place a tick beside sentences that apply to you. Next to sentences with an asterisk (*), write the number of times this sentence applies to you.

(tick) **A. Visual Arts (painting, sculpture)**

	0. I have no training or recognized talent in this area. (Skip to **Music**).
	1. I have taken lessons in this area.
	2. People have commented on my talent in this area.
	3. I have won a prize or prizes at a juried art show.
	4. I have had a showing of my work in a gallery.
	5. I have sold a piece of my work.
	6. My work has been critiqued in local publications.
	*7. My work has been critiqued in national publications.

(tick) **B. Music**

	0. I have no training or recognized talent in this area (Skip to **Dance**).
	1. I play one or more musical instruments proficiently.
	2. I have played with a recognized orchestra or band.
	3. I have composed an original piece of music.
	4. My musical talent has been critiqued in a local publication.
	5. My composition has been recorded.
	6. Recordings of my composition have been sold publicly.
	*7. My compositions have been critiqued in a national publication.

(tick)	**C. Dance**
	0. I have no training or recognized talent in this area (Skip to **Architecture**)
	1. I have danced with a recognized dance company.
	2. I have choreographed an original dance number.
	3. My choreography has been performed publicly.
	4. My dance abilities have been critiqued in a local publication.
	5. I have choreographed dance professionally.
	6. My choreography has been recognized by a local publication.
	*7. My choreography has been recognized by a national publication.

(tick)	**D. Architectural Design**
	0. I do not have training or recognized talent in this area (Skip to **Writing**).
	1. I have designed an original structure.
	2. A structure designed by me has been constructed.
	3. I have sold an original architectural design.
	4. A structure that I have designed and sold has been built professionally.
	5. My architectural design has won an award or awards.
	6. My architectural design has been recognized in a local publication.
	*7. My architectural design has been recognized in a national publication.

(tick)	**E. Creative Writing**
	0. I do not have training or recognized talent in this area (Skip to **Humour**).
	1. I have written an original short work (poem or short story).
	2. My work has won an award or prize.
	3. I have written an original long work (epic, novel, or play).
	4. I have sold my work to a publisher.
	5. My work has been printed and sold publicly.
	6. My work has been reviewed in local publications.
	* 7. My work has been reviewed in national publications.

(tick)	**F. Humour**
	0. I do not have recognized talent in this area (Skip to **Inventions**).
	1. People have often commented on my original sense of humour.
	2. I have created jokes that are now regularly repeated by others.
	3. I have written jokes for other people.
	4. I have written a joke or cartoon that has been published.
	5. I have worked as a professional comedian.
	6. I have worked as a professional comedy writer.
	*7. My humour has been recognized in a national publication.

G. Inventions (tick)

- 0. I do not have recognized talent in this area (Skip to **Scientific Discovery**)
- 1. I regularly find novel uses for household objects.
- 2. I have sketched out an invention and worked on its design flaws.
- 3. I have created original software for a computer.
- 4. I have built a prototype of one of my designed inventions.
- 5. I have sold one of my inventions to people I know.
- *6. I have received a patent for one of my inventions.
- *7. I have sold one of my inventions to a manufacturing firm.

H. Scientific Discovery (tick)

- 0. I do not have training or recognized ability in this field (Skip to **Theatre**)
- 1. I often think about ways that scientific problems could be solved.
- 2. I have won a prize at a science fair or other local competition.
- 3. I have received a scholarship based on my work in science or medicine.
- 4. I have been author or co-author of a study published in a scientific journal.
- *5. I have won a national prize in the field of science or medicine.
- *6. I have received a grant to pursue my work in science or medicine.
- 7. My work has been cited by other scientists in national publications.

I. Theatre and Film (tick)

- 0. I do not have training or recognized ability in this field (Skip to **Culinary Arts**).
- 1. I have performed in theatre or film.
- 2. My acting abilities have been recognized in a local publication.
- 3. I have directed or produced a theatre or film production.
- 4. I have won an award or prize for acting in theatre or film.
- 5. I have been paid to act in theatre or film.
- 6. I have been paid to direct a theatre or film production.
- *7. My theatrical work has been recognized in a national publication.

J. Culinary Arts (tick)

- 0. I do not have training or experience in this field (Skip to question **K**).
- 1. I often experiment with recipes.
- 2. My recipes have been published in a local cookbook.
- 3. My recipes have been used in restaurants or other public venues.
- 4. I have been asked to prepare food for celebrities or dignitaries.
- 5. My recipes have won a prize or award.
- 6. I have received a degree in culinary arts.
- *7. My recipes have been published nationally

K. Please list other creative achievements not mentioned above:

Appendix 3: Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist

Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist

Patient Name		Today's Date						
Please answer the questions below, rating yourself on each of the criteria shown using the scale on the right side of the page. As you answer each question, place an X in the box that best describes how you have felt and conducted yourself over the past 6 months. Please give this completed checklist to your healthcare professional to discuss during today's appointment.				Never	Rarely	Sometimes	Often	Very Often
1. How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?								
2. How often do you have difficulty getting things in order when you have to do a task that requires organization?								
3. How often do you have problems remembering appointments or obligations?								
4. When you have a task that requires a lot of thought, how often do you avoid or delay getting started?								
5. How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?								
6. How often do you feel overly active and compelled to do things, like you were driven by a motor?								
								Part A
7. How often do you make careless mistakes when you have to work on a boring or difficult project?								
8. How often do you have difficulty keeping your attention when you are doing boring or repetitive work?								
9. How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?								
10. How often do you misplace or have difficulty finding things at home or at work?								
11. How often are you distracted by activity or noise around you?								
12. How often do you leave your seat in meetings or other situations in which you are expected to remain seated?								
13. How often do you feel restless or fidgety?								
14. How often do you have difficulty unwinding and relaxing when you have time to yourself?								
15. How often do you find yourself talking too much when you are in social situations?								
16. When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves?								
17. How often do you have difficulty waiting your turn in situations when turn taking is required?								
18. How often do you interrupt others when they are busy?								
								Part B

Appendix 4: Daydreaming Frequency Scale (DDFS)

This is a questionnaire about your tendency to daydream, to let your mind-wander and to get lost in your thoughts.

Be careful to make the difference between thinking about what you are doing at any given time (e.g., actively imagining solutions to a problem you're trying to solve at the time) and daydreaming about something else (e.g., thinking about the next film release while you're studying).

Thinking of a job whilst you are in the process of doing it is not daydreaming. By contrast, thinking about this task at other times of the day, such as just before sleep or during a bus ride is daydreaming.

1. I daydream:

Infrequently	Once a week	Once a day	A few times a day	Many times a day

2. What percentage of your day is filled with dreaming and mind-wandering?

0%	Less than 10%	At least 10%	At least 25%	At least 50%

3. I describe myself as someone who daydreams:

Never	Rarely	Sometimes	Frequently	Always

4. I remember and think about my dreams:

Infrequently	Once a week	Once a day	A few times a day	Many times a day

5. When I am not paying close attention to some job, book or TV, I tend to be daydreaming:

0%	Less than 10%	At least 10%	At least 25%	At least 50%

6. What percentage of your time is spent lost in thought, when you should be paying attention to people or events around you?

0%	Less than 10%	At least 10%	At least 25%	At least 50%

7. I daydream at work (or college/university):

Infrequently	Once a week	Once a day	A few times a day	Many times a day

8. What percentage of your daily thoughts are spent remembering the past, thinking of the future, or imagining unusual events?

0%	Less than 10%	At least 10%	At least 25%	At least 50%

9. I lose myself in active daydreaming:

Infrequently	Once a week	Once a day	A few times a day	Many times a day

10. Whenever I have time on my hands I daydream:

Never	Rarely	Sometimes	Frequently	Always

11. When I am in a meeting or show that is not very interesting, I daydream rather than pay attention:

Never	Rarely	Sometimes	Frequently	Always

12. On a long bus, train, or airplane ride I daydream:

Never	Rarely	Sometimes	Frequently	Always

Appendix 5: Mind-Wandering Questionnaire (MWQ)

Mind-Wandering Questionnaire

Each statement covers an aspect of mind-wandering. Please indicate your response to each statement by ticking the one box that best describes you.

1. I have difficulty maintaining focus on simple or repetitive work

Almost Never	Very Infrequently	Somewhat Infrequently	Somewhat Frequently	Very Frequently	Almost Always

2. While reading, I find I haven't been thinking about the text and must therefore read it again

Almost Never	Very Infrequently	Somewhat Infrequently	Somewhat Frequently	Very Frequently	Almost Always

3. I do things without paying full attention

Almost Never	Very Infrequently	Somewhat Infrequently	Somewhat Frequently	Very Frequently	Almost Always

4. I find myself listening with one ear, thinking about something else at the same time

Almost Never	Very Infrequently	Somewhat Infrequently	Somewhat Frequently	Very Frequently	Almost Always

5. I mind-wander during lectures or presentations

Almost Never	Very Infrequently	Somewhat Infrequently	Somewhat Frequently	Very Frequently	Almost Always

Appendix 6: Unusual Uses Task – Tin Can (UUT-TC)

Task

In the next five minutes, think of as many unusual uses for a TIN CAN as possible.

Write your ideas down in the space below to create a list of as many ideas as you can.

Think of the cleverest, most interesting, and most unusual uses. Try to think of things that no one else will think of.

Appendix 7: Unusual Uses Task – Cardboard Box (UUT-CB)

Task

In the next five minutes, think of as many unusual uses for a CARDBOARD BOX as possible.

Write your ideas down in the space below to create a list of as many ideas as you can.

Think of the cleverest, most interesting, and most unusual uses. Try to think of things that no one else will think of.

Appendix 8: Circles Task

Task

In five minutes see how many objects or pictures you can make from the circles below and on the reverse of this page. The circles should be the main part of whatever you make.

With the pencil or pen add lines to the circles to complete your picture. You can place marks inside the circle or outside of the circle – wherever you want to in order to make your picture.

Try to think of things that no one else will think of. Make as many different pictures or objects as you can and put as many ideas as you can in each one. Make them tell as complete and as interesting a story as you can.

Add names or a title in the space below each circle.
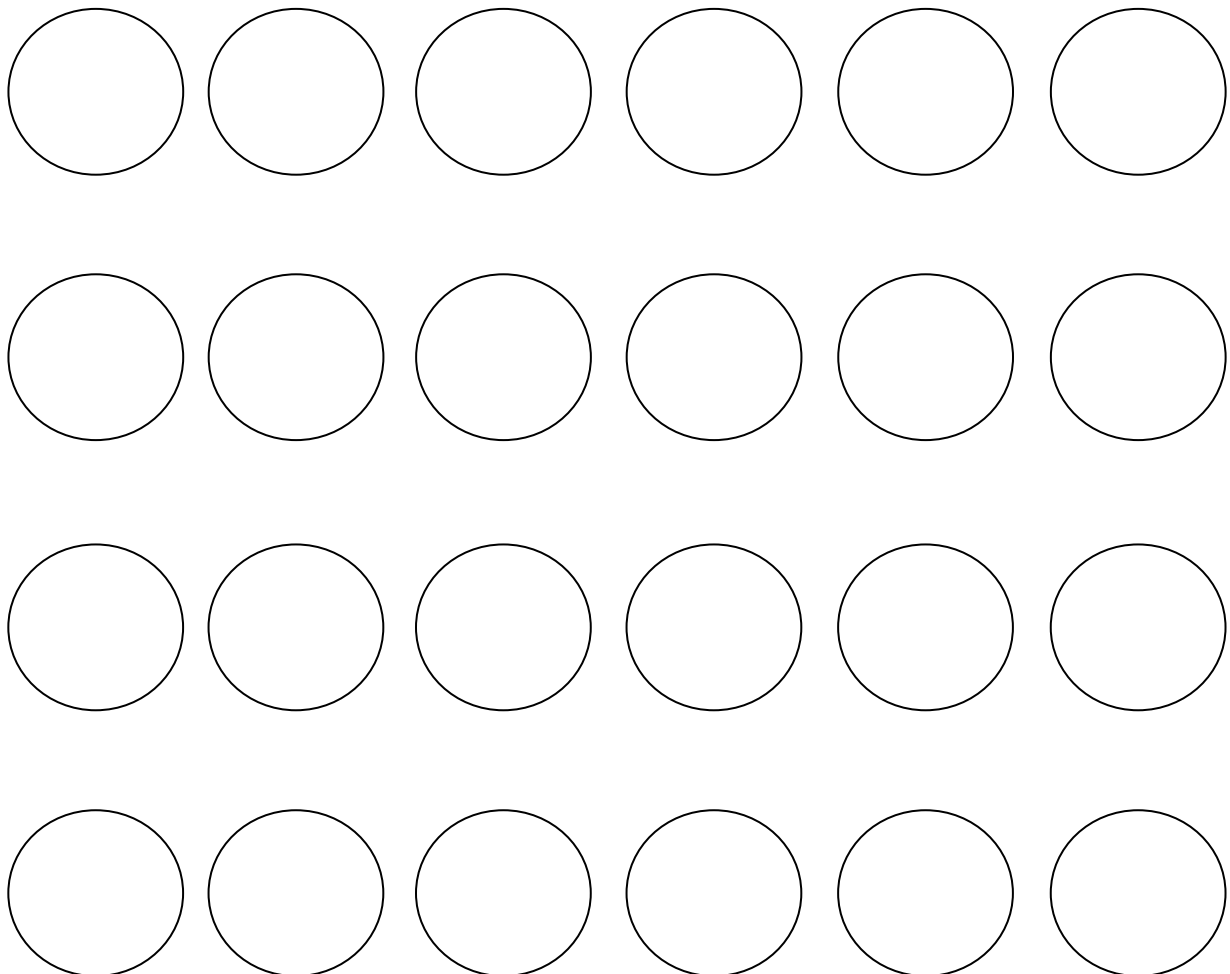
Appendix 9: Collage Materials

Material	Colour	Quantity
PVA Glue and Glue Brush	-	-
Scissors	-	-
A3 Card	White	1 (base)
A2 Tissue Paper	White, Brown, Black	3 (1 of each)
A6 Card	Red, Blue, Green, Yellow, Orange	5 (1 of each)
6cmX5cm Card	Red, Blue, Green, Yellow, Orange	5 (1 of each)
6cmX5cm Metallic Card	Red, Blue, Green, Gold, Silver	5 (1 of each)
3cmX3cm Tissue Paper	Red, Dark Blue, Light Blue, Dark Green, Light Green, Yellow, Orange, Purple, Pink, Brown, Black, White.	60 (5 of each)
Tissue Paper Cut-Offs	Multi	Approx 50
Gummed Paper Shapes	Red, Blue, Green, Yellow, Gold, Silver	Approx 50
Sequins	Multi	Approx 100
Pipe Cleaners	Red, Blue, Green, Yellow, Orange, Purple, Pink, Brown, Black, White.	10 (1 each)
Artificial Feathers	Multi	4

Appendix 10: Collage Instructions

Collage Task

In the next ten minutes, use the provided materials to create a collage.

Use as many or as few of the materials as you wish, and try to make something that no one else will think of.

Appendix 11: Rapid Serial Visual Presentation (RSVP) Task Instructions

This experiment contains 32 trials. The screen will turn grey and there will be a fast stream of black letters in the centre. One letter will appear in white and will be B, G, or S. Bear in mind this letter.

The letter X may or may not appear at any point AFTER the white target letter. This will be in black along with the other letters.

When the fast stream of letters have finished, you will be asked if the target letter was B, G or S. Then, you will be asked whether or not the letter X was presented following the white target letter.

Reaction time is not being measured. Please take your time in answering the questions. Please pay close attention and answer to the best of your ability.

Press the space bar to advance to the next screen.

Appendix 12: Continuous Performance Task (CPT) Introductory Instructions

Please note that these appeared on screen for the participant, with white writing and a black background.

In the following task, a single coloured shape will appear in the centre of the computer screen.

The shape will be a triangle, circle, square or a star, and will be yellow, green, blue or red.

The shape will appear for 100ms before disappearing.

The task is to react only when the shape is a RED SQUARE.

When a RED SQUARE appears, press the spacebar as soon as possible.

Do not press the spacebar for any other coloured shape.

Don't worry if you make a mistake; just carry on from where you left off.

This task requires you to concentrate and pay continuous attention to the centre of the screen.

Please make sure you are sitting comfortably.

Press any key to begin a short practice run.

Appendix 13: Continuous Performance Task (CPT) Post Practice Instructions

Please note that these appeared on screen for the participant, with white writing and a black background.

That was a practice run.

In the next task, please respond in the same way as you did before.

This means pressing the SPACEBAR every time you see a RED SQUARE.

Remember to maintain a high level of concentration. This section will last longer than the practice run.

If you are comfortable, please press any key to begin.

Appendix 14: Stroop Test Instructions

Start a trial by pressing the space bar. A fixation dot will appear in the middle of the window. Focus on the dot. A short time later (less than a second) a word (either RED, GREEN, or BLUE) will appear on the screen, and the word will be drawn in either red, green, or blue font colour. Your task is to classify, as quickly as possible, the font colour, regardless of the word name.

If the font colour is red, press the h-key; for green, press the j-key; for blue, press the k-key. It may take a bit of practice to make certain you remember which key corresponds to which font colour. You can change which keys go with which colour below.

After pressing a key to identify the font colour, you will receive feedback on whether you were correct. If you were incorrect the trial will be repeated later in the experiment. If you find you are making lots of mistakes you should slow down, or make certain you understood which key goes with which font colour.

Red – 'h'

Green – 'j'

Blue – 'k'

Appendix 15: Dual Task Number Lists

Part One: Lists for Digit Span Determination

List	Result (√ or ×)	List	Result (√ or ×)	List	Result (√ or ×)
For Span = 2					
83		54		27	
28		37		91	
68		96		87	
For Span = 3					
829		687		871	
132		356		251	
152		637		915	
For Span = 4					
6241		1372		5316	
2359		7392		4815	
7132		6539		1872	
For Span = 5					
84132		85293		79514	
62143		91635		82691	
97438		16592		75468	
For Span = 6					
587261		492617		148239	
261384		247681		423896	
632147		429735		641357	
For Span = 7					
2941378		6297865		1897562	
1285394		8243167		3185624	
8693735		3945782		2473961	
For Span = 8					
65148279		28653197		85729136	
18472913		65792381		76591243	
42785921		74529638		76921358	
For Span = 9					
679174382		239874615		539748216	
746231958		867934612		513985267	
398724615		794831265		231986734	
For Span = 10					
4982176453		2853967624		2914984357	
5731298426		9781734826		6983285149	
8182397465		8491287637		6391727362	

Part Two: Single Task Lists

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Score	Score/n
A	1	5	8	7	3	6	2	9	5	4		
B	3	7	9	8	1	4	6	1	2	5		
C	6	9	3	1	4	7	5	9	8	2		
D	2	4	3	8	7	1	9	4	2	3		
E	2	1	5	3	8	6	4	7	9	6		
F	7	9	6	3	1	4	2	8	3	5		
G	8	1	6	3	9	5	7	4	2	1		
H	1	7	3	2	9	3	6	4	8	5		
I	9	6	1	2	5	3	8	2	7	4		
J	8	7	1	3	9	4	6	5	7	2		
K	3	2	1	9	5	4	3	6	8	7		
L	4	7	2	4	5	8	1	9	3	6		
M	8	4	5	1	6	2	3	4	9	7		
N	6	2	7	1	3	8	5	2	9	4		
O	8	3	9	1	6	2	7	6	5	4		

List Memory (Single Task). Table for converting raw scores to proportions.

Length. of list	Score										
	0	1	2	3	4	5	6	7	8	9	10
2	0	.5	1								
3	0	.33	.67	1							
4	0	.25	.5	.75	1						
5	0	.2	.4	.6	.8	1					
6	0	.17	.33	.5	.67	.83	1				
7	0	.14	.29	.43	.57	.71	.86	1			
8	0	.13	.25	.38	.5	.63	.75	.88	1		
9	0	.11	.22	.33	.44	.56	.67	.78	.89	1	
10	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1

Part Four: Dual Task Lists

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Score	Score/n
9	5	6	1	3	6	1	9	8	2		
7	2	9	1	5	4	8	1	6	3		
5	8	9	7	2	4	5	3	1	4		
9	6	3	8	2	5	4	7	1	8		
2	4	6	3	1	8	7	2	5	4		
5	7	8	7	2	9	4	3	5	2		
1	3	4	8	3	1	2	6	2	9		
8	2	7	5	4	6	1	3	8	9		
1	9	4	2	7	4	8	3	6	2		
3	1	2	6	9	4	8	3	5	2		
2	5	4	9	6	1	9	4	8	2		
3	8	6	4	5	7	5	2	9	6		
7	5	6	3	2	8	5	1	9	1		
9	3	5	9	6	8	2	1	3	7		
5	4	3	6	5	7	3	8	7	3		

Appendix 16.1: Information Sheet

Edinburgh Napier
UNIVERSITY

Information Sheet: Which specific attentional processes are related to creativity?

My name is Lindsey Carruthers and I am a postgraduate student at Edinburgh Napier University. I am currently undertaking research as a part of my Masters Project. I am aiming to determine how aspects of creativity (e.g. divergent thinking, picture completion) are related to variable attention factors (e.g. sustaining attention, completing two tasks at once, and ignoring irrelevant stimuli).

I am looking for volunteers over the age of 18 and who are fluent in English to take part in my research. It will take approximately one hour and 15 minutes to complete.

The experiment will consist of several short tests which will measure different aspects of attention and creativity. Two of these will be computer based and five will be paper based. There will be short breaks available for participants between these tests. There will also be two short questionnaires regarding demographic information, for example your age and gender, plus any past creative recognition you may have achieved.

The data I collect will be used in a project report for my academic work and may be used towards an oral presentation. Your data will only be viewed by me and my project supervisors, and we will ensure that you cannot be identified in any way.

You do not have to take part in this study if you do not wish to do so. If you decide to take part, you do not have to answer any question that you do not wish to answer. You may withdraw from the research at any time without giving a reason and any data that have been collected on you will be deleted from the study. You have been provided with a participant number at the top of this page. All of the data you provide will be coded with this number. If you wish to withdraw your data, please e-mail me, quoting your participant number, at the address provided below. This will allow me to retract all of your data.

If you wish to contact me for more information or to retract your data, please e-mail me at L.Carruthers@napier.ac.uk. Or alternatively to contact my project supervisor about this research, please e-mail Dr. A. Willis, at Edinburgh Napier University, A.Willis@napier.ac.uk for more information.

This information sheet is for you to take away with you.

Thank you very much for your time and please to not hesitate to get in touch afterwards with any questions or queries about the research.

Appendix 16.2: Information Sheet

Edinburgh Napier
UNIVERSITY

Information Sheet: The differences in eye movements, and the effect of a visually stimulating environment, on performance of attention and creativity tasks between those with and without ADHD.

My name is Lindsey Carruthers and I am a postgraduate student at Edinburgh Napier University. I am currently undertaking research as a part of my PhD Project. I am aiming to determine how aspects of creativity (e.g., divergent thinking) are related to variable attention factors (e.g., sustained, selective, and divided attention). I am also interested in how the type of environment these tasks are completed in may influence performance.

I am looking for volunteers who are to take part. Participants need to be over the age of 18 and fluent in English to contribute. It will take approximately 55 minutes to complete and takes place at the Sighthill campus of Edinburgh Napier University. A £10 gift voucher will be given to each participant.

The experiment will consist of several short computer- and paper- based tests which will measure different aspects of attention and creativity. There will be short breaks available for participants between these tests. There will also be a short questionnaire regarding demographic information, for example your age and gender, plus a self-assessment of your attention skills.

Participants would be required to wear eye-tracking glasses (these fit like spectacles) during the completion of these tasks, although they can be removed during short breaks. This is in order to assess distraction levels and focus priorities.

The data I collect will be used in a project report for my academic work and may be used towards an oral presentation or publication. Your data will only be viewed by me and my project supervisors, and we will ensure that you cannot be identified in any way. The information I collect will be kept in a secure, locked drawer and will only be unlocked by me, and will be destroyed after use.

You do not have to take part in this study if you do not wish to do so. If you decide to take part, you do not have to answer any question that you do not wish to answer. You may withdraw from the research at any time without giving a reason and any data that have been collected on you will be deleted from the study. You have been provided with a participant number at the top of this page. All of the data you provide will be coded with this number. If you wish to withdraw your data, please e-mail me, quoting your participant number, at the address provided below. This will allow me to retract all of your data.

If you wish to contact me for more information or to retract your data, please e-mail me at L.Carruthers@napier.ac.uk or write to me at Room 2B46, Edinburgh Napier University, Sighthill Campus, Edinburgh. Or alternatively to contact my project supervisor about this research, please e-mail Alex Willis at Edinburgh Napier University, A.willis@napier.ac.uk for more information. Should you wish to discuss any issues or questions regarding this research with someone who is not involved, the independent advisor is Barbara Neades: B.neades@napier.ac.uk.

This information sheet is for you to take away with you.

Thank you very much for your time and please to not hesitate to get in touch afterwards with any questions or queries about the research.

Appendix 16.3: Information Sheet

Information Sheet: Individual Differences in Attentional Control and the Effectiveness of Incubation on Creative Problem Solving

My name is Lindsey Carruthers and I am a postgraduate student at Edinburgh Napier University. I am currently undertaking research as a part of my PhD Project. I am aiming to determine which aspects of attentional control (sustained, selective divided, and self-report attention) are related to creativity, and how they affect the success of incubation.

I am looking for volunteers over the age of 18 and who are fluent in English to take part in my research. It will take approximately 50 minutes to complete.

The experiment will consist of several short tests which will measure different aspects of attention and creativity. Four of these will be computer based and four will be paper based. The longest of these tasks lasts for 12 minutes; otherwise they are all five minutes long.

The data I collect will be used in a project report for my academic work and may be used towards an oral presentation or journal publication. Your data will only be viewed by me and my project supervisors, and we will ensure that you cannot be identified in any way.

You do not have to take part in this study if you do not wish to do so. If you decide to take part, you do not have to answer any question that you do not wish to answer. You may withdraw from the research at any time without giving a reason and any data that have been collected on you will be deleted from the study. You have been provided with a participant number at the top of this page. All of the data you provide will be coded with this number. If you wish to withdraw your data, please e-mail me, quoting your participant number, at the address provided below. This will allow me to retract all of your data.

If you wish to contact me for more information or to retract your data, please e-mail me at L.carruthers@napier.ac.uk. Or alternatively to contact my project supervisor about this research, please e-mail Dr A. Willis at Edinburgh Napier University, a.willis@napier.ac.uk for more information. Alternatively you can contact an independent advisor, Barbara Neades, at b.neades@napier.ac.uk.

This information sheet is for you to take away with you.

Thank you very much for your time and please to not hesitate to get in touch afterwards with any questions or queries about the research.

Appendix 17: Consent Form

Edinburgh Napier
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Consent Form

- I have read the information sheet.

- I have had an opportunity to ask questions.

- I have received satisfactory answers to my questions.

- I know that I am free to withdraw from the study at any time, without giving a reason.

Please sign below to indicate that you are willing to take part in the study.

I consent to taking part in this study:

Participant's Signature   …………………….....
Date   …………………….....

_____

Participant Number   …………………….....
Researcher's Signature   …………………….....
Date   …………………….....

Appendix 18: Warm Up Task

Below is a curved shape. Think of a picture or an object which you can draw with this shape as a part.

Try to think of a picture that no one else will think of. Keep adding new ideas to your first idea to make it as interesting and exciting as you can. You have **3** minutes to complete this task.

When you have completed your picture, think up a name or title for it and write it at the bottom of the page in the space provided. Make your title as clever and unusual as possible. Use it to help tell your story.
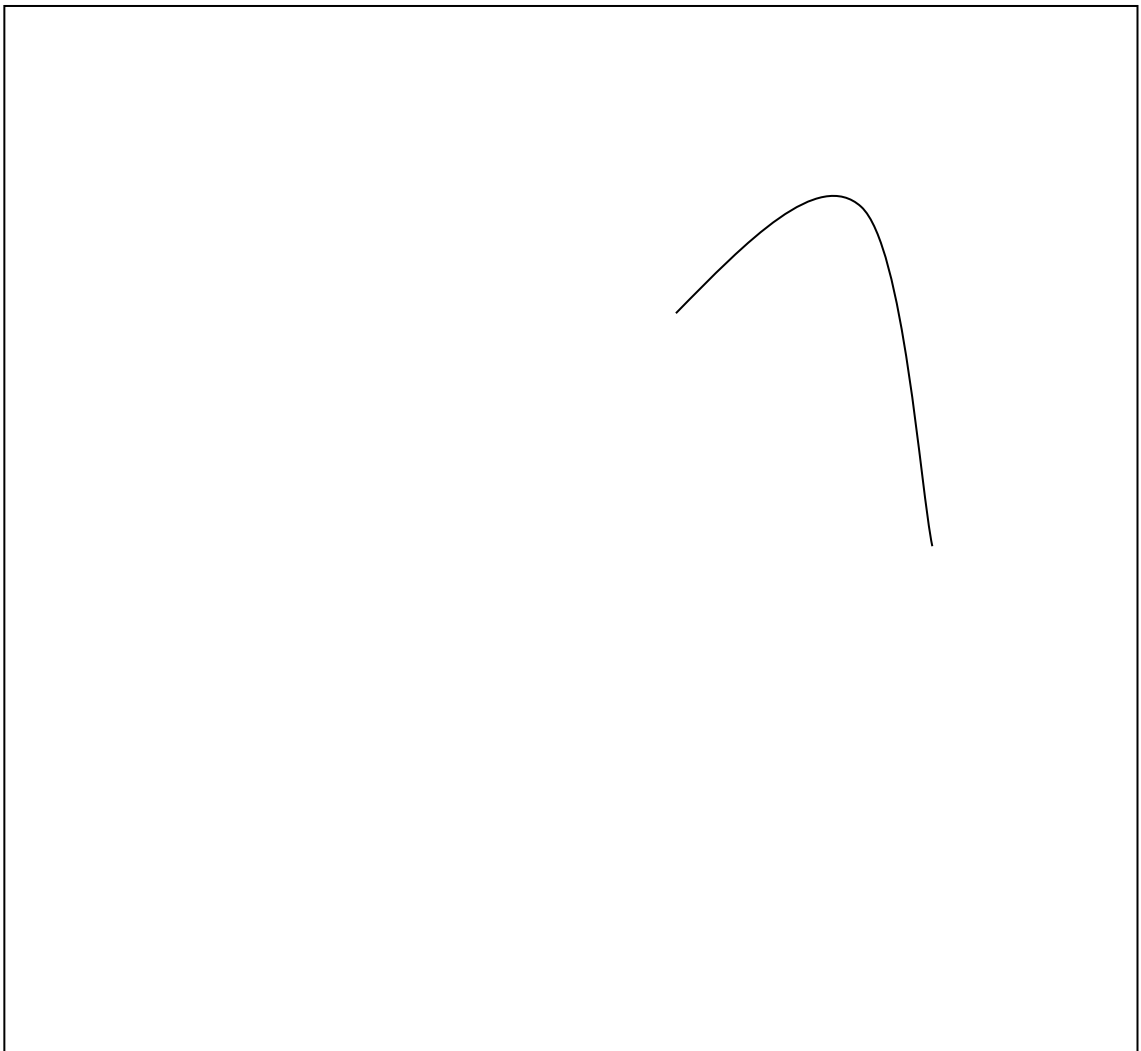
Title:

Appendix 19.1: Debrief

Debrief Sheet: Which specific attentional processes are related to creativity?

Thank you very much for taking part in this research. The main aim of this study is to determine which aspects of attention have an effect on creativity.

Participant attention was measured by using two computer based and one paper based tasks. In particular, these tasks measured the ability to ignore irrelevant stimuli (i.e. distractibility), sustaining attention, and Dual-Task Processing.

Four types of paper based tasks were used to measure creativity, or creative potential. Several of these tasks measured divergent thinking, which is the generation of several, varied responses to open questions (Runco, 1991, 2007). For example, to think of as many different uses for a cardboard box as you can, would be a measure of divergent thinking. The answers given on this measure are scored in terms of fluency (total number of ideas), originality (uniqueness of answers compared to other participants), flexibility (the number of discreet categories that the answers can be grouped in to) and elaboration (additional detail provided by the participant to their own ideas) (Kaufman, Plucker & Baer, 2008). Furthermore, divergent thinking was measured in terms of verbal (words) and figural (pictures) creativity. Participants were also asked to physically produce a creative product.

During the experiment, the participants were also asked to complete two questionnaires. One was concerning simple demographics such as age and gender, as well nine questions regarding participant's creative self-efficacy, which explicitly asked the participants to rate their own creative abilities. The other was the Creative Achievement Questionnaire, which is used to determine whether or not participants have had past recognition for their creativity.

Previous research has been incoherent in terms of clarifying the relationship between attention and creativity. For example, it has been posited by several researchers that creative performance is supported by a wide breadth of attention (a summary of this research is provided by Kasof, 1997), however the findings have been inconsistent and most studies only measured one aspect of creative ability or attention. Therefore the present study is addressing this issue by aiming to thoroughly investigate the relationship between attention and creativity by using a variety of numerous tasks. The scores from the attention tests will be correlated with the scores from creativity tests in order to determine any links. This should allow the researcher to clarify which aspects of attention are related to creative performance.

If you wish to contact me for more information or to retract your data, please e-mail me at L.Carruthers@napier.ac.uk. Or alternatively to contact my project supervisor about this research, please e-mail Dr. A. Willis at Edinburgh Napier University, A.Willis@napier.ac.uk for more information.

Thank you for taking part in my research, any feedback would be welcomed.

Appendix 19.2: Debrief Sheet

Edinburgh Napier
UNIVERSITY

Debrief Sheet: The differences in eye movements, and the effect of a visually stimulating environment, on performance of attention and creativity tasks between those with and without ADHD.

Thank you very much for taking part in this research. I am investigating the relationship between attention and creativity, and how this might differ in those with ADHD. Furthermore, I would like to investigate the effect of a visually stimulating environment on performance. Eye-tracking measures were taken in order to test for distractibility and the difference of visual focus in those with and without ADHD.

Participant attention was measured by using two computer based and questionnaires. In particular, these tasks measured the ability to sustain attention and ignore irrelevant stimuli. The ASRS – v1.1 is a symptom checklist for ADHD. Reading speed and comprehension was also measured.

Three types of paper based tasks were used to measure creativity, or creative potential. The tasks measured divergent thinking, which is the generation of several, varied responses to open questions (Runco, 1991, 2007). For example, to think of as many different uses for a cardboard box as you can, would be a measure of divergent thinking. Divergent thinking was measured in terms of verbal (words) and figural (pictures) creativity. The opposite, convergent thinking, was also measured with the remote associates task.

Previous research has been incoherent in terms of clarifying the relationship between attention and creativity. For example, it has been posited by several researchers that creative performance is supported by a wide breadth of attention (a summary of this research is provided by Kasof, 1997), however the findings have been inconsistent and most studies only measured one aspect of creative ability or attention. Therefore the present study is addressing this issue by aiming to thoroughly investigate the relationship between attention and creativity by using a numerous of variety tasks. Furthermore, the optimal stimulation theory states that a "there exists a biologically determined optimal level of arousal for achieving the best level of cognitive functioning" (Leung, Leung, & Tang, 2000:189). It is suggested that those with ADHD behave in a hyperactive or inattentive manner in an attempt to raise their naturally low cognitive arousal to an optimal level (Zentall & Zentall, 1983). Studies have found beneficial effects of background auditory and visual stimulation on task performance in those with ADHD, compared to silent or neutral conditions (e.g., Abikoff, Courtney, Szeibel, & Koplewicz, 1996; Leung et al., 2000; Soderlund, Sikstrom, & Smart, 2007).

In order to make recommendations about the type of environments those with ADHD should be learning and working in, it is necessary to measure the effect of a visually stimulating environment, against that of a visually neutral environment on computer- and paper-based task performance. A mobile eye-tracker (fits like a pair of spectacles) was used to determine where visual attention is drawn, and if there is a relationship with distractedness and the type environment.

For more information about ADHD, please visit http://www.addiss.co.uk/ or call 020 8952 2800, which is the National Attention Deficit Disorder Information and Support Service. If you wish to contact me for more information or to retract your data, please e-mail me at L.carruthers@napier.ac.uk. Or alternatively to contact my project supervisor about this research, please e-mail Dr. A. Willis at Edinburgh Napier University, A.willis@napier.ac.uk for more information.

Thank you for taking part in my research, any feedback would be welcomed.

Appendix 19.3: Debrief Sheet

Debrief Sheet: Individual Differences in Attentional Control and the Effectiveness of Incubation on Creative Problem Solving

Thank you very much for taking part in this research. The main aim of this study is to determine which aspects of attentional control are related to creativity, and how they affect the success of incubation.

It has been found that periods of time spent away from a problem can be beneficial to coming up with the solution (Baird *et al.,* 2012; Gilhooly, Georgiou & Devery, 2013; Wallas, 1926). This break is called incubation, and it is thought to allow non-conscious processing of the problem to continue whilst conscious processing works on something else (Gilhooly *et al.,* 2013). Previous studies have alluded to the concept of attention in their explanations of how incubation may work, but it has not been thoroughly measured, leaving a gap in the literature. This study will make a unique contribution to the literature as it will determine which aspects of attentional control are important for incubation during a creative problem solving task.

Attentional control was measured by using two computer based and three paper based tasks. In particular, these tasks measured the ability to ignore irrelevant information (i.e., selective attention), sustaining attention over time, and dual-task processing. The Adult ADHD self-report scale was used as a further measure of distractibility and the Daydreaming Frequency Questionnaire measures just that, the propensity to daydream.

Creative problem solving was measured using the unusual uses task (UUT). The instruction was to produce as many unusual, novel and creative uses for a tin can as possible. This is a measure of divergent thinking, coming up with many ideas for one question. This type of task is very common in creativity research and will be scored for the number of ideas produced as well as the originality of them, according to the guidelines provided by Torrance (1990).

There were four test conditions within the study. Condition one was the control group, where there was no incubation break during the 10 minute UUT. Participants in condition two had a five minute break, but this involved sitting quietly with no other task involvement. Those in conditions three and four both had to complete a five minute task during their incubation period, a cognitively undemanding task (target response) in condition three and a demanding task (odd/even number distinction) in condition four (as in Gilhooly *et al.,* 2013).

If you wish to contact me for more information or to retract your data, please e-mail me at L.Carruthers@napier.ac.uk. Or alternatively to contact my project supervisor about this research, please e-mail Dr. A. Willis at Edinburgh Napier University, a.willis@napier.ac.uk for more information.

Thank you for taking part in my research, any feedback would be welcomed.