Exploring the role of schizotypy in creative cognition

By

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A thesis submitted to Victoria University of Wellington in fulfilment of the requirements for the degree of

Doctor of Philosophy

Victoria University of Wellington

2020

ABSTRACT

Creativity is hugely important in our everyday lives. Understanding what makes some people more creative than others is not just important in traditional creative fields. Creative problem solving is the key to solving all significant challenges we face as a society, including but not limited to technological, political and environmental challenges. Mental illness, in both popular culture and in psychological science, have long been linked to creative thought. Many eminent creatives, both past and current, attribute their success to their mental illness. For example, in schizophrenia, the grandiose thinking and florid hallucinations that characterise this disorder may be supportive of creative thinking. However, schizophrenia is characterised by severe cognitive deficits that, according to models of creativity, would be disadvantageous to creative thinking. Schizotypy is a personality trait that is characterised by some features of schizophrenia (unusual thinking, poor interpersonal communication), but is not accompanied by the same severe cognitive deficits seen in schizophrenia. Based on this view, it is reasonable to assume that people high on schizotypal traits may be more creative than those who are low on schizotypal traits.

While there a number of studies examining this relationship, findings are inconsistent, with effect sizes ranging from -.42 to .8. In my thesis, I explored a) whether there was a relationship between schizotypy and creativity and b) whether that relationship could be explained by underlying differences in cognitive processing (associative processing and executive control). I predicted that positive schizotypy in particular (typified by unusual thinking, superstitious beliefs) would be positively correlated with schizotypy in three different measures of creativity (two performance based tasks and one self-report measure) in two different samples of participants.

In Chapters 3 + 4, I tested the relationship between schizotypy and creativity using two different methods. In chapter 3, I found no evidence for the predicted effect. In fact, I found a *negative* association between positive schizotypy and scores on one measure of creativity (the Remote Associates test) and a *positive* association between negative schizotypy (characterised by interpersonal deficits) and performance on the RAT. These effects did not replicate in the second sample. Finally, there was a *positive* association between disorganised schizotypy and creativity on the Alternate Uses task. The results of Chapter 4, using a latent profile analytic approach, mirrored the results of Chapter 3. Finally,

Chapter 5, found no support for any relationship being mediated by associative processing or executive control; however, there was partial support for two models of creativity. Overall, evidence suggests that schizotypal traits are not helpful for creativity. These results shed light on some of the challenges when conducting research regarding both schizotypy and creativity.

Acknowledgements

To my participants both here and in the United States, thank you for taking the time to participate in my research – without you my research would not be possible.

To the wonderful staff in the School of Psychology who helped me in little ways, and big ways, towards achieving this goal. To the admin staff who work tirelessly behind the scenes, to the IT staff who helped me problem solve my way through many programming errors, and to the other academic staff who gave me feedback and encouragement throughout my time at Victoria University.

To the Canlab (Cognitive Affective Neuroscience Lab, Victoria University) past and current members; thank you for your encouragement, pearls of wisdom and mentorship. You guys have always been so inspiring to me; trying to be worthy of the title of Canlab student has kept me striving to be a better researcher.

To all my friends who have supported me through this journey. Some of you were a shoulder to cry on in difficult times, some of you helped me carve a life outside of work and some of you helped me forge through challenging parts of my research. All of you in your own ways have helped make this achievement possible.

To my family – thank you for your support throughout my long years of study. You are such a great sideline cheer squad. You always had faith in me throughout this long process - I couldn't have got through without you.

To my secondary supervisor Marc Wilson – thank you for your stats wizardry, kindness and all the phd-related banter. Your help and feedback greatly improved this thesis.

Finally thank you to my primary supervisor Gina Grimshaw. Thanks for always believing in me, even when I frequently did not. I've learned so much from you over the years, about how to be a scientist, writer and all-round person. Thank you for this wonderful opportunity.

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Chapter 1: General Introduction

When examining a work of art or reading a moving piece of writing, one is often left in awe of the abilities of the person who created it. What qualities led them to combine such disparate ideas in this novel piece of work? We often laud famous creative people such as Beethoven, Van Gogh or Sylvia Plath for being 'creative geniuses'. What characteristics do these creative people have in common? Which of these characteristics help creativity flourish within that individual?

One thing these creative geniuses have in common is a history of mental illness. The "mad genius" is a pervasive archetype in our culture (e.g., Redfield Jamison, 1996), and one that raises many questions about the relationship between mental disorder and creative thought. Although it is clear that people with psychotic disorders such as schizophrenia or bipolar disorder have severe deficits in a wide range of cognitive and affective functions, might they also have cognitive and/or personality traits that can facilitate a creative spark? And if so, might this help us to understand creativity itself?

These turn out to be very difficult questions to answer, in part because creative cognition in people with such disorders may be masked by psychotic symptoms, medication, and co-morbid psychopathology. Or these may distort creative processes, leading to creative outputs that are better characterised as bizarre than creative (Bortolato, Miskowiak, Kohler, Vieta & Carvalho, 2015). However, some of the cognitive traits that are associated with schizophrenia are also seen in people who are high in schizotypy, a constellation of personality and cognitive traits that are distributed in the healthy population. Because people high in schizotypy may share the cognitive traits that facilitate creativity in schizophrenia, without the deficits and confounding factors, they may provide unique insights into the nature of the creative mind.

The overarching aim of this thesis is to clarify and explain the relationship between schizotypy and creativity, in order to further our understanding of how certain cognitive processes support creative thinking. In doing so, I will further both our current understanding of cognitive and creative processes in schizotypy (and perhaps by extension in schizophrenia), but also our current understanding of creativity itself.

Defining schizotypy

The term schizotypy was originally coined by Rado (1960, cited in Lenzenweger & Korfine, 1992) to describe a latent liability to develop schizophrenia. Schizotypal traits combined with a genetic risk and life stress significantly increases the risk of developing schizophrenia (Meehl, 1989; Lenzenweger, 2006). A person with high levels of schizotypy may come across as slightly eccentric in their thinking, believe in multiple conspiracy theories, and have trouble making friends (Lenzenweger, 2015). A number of studies suggest that schizotypy may be associated with creativity (see Acar & Sen, 2013, for a meta-analytic review).

Schizotypy is a multi-dimensional construct consisting of a number of heterogeneous traits that fall into three main categories that are typically identified as positive, interpersonal and disorganised, intended to mirror the three main symptom categories that characterise schizophrenia. These include positive symptoms (hallucinations, delusions), negative symptoms (anhedonia, poverty of speech, blunted affect) and disorganised symptoms (looseness of speech, impulsive behaviour; Raine, 1991). Positive schizotypy includes traits that reflect the positive symptoms of hallucinations and delusions. These include magical thinking, superstitious beliefs, minor perceptual aberrations and paranoid beliefs. People who are high on positive schizotypal traits are more likely to believe in conspiracy theories, have atypical sensory experiences, and express 'weird' ideas about other people and the world around them. Interpersonal schizotypal traits reflect the negative symptoms of social withdrawal and blunting of affect; people high on these traits struggle to make friends, express their own emotions or recognise them in others, and typically prefer their own company. Disorganised traits include odd speech and behaviour that reflect the cognitive symptoms of thought disorder; people high on these traits are seen as 'eccentric' by their peers and often have 'odd' habits. They also tend to ramble in conversation and are sometimes quite difficult to understand.

There are two theoretical approaches to understanding schizotypy: a taxonic approach and a dimensional approach. A taxonic view (also known as a categorical view) attributes schizotypal traits to an underlying taxonic population structure (Everett & Linscott, 2015), which distinguishes a discrete group of people with schizotypal traits who are at risk of developing schizophrenia. Paul Meehl (1962) originally championed this view, arguing that schizophrenia is a product of the interaction of a genetic vulnerability for schizophrenia, known as schizotaxia (present in a small percentage of the population) with a

stressful environment. This view suggests it should be possible to define different classes of people based on whether or not they have certain underlying phenotypes. A key assumption of the taxonic view is that the small group of people who are in this high risk category are distinctly different from the rest of the population. This group of people will also present with high levels of schizotypal traits (Everett & Linscott, 2015). A dimensional approach, on the other hand, assumes that schizotypal traits are determined by an underlying dimensional process or processes present in all individuals to varying degrees; from this perspective, schizotypy is not conceptually distinct from schizophrenia but represents the milder end of a continuum of traits (Claridge & Beech, 1995).

These two theoretical approaches have led to the parallel development of two questionnaires commonly used to assess schizotypy. Both the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) and Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE; Mason, 1995) ask individuals to indicate whether particular thoughts, feelings, or behaviours linked to schizotypy are characteristic of them. The SPQ was inspired by a categorical approach, constructed to mirror the three main symptom clusters present in schizophrenia: Cognitive-Perceptual (positive symptoms), Interpersonal (negative symptoms), and Disorganised (cognitive symptoms). By reflecting the symptoms of schizophrenia, the questionnaire is intended to identify those who share schizophrenic symptoms, and to indicate a person's risk for developing schizophrenia. In contrast, the O-LIFE was developed as a research tool based on a dimensional approach to understanding schizotypy (Mason, Claridge & Jackson, 1995; Grant, Green & Mason, 2018). The questionnaire was developed by first combining multiple questionnaires assessing all aspects of schizotypy and related personality traits (e.g. psychoticism and neuroticism; 420 items in total). Exploratory factor analyses then revealed four factors that reflect aspects of psychotic experiences (Unusual Experiences); social functioning (Introvertive Anhedonia); emotional and attentional difficulties (Cognitive Disorganisation); and impulsivity problems (Impulsive Non-conformity; Mason & Claridge, 2006). While the O-LIFE is a well-established measure used in the schizotypy literature, there is mixed evidence for the validity of the proposed four-factor structure, with some researchers questioning whether Impulsive Non-conformity should be considered part of the constellation of schizotypal traits (e.g., Kwapil & Chun, 2015).

The two questionnaires may be motivated by different theoretical perspectives, but do in fact measure very similar constructs. Positive schizotypy is reflected in Unusual Experiences and Impulsive Non-conformity in the O-LIFE and the Cognitive-Perceptual factor in the SPQ; negative schizotypy corresponds to Introvertive Anhedonia in the O-LIFE and the Interpersonal factor on the SPQ, and disorganised schizotypy is reflected in the Cognitive-disorganised factor of the O-LIFE and the Disorganised factor of the SPQ.

These two questionnaires are simply two examples of questionnaires utilising either a dimensional or a taxonic perspective. More recently Kwapil and colleagues have developed the Wisconsin Schizotypy scale, which most closely aligns with a dimensional perspective, and builds on the work done by Mason and Claridge and colleagues (Kwapil, Barrantes-Vidal & Silvia, 2008).

Most studies that explore relationships between schizotypy and other variables use a dimensional approach, correlating particular factors of one measure (either the SPQ or O-LIFE) to specific outcome measures in a sample of participants. For example, a number of studies have found associations between personality traits (including schizotypy; Ross, Lutz & Bailley, 2010; Chmielewski, Bagby, Markon, Ring & Ryder, 2014), and psychological well-being (Abbott & Byrne, 2012; Unterrainer & Lewis, 2014). In recent years a statistical approach known as latent profile analysis (LPA) has been developed that can identify sub-groups in a heterogeneous population, and therefore is a good tool to help identify a distinct latent class or profile as proposed by taxonomic theories (Oberski, 2016). The approach allows researchers to identify sub-groups of people based on their combinations of schizotypal traits, and then determine if sub-group membership meaningfully predicts some outcome. For example, Fonseca-Pedrero and colleagues (Fonseca-Pedrero, Ortuno-Sierra, de Albeniz, Muniz & Cohen, 2017) used LPA to identify four groups of people based on their scores on subscales of the SPQ. Consistent with a taxonic perspective, those in the "high schizotypy" group, who had consistently high scores across all three factors, were also highest on a number of measures of mood disorder and mental distress, suggesting they were at higher risk of schizophrenia.

Other researchers have used LPA to identify cognitive processes associated with schizotypy. Hori and colleagues (2014) observed three latent profiles in participants' self-report of schizotypal traits: those who scored high on all three subscales (high schizotypy/maladaptive group), those who scored low on all three subscales (low

schizotypy/adaptive group) and those with high scores on positive schizotypy only (high positive schizotypy/adaptive group). These different profiles predicted performance on other, cognitive tasks. For instance, the high positive schizotypy (adaptive) group showed significantly better performance in a working memory task compared to either of the other two groups. The high positive schizotypy group also performed better in visual memory than the other two groups.

With respect to creativity, a dimensional approach predicts that schizotypy (or a particular factor of schizotypy) will be correlated with creativity. However, a traditional factor-driven approach does not allow for the possibility there are qualitative differences between subgroups on some outcomes. Using LPA, it is possible to establish smaller homogeneous sub-groups based on schizotypy scores, and determine whether there are differences in creative performance based on profile membership. Despite its potential value, LPA is still relatively rare in schizotypy research, with only 9 studies reporting its use, and none that examine creativity (Cella et al., 2013; Fonseca-Pedrero et al., 2017; Hori et al., 2014; Tuchman-Tabak & de Mamani, 2013; Denovan et al., 2018; Ford et al., 2018; Fonseca-Pedrero, Ortuno-Sierra, Muniz & Bobes, 2019). Both a latent profile approach and a dimensional approach have potential value in understanding creativity in schizotypy, and therefore I will use both approaches in this thesis.

Defining Creativity

Creativity is a complex, multi-faceted process that almost defies definition. However, its value in every aspect of our daily lives is indisputable. While creativity clearly is demonstrated in inherently artistic or explicitly creative tasks, it also has value in other disciplines; for example, we are heavily reliant on creative innovation “as a powerful propellant for social transformation and economic growth” (Shneiderman, Fischer, Czerwinski, Myers & Resnick, 2005, cited in Zeng, Proctor & Salvendy, 2011). While people often intuitively recognise creativity when they see it, it is very likely that this intuition varies a lot from person to person, and from group to group. Evaluations of creativity are also inherently socially/culturally dependent. When we define and evaluate creative work, our specific cultural lens and societal views guide us in that process (Leung, Maddux, Galinsky & Chiu, 2008). The subtle differences in how we define creativity change the way we evaluate creative ideas/products.

Despite this conceptual murkiness, there appears to be some agreement (perhaps implicitly) on the characteristics of creative success. For example, Hennessey (1994) found relatively good agreement amongst people on which ideas were more or less creative. The 'standard' definition of creativity commonly used dictates that a creative idea must be highly original/novel (Barron, 1955; Stein, 1953; Runco & Jaeger, 2012). In addition, it also needs to be useful. For example, the disorganised speech of someone who is acutely psychotic is often highly original, but not useful and therefore not creative (Runco & Jaeger, 2012). Usefulness can be defined in terms of productivity (i.e. having economic value) and/or aesthetics (i.e., given value by society). In addition, other definitions require that a creative idea must also be remote and surprising to the observer. Remote implies that an idea is out of the normal realm of possibility (Silvia, Nusbaum, Berg, Martin & O'Connor, 2009). The working definition of creativity I use in this thesis incorporates aspects from several different definitions, as described by Silvia and colleagues (Silvia & Willse, 2008). Creativity here is defined as the ability to generate and evaluate original ideas that are considered remote, surprising, and useful or of value in the current context.

Measuring creativity

While there are some consistent themes in how people define creativity, creative assessments vary widely. A major distinction in measurement approaches is between those that ask people directly about aspects of creativity (self-report measures) and those that ask people to demonstrate their creativity in some way (performance-based measures).

Self-report. Self-report measures can be divided into three broad types: creative achievement measures, creative behaviour measures, and personality trait measures.

*Achievement questionnaire*s. Creative achievement questionnaires ask people to report their creativity-related achievements. The Creative Achievement Questionnaire (CAQ; Carson, Peterson & Higgins, 2005) measures self-reported achievement in ten different creative domains, including various artistic categories, science and technology, and humour. Evaluative studies have shown the questionnaire has good internal reliability (alpha = .96) and test-retest reliability (.81). It also shows good convergent and discriminant validity. Scores on the CAQ positively correlate with other self-report measures of creative personality (.33) and measures of originality and flexibility from performance-based measures (.32 and .34 respectively; Carson et al., 2005). It also distinguishes artistic from

non-artistic students (Vellante et al., 2011); furthermore, scores are not related to general academic achievement (Hirsh & Peterson, 2008).

Creative achievement is a useful proxy for creativity that is relatively easy to define and measure. An individual's self-report of their objective achievements are likely to be more accurate than more subjective measures, such as personality (Silvia, Wigert, Reiter-Palmon & Kaufman, 2012). A significant disadvantage, however, is that achievement captures a very narrow conceptualisation of creativity; only behaviours that have gained recognition within society are deemed creative. This criterion excludes many significant creative people who might never gain recognition for their creative ability (including Vincent Van Gogh, at least in his lifetime). This is evident in the data; CAQ is commonly atypically distributed, with a skew towards lower scores, as relatively few people in the general population receive any acclaim for their creative work.

Creative behaviour questionnaires. Creative activities questionnaires ask to what extent people participate in creative activities in their everyday life. The Creative Behaviour Inventory (CBI; Hocevar, 1979) contains a list of various creative activities (e.g. *designed a costume/textile*) and assesses the number of creative activities performed within a certain time period. Creative activities correlate with personality traits linked to creativity (such as openness to experience) as well as with self-rated creativity (Dollinger, 2007 and Wigert et al., 2012 both cited in Jauk, Benedek & Neubauer, 2014). These scales have the benefit of acknowledging creativity in all aspects of our lives. While self-reported creative activities questionnaires consider a much broader conceptualisation of creativity than the creative achievement questionnaire, they still rely on a person's judgement of what is creative. Furthermore, similar to the CAQ the data are commonly skewed towards lower scores. Both types of questionnaire also focus on the end result, and therefore do not give any insight into how the creative process unfolds.

Personality trait measures. Personality measures do not directly assess creativity per se; rather they assess personality traits that are linked with creativity. The Creative Personality Scale (CPS; Gough, 1979) consists of a subset of items from Gough's adjective checklist, and identifies a number of them that are associated, either positively or negatively, with being creative. The scale was developed by working with a large sample (1700 participants) in which creativity had already been assessed with a range of self-report and performance measures. Participants then indicated which adjectives described

themselves, to identify those adjectives that best discriminated creative and non-creative people. Kaduson and Schaefer (1991) administered the CPS to a group of high school students, and then followed up with the same students 25 years later. They found that initial scores on the CPS in adolescence predicted higher scores on a battery of creativity tasks in adulthood. However, beyond this study there is limited information about the reliability and validity of this questionnaire.

Self-report measures provide several advantages. On a practical level, once developed they are easy to administer and relatively easy to score. They also typically have good face validity and good convergent/discriminant validity. However, there are some important disadvantages. Any self-report questionnaire will be subjective and scores will somewhat depend on an individual's interpretation of the items. People also vary in their degree of insight into their own personality or behaviours. This is particularly problematic with a scale like the CPS, when the creative traits are clearly more positive (e.g. wide range of interests, self-confident, etc.) than the non-creative traits (e.g. narrow range of interests, cautious).

Proxy-measures of creativity. Some creativity measures do not directly assess creativity, but instead measure ways of thinking or qualities that are arguably prerequisites for creative thinking. These tasks could be described as 'proxy' measures of creativity, as they do not directly assess creativity. A commonly used proxy measure is the figure preference task. In this task, participants are shown a complex or simple figure and asked to judge which they prefer. The assumption is that people who are more creative will pick the more complex figure. However, there are several problematic assumptions with this approach. First, it assumes that creative products are inherently more complex. In reality, many truly creative ideas are elegant, minimal solutions that make you think, 'how did I not think of that! It's so simple!' Secondly it assumes that the creative mind will automatically prefer more complicated things (which given the previous observation, is unlikely to be true). Finally, this type of task is likely more prone to biases in responding (i.e. people who like to consider themselves creative are easily able to respond so as to make themselves look creative).

Performance-based measures. Personality- and achievement-based measures view creativity as successful implementation of a series of stable cognitive processes into a final product/outcome.

Performance-based measures, on the other hand, often capture the types of thinking that are important for creating those products. These processes can be broadly categorised as *divergent* thinking, which involves the generation of many novel ideas, and *convergent* thinking, which requires the evaluation and elimination of possible solutions to select the optimal one. There are a number of different performance measures, with most tasks focussing on different aspects of creative thinking.

Torrance test of creativity. The Torrance Test of Creative Thinking (TTCT; Torrance, 1974) is a battery of creative tasks that reflects multiple facets of creativity. There are two versions of the TTCT: a verbal form and a figural form. In both versions, tasks require both idea generation and idea evaluation. Some tasks are more process-driven (i.e., they tap creative thinking) while some are more product-driven (i.e., they evaluate success in producing a creative result). As the battery assesses divergent thinking it is only a proxy for creative thinking (Kim, 2006).

Instances task. The instances task is an example of an adapted version of a verbal TTCT sub-test. In this task, the participant generates different instances of items that have a common feature, e.g. instances of things that are round. The task requires simultaneous generation and evaluation of ideas, to make sure each idea fits the criteria.

Alternate uses task. The Alternate Uses Task (AUT; Guilford et al., 1960, cited in Dippo, 2013, also known as the unusual uses task) is one of the most commonly used tasks from the TTCT; it is also often used as a standalone measure of creativity. Like the Instances task, it requires the generation of multiple ideas. In the AUT, the participant generates multiple new uses for an everyday object, such as a paper clip or a ping pong ball. The way this task is implemented varies considerably; in the specific item used, the number of items used, as well as the outcome measures (Kim, 2006).

The AUT is widely used in the creativity literature. However, the way in which success is measured varies widely, leading to several potential dependent variables. The primary measures used are fluency, flexibility, and originality. Fluency is one of the more consistently applied outcome measures, usually calculated as the number of uses generated. Flexibility is most commonly used as a supplementary measure related to creativity/originality and is usually defined by the number of category shifts in the uses given by the participant. For example, a person might generate the following uses for a ping pong ball: table tennis, jewellery, necklace, container. These four items fall into three

distinct categories; greater flexibility is reflected in more category shifts. While fluency and flexibility are commonly used, the most common and arguably the most important outcome measure is originality. Originality can be broken down into objective and subjective measures.

Objective originality/statistical frequency. Some researchers measure originality as the frequency of each response within the sample overall. Objective measures have the benefit of ensuring consistent measurement across the sample; reliability is much higher than in subjective scoring methods, allowing for better comparisons across samples. It is also not overly resource-intensive to implement, as the scoring can be done by one person. However, it assumes that a unique response is always more creative, and so often classifies bizarre, random or inappropriate uses as original. This is a problem, because most definitions of creativity value usefulness highly.

Subjective originality. Subjective ratings of creativity are most common. Subjective ratings require the research team to develop a set of criteria to judge the creativity of an idea. Most definitions revolve around the principles of usefulness, originality, and remoteness to the original concept. Then all uses are scored (most commonly on a scale of 1 to 3 or 1 to 5) by multiple scorers (typically from 2 to 6).

Advantages and disadvantages of subjective scores of creativity. One important concern in creativity research is validity of measurement. According to research comparing scoring methods, subjective scoring methods increase the validity of creativity ratings, relative to objective scoring methods. The argument for this is two-fold. Subjective scoring methods have better face validity, i.e. ratings more accurately reflect the true essence of creativity, which at its core most humans are able to recognise, if not explicitly describe (Silvia, 2011). Secondly, they have better construct validity, as ratings are better able to capture the multi-faceted nature of creativity. Raters can score an idea based on multiple features, balancing the originality, usefulness, and remoteness of an idea, as well as features that are difficult to quantify such as the feeling of surprise that a particular use might generate.

The strength of subjective scoring methods, however, also means that there is significant variability in their implementation. Even when using the exact same instructions, different raters will interpret/prioritise aspects of the instructions differently. There are also multiple methods for computing total scores for subjective ratings, with two methods used

most frequently. The first is to derive an average creativity score for each participant. In this method, each idea that the person generates is scored, and the dependent measure is the mean creativity rating across all uses. The second method asks the participant to select their two most creative ideas. The creativity score for the participant is the mean of those two. This approach emphasises both the generation of creative ideas and the participants' evaluation of their own creativity.

Within both methods, however, there is still variability in how research groups score ideas. While most creativity definitions focus on the same key qualities, the way these are evaluated can vary considerably (Silvia & Wilse, 2008). Moreover, very few studies provide sufficient detail about their scoring procedures, or indicate what types of ideas or uses would score low or high. While subjective scoring methods have many advantages, it is a resource intensive process compared to statistical frequency or other objective measures.

Remote Associates Task. Other creativity tasks have objectively correct answers, making them simpler to score. In the Remote Associates Task (RAT; Mednick, 1962), the participant is presented with three words, and their task is to generate a fourth word that is an associate of all three, a process that requires good convergent thinking (Cropley, 2006). While the original generation of these items is fairly research intensive, once the items are developed, accuracy can be used an objective dependent measure.

Advantages and disadvantages of performance tasks. Some researchers have challenged the validity of creative performance tasks. According to Simonton (2003; cited in Silvia & Willse, 2008), they do not meet the basic criteria that most psychometric tests are expected to fulfil in terms of divergent validity (often not separable from intelligence), convergent validity (correlate very weakly with each other), and predictive validity (often do not predict creative behaviour). Silvia and Willse (2008) disagree, claiming that the validity in the AUT is better than Simonton claimed. They compared scoring criteria for multiple divergent thinking tasks, including the AUT, and found that divergent thinking tasks have good convergent validity, in that they strongly relate to measures that are highly correlated with creativity like openness to experience. They also correlate strongly with creative behaviour and creative personality (viewing of oneself as a creative person).

Silvia and Willse also compared these tasks in terms of reliability. Reliability was measured using generalisability analysis, which is a good measure for estimating both how consistently items are rated, as well as how consistently different raters score the same

items. These scores, known as dependability scores, range from 0 to 1, with 1 reflecting high reliability. Table 1.1 compares these tasks by dependability scores. Overall, reliability increases when using an average scoring method, and with multiple raters (with five raters being the best). The unusual uses task was also the most reliable task out of the three divergent thinking tasks considered.

Table 1.1. Dependability scores in multiple Divergent Thinking tasks under different scoring conditions.

Scoring method	Number of Raters	Unusual Uses Task	Instances Task	Consequences Task
Average	1	0.70	0.73	0.54
	3	0.87	0.89	0.78
	5	0.92	0.93	0.86
Top Two scoring	1	0.58	0.55	0.49
	3	0.81	0.78	0.74
	5	0.87	0.86	0.83

Reliability in convergent thinking tests is also good. For example, Lee, Huggins, and Therriault (2014) tested the internal reliability of 30 commonly used RAT items and found good internal reliability (Cronbach's alpha = .82).

Creativity likely reflects the effective combination of multiple processes. Most performance-based creativity tasks will reflect a few of the processes crucial to creative success. Questionnaires that reflect creative behaviour or creative achievement may better reflect "real world" creativity, but are likely confounded by a number of social factors, such as previous experience and opportunities to be creative. Therefore, performance-based tasks should not perfectly predict creative behaviour or creative achievement, but may still be better suited to identifying the cognitive processes that support creative thinking.

It is likely that the same cognitive systems generate all cognitions, whether creative or non-creative. That is, creative thought does not require different cognitive processes to non-creative thought; rather, it requires cognitive processes (and their associated brain networks) to work together in specific ways to achieve creative outcomes. By understanding how these processes are important to creativity, we can better understand their value in

other contexts. Furthermore, by identifying and understanding these processes, we can identify and explain individual differences in creativity.

Creative processes: divergent/convergent thinking.

Creativity appears to be a balance of *divergent* and *convergent* thinking styles (Runco, 2015). Divergent thinking involves generating multiple ideas; there is no one correct response. Divergent thinking is often associated with creativity; it is an important starting point in creative endeavours. Many of the creativity tasks frequently used in the literature, such as the AUT, measure divergent thinking (Cropley, 2000).

In contrast, convergent thinking is the process of narrowing down a series of generated ideas to one that best fits your current requirements. A task that demonstrates this well is the Remote Associates Task (RAT); success in this task relies on the efficient evaluation of lots of options to reach one final answer. Convergent thinking is more effective in situations in which a correct answer exists. Convergent thinking relies on successfully manipulating existing knowledge to generate further knowledge (Cropley, 2006).

If a person excels in both divergent and convergent thinking, they can be both flexible (i.e., open to new ideas), as well as practical and considerate about their selection and implementation. Both divergent and convergent thinking styles are important when considering overarching theories of how creative thinking works, and when designing tools to measure creativity. While they may be distinct processes, the tasks designed to measure them are not process-pure. While the AUT relies more on divergent thinking and the RAT on convergent thinking, both processes are involved in both tasks. For example, when generating ideas for the AUT, the person will likely be evaluating their ideas before writing them down. The notion of divergent thinking and convergent thinking are very influential in creativity research, and their influence is felt in theories of creativity.

Theories of creativity

Contemporary theories of creativity fall into one of three main camps: associative processing theories, executive control theories and dual process model theories.

Associative processing theories of creativity

Mednick (1962) put divergent thinking at the heart of his theory of creativity when he proposed that highly creative people differ in the way semantic information is organised and accessed in memory. Mednick proposed that highly creative people have diffuse

semantic networks in which many concepts are linked; in contrast, less creative people have more localised networks in which only a few common associations are represented. Through the process of spreading activation (Collins & Loftus, 1975), highly creative people would therefore generate more related (and more-distantly related) ideas than less creative people. Based on this theory, Mednick predicted that performance on word association tasks would discriminate between high and low creative people. Specifically, he predicted that in highly creative people, activation would spread widely in semantic networks,

allowing them to generate more remote words in response to a target than less creative people. For example, when given a word association task in which people are asked to list words related to the target word 'table,' a less creative person would be more likely to demonstrate a *steep associative hierarchy*, generating several highly semantically related words (i.e. much more obviously linked) such as '*leg'*, and fewer remotely associated words, such as *food*. In contrast, highly creative people would be predicted to show a *shallow associative hierarchy*, generating a more even distribution of close and distant associates.

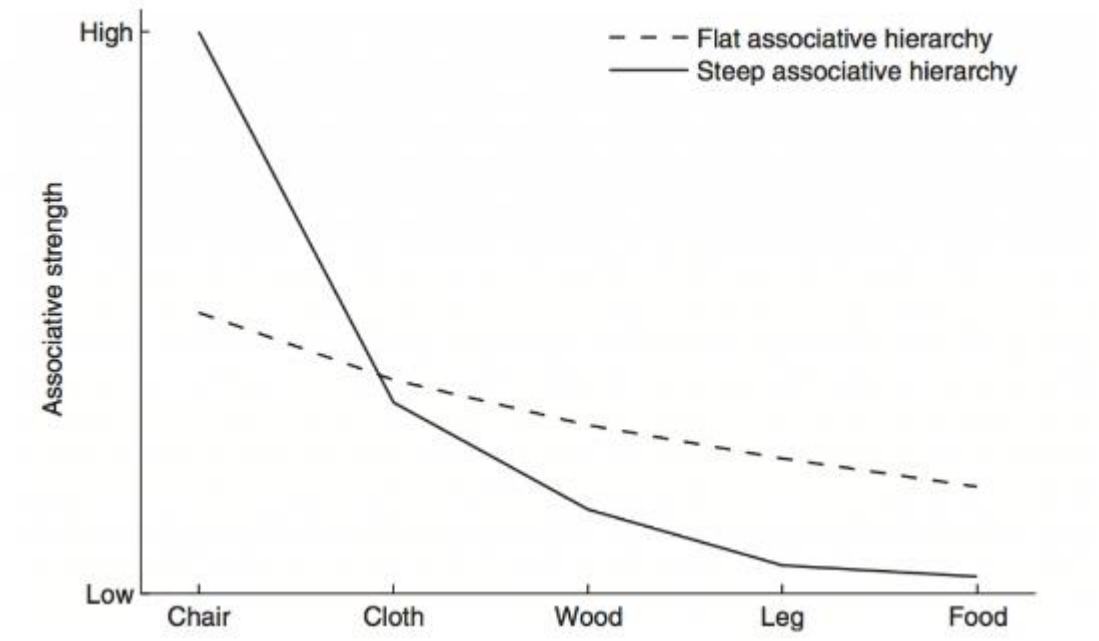


Figure 1.1. Mednick's illustration of an associative processing account of creativity (Mednick, 1962). The graph shows hypothetical steep and shallow associative hierarchies, associated with low and high creativity, respectively

Mednick's predictions are illustrated in Figure 1.1 (Mednick, 1962) for responses to the word association task. As can be seen in this figure, non-creative people might generate one or two obvious words (such as *chair* and *cloth*) with a much higher frequency than highly creative people. A highly creative person, however, might generate more distantly related words such as 'food.' Highly creative people should demonstrate flatter associative hierarchies in response to the target words compared to people who are less creative.

Mednick and colleagues (Mednick, Mednick & Jung, 1964) partially tested this theory by assessing whether creativity predicts the number of uncommon words generated during a Word Association Task (WAT) overall, as well as the rate at which participants generate them. In order to assess creativity, they asked participants to complete a series of Remote Associate Problems. They found that better performance on the RAT was associated with more uncommon responses in the word association task. People also differed in the rate at which they generate words, with highly creative people generating new words more quickly.

However, Mednick and colleagues did not fully test the theory (Benedek & Neubauer, 2013). They reported only the extent to which people generated uncommon responses, but did not test a second prediction of the theory: that highly creative people should generate *fewer* common responses than less creative people. Moreover, the original finding does not always replicate. For example, Olczak and Kaplan (1969) found that people who had a high RAT score did not give more uncommon responses in the WAT than people who had a low RAT score.

To fully test the theory, Benedek and Neubauer (2013) did a follow up study where 150 participants completed a word association task, freely associating responses to six words for 60 seconds each. Participants produced approximately 13,000 responses in total. Benedek and Neubauer based their methodology on Mednick's work. Mednick described the association hierarchy as the set of most common associative responses to a particular word. They then identified the top ten most common responses to the target word in the entire sample and calculated their associative strength (i.e. how frequently they were identified in the entire group). From this, they can calculate the uncommonness of an association (1-frequency), i.e. a response with an associative strength of .65 would have an uncommonness score of .35. Mednick's theory would predict that more creative people should have a higher uncommonness score.

They then split participants into high and low creative groups based on a number of creative tasks (AUT, a self-report creative behaviour scale, and an explicit question asking about their creativity), and compared them based on how frequently they generated one of these top common responses. They found that the high creative group and the low creative group did not differ in their rate of responding. The high creative group was also no more likely to generate uncommon words than the low creative group.

One concern with this study is the reliance on measuring associative strength relative to the ten most frequent responses of the group. Differences between high and low creative people may only be evident when looking at more remote/unique associations (Benedek & Neubauer, 2013). To address this concern, other studies have used different methods to assess the associative strength of responses given in a word association task that are independent of sample size. Prabhakaran and colleagues measured associative processing using a verb generation task that is designed to study semantic processing (Prabhakaran, Green & Gray, 2014). Rather than measure the uncommonness of responses within the sample (like Benedek and Neubauer) they calculated the semantic distance of each response to the target word using a large corpus of text for comparison, creating a score that reflects the strength of the word association in natural language across common usage, rather than just to individual items and in relation to the sample. In addition, all participants completed an abbreviated version of the Torrance test of creative thinking. Using this slightly different measure of associative strength, they found that the extent to which participants generate unusual words positively correlated with performance on the two figural creativity tasks (the picture completion task and the picture construction task).

Overall, there is some support, if rather inconsistent, for an associative processing account of creativity. Some of this variability in findings likely depends on methodological differences in how associative processing differences are scored and how low and high creativity groups are defined. Evidence from the associative processing literature suggests that having diffuse semantic networks is important in accessing novel information when generating ideas. However, while generating many unusual or remotely related ideas is undoubtably a key component of creativity, this process is only valuable if there is some way to evaluate the usefulness and value of these ideas in a specific context. Associative processing may therefore be necessary, but not sufficient, to explain creativity.

Executive control/intelligence and creativity.

Other theoretical accounts state that individual differences in creativity stem from differences in intelligence and executive control.

Intelligence and creativity. A number of studies have found a relationship between creativity and intelligence. (e.g., Kim, 2008; Benedek, Jauk, Sommer, Arendasy & Neubauer, 2014; Jauk, Benedek, Dunst & Neubauer, 2013; Benedek, Konen & Neubauer, 2012). Intelligence also moderately correlates with cognitive indicators of creativity, e.g., tasks that tap into convergent thinking like the Remote Associates Task. There is also a small but significant positive correlation between IQ and the self-report Creative Achievement Questionnaire (Jauk et al., 2013).

However, it has been suggested that intelligence is a necessary but not sufficient condition for creative ability (Guilford, 1967). An early study by Guilford found a positive correlation between IQ scores and creativity, but only within the low-average IQ range. This suggests, beyond a certain threshold, intelligence does not further one's creative potential. Jauk and colleagues replicated this effect more recently (2013); there was no relationship between originality scores in a divergent thinking task and intelligence beyond an IQ of 120. Overall, there is good evidence that intelligence is important for creative performance. However, intelligence itself is very difficult to define, and, like creativity, reflects the coordinated activity of multiple cognitive processes. Thus, correlations between intelligence and creativity suggest that they may share underlying cognitive systems, but do not tell us what specific cognitive processes or interactions are important.

Executive functioning and creativity. Executive functioning is a blanket term for a set of processes that configure other cognitive systems so that we can achieve our goals (Banich, 2009). According to Miyake and Friedman (2012), executive functioning can be broken down into three main domains: updating, shifting, and inhibition. Updating refers to the monitoring and editing of information in memory. It is typically measured using memory span tasks in which one is required to hold information in mind while solving a problem, such as math calculations. The task requires a person to continually update the information held in mind while they solve the math problem. Inhibition refers to the ability to inhibit a pre-potent process in favour of another, more goal-relevant process. Shifting refers to the ability to switch from one task or set of processes to another (Miyake & Friedman, 2012).

Are all executive functioning processes equally important for creative thinking? Benedek, Jauk and colleagues (2014) found that creative ability (as measured by multiple

divergent thinking tasks) is correlated with updating and inhibition, but not shifting, suggesting that these two processes may be more crucial in creativity. The following section will review the literature linking first cognitive inhibition, and then updating/working memory, to creative performance.

Cognitive inhibition and creativity. Cognitive inhibition could serve an important function at the evaluation stage of the creative process. According to spreading activation theories of semantic memory, after the initial activation of semantic concepts, inhibition is required to select goal-relevant concepts. In order to empirically test whether cognitive inhibition is important for creativity, Benedek, Konen & Neubauer (2012) asked participants to complete a Random Motor Generation task (RMG), which requires participants to generate random sequences of key responses at a consistent rate. This task requires that participants inhibit all previously used sequences in order to keep generating new sequences. They found that RMG performance positively correlated with AUT fluency. They also measured intelligence using a standardised German language intelligence battery (the Berlin-Intelligence-Structure Test; BIS). While cognitive inhibition was positively linked to *fluency*, intelligence was positively linked to *originality*. This suggests that aspects of executive functioning play different roles in creative processing. Cognitive inhibition is useful in discarding irrelevant or unoriginal responses, while intelligence enables the generation of more original responses.

One way to test the role of cognitive inhibition in creativity is by measuring creativity in a group of participants who show deficits in inhibition. People with Attention Deficit-Hyperactivity Disorder (ADHD) typically show deficits in aspects of executive functioning, including working memory and response inhibition (Slaats-Willemse, Swaab-Berneveld, de Sonneville, Van Der Meulen & Buttelaar, 2003). If executive processes are essential to creativity, then people with ADHD would show worse performance in creative problem solving tasks.

White and Shah compared participants diagnosed with ADHD to healthy, matched controls (White & Shah, 2006). All participants completed two creativity tasks: the RAT and the AUT. To measure inhibitory control, participants completed a semantic inhibitory control task. Participants are presented with a word (e.g. *tiger*) that represents a semantic category (animals), followed by a second word from a different category (e.g. *pen* from the category writing tools). Finally, a third target item is presented that is either related or

unrelated to the initial category of animals, and participants determine whether this is a word or a non-word. Participants who struggle to inhibit the previously unrelated category word *pen* will take longer to judge whether the target is a word or non-word. As expected, participants with ADHD were worse at inhibiting unrelated responses in the semantic inhibitory control task and they performed badly on the RAT compared to controls. However, they performed *better* than the control group on the unusual uses task. This finding suggests that strong inhibition may facilitate convergent thinking, but impair divergent thinking (or conversely that weak inhibition my impair convergent thinking but facilitate divergent thinking)..

Radel, Davranche, Fournier and Dietrich (2015) tested this hypothesis directly by impairing people's ability to use cognitive inhibition during a creative task (Radel et al., 2015). Participants completed a very difficult flanker task to exhaust their inhibitory abilities. They then immediately did a divergent (AUT) and a convergent (RAT) thinking task. Completing a flanker task before a creativity task improved fluency and flexibility, but not originality, on the AUT, suggesting that cognitive inhibition may cull unoriginal/irrelevant ideas early on in the process of idea generation, as concepts are being activated in semantic memory. Taken together, these findings suggest that reduced cognitive inhibition facilitates the production of ideas, as well as switching between themes when generating new ideas. Intelligence facilitates generating more original ideas.

Working memory and creativity. Working memory is an active memory system used to access task-relevant information while performing cognitive tasks (Baddeley, 2011). Working memory relies heavily on a person's updating ability, as efficient updating ensures that information kept in working memory is still relevant for one's goals. Active maintenance of information relies on both domain-specific storage and rehearsal processes, as well as domain general executive attention processes (Conway et al., 2005).

People's ability to hold information in mind varies considerably. There are several ways to measure working memory capacity The prototypical working memory task, the n-back, was constructed by Kirchner in the 1950s (Kirchner, 1958). In this task, participants are presented with a sequence of stimuli one-by-one. For each stimulus, the participant makes a judgement as to whether the current stimulus is the same as the one presented X number of trials previously. The n can be 1, 2, 3 trials, or even more. The greater the number of trials that must be tracked, the more difficult the task becomes.

Other more recently constructed working memory tasks, known as complex span tasks, require the participant to hold one sort of information in memory while manipulating another set of information in a secondary processing task. The reading span task, for example, requires a participant to make judgements about a series of sentences, and then recall the last word of each sentence. People must therefore be able to hold the final words in memory while also engaging the cognitive processes necessary for language processing. The complex span task reflects the dual nature of Baddeley's model of working memory, which outlines a storage component and a central attentional control system (Mathy, Chekaf & Cowan, 2018). There are multiple complex span tasks that utilise different types of information (e.g. auditory, verbal, spatial, etc).

Working memory span performance should predict cognitive behaviour in a variety of different domains, including creative problem solving (Conway et al., 2005). The ability to hold information in mind is crucial for successful completion of cognitive tasks, including creativity tasks (De Dreu, Nijstad, Baas, Wolsink & Roskes, 2012). The working memory system allows one to weigh up different ideas while working on a task in real time (De Dreu et al., 2012). Working memory capacity seems particularly crucial for convergent thinking creativity tasks like the RAT, where one has to keep multiple pieces of information in memory while evaluating many possible responses (Rosen & Engle, 1997 cited in Ricks, Turley-Ames & Wiley, 2007). WM consists of domain general executive attention skills that likely help creative problem solving through focusing of attention, resisting distraction, and narrowing down the search space in a creative task (Wiley & Jarosz, 2012).

Individual differences research has shown support for a relationship between working memory and creativity. De Dreu and colleagues (De Dreu et al., 2012) found a small but significant positive correlation between working memory capacity and performance on the RAT. Benedek and colleagues (2014) also found that working memory (as measured using multiple N-Back tasks) positively correlated with divergent thinking creative tasks. Other researchers have experimentally manipulated working memory load (to reduce available capacity) and assessed the impact on creative performance. Participants performing under high working memory load solved fewer RAT problems (De dreu et al., 2012).

While some studies have found that working memory is implicated in creativity, other studies have not observed this relationship. A paper by Smeekens & Kane (2016),

using multiple samples and multiple measures of divergent thinking found that working memory capacity was not correlated with creativity. Sharma and Babu (2017) also failed to find a relationship between working memory capacity and divergent measures of creativity in a group of middle-older aged adults. One possible explanation for these discrepancies is that working memory is only helpful in some situations, e.g. when engaging in tasks like the RAT, which requires the person to keep a number of words active in working memory as they work towards a solution.

Summary. Overall, cognitive inhibition and working memory both appear to be important in the creative process, but in different ways. Cognitive inhibition allows for the pruning back of less relevant ideas, and also prevents jumping from one idea to another too quickly. Working memory capacity, however, appears to be more important for holding information that is deemed important for the task in memory, allowing for more original ideas, and for more effective solutions to tasks like the RAT to be found. This suggests that the relationship between executive processes and creativity goes beyond a straightforward executive control account of creativity.

Dual process accounts.

Inspired by the two systems approach of Kahneman (Kahneman, 2011) dual process models of creativity incorporating both associative processing and executive control have gained momentum. While multiple versions exist, most dual process accounts are variations on the same theme: there are two processes associated with creativity: associative processing – a faster, more automatic process - and executive processing - a slower, more controlled process. Where accounts differ is in how these two systems interact.

Sowden and colleagues (2015) describe a two-phase model with associative processes engaged in the initial, idea generation phase and executive control engaged in the secondary, evaluation phase. The interaction of associative processing and executive control may explain some of the inconsistencies in the associative processing/creativity literature, as diffuse associative processing in a creative task may only be useful when combined with good use of executive control. Similarly, a two stage version of a dual process model may explain some inconsistencies in the executive functioning literature. Successful creative thinking may rely on naturally integrating both associative processing and executive control.

Individual differences approach to a dual process model of creativity. Individuals may differ in the extent to which they rely more heavily on associative or executive control

processes when engaging in a task. For example, person A might be particularly strong in associative processing and therefore rely more on associative processing when engaging in creative tasks, whereas person B might be stronger in executive control and will therefore engage these skills more in creative tasks. These two hypothetical people would then perform differently in different types of creativity tasks; people with strong associative processing may excel specifically in divergent thinking heavy tasks, but not necessarily in convergent tasks that also require strong executive skills.

While a number of researchers have posed different iterations of the dual process model, few have explicitly tested it. A mediation analysis can explicitly test to what extent either associative processing or executive control may explain individual differences in creativity. However, using a moderation model will also see to what extent the relationship between associative processing and creativity depends on the ability to engage executive control, which is a strength of the current thesis.

Schizophrenia/schizotypy and creativity

Can these theoretical models of creativity help explain associations between schizotypy and creativity? In this section, I will review evidence that 1) schizotypy is associated with creativity and 2) schizotypy is associated with the proposed cognitive processes (associative processing and executive processing) that might mediate such a relationship.

From a dimensional perspective, if schizotypy is associated with creativity, then schizophrenia should also be associated with creativity. Contrary to our preconceived notions about mental illness and creativity, a recent meta-analytic review including 42 studies (with a total of 200 effect sizes) found a small negative association between schizophrenia and creativity (Correlation coefficient $r = -0.324$; Acar, Chen & Cayirdag, 2018). However, the association depended on the status of participant (in-patient or out-patient), the severity of their illness (the more severe the stronger the negative relationship between schizophrenia and creativity) and on the type of creativity task. The association between creativity and schizophrenia was strongest when using fluency tasks, e.g. a letter fluency task, significantly weaker for divergent thinking tasks like the AUT, and weakest of all for tasks like the RAT.

Like schizophrenia, schizotypal traits are also associated with differences in associative processing but with much less severe cognitive deficits than are present in

schizophrenia (Fioravanti, Bianchi & Cinti, 2012). Eysenck (1993; cited in Holt, 2018) proposed that the ability to make remote associations underpins both schizotypal and creative ideation, leading to delusional thoughts in the context of psychopathology, and original thoughts in the context of creativity. Because of this proposed link, many researchers have predicted that those high in schizotypal traits will also be more creative (e.g., Eysenck & Furnham, 1993; Gianotti, Mohr, Pizzagalli, Lehmann & Brugger, 2001; Folley & Park, 2005, Wang et al., 2018). Exploring how schizotypal traits are relevant to creativity is important in understanding both the relationship between the two, but also in understanding what factors facilitate creative thinking. If schizotypal traits are positively or negatively associated with creativity, then the relationship should be supported by relationships with core processes of creativity.

Evidence for a relationship between schizotypy and creativity: Acar and Sen meta-analysis.

Despite conventional wisdom that schizotypy should be related to creativity, the empirical evidence is not entirely consistent. A meta-analysis by Acar and Sen (2013) compiled all 45 studies conducted between 1980 and 2012 that measured this relationship in any way. Overall, they found a small but significant correlation between positive schizotypy and creativity (r = .14) and a slightly smaller correlation between total schizotypy and creativity (r = .11), suggesting a small association between the two. However, there are some concerns that may affect the interpretation of these results.

A common problem in individual differences research, particularly in personality research within cognitive psychology, is that many studies are statistically underpowered. This is a problem because underpowered studies are more likely to produce false negatives (i.e., no correlation when there is a relationship), but also false positives (i.e., spurious correlations when there is no relationship; Button et al., 2013). If we assume that the true effect size (as indicated by the meta-analysis) is r = .14, then almost all studies included in Acar & Sen (2013) are underpowered. A G*Power analysis indicates a required sample of 314 participants in order to achieve 80% power to detect an effect size of 0.14, and yet the majority of sample sizes in the meta-analysis range from 27 to 222, with one outlying at 1108 (mean = 154). Correlation coefficient r effect sizes included in the meta-analysis ranged widely, from -.42 to .8.

The 45 included studies vary considerably in type of creativity task used (self-report, performance based), creativity scoring procedure, types of participants (undergraduate or postgraduate university students, healthy adult populations, eminent creatives, clinical populations, and scientists) and schizotypy measures (specific subscales, all subscales, research or clinically focussed). The meta-analysis did test some of these factors as potential moderators of the relationship (gender, measure of creativity (performance versus self-report), content of creativity (verbal, figural or both), creativity index (fluency, originality, or other), and schizotypy factor). Only schizotypy factor was significant, with positive schizotypy slightly more strongly correlated with creativity performance than any other sub-factor, or total schizotypy score. However, meta-analyses, just like individual studies, rely on adequate power to detect an effect, and it is likely that the current meta-analysis was underpowered for this number of moderators (Hedge & Pigott, 2004). This may have contributed to the decision by the authors to not include other useful moderators, such as creativity task, in order to determine whether schizotypy is differentially related to divergent versus convergent thinking.

Post meta-analysis review of literature.

To review the literature subsequent to the meta-analysis, I ran a general search using a database specific to Victoria University, Te Waharoa. Te Waharoa searches through a number of well-known databases, including but not limited to psychinfo, psycarticles and proquest (for a full list of databases included in Te Waharoa search, see appendix A). The terms “schizotypy” and “creativity” found 17 studies that tested the relationship between schizotypy and creativity from late 2012-November 2019. All these studies used well-established measures of schizotypy, and a mixture of self-report and performance based measures of creativity. Table 1.2 outlines sample size, creativity tasks used and a brief description of the main finding of each individual study. A notable change is that more recent research has greater statistical power than earlier studies, with most studies using much larger samples (*M* = 186), as well as methods to select for the tail ends of the normal distribution of schizotypal traits.

Notably, there are significantly fewer individual studies (7 out of 17) post-2013 that show a positive relationship between schizotypy and creativity. Out of these, the majority find an association with the positive schizotypy sub-factor. While there is significantly more

consistency in the literature in recent years, there is still a lot of variability in the association between schizotypy and creativity.

Table 1.2. Table outlining all articles that have tested the relationship between schizotypy and creativity from late 2012 to November 2019, in the period not covered by the Acar and Sen meta-analysis.

Article	Sample	Performance task?	Self-report task?	Main finding
Armstrong, 2012	114	Remote Associates Task, creative ideation task	Creative Personality Scale	Very tiny non-significant correlations between schizotypy and all creativity measures
Beaussart, 2012	708	NA	Creative activities self-report	schizotypy and creative activities positively correlated with each other
Fisher, 2013	69 (high and low scoring schizotypy)	Alternate uses task, figural creative ideation task (index score)	NA	Positive schizotypy correlated with creative ideation index score
Michalica & Hunt, 2013	31 artists, 10 schizophrenia diagnosis 30 control	Art evaluation task	Self-rated creativity	Artists were significantly higher on positive schizotypy compared to controls
Leboutillier et al,. 2014	133	Creative imagery task		Positive schizotypy positively correlated with creative imagery task, negatively

				correlated with originality score on imagery task
Rominger et al., 2014	40 (20 per condition)	TTCT picture completion task (sum of originality, fluency, elaboration, flexibility scores)	NA	No significant correlation between positive schizotypy and creativity
Park, 2015	48	TTCT - six verbal tasks and three figural tasks	NA	Brain activation associated with creative performance is negatively associated with higher levels of schizotypy
Le Boutillie et al., 2016	203	Alternate uses Task	Self-rated creativity	Positive schizotypy positively correlated with creativity (.30, .36)
Rominger 2017	46, representing scores across distribution (positive schizotypy)	Alternate uses task, one figural task of the TTCT Composite creative thinking index =	NA	Positive schizotypy was correlated with higher creative thinking (r = .34)

		originality and fluency scores for both tasks		
Mcribber & Silvia, 2017	204	NA	Creative Achievement Questionnaire, Biographical Inventory of Creative behaviours	does not actually report the statistics for schizotypy-creativity
Wang et al., 2017	117	2 Divergent Thinking tasks (alternate uses and figural completion), 2 insight tasks		High schizotypy group did better than low schizotypy and schizophrenia group on DT. Low and high schizotypy group had same performance on CT tasks.
Stanciu & Papasteri, 2018	229	Insight task	NA	There was a non-significant negative correlation between insight and schizotypy

Wang et al., 2018	388	Alternate uses task, other figural Divergent Thinking task	NA	High schizotypy group was marginally more creative in alternate uses task, more creative in other figural DT task
Polmer et al., 2018	182	Divergent Thinking task	Creative achievement	Positive schizotypy was positively correlated with achievement but not divergent thinking
Carter et al., 2019	156	Alternate uses task x3, two figural fluency tasks	Creative Achievement questionnaire	CAQ positively correlated with positive and disorganised schizotypy. No correlations between schizotypy and performance creativity measures
Gross et al., 2019	96	Figural fluency task from the Torrance Test of Creative Behaviours battery	Creative Behaviour Inventory and CPS	Ns correlation between magical ideation and fluency task (-.01) and small non-sig correlation between CBI and CPS and magical ideation (.16, .11)

Some of the variability between studies may be due to other methodological concerns. There is commonly a lack of transparency in the way that data are scored for creativity. The literature is also particularly at risk of false positives due to a high number of tasks or dependent measures per study. In many papers, there are multiple measures of various personality traits, multiple creativity tasks, and multiple dependent measures of creativity within each task. Furthermore, in many cases there is no evidence of corrections for multiple comparisons. These questionable research practices may further prevent solid conclusions about any relationship between schizotypy and creativity.

While the meta-analysis does provide an objective way of reviewing a large amount of research related to schizotypy and creativity, a meta-analysis is only as good as the individual papers that it summarises (Borenstein et al., 2009). Meta-analytic work is also prone to publication bias, as a lot of null results are left unpublished in file drawers, so it is difficult to determine whether the published literature is an accurate reflection of existing research or whether it is biased towards the publication of significant results, at the expense of null results. Problems with the included studies will bias the results of the meta-analysis and reduce how well it can summarily answer the question posed. Furthermore, a meta-analysis tends to ask a very broad question: is schizotypy related to creativity, which fails to identify any potential third variable that might mediate the relationship.

Schizotypy and Associative Processing.

A common explanation for a relationship between schizotypy and creativity is that high levels of schizotypy are characterised by flatter associative hierarchies, i.e. activation of more remote words (relative to frequent words) in semantic memory. The same pattern is also present in those diagnosed with schizophrenia, as evidenced by the remote associations and referential ideas commonly seen in schizophrenia (Bleuler et al., 1911 cited in Mohr et al., 2001; Kiang & Kutas, 2005). Typically, semantic networks connect a number of different, but related, concepts. When a particular concept is activated in memory, highly related concepts are also activated. Activation spreads from one node to another in a highly efficient manner. However, in people diagnosed with schizophrenia, activation does not spread efficiently from one closely related concept to another, but instead proceeds along new links and activates a much broader network of more-weakly related concepts (Kwapil, Hegley & Chapman, 1990). These differences in patterns of semantic activation are also reflected in patterns of brain activity revealed in EEG and neuroimaging studies

(Minzenberg, Ober & Vinogradov, 2002; Wang et al., 2013). A similar pattern of broad activation of semantic networks is evident in people who score highly on psychometric schizotypy. A number of different paradigms have been constructed to test semantic activation in healthy subjects; these fall into two main camps: semantic priming and category fluency tasks.

Semantic priming occurs when a response to a target (e.g. cat) is faster when it is preceded by a semantically related prime (e.g. animal) versus an unrelated prime (e.g. holiday). This priming effect occurs because the prime partially activates related words or concepts, leading to faster recognition. Faster recognition of related words is consistent with relatively greater activation of weaker associates and broader associative priming. A number of semantic priming studies have found increased priming in schizotypy (Pizzagalli, Lehmann & Brugger, 2001; Gianotti et al., 2001; Neill, Rossell & Kordzadze, 2014). Some studies, however, do not show this effect (Johnston, Rossell & Gleeson, 2008; Tan & Rossell, 2017).

An alternative method to assess associative processing is the category fluency task, in which a participant names as many items as possible from a certain semantic category in a limited time period, commonly 60 seconds. A number of studies have also used this approach to test differences in associative processing related to schizotypy. Some studies have found that category fluency tasks do reveal more diffuse activation of semantic information in memory based on schizotypal traits (Kiang & Kutas, 2005; Elvevag, Foltz, Weinberger & Goldberg, 2007), while some find no difference based on schizotypal traits (Tan & Rossell, 2017). Overall, there is some evidence to conclude that there are differences in semantic processing due to schizotypal traits; however, in both dominant methodologies there are still some inconsistencies in the literature.

Factor specific differences. Most studies focus on the relationship between associative processes and total schizotypy scores; very few focus on specific factors of schizotypy. Here the findings are also inconsistent, some studies find that disorganised schizotypy is linked with facilitated priming, (Neill et al., 2014; Kiang & Kutas, 2005) some find that it is not (Tan & Rossell, 2017). Overall, there is evidence, using multiple paradigms and multiple ways of assessing schizotypal traits, that schizotypy is associated with broader activation of concepts in memory, in ways that parallel evidence of thought disorder in those diagnosed with schizophrenia.

Schizotypy and Executive Control.

Schizotypy is associated with mild deficits across a range of executive processing domains (Ettinger et al., 2015), including cognitive inhibition (Kane et al., 2016), latent inhibition (Braunstein-Bercovitz & Lubow, 1998; Granger, Prados & Young, 2012) and working memory (Tallent & Gooding, 1999; Lenzenweger & Gold, 2000). However, there are some inconsistencies in the literature. In this section, I will outline the literature related to schizotypy and specific aspects of executive functioning.

Schizotypy and Cognitive Inhibition.

It is unclear from the literature whether high levels of schizotypy are associated with poor cognitive inhibition. For example, schizotypy has been reported to be positively correlated with interference on the stroop task (a common measure of cognitive inhibition) that is, people high in schizotypy show poorer inhibition (Moritz & Mass, 1997). However, similar studies have reported no significant relationship between schizotypy and cognitive inhibition (Green & Williams, 1999; Peters, Pickering & Hemsley, 1994; Moritz & Mass, 1997). Methodological differences between studies might explain some of the inconsistencies. For instance, some studies are underpowered (Peters et al., 1994; Moritz & Mass, 1997), and rely on only one measure of schizotypy or cognitive inhibition (Green & Williams, 1999). More recently, Kane and colleagues (2016) tested the relationship between cognitive inhibition and schizotypy in a highly powered study using multiple tasks to capture individual differences in cognitive inhibition. The use of multiple tasks is consistent with recommendations from a study by Hedge and colleagues (2017): a composite measure produces a better and more reliable indicator of cognitive inhibition. They found that people high on disorganised and paranoid schizotypal traits did show poorer cognitive inhibition compared to those who exhibited low levels of schizotypal traits.

Another possible explanation for the inconsistent findings could be differences in the measurement of cognitive inhibition in each of these studies. Inhibition can be broken down into two main types: cognitive and behavioural inhibition. A number of tasks that are used to measure cognitive inhibition reflect behavioural inhibition as well, and vice versa. For example, the flanker task requires inhibition of both the perceptual interference from the flankers (cognitive inhibition) and the pre-potent motor response (behavioural inhibition). The study by Kane and colleagues controlled for some of the variability seen within

inhibition tasks by creating a latent variable of cognitive inhibition that encompassed several typical cognitive inhibition tasks.

Inhibition also plays an important role in learning. For example, we use inhibition to help us ignore environmental stimuli that are irrelevant to our goals. This inhibition can be measured in the lab as latent inhibition – the tendency for a previously irrelevant cue to be harder to learn when it later becomes relevant (Lubow & Weiner, 2010). Multiple studies have shown that people high on schizotypy have reduced latent inhibition (Allan et al., 1995; Lubow & de la casa, 2002; Kaufman & Paul, 2014; for a review see Braunstein-Bercovitz, 2003), suggesting that they had not learned to inhibit the irrelevant cue. Poorer cognitive inhibition in schizotypy may result in much greater activation of remote concepts in semantic memory, leading to far more remote and original ideas when being creative. Inhibition might have differential effects on divergent thinking and convergent thinking; it might be good for convergent thinking tasks (helps with narrowing the search to appropriate responses) and might be bad for divergent thinking tasks (prevents more interesting, unusual responses from being considered).

Schizotypy and Working Memory.

People high on schizotypy also shows deficits in working memory. These effects, while relatively small, are reliable (Ettinger et al., 2015). People high on schizotypal traits show deficits in a number of different working memory tasks, including spatial working memory tasks (Park, Holzman & Lenzenweger, 1995; Park & McTigue, 1997; Tallent & Gooding, 1999); visual working memory tasks (Farmer, 2000; Mitropoulou et al., 2005; Lees Roitman et al., 2000, cited in Xie et al., 2018) and executive working memory tasks (Zouraraki et al., 2016).

While the majority of research suggests that schizotypy is associated with working memory deficits, other studies have found no deficits in working memory (Park et al., 1995; Lenzenweger & Gold; Kane et al., 2016). However, the weight of evidence suggests that working memory deficits are fairly reliable in high schizotypal and psychosis prone samples, making it useful to consider as a mediator when testing the relationship between schizotypy and creativity. The literature would suggest that high schizotypal traits are linked to worse creativity, and this relationship would be mediated by deficits in executive functioning, contrary to the overall hypothesis. It is worth noting that the meta-analysis and subsequent literature search revealed a huge range of effect sizes in the relationship between

schizotypy and creativity, including both positive and negative effects. Perhaps studies that use creativity tasks with a heavy working memory component are the ones that show negative relationships.

Finally, because there is evidence that schizotypy is positively associated with broader/looser associative processing and negatively associated with executive control, and because both these cognitive processes are thought to contribute positively to creative cognition, these theories predict different directions for the schizotypy X creativity association. Therefore, schizotypal performance can help adjudicate between these basic theories.

Aims of the thesis

Despite a large body of research exploring the relationship between schizotypy and creativity, many questions remain about the nature of the relationship, and the cognitive mechanisms that might support it. The overarching aim of this thesis is to characterise the relationship between schizotypy and creativity, and to identify the supporting cognitive mechanisms using models that are informed by current theories of creativity.

This thesis will address two important gaps in the literature. First, no other studies have used both a dimensional and a taxonic approach to test the relationship between schizotypy and creativity. In fact, only a few studies have used LPA with schizotypy data at all, and none in such a large sample. Second, no other studies have looked at the relationship between schizotypy and creativity in tandem with both associative processing and executive control measures.

To that end, I gathered data from two large samples of people who completed a number of different creativity, associative processing and working memory tasks. The first sample, called the MTurk sample, consisted of a large community sample who completed all tasks online, and the second sample, known as the Lab sample, were undergraduate students who completed all tasks in an individual laboratory session. All participants completed standard questionnaire measures of schizotypy (SPQ and O-LIFE in the MTurk sample; SPQ in the Lab sample) and both divergent (AUT) and convergent (RAT) measures of creativity. In addition, participants in the Lab sample completed laboratory-based tasks to assess associative processing and working memory, along with the Creative Personality Questionnaire.

I have two goals in my research. The first is to clarify the relationship between schizotypy and creativity using multiple, reliable tasks in two well-powered samples, using both online and lab-based methods of data collection. The use of two samples allows me to test both the replicability and generalisability of any schizotypy-creativity relationship. Previous studies of this relationship have yielded inconsistent results, so I will seek to replicate existing studies that have used a dimensional, factor-driven approach. I will then extend this knowledge by using latent profiles to predict creativity, to determine whether any relationship between schizotypy and creativity is better understood from a dimensional or taxonic perspective.

Once I have described the relationship between schizotypy and creativity, my second goal is to test whether executive functioning and associative processing, either individually or combined, underlie their relationship. Based on associative and executive processing accounts of creativity, either of these are potential mediators of the relationship between schizotypy and creativity. However, a dual processing account predicts a moderated mediation. Specifically, an association between schizotypy and creativity would be mediated by performance on measures of associative processing, but that the mediation might depend on the person demonstrating high working memory capacity.

So far, in Chapter 1 I have outlined the theoretical rationale for a relationship between schizotypy and creativity, presented possible mechanisms that might support any relationship, and reviewed existing knowledge relevant to my research questions. In Chapter 2 I will discuss my methodology for my thesis; I will describe the MTurk and the Lab samples, and the specific measures that they completed. I will also outline the ways in which the two samples are similar and the ways in which they differ. In Chapters 3 and 4 I will test the relationship between schizotypy and creativity in two different ways. Chapter 3 will use a dimensional perspective to test the relationship between schizotypy and creativity using different factors of schizotypy as predictors. Chapter 4 will explore an alternative approach to answering this question, analysing the relationship between schizotypy profiles (determined using latent profile analysis) and creativity. In Chapter 5, I will analyse data from the Lab sample to investigate the role of associative processing and working memory as potential mediators and moderators of the relationship between schizotypy and creativity. Finally, in Chapter 6 I will conclude with a general discussion of all findings and their implications for research in this area.

Chapter 2: Methods

Data described in this thesis are drawn from two samples; the first sample is a group of North American MTurk workers who completed the study online, and the second is a group of first year university students who participated in the study in a lab. Both samples completed measures of schizotypy and creativity; the Lab sample additionally completed tasks to assess associative processing and working memory. The data from both samples will be analysed together in Chapter 3 (using a dimensional approach to predict creativity) and in Chapter 4 (using a profile approach to predict creativity). Only the Lab sample will be used in Chapter 5 (testing the mediating roles of associative processes and working memory in explaining the schizotypy-creativity relationship). In this chapter, I will describe the participant characteristics for each sample and methods of data collection.

MTurk sample: Mechanical Turk Participants (data collected June, 2017)

Participants were recruited using an online system, Amazon Mechanical Turk (MTurk). All measures were administered online hosted on Qualtrics (Qualtrics, Provo, UT). Recruitment was limited to those registered MTurk workers in North America who reported that they could speak English fluently.

Other researchers have previously voiced concerns about the performance of MTurk workers, suggesting they are less likely to completely follow instructions or give the task their full attention (Crump, McDonnell & Gureckis, 2013). On the other hand, Hauser and Schwarz (2016) found MTurk participants were in fact better at paying attention to instructions than the typical introductory psychology student. Studies have shown that, while MTurk workers do participate in research for monetary reward, many workers report that they find the work itself intrinsically rewarding (Chandler & Shapiro, 2016), suggesting they are motivated to pay attention and complete the task according to the instructions given. This is the first study that has assessed both the SPQ and creativity in an MTurk sample. However, other studies have assessed creativity using self-report measures (Mckay, Karwowski & Kaufman, 2017), divergent thinking tasks (Gray et al., 2018), convergent thinking tasks (Marin, Reimann & Castano, 2014; Huang, Gino & Galinsky, 2015; Kim & Zhong, 2016) or a combination of both divergent and convergent thinking tasks (Lu et al., 2017). A number of studies have also assessed schizotypy with other measures using MTurk

and found that scores do not significantly differ compared to undergraduate student samples (Kwapil et al., 2018).

Only one study has used the SPQ in an MTurk sample. They did find evidence for differences in scores between an MTurk sample and an undergraduate sample on total SPQ score and on certain subscales related to positive and interpersonal schizotypy (Zhang & Brenner, 2017). The current study will be able to further verify whether scores differ between undergraduate and MTurk populations for this particular scale.

In order to ensure that participants paid attention to the task and completed the tasks correctly, I gave clear instructions at the start of the survey about what was expected of participants, and asked follow-up questions at the end of the session to assess compliance. A study by Rouse showed that score reliability was improved when workers completed instructions regarding paying close attention to the task (Rouse, 2015). The following is the set of instructions given at the beginning of the survey:

> ***During this survey, we ask that you comply with the following requirements:***
> *1) Please **maximize the size of your web browser** so that it covers your entire screen. Complete this survey on a desktop computer, laptop computer, or large tablet, not on a mobile phone or similar device.*
>
> *2) Please complete the survey in a single session, and **do not leave the survey to engage in other tasks**. So don't check your mail, look at Facebook, send or read a text message, get up for a drink, etc.*
>
> *3) Please **do not use your web browser's back or refresh buttons** at any point during the survey.*
>
> *4) Because this survey requires your close attention, we ask that you **complete the survey in an environment that is free of noise and distraction**. Please do not speak to anyone, or have anyone near you. Ideally, you would be alone in a quiet room, or in a room where other people are quiet (such as a library).*
>
> *The reason we ask you to follow these instructions is to ensure the quality of the*

information you give us. We know from previous research that if you do take a break, chat with others, etc, it will impair your ability to do the tasks set in this survey.

Six follow up questions were administered after the tasks to determine whether participants followed instructions. They responded either yes/no to each of the following questions (positive response provided in brackets):

1) *Did you maximise the size of your web browser so that it covers your entire screen? (yes)*
2) *Did you complete the survey in a single session, without stopping? (yes)*
3) *Did you pause or leave the survey to engage in other tasks, even if they were other computer tasks? (no)*
4) *Did you complete the survey without anyone helping you? (yes)*
5) *Did you complete the survey in an environment that is free of noise and distraction? (yes)*
6) *Did you speak with anyone at any time during the survey? (no)*

Participants.

A sensitivity analysis was performed using G*Power (Faul, Erdfelder, Buchner & Lang, 2009) based on the expected effect size of r = 0.14, which reflects the overall relationship between creativity and total schizotypy score as reported in the meta-analysis by Acar and Sen (2013). An estimated sample size of 426 participants was required to reach 90% statistical power to detect a relationship between schizotypy and creativity (two-tailed). In anticipation of some data loss (through technical problems/non-completion/failure to pass follow-up questions) we initially recruited 475 participants. Forty-seven participants (9.8%) failed on one or more of the follow-up questions and were subsequently excluded from analysis, leaving 428 participants (191 women, 236 men, 1 not specified). Participants provided informed consent before completing the tasks and were compensated $3.00 (USD) for participating, a relatively high amount for MTurk at the time of data collection in 2017. This rate of compensation reflects the relatively challenging nature of the tasks compared to other MTurk tasks.

Participants were around 35 years of age (*M* = 35.54, *SD* = 10.54) and relatively well-educated (74.3% had at least a university degree or higher, 15.2% were either completing or had completed a postgraduate degree). Ages ranged from 18 to 73. There were more men

(*n* = 235) than women (*n* = 187) overall. The sample was comparable to that in other MTurk research (Paolacci & Chandler, 2014). Ethical approval was granted by the Victoria University of Wellington School of Psychology Ethics sub-committee under delegated authority of Victoria University of Wellington's Human Ethics committee (#25592). This correlational study was pre-registered on the Open Science framework at the following URL (https://osf.io/dcrk5). All registration details were adhered to with the exception of scoring procedure in the AUT. In the registration report, the proposed rating scale for each item was 1-3, whereas I ultimately decided to use a rating scale on a scale of 1-5, as suggested by Silvia and Willse (2008). Creativity rating instructions were also modified to be in line with recent open source instructions developed by Silvia and Benedek (2013; OSF page https://osf.io/4s9p6/).

Materials.

Schizotypy Questionnaires. As already described in the general introduction chapter, there are some theoretical differences in the conceptualisation of schizotypy in the literature. I chose to use two questionnaires to reflect these differences: the Schizotypal Personality Questionnaire (SPQ; Raine, 1991), which reflects a taxonic approach, and the Oxford-Liverpool Inventory of Feelings and Experiences Questionnaire (O-LIFE; Mason & Claridge, 2006), which reflects a dimensional approach. By using both, I can increase the validity of any conclusions I draw (by comparing them across two measures of schizotypy) and also compare the scores for each questionnaire with each other.

The SPQ consists of 74 items that comprise 3 factors: Cognitive-perceptual (16 items), Interpersonal (25 items) and Disorganised (16 items). The minimum score for a participant who endorses none of the items is 0 and the maximum score for a participant who endorses all items is 74. Positive schizotypy is defined as the score on the Cognitive-perceptual factor only which consists of four subscales: Magical Ideation, Ideas of Reference, Perceptual Aberrations and Suspiciousness. An example question is 'have you had experiences with the supernatural?' (from the Magical Ideation subscale). Interpersonal schizotypy is defined as the scores on the interpersonal factor, a factor that consists of 3 subscales: Constricted Affect, No Close Friends and Excessive Social Anxiety. An example question is "I find it hard to be emotionally close to other people" (from the 'No close friends' subscale). Disorganised schizotypy is defined by the score on the disorganised factor, which consists of 2 subscales: Odd speech and Odd/eccentric behaviour. An example

question is “I sometimes forget what I am trying to say” (from the ‘Odd speech’ subscale). The SPQ has good internal reliability (0.91), 2-month test-retest reliability (0.82), convergent validity (0.59-0.81), and discriminant validity (0.63; Raine, 1991). Wuthrich & Bates (2005) more recently found that internal reliability for all subscales of the forced choice version of the SPQ is adequate, ranging from 0.58 to .93 (skewed towards the higher end of this range). The full questionnaire can be found in Appendix B.

The O-LIFE consists of 104 items. The O-LIFE has a slightly different factor structure: Unusual Experiences (30 items), Cognitive Disorganisation (24 items), Introvertive Anhedonia (27 items, 12 reverse coded) and Impulsive Non-conformity (23 items, 6 reverse coded). The maximum score a participant can receive on the O-LIFE is 104. Mason and colleagues reported good internal reliability for the four sub-factors (ranging from 0.77-0.90; Mason et al., 1995 cited in Mason & Claridge, 2006) and test-retest reliability (Burch, Steel & Hemsley, 1998; Fonseca-Pedrero et al., 2015). The full questionnaire can be found in Appendix C.

While there are some differences in the factor structure in the SPQ and the O-LIFE, they are believed to tap into the same schizotypal constructs. Furthermore, there is some evidence that the relevant factors of each scale are positively correlated with each other (Asai, Sugimori, Bando & Tanno, 2011). That is to say, the positive schizotypy factors of each scale (Unusual Experiences for the O-LIFE and Cognitive-Perceptual factor for the SPQ), the interpersonal schizotypy factors of each scale (Introvertive Anhedonia for the O-LIFE and Interpersonal for the SPQ), and the disorganised schizotypy factors of each scale (Cognitive Disorganised in the O-LIFE and Disorganised in the SPQ) have shown that the relevant factors are moderately to strongly correlated with each other. Impulsive non-conformity, the additional factor of the O-LIFE, is moderately positively related to the positive schizotypy factors of both scales).

Creativity measures. Participants completed two performance-based creativity measures: the Alternate Uses Task (AUT; Guilford, Christensen, Merrifield & Wilson, 1960) and the Remote Associates Task (RAT; Mednick, 1968).

Alternate Uses Task (AUT). In the AUT, participants generate alternative uses for a ping pong ball for a company that wants to diversify its product sales. Participants were given a maximum of 15 minutes to generate as many uses as they could up to a maximum of 10. Most participants did not use the full allotted time; the average time taken to complete

the task was 5.35 minutes. The session moved on to the next task when the 15 minute time cap elapsed, or when the participant chose to move on. Participants did not receive any instructions on how they should respond beyond these instructions. They were able to look back on previous uses that they had written.

Scoring process. Alternate uses tasks (and other related tasks such as the instances task) are scored in a multitude of ways across the psychology-creativity literature. While there are some consistencies or trends within research groups, there are more differences than similarities. When scoring the data, I wanted it to be comparable to the literature that is relevant to the primary research question, while also making defensible decisions that capture the creative abilities of the participants. Two measures were calculated for each participant: Fluency and a composite measure of Creativity.

I first calculated the number of unique, separate responses for each participant, as a measure of Fluency. To determine a measure of Creativity, five raters who were blind to the hypotheses of the study and to individual scores on schizotypy measures scored all responses for both samples. Raters used the same set of instructions used by Paul Silvia and Matthias Benedek. This set of instructions are publicly available on the Open Source Framework website (https://osf.io/hsx7w/) alongside other creativity task materials. An item's creativity was assessed using three main criteria: uncommonness, remoteness, and cleverness. A description of how these concepts are defined is outlined below. The complete instructions given to raters (which includes a reminder of the task instructions given to participants as well as extra information to make rating easier) can be found in Appendix D.

Three primary creativity characteristics.

1. Uncommonness

Creative ideas are uncommon: they will occur infrequently in our sample. Any response that is given by a lot of people is common, by definition. Unique responses will tend to be creative responses, although a response given only once need not be judged as creative. For example, a random or inappropriate response would be uncommon but not creative.

2. Remoteness

Creative ideas are remotely linked to everyday objects and ideas. For example, creative uses for a brick are “far from” common, every day, normal uses for a brick, and creative instances of things that are round are “far from” common round objects. Responses that stray from obvious ideas will tend to be creative, whereas responses close to obvious ideas will tend to be uncreative.

3. Cleverness

Creative ideas are often clever: they strike people as insightful, ironic, humorous, fitting, or smart. Responses that are clever will tend to be creative responses. Keep in mind that cleverness can compensate for the other facets. For example, a common use cleverly expressed could receive a high score.

Each of the uses was rated on a scale from 1-5, with 1 being least creative and 5 being most creative. Before scoring took place, all responses from all participants were randomised, so the scorers were not biased in their judgments of how creative a particular item was by a previous item given by a participant.

Raters were encouraged to give high marks to uses that were uncommon (but not random), that seemed remotely linked to everyday objects, and struck the rater as being insightful, ironic, humorous or smart in some way. Raters were encouraged to save scores of “1” for items that were really poor or obvious responses. Raters were also encouraged to revise all ratings after they had completed a first pass through all responses, to ensure consistency in their judgments and to modify ratings once they had a more accurate sense of the range in creative responses. The Creativity score for each response was then calculated as the average score across all five raters. The final average Creativity score for each participant was the average Creativity score across all their responses. A significant advantage of this method compared to other methods (such as sum of scores across items methods) is that ratings are independent of fluency sores (Silvia & Willse, 2008). Inter-rater reliability was calculated using an intra-class correlation coefficient; inter-rater reliability was fair (ICC = .8) and comparable to other creativity studies (Lu et al., 2017; Smeekens & Kane, 2016).

Remote Associates Task (RAT). In the RAT (Mednick, 1962) the participant is presented with three words and must provide a fourth word that is a common associate of all three. For example, if presented with the words: *stick*, *maker,* and *point*, the participant

would provide the associated word *match (i.e., match stick, match maker, match point)*. Participants were presented with 35 items that represented a wide range of difficulty, as determined by pilot testing with 46 participants not included in this study (Brown & Grimshaw, 2014, unpublished raw data). Easy questions and difficult questions were randomly distributed throughout the list of items; all participants completed the questions in the same order. Participants had thirty seconds to consider each item – at that point the screen timed out and they were presented with the response box. They had the option to type 'pass' and continue on to the next question before the end of the allotted time if they did not know the answer. For a list of all items used, see Appendix E.

Additional questionnaires: Autistic Traits Questionnaire (ATQ) and Waterloo Handedness Inventory (WHI). The ATQ assesses sub-clinical autistic traits (Booth et al., 2013) and the WHI assesses hand preference for a variety of tasks (Bryden, 1977). The ATQ was included in the MTurk sample only, and the WHI was included in both samples. Both questionnaires were included as part of another research project that is not relevant to the questions addressed in this thesis. The data will not be presented here.

Procedure.

The entire study took between 45 minutes and 1 hour to complete. Following standard individual differences research procedure (Hedges & Pigott, 2017; Goodhew & Edwards, 2019), participants completed all tasks in the same order: AUT; RAT; Handedness questionnaire, Autism Traits questionnaire, the two Schizotypy questionnaires (SPQ then O-LIFE), and finally the 6 follow-up questions.

Lab sample: First year psychology students (sample collected between June-October 2018)

Participants

A power analysis was conducted to determine the number of participants required to detect an effect of 0.14 (taken from the Acar and Sen meta-analysis, Acar & Sen, 2013). 420 participants would be required in order to reach the effect at 90% confidence interval.

Data collection occurred over a five month period across two trimesters. The stopping rule was to complete data collection at the end of the five month period allotted, or when a sample size of 420 participants was collected, whichever came first.

The final sample consisted of 361 first year university students and fluent English speakers who took part in this study for course credit. The group therefore were younger compared to the MTurk sample, (M = 19.09 years, SD = 1.86) and the majority of

participants were female (female = 77.2% and male = 22.5%). Unlike the MTurk participants, these participants took part in this study individually in a small testing room. This allowed for more control over testing procedures and the opportunity to provide clear instructions for the associative processing and working memory tasks included for this sample. Ethical approval was granted by the Victoria University of Wellington School of Psychology Ethics sub-committee under delegated authority of Victoria University of Wellington's Human Ethics committee (#25992).

Materials.

Schizotypy questionnaire. In this sample, participants completed the SPQ only, in the same format as provided to the MTurk sample. The O-LIFE was removed in order to save time; one measure was deemed efficient given that, in the MTurk sample, the relevant sub-factors of each scale positively correlated with each other (positive schizotypy factors, r = .812; interpersonal schizotypy factors, r = .761; disorganised schizotypy factors, r = .654; total schizotypy scores, r = .879).

Creativity measures.

Performance based measures: Remote Associates Task and Alternate Uses Task. The Remote Associates Task (RAT) and the Alternate Uses Task (AUT) were used in both samples. However, there are some differences in how both tasks were administered to accommodate the constraints of the longer individual testing session. Thus, the Lab sample presents a conceptual, but not direct, replication of the methods used with the MTurk sample. In the MTurk sample, participants had a maximum of 15 minutes to complete the AUT before the computer automatically proceeded to the next task. In the current version of the task completed by the Lab sample they had 10 minutes.

There are also some subtle differences in the presentation of the AUT since sample two was administered using E-Prime (Psychology Software Tools, Pittsburgh, PA) rather than online in Qualtrics as per The MTurk sample. In the MTurk sample, participants completed the AUT by typing individual uses into separate boxes. In the Lab sample, participants typed all responses into an open text box. Participants could change previous responses, but the nature of the textbox meant they had to delete the entire line in order to do so, making it slightly more challenging to delete responses. They had an opportunity to practice typing into the textbox before the trial started in order to get familiar with the procedure.

In the Lab sample, when completing the RAT participants were explicitly told that, if they could not generate a response to a problem, they could pass. This was possible in the MTurk sample as well; however, it was not explicitly stated.

Self-Report measures: Creative Personality Scale. In addition to the two performance measures, a self-report measure of creativity was also included in this study. The Creative Personality Scale (CPS) is a commonly used self-report measure of certain characteristics judged as related to creative ability, such as confidence, self-esteem and wide range of interests (Gough, 1979). There were also some qualities that are inversely related to creativity which were reverse coded, including narrow range of interests, submissive, and conservative (all items can be found in Appendix F). Reliability for this scale is adequate (alpha = .73; Zhou & Oldham, 2001). By including the CPS, I can assess the extent to which the two performance measures and the self-report measure are related to each other, and to what extent schizotypal traits predict a creative personality.

Working memory tasks. Two complex span measures were used to assess working memory. A complex span task requires encoding information into working memory (the primary task), and maintaining it while completing another (secondary) task. Primary and secondary tasks alternate until participants are cued to recall all the stored items from the primary task. The final outcome measure is the number of elements of the secondary task that are recalled across all sets, while maintaining at least 80% accuracy (Conway et al., 2005). Complex span tasks can take a long time to complete, which can make experiments much longer and more taxing for participants. To that end, shortened versions of the Operation Span and Symmetry span were used, both constructed by Engle's Working Memory Capacity Lab (Foster et al., 2015; available for download via the following link http://englelab.gatech.edu/engle.html). Using two shortened measures of WM maximises the variance in general intelligence and working memory capacity that the tasks capture, while minimising the amount of time they take to complete. It represents a good compromise, still accurately assessing working memory capacity in a relatively short period (about 30-40 minutes, including practice trials), while accounting for 86.1% of gf (fluid intelligence) variance (Foster et al., 2015).

Operation Span Task. In the Operation Span task, participants alternate between completing two tasks: encoding and rehearsing a string of letters (primary task) and completing a series of math problems (secondary task), as shown in Figure 2.1. In a typical

sequence, the participant sees a math problem, solves it, and then judges whether an answer provided is correct or incorrect by clicking true/false. They then see a letter to remember. After a series of math-letter trials, the participant has to recall all the letters in the correct order on a letter grid. The size of each set ranged from 3-7 math-letter pairs, and three sets of each size were presented randomly during the experiment.
Unlike other traditional working memory tasks (e.g. the n-back) there is no stopping rule.

Symmetry Span Task. In the Symmetry Span task (see Figure 2.1), participants remember the position of a filled square in a 4 x 4 grid (primary task). The number of squares marked in the grid varies from 3-7. This task alternates with a symmetry task, in which the participant sees an 8 x 8 grid with some squares shaded in to form a shape. They report whether the shape presented is symmetrical or not. Finally a series of symmetry-square trials, the participant has to recall all the squares in the correct location on a grid. The size of each set ranged from 3-7 symmetry-square pairs, and three sets of each size were presented randomly during the experiment.

Span Task Procedure. For both working memory tasks, participants read a series of detailed instructions and worked through about 10-15 minutes of practice trials. Participants first learnt how to complete each element of the task (primary task first, then secondary task); only then were the tasks combined. The presentation time of the symmetry images and the math problems depends on the reaction time when completing these tasks individually. In the experimental trials, participants need to maintain a response time to the symmetry or math problems within 2.5 standard deviations of their mean response time in the practice trials. This ensures that the task is challenging and engaging as a secondary task.

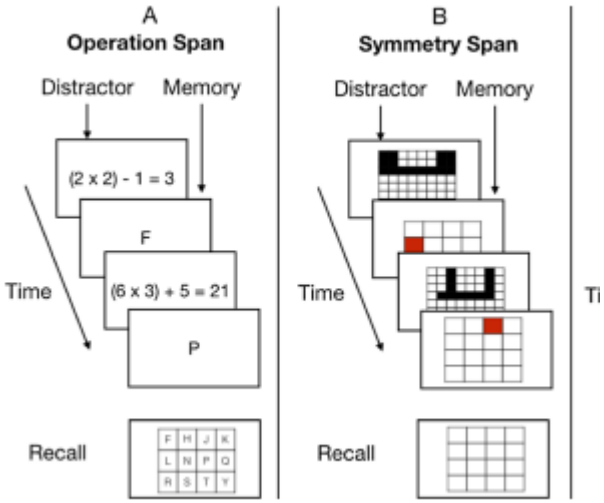


Figure 2.1. Trial diagrams for the two complex span working memory tasks. In this trial of the operation span, participants first solve a basic math problem, then remember the letter present, then solve a second math problem and remember a second letter. At the end of this example trial, they recall the two letters that they saw during the trial (F and P). Photo courtesy of Foster et al., 2015.

Scoring the complex span WM tasks. Twenty-nine participants who were not able to maintain at least 80% accuracy on the secondary task for either the symmetry or operation span were excluded from subsequent analyses. The dependent measure was the number of letters/squares the participant recalled correctly. Working memory performance was calculated using a partial credit score, which enables participants to get credit if they managed to recall some of the items in the right position, as opposed to an absolute credit score which only credits participants who are able to recall all items in the correct position. For example, if a participant is presented with a set that shows 4 squares, but they only correctly recall the location of 3 of the squares, they would get a score of 3, rather than getting a score of 0 for not being completely accurate. The total number of squares or letters correctly recalled is added over the course of the task. The final dependent measure is the average score in across both tasks. Scores in the current study ranged from 11 to 42.

Associative processing task. I used a word association task to measure associative processing (Benedek et al., 2014). Participants generated associates in response to a target word; they had 60 seconds to generate as many associates as possible. There were six target words in total: *street, light, red, mountain, lion and king*, always presented in the same order. These are the same words used by Benedek and colleagues (Benedek & Neubauer, 2013). They come from the Kent-Rosanoff Word Association Test (WAT; Kent & Rosanoff,

1910, cited in Benedek & Neubauer, 2013). These specific words were chosen because they do not elicit one primary response from all participants; norms have shown that they elicit a variety of different responses from different people (Benedek & Neubauer, 2013).

We used Latent Semantic Analysis (LSA) software (Landauer, Foltz, & Laham, 1998; http://lsa.colorado.edu) to calculate a semantic similarity score for each response to the target word. This software determines how semantically similar each response is to the target word based on how frequently the response and the target words co-occur within a large corpus of text that represents the standard semantic knowledge of a first year university student. A word that is very similar to the target word in meaning will get a high score. A word that is less similar to the target word will get a low score.

LSA is a useful tool for understanding language in psychological research. It is used in a wide variety of language tasks, such as category fluency tasks (Elvegag et al., 2007), verb-noun categorisation tasks (Prabhakaran, Green & Gray, 2014), as well as creativity tasks (Prabhakaran et al. 2014). It is also used in the schizophrenia literature. For example, Elvevag and colleagues (2007) using LSA found that people diagnosed with schizophrenia have reduced semantic coherence compared to healthy controls. Minor, Marggraf, Davis, Mehdiyoun & Brier, (2016) also found similar results using a similar task with an early psychosis sample. Not only is it widely used, it is also very reliable. Computer LSA based assessments are as reliable as human raters, while also being much less labour intensive (Wolfe & Goldman, 2003).

Initial LSA scores for each response range from -1 to 1, with -1 = not at all similar and 1 = the same word. For each participant I calculated the average score for each target word, and then averaged across target words to create the grand average which became the dependent measure for each participant. High positive scores reflect steep associative processing hierarchies, that is, a high proportion of closely related associates. Lower positive scores reflect shallow associative processing, that is, a range of close and distant associates. Negative scores reflect a high proportion of nonsense (i.e. non-associated responses). I also calculated how many words they generated per target, and how many words they generated overall.

Generated words were excluded if they were proper nouns, non-English words, or phrases. Words with typos/non-American spellings weren't accurately classified by the LSA software; these words were manually corrected and then scored accordingly. For examples

of words/phrases that were excluded and examples of how words were corrected before scoring, see Appendix G.

Procedure.

Participants completed the battery of tasks one at a time, in a quiet single occupancy room. The entire session took between 1 hour 15 and 1 hour 30 minutes and they were encouraged to take short breaks between tasks if needed. The order was consistent for all participants, with the two working memory tasks first (Operation span then Symmetry span), followed by the Alternate Uses Task, Remote Associates Task, Word Association Task, then finishing with the Waterloo Handedness Inventory, Creative Personality Scale and the Schizotypal Personality Questionnaire. Data collection took place over five months, across two semesters.

Chapter 3: Predicting creativity

In the general introduction, I reviewed the existing literature testing the relationship between schizotypy and creativity. Overall, there was some evidence for a small, but positive, association between schizotypy and creativity. This effect was marginally stronger when testing the relationship between positive schizotypy and creativity (Acar & Sen, 2013). However, very few studies examined the relationship between schizotypy and creativity in a highly powered sample, using multiple measures of creativity in a transparent manner. Moreover, increasing concerns about false positive findings (Simmons, Nelson & Simonsohn, 2011) and publication bias (Borenstein, Hedges, Higgins & Rothstein, 2009) cast some doubt on the strength of the relationship. Notably, there is considerable heterogeneity in effect sizes, and even in the direction of the effects. Moreover, there is no clear consensus on whether the relationship is modified by type of creative measure (e.g., self-report vs. performance measures) or type of task (e.g. those relying on convergent vs. divergent thinking). Marked inconsistencies in the literature make it difficult to determine the nature of the relationship between schizotypy and creativity, and indeed, whether there is a meaningful relationship at all.

In order to characterise the relationship between schizotypy and creativity, the next two chapters are dedicated to testing this relationship in two highly powered samples. The MTurk sample consists of North American Amazon Mechanical Turk workers, who participated online for a small monetary reward. The Lab sample consists of introductory psychology students from New Zealand who participated for course credit. Both samples are described in more detail in Chapter 2. The primary measures of schizotypy and creativity are the same across both samples; the Lab sample additionally completed laboratory tasks of working memory and associative processing, which will be used to test the cognitive mechanisms by which schizotypy and creativity might be related (see Chapter 5).

The vast majority of existing research takes a dimensional approach to schizotypy, correlating the individual factors of schizotypy with individual measures of creativity. Different factors are said to capture different underlying cognitive and affective traits, some of which may be more relevant for creative thinking than others. In this chapter, I will also take this approach. Based on the previous literature (and as indicated in the preregistration for the MTurk sample), I would expect that positive schizotypy (as assessed by the Cognitive

Perceptual subscale of the SPQ or the Unusual Experiences subscale of the O-LIFE) would positively predict performance on the two creativity tasks (RAT and AUT). Positive schizotypy is defined by magical ideation, perceptual aberrations and ideas of reference. These traits are considered by some to be helpful in producing interesting, creative ideas. Total schizotypy will also positively predict creative performance.

There are no specific predictions about the Disorganised and Interpersonal factors of the SPQ (or the Cognitive-Disorganised and Introvertive Anhedonia factors of the O-LIFE), so these associations will be considered exploratory.

Method

The following is a brief description of participant and task characteristics for the two samples included in this thesis. For more detail, refer to Chapter 2.

MTurk sample: data collected July 2017.

After exclusions, the MTurk sample consisted of 428 participants living in North America, (235 men, 187 women; 1 did not specify gender, mean age = 28 years, *SD* = 11.36). Participants completed the following tasks and questionnaires online via the Mechanical Turk platform, in the following order: Alternate uses task (AUT), Remote Associates Task (RAT), Waterloo Handedness Questionnaire (WHI), Schizotypal Personality Questionnaire (SPQ), Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE), Autism traits questionnaire (ATQ). Participants then completed the six post-study follow-up questions to assess compliance with instructions. The entire study took approximately 1 hour to complete.

Lab sample: data collected March to October 2018.

The Lab sample consisted of 361 participants completing a first-year psychology course (80 men, 279 women; 1 gender diverse, mean age = 19 years, SD = 1.86). Participants received course credit in return for their participation. They completed the tasks and questionnaires in the following order: Working memory tasks (Operation Span then Symmetry Span), AUT, RAT, Word Association Task (WAT), Creative Personality Questionnaire (CPS), SPQ, WHI. All participants completed the study in a single-capacity testing room in order to limit distractibility. On the basis of the strong associations between factors of the SPQ and O-LIFE in the MTurk sample, the O-LIFE was omitted for the Lab sample. The SPQ, RAT and the WHI were administered in exactly the same fashion as in the MTurk sample. Given time constraints, the creativity tasks were modified slightly;

participants in the Lab sample had slightly less time to complete the AUT (10 minutes instead of 15), and were able to pass on a RAT question without waiting the full 30 seconds. The entire study took about 1 hour 30 minutes to complete.

Statistical analysis.

Data were analysed in four stages. First, descriptive statistics were calculated for each measure and compared across samples. Correlations were also calculated between different creativity measures, and between schizotypy factors. Next, I calculated simple correlations between schizotypy factors (and total schizotypy scores) and creativity measures in each sample. These two stages were conducted as outlined in the pre-registration for the MTurk sample.

The following analyses were done in addition: Differences in the schizotypy-creativity correlations between samples were tested using Fishers Z scores. Multiple regression analyses were conducted to assess the extent to all three factors of schizotypy significantly predicted variance in creativity over and above any association with demographic variables.

Results

Descriptive statistics

Table 3.1 presents the means and standard deviations for participants' scores on the SPQ, O-LIFE and all creativity measures in both the MTurk sample and the Lab sample. Average creativity rating for the AUT did not significantly differ between samples $t(770) = .789$, ns, nor did the number of words generated $t(770) = -1.623$, ns. Participants in the MTurk study were significantly more accurate than the Lab sample participants in the RAT $t(776) = 17.621$, $p < .001$, $d = 1.85$.

The two samples also differed in schizotypy scores. Cognitive-Perceptual scores in the MTurk sample were significantly lower than in the Lab sample, $t(790)= -3.217$, $p = .001$, as were scores in the Disorganised factor, $t(790)= -4.465$, $p <.001$. The same difference was found for interpersonal, although the effect was only marginally significant, $t(790)= -1.892$, $p = .059$,ns, and total scores were also not significantly different $t(790)= -1.826$, $p = 0.74$.

Table 3.1. Descriptive statistics for all schizotypy and creativity measures across both samples.

Questionnaire	Factor	MTurk sample N = 428		Lab sample = 364		
		Mean	SD	Mean	SD	Max score
SPQ	CogPerceptual	8.01	7.58	9.63	6.33	16
	Interpersonal	12.55	8.78	11.49	6.75	26
	Disorganised	4.69	4.34	6.01	3.95	16
	Total	22.65	16.16	24.52	12.97	74
OLIFE	Unusual Experiences	6.83	6.77	-	-	30
	Introvertive Anhedonia	11.01	4.73	-	-	27
	Cog Disorganised	8.29	6.76	-	-	24
	Imp nonconformity	6.46	3.65	-	-	23
Creativity	AUT (creativity)	2.28	.38	2.26	.35	5
	AUT (fluency)	8.25	2.68	8.53	1.85	10
	RAT	19.31	7.99	10.42	5.56	25
	CPS	-	-	3.95	3.48	-12/+12

One possible explanation for the significant difference in RAT scores between the two samples may be subtle methodological differences in procedure. In the Lab sample, participants were given the option to pass on a problem if they could not solve it, whereas in the MTurk sample they had to wait until the timer ran out (at 30 seconds) before continuing onto the next one. Participants in the MTurk sample were more likely to attempt a response, whereas participants in the Lab sample were more likely to either pass or let the time allotted expire. The average number of attempts (correct/number attempted) in the MTurk sample was 19.13/31.33 responses, whereas the average number of attempts in the Lab sample was 10.42/32.76 responses.

Table 3.2: Correlations between the SPQ and the O-LIFE in MTurk sample

O-LIFE	SPQ			
	Cognitive-perceptual	Interpersonal	Disorganised	Total
Unusual Experiences	**.812****	.455**	.568**	.689**
Introvertive Anhedonia	.369**	**.761****	.472**	.633**
Cognitive Disorganised	.613**	.776*	**.654****	.782**
Impulsive Non-conformity	**.508****	.373**	.564**	.519**
Total score)	.783**	.789**	.743**	**.879****

Note. ** = p < .001. Corresponding factors are in bold.

Table 3.2 presents correlations between sub-scales of the SPQ and the O-LIFE in the MTurk sample; corresponding sub-factors (i.e. both factors related to positive schizotypy) are in bold. There were moderate-strong positive correlations between all corresponding sub-scales as well as total scores, suggesting strong convergent validity. The strength of these correlations gives me confidence that both questionnaires are assessing the same construct; therefore, I used one (the SPQ) rather than both in the follow up Lab sample to increase efficiency and reduce participant fatigue during data collection.

Correlations between creativity measures.

Correlations were calculated amongst the creativity measures, collapsed across the two samples (see Table 3.3). Average creativity in the AUT was positively correlated with performance on the RAT $r(770) = .137$, $p < .001$, providing some convergent validity for the two tasks as measures of creativity. Average creativity in the AUT was positively correlated

with fluency in the AUT. That is to say, people who generated more uses also tended to generate the more creative uses $r(770) = .139$, $p < .00$). There was no correlation between performance on the RAT and the number of words generated in the AUT $r(770) = -.004$, ns.

In the Lab sample, the Creative Personality Scale (CPS) was also included. Scores on the CPS were positively correlated with average creativity in the AUT $r(344) = .107$, $p = .046$, and fluency in the AUT $r(344) = .187$, $p < .001$. CPS scores were not correlated with performance on the RAT, however $r(348) = .009$, $p = .866$. These results suggest that scores on performance-based measures of creativity (Creativity in the AUT and RAT scores) mostly align better with each other than with other, self-report measures of creativity. This is consistent with the idea that similar measures will naturally correlate better (personality measures will be much more highly correlated with other personality measures, performance-based measures with other performance-based measures).

Table 3.3. Correlations between creativity tasks across the two samples.

	AUT (creativity)	AUT (fluency)	RAT	CPS
AUT (creativity)	1	.139**	.137**	.107*
AUT (fluency)	-	1	-.004	.187**
RAT	-	-.004	1	.009
CPS^		-	-	1

Note. ^ = Lab sample only

Is schizotypy correlated with creativity?

Correlations between all creativity tasks and all sub-factors of the SPQ are outlined in Table 3.4. Correlations between creativity tasks and all sub-factors of the O-LIFE (for the MTurk sample only) are outlined in Table 3.5. Although some associations were observed, these were inconsistent across samples. I will describe the correlations for each of the samples in turn, and reflect on similarities and differences between the two groups.

Table 3.4. Correlations between the three creativity measures and schizotypy across the two samples.

		Cog-Perceptual	Z-score (p-value)	Cog-Disorganised	Z-score (p-value)	Interpersonal	Z-score (p-value)	Total	Z-score (p value)
Alternate uses: Average creativity	MTurk	-.026	-.05 (.617)	.071	-.084 (.401)	.026	.036 (.719)	.021	.017 (.865)
	Lab	.010		.131**		.000		.009	
Alternate uses: Number of words	MTurk	-.040	**-2.42 (.015)**	.005	**-2.07 (.04)**	-.025	-.061 (.542)	-.030	-.066 (.509)
	Lab	.135**		.154*		.019		.018, ns	
RAT	MTurk	-.217*	**-2.83 (.01)**	-.115**	**-2.24 (.03)**	-.021	-1.05 (.294)	-.123**	-.158 (.114)
	Lab	-.015		.047		.055		-.009	
CPS	MTurk	-		-		-		-	
	Lab	-.097		-.002		-.362*		.033	

Note. * = Correlation is significant at the .05 level (2 tailed). ** = Correlation is significant at the .01 level (2 tailed). Fisher Z scores were calculated comparing MTurk correlations to lab based correlations. A negative z-score indicates that the correlation in the Mturk sample was greater than the correlation for the lab based sample. The p-value indicates whether this is significant (two-tailed). Z scores that mark significant differences between correlations are in bold.

Table 3.5. Correlations between creativity measures and the O-LIFE in the MTurk sample

		Unusual experiences	Cognitive Disorganised	Introvertive Anhedonia	Impulsive non-conformity	Total
Alternate uses: average creativity	MTurk Lab	.004	.038	.002	-.048	.008
Alternate uses: Number of words	MTurk Lab	-.033	.013	-.071	.039	-.019
RAT	MTurk Lab	-.213**	-.041	-.005	-.180**	-.140**

Note. * = significant at p < .05 level, ** = significant at p < .001 level. N = 428.

Predicting creativity.

Contrary to hypotheses, in the Lab sample, there was *no* association between schizotypy and performance on the RAT. In contrast, in the MTurk sample there was a *negative* association between positive (Cognitive-perceptual sub-scale), disorganised (Disorganised sub-scale) and total schizotypy scores from the SPQ and the RAT. As shown in Table 3.5, there were also the same relationships between positive (Unusual Experiences), disorganised (Cognitive Disorganised) and total schizotypy scores from the O-LIFE and the RAT. Interpersonal schizotypy was not correlated with RAT performance in the SPQ or O-LIFE.

There was no association between Creativity in the AUT and any factor of schizotypy in the MTurk sample. In the Lab sample, there was a positive association between disorganised schizotypy and AUT; however, no other associations were significant. Fluency on the AUT was not positively correlated with any factor of schizotypy in the MTurk sample. However, fluency was positively correlated with positive and disorganised

schizotypy in the Lab sample, but not interpersonal or total score. In the Lab sample, scores on the CPS were negatively correlated only with the interpersonal factor of the SPQ.

Controlling for other factors. Although schizotypy was correlated with some measures of creativity in each sample, these relationships were not consistent in the two samples. One possible explanation for the differences between correlations in the two samples is differences in demographic characteristics. For example, participants in the MTurk sample were significantly older than participants in the Lab sample $t(786) = 29.205$, $p < .001$. The mean age of participants in the MTurk sample is 35.53 years ($SD = 10.54$; range = 18-73) and the average age in the Lab sample is 19.10 years ($SD = 1.86$; range = 18-30). Not only are the MTurk sample participants older, but they are also more variable in age, ranging from 18-73, whereas ages ranged from 17-30 in the Lab sample. This is to be expected when comparing a university student sample to a community sample.

The relationship between schizotypy and creativity was therefore assessed using multiple regression. Because simple correlations suggest that age is a predictor of some aspects of creativity, age was entered at step 1. At step 2, the three schizotypy factors were entered, to determine whether schizotypy accounted for variance in creativity over and above that accounted for by age. Regressions were conducted separately for MTurk and Lab samples due to significant differences both in demographic variables (Lab sample participants were significantly younger), differences in performance on the RAT, and differences in the simple correlations between schizotypy and creativity (e.g., negative correlations between schizotypy and RAT performance that were not replicated in the Lab sample).

Regression results for prediction of RAT performance appear in Table 3.6. In the MTurk sample, the addition of schizotypy factors at Step 2 explained an additional 6.8% of variance $F(1,426)= 10.019$, $p < .001$ over and above that accounted for by age. Examination of the individual beta weights showed that the Cognitive-Perceptual factor *negatively* predicted RAT performance, b = -.337, $t(423) = -4.871$, $p < .001$, whereas the interpersonal factor positively predicted RAT performance, b = .223, $t(423) = 3.530$, $p < .001$. However, in the Lab sample, neither age (at Step 1) nor the addition of schizotypy factors (at Step 2) accounted for any variance in RAT performance.

Table 3.6. Schizotypy predicting scores in the RAT (Remote Associates Task).

Sample		B	S.E B	β	R^2	$R^2\Delta$
Mturk						
Step 1	age	.104	.036	.138	.019	.019
Step 2	Age	.086	.036	.113	.087	.078
	Cog perc	-.337	.069	-.319		
	Disorg	-.111	.127	-.060		
	interpers	.223	.063	.245		
Lab						
Step 1	Age	.244	.160	.082	.007	.007
	Age	.221	.161	.074		
Step 2						
	Cog Perc	-.084	.064	-.096		
	Disorg	.067	.092	.048		
	Interpers	.076	.058	.093		

Regression results for prediction of AUT creativity appear in Table 3.7. In the MTurk sample, the addition of schizotypy factors at Step 2 explained an additional 1.6% of the variance $F(1,424)=4.087$, $p = .003$ over and above that accounted for by age. Examination of the individual beta weights shows that the Cognitive-Perceptual factor does not account for any variation in AUT Creativity. However, the Disorganised factor *positively* predicts AUT Creativity, b = .014, $t(421) = 2.265$, $p = .024$.

In the Lab sample, the addition of schizotypy factors at Step 2 significantly increased variance accounted for $F(1,342)=2.725$, $p = .029$. Schizotypy accounted for 2.1% of the variance over and above the variance accounted for by age. Looking at the individual beta weights, once again, the Cognitive-Perceptual factor does not significantly predict AUT Creativity. However, as in the MTurk sample, the Disorganised factor *positively* predicts AUT Creativity, b = .016, $t(339) = 2.705$, $p = .007$.

Table 3.7. Schizotypy predicting scores in the AUT (Alternate Uses Task).

Sample		B	S.E B	β	R2	$R^2\Delta$
Mturk						
Step 1	age	.005	.002	.146	.021	.021
Step 2	Age	.006	.002	.156	.037	.016
	Cog perc	-.006	.003	-.112		
	Disorg	.014	.006	.161		
	interpers	.001	.003	.012		
Lab						
Step 1	Age	.019	.010	.100	.010	.010
Step 2	Age	.016	.010	.085	.031	.021
	Cog Perc	-.003	.004	-.047		
	Disorg	.016	.006	.177		
	Interpers	-.003	.004	-.067		

Regression results for prediction of AUT fluency appear in table 3.8. In the MTurk sample, neither age (at Step 1) nor the addition of schizotypy factors (at Step 2) accounted for significant variance in AUT fluency. However, in the Lab sample, the addition of schizotypy factors (at Step 2) significantly increased variance accounted for $F(4,339) = 11.553$, $p = .009$. Schizotypy accounted for 3.9% of the variance over and above that accounted for by age. Examination of the individual beta weights shows that the Cognitive-Perceptual and Disorganised factors *positively* predicted AUT fluency ($b_{CP} = .044$, $t(336)=2.054$, $p = .041$; $b_D = .068$, $t(336) = 2.221$, $p = .027$, respectively), while the Interpersonal factor *negatively* predicted AUT Fluency, $b = -.043$, $t(336)= -2.197$, $p = .029$.

Table 3.8. Schizotypy predicting scores in fluency in the AUT

Sample		B	S.E B	Beta	R2	R2delta
Mturk						
Step 1	age	.018	.012	.070	.005	.005
Step 2	Age	.017	.013	.068	.008	.003
	Cog perc	-.021	.024	-.059		
	Disorg	.045	.044	.073		
	interpers	-.008	.022	-.027		
Lab						
Step 1	Age	.023	.054	.023	.001	.001
Step 2	Age	.014	.054	.148	.039	.039
	Cog Perc	.044	.021	.148		
	Disorg	.068	.031	.145		
	Interpers	-.043	.019	-.155		

In order to validate the results for the MTurk sample I calculated the same regression analyses using the O-LIFE data. Results for these analyses appear in Table 3.9. The addition of schizotypy factors at step two explained an additional 6.2% of the variance over and above that accounted for by age F(422)= 7.115, $p < .001$ in RAT performance. As with the SPQ, positive schizotypy predicted worse performance, with negative associations for both Unusual Experiences b = -.279, $t(419)$= -4.033, $p < .001$ and Impulsive-Nonconformity b = -.257, $t(419)$= =.2050, $p = .038$. Unlike results from the SPQ, the Cognitive Disorganised factor positively predicted RAT performance, b = .152, $t(419)$ = -2.080, $p = .038$. Furthermore, unlike results from the SPQ, schizotypy factors did not explain significantly more variance in AUT Creativity above and beyond that accounted for by age. And neither age (at step 1) nor schizotypy (at step 2) accounted for significant variance in AUT Fluency.

Table 3.9. O-LIFE Schizotypy predicting scores in the RAT in the MTurk only

Sample		B	S.E. B	β	R^2	$R^2\Delta$
MTurk						
Step 1	Age	.104	.036	.138	.019	.019
Step 2	Age	.089	.037	.117	.081	.062
	UnusExp	-.279	.069	-.236		
	CogDis	.182	.076	.161		
	IntroAnhe	.011	.095	.007		
	ImpulsNon	-.257	.124	-.117		

Discussion

In the current chapter, I tested the relationship between factors of schizotypy and creativity, using data from two highly powered samples who completed similar measures. Based on existing literature, I hypothesised that positive schizotypy (as measured by the Cognitive-Perceptual factor of the SPQ and the Unusual Experiences factor of the O-LIFE) and total schizotypy would be positively associated with creativity performance (as measured by the RAT and the AUT). I considered relationships with other factors of schizotypy to be exploratory.

With respect to the predicted associations, there was no significant association between positive schizotypy and average Creativity on the AUT, although positive and disorganised schizotypy were positively associated with Fluency on the AUT in the Lab sample. Positive schizotypy was correlated with RAT performance in the MTurk sample, but this was a *negative* relationship: higher levels of positive schizotypy (on both SPQ and O-LIFE) were associated with worse performance on the RAT. This negative relationship did not replicate in the Lab sample.

Exploratory analyses probed the associations between creativity and other schizotypy factors; these relationships are frequently unreported in the literature, and so I had no strong a priori predictions about them. Interpersonal schizotypy was positively related to performance in the RAT, but only in the MTurk sample. In both the Lab sample and the MTurk sample, disorganised schizotypy was positively correlated with AUT Creativity. Disorganised schizotypy also positively predicted AUT fluency; interpersonal schizotypy, in contrast, negatively predicted fluency. Finally, the interpersonal factor of

schizotypy was negatively correlated with the CPS, i.e. interpersonal schizotypy was associated with less creative personality.

Taken together, findings are not in line with predictions. Convergent thinking (as measured by the RAT) was *negatively* associated with positive schizotypy (as measured by both the SPQ and O-LIFE) but this relationship was not replicated in the Lab sample. Divergent thinking (as measured by AUT Creativity) was associated with greater schizotypy, but with the disorganised, and not positive factor. This relationship was observed in both samples; additionally, disorganised schizotypy predicted greater AUT fluency, but in the Lab sample only. Finally, there were some unpredicted associations with interpersonal (positively related to RAT performance in the MTurk sample, negatively related to AUT fluency in the Lab sample) that were observed in one sample only. In the following discussion, I identify strengths and weaknesses of the current research and then consider possible sources for the two types of inconsistency – the inconsistency across two samples, and the inconsistency of these findings with respect to the broader literature on schizotypy and creativity.

Strengths.

Before discussing the inconsistencies both across samples and across the literature, it is important to consider the quality of the data and the research design. The current research has a number of strengths compared to other research on schizotypy and creativity. Firstly, both studies included are well-powered to detect a small effect (MTurk sample n = 428, Lab sample n = 361). This is unusual in this literature, as many of the existing studies are underpowered. Existing study sample sizes range from as few as 27 to as many as 1108. Sample sizes have increased in more recent years; the average sample size of studies included in the Acar & Sen (2013) meta-analysis was 154 (Median = 93), whereas the mean sample size of studies included in articles published since the meta-analysis was 186 (Median = 133). While increasing sample sizes in individual differences research is a positive step, underpowered research is still very common. Secondly, my study uses multiple measures of creativity. As discussed in the general introduction, creativity is a multi-faceted construct that likely involves a number of complex, related but separable processes.

The two primary performance based tasks measuring creativity reflect two important general processes thought to underlie creativity: convergent thinking (RAT) and divergent thinking (AUT). Using both, I can compare and contrast the relative roles of these

processes in creativity and how they might explain differences in the schizotypy-creativity relationship. There is a much smaller group of studies that use both divergent and convergent thinking creativity tasks. From that sample, there is an even smaller set that have a large enough sample to detect the small effect described by Acar and Sen (2013).

It is also unusual to have the opportunity to compare two different samples using identical tasks and identical scoring methods. All uses generated in the AUT from both samples were scored simultaneously by the same group of five raters, and inter-rater reliabilities for the two sample were high (MTurk ICC and Lab ICC = .828).

Although this research relies primarily on performance-based tasks to assess creativity, theoretically, self-report measures reflect another important conceptualisation of creativity. Creativity, in the personality psychology literature, is defined as a quality/characteristic that a person can have. While performance measures are the gold standard for assessing creativity, it may be that the relationship between schizotypal traits is stronger when creativity is measured using self-report, which better taps into the 'creative personality.' In order to test this, in the Lab sample, the creative personality scale (CPS) was also added. Interestingly, interpersonal schizotypy was associated with less creative personality. The creative personality scale includes many traits that would be considered unhelpful in a variety of contexts, not just in creative contexts.

Similarities and differences across samples.

While the effect of disorganised schizotypy in the RAT and the null effect in the AUT both replicated, most other findings did not. Table 3.10 summarises the regression results based on whether there was a positive (+ve), negative (-ve) or non-significant (ns) result. Each row compares the findings based on the regression analyses for each sample.

Table 3.10. A comparison of findings between the AUT, RAT and the different factors of schizotypy (regressions)

	Cognitive Perceptual	Disorganised	Interpersonal
AUT (Creativity)			
MTurk	ns	+ve	ns
Lab	ns	+ve	ns
RAT			
MTurk	**-ve**	ns	**+ve**
Lab	**ns**	ns	**ns**
AUT (fluency)			
MTurk	**ns**	ns	**ns**
Lab	**+ve**	+ve	**-ve**

Note. +ve=positive association, -ve=negative association, NS = no significant association

It is important to note that the MTurk sample was collected a year before the Lab sample. One of the primary aims of the Lab sample was to provide a conceptual replication of the MTurk sample, and therefore we would expect the results to be the same. However, the results for some factors were different from each other.

Should the fact that the schizotypy-creativity relationships differ between the two samples undermine my confidence in the results in one or both of the samples? Given the high statistical power in both samples, inconsistencies are unlikely to reflect Type 1 or Type 2 error. Differences are more likely to reflect differences in the populations the two samples are taken from, or differences in the way the data were collected. The two samples are similar in that they are English speaking, but different in age and country of origin.

Age differences may well account for the difference; MTurk sample participants were older on average than the first year psychology students. There is also developmental research that supports these age effects, showing that creativity on the same tasks

improves from childhood to young adulthood (Wu et al., 2005). Insight ability (Kleibeuker et al., 2013, cited in Barbot, Lubart & Besancon, 2016) and the ability to identify original and appropriate ideas (Charles & Runco, 2001, cited in Barbot et al., 2016) also both seem to improve with age. While it is unclear why that might be, there are some potential explanations. One possible explanation is that with age comes development of important meta-cognitive skills such as critical thinking, reflective skills and other problem solving skills likely necessary for creativity tasks (Dawson, 2008). Interestingly, all these aforementioned skills seem intuitively particularly useful for solving RAT problems.

Older adults may also have an advantage in the RAT in particular, as some of the problems use language that is likely more familiar to older participants. The MTurk sample performed much better on the RAT. The RAT problems used are now quite old, and some items may be anachronistic or not reflective of current usage, or New Zealand usage. Some of the items also reflect cultural references that are no longer relevant to young people. When solving the problem 'animal, back, rat' a young person is not likely to make the connection to pack with 'Rat', as the term 'Rat pack' is very old and does not have the same current cultural resonance. Finally, the older participants are, the more likely they are to have had experience with the AUT or the RAT or similar tasks in another setting. This is even more likely in an MTurk sample, as participants may have completed the RAT in another study. This would reduce the overall correlation between schizotypy and creativity in the Lab sample compared to the MTurk sample, by limiting the ability to see associations with schizotypy with such a restricted range of scores on the RAT in the Lab sample.

Age may play a role, not because we would expect that age would influence the correlation between schizotypy and creativity, but because age may influence the validity of the task. Given that age is one factor in which the two samples differ, does the creativity task have higher validity in one sample over the other?

In order to explore the possibility that age accounted for the different schizotypy-creativity relationships in the two samples, age was added as a first step in the multiple regression analyses for the two samples separately. In the MTurk sample, age accounted for a significant portion of the variance in creative performance, for both the RAT and the AUT. However, it did not explain any variance in the Lab sample. This suggests that age has played a part, at least in the MTurk sample. One reason why the age effect might not be apparent in the Lab sample is due to a lack of variability in age of participants.

The two samples also participated in research for different reasons, raising speculation that they may differ in motivation. On the one hand, we might assume the Lab sample is more motivated to do well as they are more interested in psychological research in general, as psychology students. On the other hand, they may be less motivated to do well; studies have found that participants in student pools are less motivated and have reduced concentration compared to online participants (Hauser & Schwartz, 2016). Motivation may lead to fewer genuinely creative ideas on the AUT or fewer attempts to solve problems on the RAT, as well as reducing the strength of any association between schizotypy and creativity in the Lab sample. There is some evidence for this. For example, reward is positively correlated with creative behaviour (Friedman, 2009; Eisenberger & Rhoades, 2001).

Different findings across samples may also stem from the way data were collected. While the two studies used the same measures and tasks, there are some differences in how they were implemented. The community/MTurk sample completed the study online, on their own, with no supervision or engagement from the researcher. While I had some ways of checking that they were putting their full effort and attention into the study, I have no way of knowing with 100% certainty that they were completely motivated to do their best with the creativity tasks, or to be completely honest when filling out the schizotypal personality questionnaire. However, the MTurk participants did score similarly to the Lab sample on the AUT, and better than the Lab sample on the RAT, indicating either high motivation or ability to do the task. However, significantly higher scores on the RAT may indicate that some of the MTurk participants searched for answers to the RAT problems online, as a lot of them are publicly available. While one of the follow-up questions asks if they got help answering any of the questions from anyone (and excluded people based on their responses) it is possible that they did not report cheating in this question.

Over the last two years since data collection for the MTurk sample there has been increasing concern about the propagation of bots in online survey websites (Kennedy et al., 2019). While it appears that this has become a challenge for research in the past couple of years, this is likely not a concern for the current MTurk sample. The data for this sample was collected mid-2017, whereas the rapid influx of bots and the corresponding decrease in reliable data started around mid-2018 (Chmielewski & Kucker, 2019). Also given the nature

of the tasks involved in this study it would be very difficult to automate one's responses. The MTurk sample also showed much higher accuracy rates than the Lab sample in the RAT.

Inconsistencies across literature.

In general, however, as the Acar and Sen meta-analysis demonstrates, inconsistency in schizotypy-creativity relationships is the rule, not the exception. In order to help contextualise the current findings, I extracted the studies from the literature that were most comparable to the current study. There were 23 studies included in the meta-analysis and my additional search that used some type of divergent thinking task similar to the AUT to measure creativity (including other tasks like the instances task or the unusual uses task, which are very similar in concept and coding, are also included). Twelve of these studies showed no relationship between schizotypy and creativity. Eleven of these studies found a positive association between schizotypy and creativity. Out of the 9 studies that used the RAT, or a similar insight-based problem solving task, 5 of these studies found no relationship, 2 found that schizotypy was positively associated with creativity and 2 found that schizotypy was negatively associated with creativity. Details of each study are outlined in Table 3.11. What are some factors that might explain this variability?

Table 3.11. Literature summary of schizotypy-creativity research including either AUT or RAT as creativity measures, divided into pre- and post-meta-analysis sections.

	Study	Sample size(s)	Group vs individual differences study	Schizotypy	Creativity	Direction
Meta-analysis	Rust et al., 1989	80	Individual diffs	RISC	AUT	Positive
	Rawlings & Toogood, 1997	170	Individuals diffs	O-LIFE	AUT	Positive
	Green & Williams, 1999	72	Individual diffs	STA	AUT	Positive
	Schuldberg, 2001	1108	Individual diffs	MI scale	AUT	Positive
	Wuthrich & Bates, 2001	94	Individual diffs	Modified SPQ (5 items only)	AUT	NS
	Gibson, Folley & Park, 2005	Study 1: 40 Study 2: 15		SPQ	AUT	NS
	Burch et al., 2006	107	Individual diffs	O-LIFE	AUT	NS

	Krysankski & Ferraro, 2007	60	group	SPQ	AUT	NS
	Claridge & McDonald, 2009	77	Individual diffs	O-LIFE	AUT	NS
	Claridge & Blakeley, 2009	78	Individual diffs	O-LIFE short	AUT	NS
Post Meta-analysis	Armstrong, 2012	114	Individual diffs	Specific subscales (Social anhedonia, PhysAnhedonia, MI, PerAB scale)	AUT	NS
	Wang et al., 2012	-	-	-	AUT	Positive
	Rominger et al., 2014	40	group	SPQ: positive schizotypy only, 5 point likert version	AUT	NS
	Le Boutillier et al., 2014	133	Individual diffs	O-LIFE	AUT	NS + positive
	Minor et al., 2014	148 (3 groups selected based on high scores)	group	SPQ-Brief	AUT	Positive

	Le Boutillier et al., 2016	203	Individual diffs	O-LIFE brief	AUT	NS
	Webb et al., 2017	Study 1 = 293, study 2 = 119	Individual diffs	O-LIFE	AUT	NS
	Winston et al., 2014	130	Individual diffs	O-LIFE brief	AUT	Positive
	Rominger et al., 2017	46	Individual diffs	SPQ: positive schizotypy only, 5 point likert version	AUT	Positive
	Polmer et al., 2018	182	Individual diffs	O-LIFE brief	AUT	NS
	Wang et al., 2018	388	group	SPQ	AUT	Positive
	Baas et al., 2019	Study 1 = 147, Study 2 = 339	Individual differences	O-LIFE	AUT	Study 1 = positive Study 2 = NS
	Carter et al., 2019	156	Individual differences	SPQ-Brief	AUT	NS
Meta-analysis	Weinstein & Graves, 2002	62	Individual diffs	SPQ (modified – 5 items)	RAT	Positive

	Gibson, Folley & Park, 2005	20 x 20 (2 groups based on musician/non-musician)	Group and individual diffs	SPQ	RAT	NS
	Karimi et al., 2007	24 x 24 (2 groups, low and high SPQ scores)	Group and individual diffs	SPQ	RAT (insight problems*)	positive
	Suzuki & Usher, 2009	53	Individual diffs	O-LIFE	RAT	NS
Post meta-analysis	Armstrong, 2012	114	Individual diffs	Specific subscales (Social anhedonia, PhysAnhedonia, MI, PerAB scale)	RAT	NS = anhedonia scales, negative = MI per ab scales
	Wang et al., 2017	117 (low scz, high scz, schizophrenia)	group	SPQ	AUT	Positive (high schizotypy better in AUT)
	Webb et al., 2017	388	group	SPQ-chinese version	AUT	Positive high schizotypy better at AUT

Polmer et al., 2018	182	Individual diffs	O-LIFE brief hungarian	AUT + RAT	NS
Stanciu & Papasteri, 2018	229	Individual diffs	O-LIFE	RAT (insight problems)	NS except impulsive non-conformity = positive

Note. AUT = Alternate uses task, RAT = Remote associates test. NS = non-significant

There are differences in the ways that creativity is assessed and scored between studies, even when using the same task. Silvia and Willse (2008) showed there were significant improvements in reliability in the AUT going from one method of scoring (scoring only the top two items) to another (scoring all items and taking the average). This difference alone increased reliability from 0.58 to 0.70. Using an average scoring system and increasing the number of raters from 1 to 5 further increased reliability from 0.70 to 0.92. The scoring process itself is also often a subjective process; what one person calls a very original idea may be seen by somebody else as completely unoriginal. What makes this even more challenging is that it is very difficult to evaluate how much variation there is in the scoring process, as very few studies publish detailed information about their scoring. There are also other contextual factors that influence variability in creativity research, such as the mode of administration (online vs in person; time pressure vs non-time pressured) as well as differences in the way the study is framed (framed as a creativity study vs no-framing). All these factors contribute to differing amounts of measurement error present in research. Measurement error reduces the maximum observable correlation, and may partially explain the small correlation coefficients that are commonly seen in the schizotypy-creativity literature (Silvia & Willse, 2008).

Next step: chapter four.

So far, the current research has taken a dimensional approach to understanding the relationship between schizotypy and creativity. This is consistent with the majority of personality research, which considers a personality trait, or a sub-factor of a personality trait as the primary unit of analysis. This variable-centred approach to personality views the sub-factors of schizotypy as related, but still very separable constructs that are meant to capture different aspects of the schizotypy construct (cognitive, affective, behavioural) that may independently be linked to differences in creative thinking. In the same way, other personality traits have been considered separate predictors of creative performance in their own right (e.g., openness to experience, neuroticism, or conscientiousness). However, in recent years there has been a shift towards considering personality from a person focussed perspective. Instead of asking whether individual factors of schizotypy separately predict levels of creativity, one can ask whether there is a potential interplay between schizotypal traits that might predict creativity. Perhaps the combination of being high on two and low on one might be important to creativity? In the next chapter, I will re-analyse the data from

both samples from a latent profile perspective to determine whether there are any patterns of schizotypal characteristics that might be more beneficial for creative thinking than others.

Chapter 4: A taxonomic perspective on schizotypy-creativity relationships

As described in the general introduction, there are two approaches to analysing schizotypy data, driven by two different conceptualisations of the schizotypy construct. In Chapter 3, I analysed the data using a factor driven approach, by testing whether any factors of schizotypy were correlated with creativity. Based on the literature I expected to find that positive schizotypy would positively predict creativity, more strongly than any other schizotypy factor. In contrast to predictions, there was some evidence that positive schizotypy negatively predicted RAT performance in the MTurk sample that did not replicate in the other sample. Only disorganised schizotypy positively predicted Creativity in the AUT, which replicated in the Lab sample. Interpersonal schizotypy positively predicted Creativity in the AUT but only in the MTurk sample. Fluency in the AUT also positively predicted schizotypy in the Lab sample, but this effect did not replicate in the MTurk sample.

I discussed some of the reasons that the current study's results may have been inconsistent with previous findings and possible reasons why there were some inconsistencies between the two samples. In the current Chapter, I will explore another approach to analysing the data to capture individual differences in schizotypy that may be meaningfully related to creativity.

In the general introduction I discussed the distinction between a dimensional and a taxonic view. A factor approach is useful in understanding how some characteristics are associated with certain outcome measures, and is consistent with a dimensional view of schizotypy. However, a latent profile analysis (LPA) approach is more consistent with a taxonic view. LPA investigates whether grouping individuals based on combinations of traits explains an outcome of interest (in this case, creativity) that is not evident when examining the data from a factor level (Olivera-Aguilar, Rikoon & Robbins, 2017). LPA is not unique in this regard; cluster analysis is another method that is commonly used to identify subgroups of individuals within a large sample. Unlike cluster analysis, however, LPA determines group membership based on probabilities. With cluster analysis, clusters are selected using an arbitrarily chosen distance measure, but LPA uses a model that describes the distribution of the data, and based on this model, assesses the probability that certain cases are members of certain classes. Because it is probabilistic, it also gives additional ways to assess model fit using likelihood statistics. Simulation studies suggest that probability-based mixture

modelling is more accurate at detecting meaningful sub-groups within the data than cluster analysis (Cleland, Rothschild & Haslam, 2000, cited in Tein, Coxe & Cham, 2013).

In the introductory chapter, I discussed one study (Hori et al., 2014) that, using LPA with a sample of 455 individuals, found that participants fit into three distinct profiles based on their SPQ scores. Profile 1 consisted of participants who scored higher on the Cognitive Perceptual factor and relatively lower on the other two factors (Disorganised and Interpersonal). Profile 2 consisted of participants who scored high on all three factors (with a particularly high score on the Interpersonal factor). Profile 3 consisted of participants who scored lower than both groups on all three sub-factors. Another study using latent profile analysis (Tuchman-Tabak et al., 2013) of the O-LIFE identified six distinct profiles: a low schizotypy group, average schizotypy group, high schizotypy group and three high factor specific groups: a high positive schizotypy group, a high interpersonal schizotypy group, and a high interpersonal/disorganised schizotypy group. Notably, this study (albeit using a slightly different questionnaire) did not find a group that reflected high positive schizotypy and low levels in the other factors.

These profiles are then used to test predictions about differences in performance on other measures of interest. For example, Hori and colleagues (2014) found that profile membership significantly predicted performance on a number of cognitive tasks, in particular several short term memory tasks, working memory tasks, and tasks of processing speed (as measured by reaction times across a number of intelligence tests). Participants in the high positive schizotypy group showed significantly better performance in these tasks compared to the high schizotypy group, suggesting that this group of individuals showed some of the characteristics of schizotypy (and specifically, some of the benefits of high positive schizotypy) without the typical cognitive deficits.

Tuchman-Tabak and colleagues (2013) also found that both the low schizotypy scoring profile and the high unusual experiences (low other factors) profile are associated with better outcomes in all measures of psychological well-being. Membership in the high schizotypy scoring profile, and the high introvertive anhedonia and cognitive disorganisation group was associated with much worse outcomes on all measures of psychological well-being.

Overall, there is evidence that taking a latent profile (taxonic) approach rather than a dimensional approach allows us to identify sub-groups within a population. This could be

important when testing the theoretical claims linking schizotypy to creativity. As already discussed, the literature on schizotypy and creativity suggests that people who are high on positive schizotypy will be more creative due to looser associative processing/greater access to more remote ideas in semantic memory (Mednick, Mednick & Jung, 1964). One potential reason why this does not receive consistent empirical support could be that this is only true in a subset of individuals, who show high levels of some traits of schizotypy but not others. By identifying sub-groups in the data we may provide a stronger test for this claim. According to Linscott, only a small proportion of people are high risk for schizophrenia, so identifying those people may be essential to detecting schizotypy-creativity relationships.

One drawback of latent profile analysis is that it requires very large sample sizes (Tein, Coxe & Cham, 2013). While there is no current standardised way to calculate power for a latent profile analysis, research suggests it requires substantially larger sample sizes than typical individual differences research. Larger samples increase the ability to discriminate accurately between profiles (Tein et al., 2013). Combining both samples in the current study yields 792 participants, which is a well powered sample size for this type of analysis. In fact, this is a much larger sample than used in other studies doing LPA within the schizotypy literature (Hori and colleagues had a sample of 455 and Tuchman Tabak a sample of 420). A review by Tein and colleagues suggests that this is a substantially larger sample than used in LPA research in psychological science in general. Out of the 32 articles published between 2007-2010 identified in their brief review, the median sample size was 377 (Tein et al., 2013). Given the lack of studies with such a significant sample size, the current thesis will provide a good opportunity to test the value of this method compared to a typical dimensional approach.

This chapter will use both samples to undertake an LPA to determine which number of profiles best fit the data. Then, in each sample individually, I will compare each profile on creativity performance, and using the data from the Lab sample, on working memory and associative processing. This analysis is mostly exploratory as there has been little research using LPA with schizotypy data before, and none that has used a latent profile approach to test relationships between schizotypy and creativity. However, previous research has identified individuals who have both high levels of positive schizotypy traits and low levels of disorganised and interpersonal schizotypal traits (Hori et al., 2014). According to theoretical models of creativity, this group is predicted to perform the best in the creativity

tasks, as they should be able to draw on diffuse semantic networks, but without the same levels of cognitive deficits as those who have high levels of all schizotypal traits (and particularly high levels of disorganised traits).

Method

Brief description of samples and methods.

Detailed methods used for data collection are presented in Chapter 2. The following briefly describes additional information regarding participant and task characteristics that are relevant for this chapter.

Participants.

In order to ensure adequate statistical power, I combined the SPQ data of the two samples (MTurk sample and the Lab sample) to gain a total sample size of 789 for the LPA. This also increased the range of our sample considerably in terms of age, making our sample much more representative of the general population than the typical sample of undergraduate psychology students.

Procedure.

Mplus Software version 7 was used to conduct the latent profile analysis, and SPSS version 24 for all follow up analyses.

Statistical analysis. Exploratory LPA was conducted to identify latent groups based on SPQ factor scores (Cognitive-Perceptual, Interpersonal, and Disorganised) in the combined MTurk and the Lab sample group. The LPA was conducted using SPQ data because it was administered to both samples, and largely converged with the O-LIFE in the MTurk sample. The model comparison was begun by evaluating the fit of a 3 class model, and the number of latent groups was increased until the data was not better explained by adding another group. This was determined by evaluating several fit indices. There are a number of different fit indices that are used to evaluate profile numbers in the literature; here I focussed on the log likelihood value and its associated significance value, as well as the Akaike Information Criterion (AIC; Akaike, 1987), which indicates how well the current model fits the data (lower number relative to other models indicates better fit). The log likelihood allows one to compare one model to another, e.g., to determine whether a 3-profile model or a 4-profile model better describe the data (Nylund, Asparouhov & Muthen, 2007). Once the optimal number of profiles was identified, groups were compared on measures of creativity, using one-way multivariate Analysis of Variance (MANOVA) with

profile and sample as between subject variables. Significant effects were followed up with individual ANOVAs where appropriate. One way ANOVAs were also used to compare groups in the Lab sample on associative processing and working memory.

Results

Goodness of fit statistics are reported in Table 4.1. AIC for the 4-class model was the lowest out of all models tested, indicating that 4 profiles is the best fit. The p-value associated with the log likelihood value indicates how well the model fits the data in comparison with other models. A p-value of $p < .05$ indicates that the current model is a good fit and should not be replaced with a smaller or larger number of profiles. The p-values associated with a 3- profile model and a 5- profile model are not significant, indicating that they do not fit the data better than a 4-profile model. The p-value for a 4 profile model approaches significance – this, combined with the AIC value suggests that a four profile model is the best fit for the data.

Table 4.1. Goodness of fit indices for all models tested in the LPA. A four class model fits the best, based on log likelihood and AIC values.

Model	AIC	BIC	Log likelihood	p value	LMR-A Log likelihood	LMR-A p value
6 class	14290.255	14411.794	-7148.583	0.1148	56.783	0.12
5 class	14341.166	1444.006	-7192.505	0.33	84.673	0.33
4 class	**14221.010**	**14505.153**	**-7227.601**	**0.08**	**67.657**	**0.0823**
3 class	14483.202	14548.646	-7289.331	0.23	119.003	0.23

Note. AIC = Akeike Information Criterion, BIC = Bayesian Information Criterion.

Profile membership based on schizotypy factor scores.

Table 4.2 outlines participant numbers in each of the four profiles by sample. The majority of participants were allocated into either profile 1 or 3. Table 4.3 outlines the means for each factor by profile membership. Profile 1 consists of participants with the lowest scores on all factors (low schizotypy group), participants in profile 2 showed higher Cognitive Perceptual and interpersonal scores but not Disorganised scores (high positive-interpersonal group) Participants in profile 3 (average schizotypy group) showed middling scores on Cognitive-Perceptual and Disorganised factors, and relatively higher scores on the Interpersonal factor, and finally profile 4 (high schizotypy group) showed relatively high scores on all factors; see Figure 4.1 for a visual comparison of average schizotypy scores for each factor based on profile membership. A chi-square analysis found that profile membership significantly differed by sample χ^2 (3, 792) = 23.746, $p < .001$. There are proportionally more low scoring schizotypy profile members and high scoring schizotypy profile members in the MTurk sample compared to the Lab sample. The numbers of people in the medium scoring schizotypy groups are relatively similar between the two samples.

Table 4.2. Number (and percentage) of participants per group, by sample based on the Latent profile analysis.

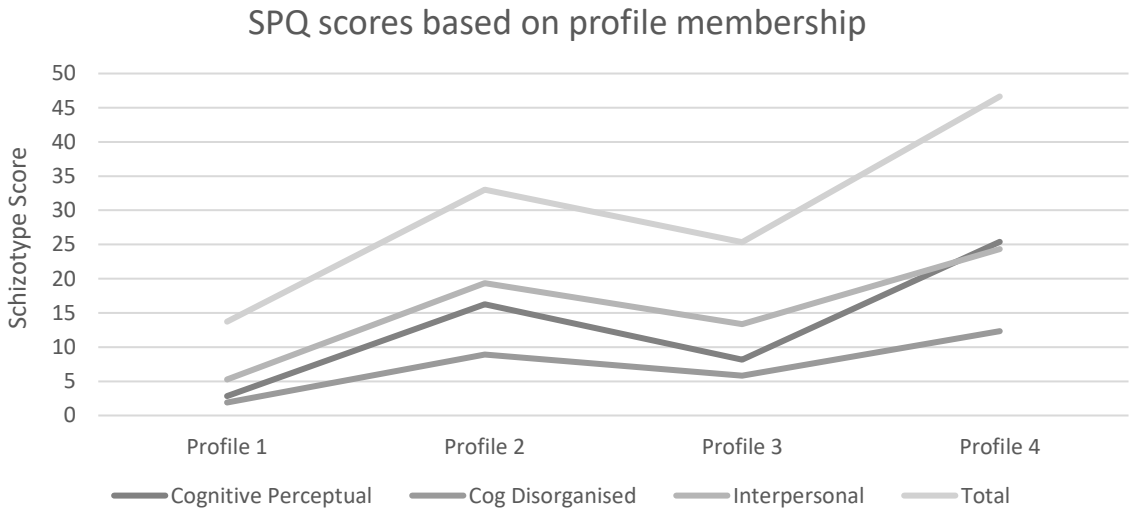
	Sample	
	MTurk	Lab
Profile 1 (low schizotypy)	195 (45.8%)	116 (32.7%)
Profile 2 (high pos-inter)	96 (22.7%)	86 (25%)
Profile 3 (average schizotypy)	110 (25.7%)	134 (39.3%)
Profile 4 (high schizotypy)	25 (5.8%)	10 (3%)

Table 4.3 SPQ scores by profile membership based on the Latent Profile Analysis.

	Cognitive Perceptual	Disorganised	Interpersonal	Total
Profile 1 (low)	2.84 (2.62)	1.90 (2.02)	5.27 (4.10)	13.72 (11.18)
Profile 2 (high positive-interpersonal)	16.28 (3.67)	8.93 (3.32)	19.34 (5.48)	33.01 (11.86)
Profile 3 (average)	8.18 (3.34)	5.83 (3.08)	13.37 (5.41)	25.34 (10.61)
Profile 4 (high)	25.39 (3.27)	12.33 (3.23)	24.33 (5.57)	46.64 (16.25)

Note. means (and std. Deviations in brackets) for scores on each factor of the SPQ within the two profiles. Maximum possible score for Cognitive-Perceptual subscale is 16; for Disorganised subscale is 16; for Interpersonal is 25; for total score is 74.

Figure 4.1 SPQ scores based on profile membership based on the LPA.



Comparison of creativity across profiles.

Table 4.4 shows average scores for the three creativity dependent measures, average Creativity and Fluency (number of words) in the AUT and scores on the RAT by profile membership in each sample. Scores on the RAT appear to have the most variability between profiles.

Table 4.4. Descriptive statistics for creativity measures based on profile membership in the two samples.

Profile	Average creativity AUT	Number of words	RAT
		M (*SD*)	
		MTurk sample	
1 (low)	2.26 (.30)	8.27 (2.60)	20.30 (8.21)
2 (high pos-inter)	2.22 (.51)	7.94 (2.97)	17.90 (7.58)
3 (average)	2.34 (.34)	8.44 (2.58)	19.78 (7.64)
4 (high)	2.34 (.45)	8.52 (2.65)	14.40 (6.88)
		Lab based sample	
1 (low)	2.20 (.32)	8.21 (2.05)	10.10 (5.65)
2 (high pos-inter)	2.29 (.37)	8.91 (1.55)	11.36 (5.38)
3 (average)	2.28 (.35)	8.56 (1.83)	10.28 (5.48)
4 (high)	2.26 (.44)	8.60 (1.71)	8.50 (7.28)

In order to test whether profile membership predicts creative performance, a two-way MANOVA was conducted, with profile membership and sample as independent variables, and the three creativity measures as dependent variables. The relationship between profile membership and creativity differed in the two samples, as shown by a significant interaction between profile and sample, $F(2,2292) = 1.767$, $p = .049$, $\eta_p^2 = .007$. Therefore, a follow-up series of one-way ANOVAs were conducted for the three dependent variables in each sample separately. There were no significant effects of profile in either sample on either of the AUT dependent measures. However, there was a significant effect

of profile on performance on the RAT in the MTurk sample only, $F(3,422) = 5.437$, $p = .001$, $\eta^2 = .037$. Follow up post-hoc comparisons show that participants in the high schizotypy profile were significantly impaired relative to others (see Table 4.5). Notably, the effect of profile on RAT performance in the Lab sample did not approach significance, $F(3, 342) = 1.365$, $p = .253$, $\eta^2 = .012$.

Table 4.5. Post-hoc analyses comparing RAT performance based on profile membership in each sample separately.

		Mean difference	p Value
	MTurk sample		
Profile 1 (low)	Profile 2	2.4652	.058
	Profile 3	.5906	.922
	Profile 4	**5.9724**	**.002**
Profile 2 (high pos-inter)	Profile 1	-2.4652	.058
	Profile 3	-1.8746	.319
	Profile 4	3.5072	.194
Profile 3 (average)	Profile 1	-.5906	.922
	Profile 2	1.8746	.319
	Profile 4	**5.3818**	**.012**
Profile 4 (high)	**Profile 1**	**-5.9724**	**.002**
	Profile 2	-3.5072	.194
	Profile 3	**-5.3818**	**.012**
	Lab sample		
Profile 1 (low)	Profile 2	-1.3025	.346
	Profile 3	-.2539	.984
	Profile 4	1.5424	.833
Profile 2 (high pos-inter)	Profile 1	1.3025	.346
	Profile 3	1.0485	.516

	Profile 4	2.8448	.417
Profile 3 (average)	Profile 1	.2539	.984
	Profile 2	-1.0485	.516
	Profile 4	1.7963	.756
Profile 4 (high)	Profile 1	-1.5424	.833
	Profile 2	-2.8448	.417
	Profile 3	-1.7963	.756

Note. Profile 1 = low scoring schizotypy group, Profile 2 = medium-high scoring schizotypy group, Profile 3 = Medium scoring schizotypy group, Profile 4 = High scoring schizotypy group. Significant analyses highlighted in bold.

Exploratory analyses: Cognitive processes based on profile membership in lab sample only.

Given that there is a significant effect of profile membership on RAT performance in the Lab sample only, and there is also corresponding cognitive task performance available for this sample (working memory and associative processing), I performed two one-way ANOVAs testing whether profile membership predicts cognitive performance (presented in table 4.6). Overall, there was a marginal effect of profile membership on WM performance $F(3, 320)=2.217$, $p = .086$, with post-hoc analyses showing worse performance in the high schizotypy group. These analyses are exploratory and significantly underpowered, particularly in profile 4 ($n = 10$) and therefore should be interpreted with caution.

Table 4.6. Means and SDs for WM ability by profile membership

Profile	Task	N	Mean	SD
1 (low)	WM	110	33.80	5.416
2 (high pos-inter)		79	33.96	7.241
3 (average)		125	34.66	5.570
4 (high)		10	29.70	7.682
1 (low)	WAT	118	.2725	.04618
2 (high pos-inter)		87	.2684	.07537

3 (average)	132	.2755	.04200
4 (high)	10	.2550	.04386

Discussion

Using a latent profile analytic approach, in contrast to a traditional factor approach revealed four distinct profiles within the SPQ data. The groups consisted of one low scoring group (lowest scores on all sub-factors), one high scoring interpersonal and positive schizotypy group (high pos-inter), an average scoring group (average scores on all factors) and a high scoring group (high scores on all factors). While the majority of the participants do not show high levels of schizotypal traits (which is to be expected in a non-clinical sample), there is still a small group of participants (n = 35 across both samples) who scored relatively highly on all factors of the SPQ. Notably, this group was highest in disorganised traits. Based on the LPA, I tested whether a person's profile membership and sample membership predicted their creativity performance. Profile membership did not predict performance on the AUT in either sample. However, in the MTurk sample people in the high schizotypy group did worse on the RAT. This finding suggests that higher levels of schizotypal traits are associated with worse performance on the RAT, but not the AUT, which contradicts the current hypotheses that schizotypy would facilitate creative thinking. These results are consistent with Chapter 3, where positive schizotypy was also associated with worse performance on the RAT. This suggests that this small group of individuals high in schizotypy show relative deficits in executive functions that contribute to analytical thinking, but not to creativity. However, as in Chapter 4, this effect did not replicate in the Lab sample. This may be because the RAT is not a good measure (of either analytic thinking or creativity) in the young NZ student population.

Comparison of profiles across studies.

Table 4.7 compares the identified profiles of three previous studies with the current profile structure. Firstly, there are some differences in the number of profiles identified overall. One study identifies three profiles, two studies identify four and one study identifies six. The summaries in Table 4.7 suggests this may be due to the type of questionnaire used to conduct the LPA, with the O-LIFE identifying more profiles. One explanation for this is that the O-LIFE has one extra factor compared to the SPQ (impulsive non-conformity), and so more possible combinations of traits.

Table 4.7. A comparison of LPA results across four studies.

Indicator	Hori study	F-P study	My study	T-T study
Sample type	Community (Japan)	University students	University students + online	University students
Schizotypy measure	SPQ-Brief	SPQ-Brief	SPQ	O-LIFE
Total sample size	455	978	792	420
Sample size breakdown by profile	Profile 1 (high pos) = 61 Profile 2 (high) = 82 Profile 3 (low) = 312	Profile 1 (low) = 639 Profile 2 (avg) = 147 Profile 3 (high neg/inter)= 161 Profile 4 (high) = 28	Profile 1 (low) = 110/118 Profile 2 (high pos-inter = 79/87 Profile 3 (avg) = 125/132 Profile 4 (high) = 10/10	Profile 1 (low) = 140 Profile 2 (high UE) = 30 Profile 3 (high IA) = 40 Profile 4 (High IA/CD) = 43 Profile 5 (avg) = 161 Profile 6 (High) = 6

Note. SPQ = Schizotypal Personality Questionnaire, O-LIFE = Oxford-Liverpool Inventory Feelings and Experiences.

Studies also differ significantly in the characteristics of the profiles identified. The current study did not identify a high positive (only) schizotypy group. This was unexpected, as two previous studies did find a high positive schizotypy group (Hori et al., 2013; Tuchman-Tabak et al., 2013). Furthermore, this group showed better outcomes in both studies. Participants in the high positive schizotypy profile group in the Hori study showed significantly better performance in cognitive tasks compared to the high schizotypy profile group. Tuchman-Tabak and colleagues also found that both the low schizotypy scoring profile group and the high Unusual Experiences/low other factors profile group are associated with *better* outcomes in all measures of psychological well-being. Conversely, membership in the high Introvertive Anhedonia and Cognitive Disorganisation group was associated with much *worse* outcomes on all measures of well-being. Furthermore, there is good theoretical reason to predict that a high positive schizotypy group would perform better in a creative task. This group would show some of the 'classic' characteristics of schizotypy, including diffuse associative processing that are shared with creative cognition without the negative side of schizotypy (cognitive deficits and poor interpersonal functioning).

One possible explanation for the difference may be due to study design. Perhaps if the sample was larger, or if I used a different measure of schizotypy, I would have found a group that was high on schizotypy only and that would have been positively associated with creativity. The nearest comparable profile found in the current study was the high positive-interpersonal group. However, this is unlikely, given the much larger sample size used in the current study compared to previous research. It is possible that individuals in this group did not perform well in this group due to social anxiety around completing the task. Finally, if I had a high disorganised only group, they may have done well in the AUT (to mirror the results in Chapter 3).

All studies identified a low scoring group (low scoring on all factors) and a high scoring group (high scoring on all factors). The high group in particular is of interest, as it is consistent with Linscott's work that identifies a 'high risk' group (Everett & Linscott, 2015). According to a taxonic view, these individuals have the genetic vulnerability for schizophrenia, as evident by high schizotypal traits that could transition into expression of schizophrenia when paired with environmental stressors. Both the current study and the Tuchman-Tabak study found that the small group of people in the high schizotypy group

were associated with worse outcomes (decreased well-being in a number of psychological well-being measures, and worse performance on the RAT). In contrast, the low scoring schizotypy profile was associated with better outcomes in all measures of psychological well-being.

Overall, the LPA studies discussed here differ in keys ways, in terms of the number of profiles identified, and the characteristics of those profiles. What might explain some of these differences? As already mentioned, differences between studies may be due to design differences, including the use of different schizotypy measures. Two of the studies (Hori et al., 2014; Fonseca-Pedrero et al., 2017) used the SPQ-Brief version and one study used the O-LIFE (Tuchman-Tabak et al., 2013). My study was the only one to use the full version of the SPQ. Future research is required to establish to what extent the type of questionnaire, the sample size, the type of sample among other factors might matter in determining the number of profiles in any individual sample and the type of profiles identified. A useful future study would be to do an LPA using a number of different measures and compare the findings of each. There is also potential value in identifying profiles based on multiple questionnaires at once.

Predicting outcomes – current study.

Based on the LPA I tested whether a person's profile membership and sample membership predicted their creativity performance. First, profile membership did not predict performance on the AUT in either sample. One possible explanation for the lack of a significant effect here (compared to the RAT), may be to do with executive functioning. Previous literature has shown that the RAT relies more heavily on executive functioning resources than the AUT (Jarosz, Colflesh & Wiley, 2012), and schizotypal traits are linked to cognitive deficits (Ettinger et al., 2015). Therefore, people with schizotypal traits are likely to perform worse on the RAT. Another possibility is that high levels of schizotypal traits are associated with poor emotional distress tolerance, which makes sitting with the discomfort of not being able to immediately solve the RAT problem more difficult, and therefore people with schizotypal traits will be more likely to give up sooner. The AUT does not come with the same pressure.

However, the effect of profile membership on RAT performance was not replicated in the Lab sample. The inconsistency in results between the MTurk and the Lab sample

mirrors those found in Chapter 3, where schizotypy (positive and interpersonal) was negatively associated with RAT performance in the MTurk sample but not in the Lab sample. In Chapter 3, I focussed on sample characteristics that may have influenced the findings, all of which are potentially applicable when explaining the inconsistent findings between samples here (particularly age).

There are a number of possible reasons that the results do not replicate, all discussed in Chapter 3 (e.g. age, motivation). However, multiple regression analyses showed that schizotypy factors did predict creativity performance over and above what was predicted by age. In addition, the small number of people in the high schizotypy group (particularly in the Lab sample) limits the power to detect differences amongst groups, even in such a large sample.

Strengths of the method.

The LPA method provides a lot of additional information that is not provided when taking a dimensional view only. By examining the effect of individual factors on an outcome measure only, individuals who are high on one factor only will be grouped together with people who are high on all three factors. Whereas the current data and other empirical work would suggest that these an individual who is high one factor (say positive schizotypy) and an individual who are high on all three factors are very different both in terms of their cognitive profiles and overall psychological well-being. For example, take a sample of 30 hypothetical people. Using this approach helps tease apart the cognitive traits that differentiate those who have some ‘quirky’ qualities that are associated with schizotypy from those who have high levels of schizotypal traits.

Chapter 5: Models of creativity

Although schizotypy is commonly claimed to be associated with creativity, and an existing meta-analysis suggests a positive (albeit weak) association between the two, effects are inconsistent and studies are often underpowered. My goal in Chapters 3 and 4, therefore, was to address this question in two highly powered samples, using two different data analytic methods in order to determine whether this relationship exists or not. Based on the literature, I predicted a positive association between schizotypy and creativity, driven primarily by positive schizotypy. Using a dimensional approach in Chapter 3 showed no evidence for positive schizotypy positively predicting creativity in either sample. In fact, positive schizotypy *negatively* predicted creativity (as measured by the RAT) in the MTurk sample only. Disorganised schizotypy positively predicted Creativity in the AUT in both samples, and disorganised schizotypy positively predicted fluency in the AUT in the MTurk sample only.

In Chapter 4, I combined the two samples to conduct a latent profile analysis (LPA) in order to identify homogeneous sub-groups based on their combinations of schizotypal factors. The LPA identified four sub-groups: a low scoring schizotypy group, a high scoring schizotypy group, a high positive-interpersonal group (high in Interpersonal and Cognitive Perceptual sub-factors but not the Disorganised sub-factor) and an average scoring group (middling scores on the Cognitive Perceptual and Disorganised factors). Of these four groups, the high scoring group performed significantly worse on the RAT than the other groups. Dividing profile membership by sample revealed that this effect was only significant in the MTurk sample. Similar to the results of the MTurk sample in Chapter 3, schizotypy was associated with worse performance in the RAT only, specifically in the MTurk sample. There was no significant difference between groups in AUT performance.

Using two different samples achieves several goals. Firstly, the combined data represents a more diverse range of participants. A lot of existing research is based on data from first year psychology students, which restricts both the age (predominantly young) and gender distribution (predominantly female) of most research samples. The Lab sample was collected a year after the MTurk sample with two additional aims in mind: to establish whether the results of the MTurk sample were replicable, and to collect data on underlying cognitive processes in the more controlled environment of the lab. My approach is

motivated by theoretical models of creativity that identify interactions amongst core cognitive processes. In chapters 3 and 4, I focussed on whether schizotypy is associated with creativity. In this chapter, I focus on how they might be associated.

Unexpectedly, the significant negative association found between schizotypy and scores in the RAT did not replicate in the Lab sample. Only disorganised schizotypy was positively associated with average Creativity in the AUT in both samples. Despite the lack of an association between positive schizotypy and creativity in the Lab sample, collection of measures of schizotypy, creativity, associative processing and working memory allows me to test a number of existing models that link these constructs. In this chapter, I will therefore test whether cognitive processes mediate the relationship between schizotypy and creativity, focussing on positive schizotypy initially (as motivated by my original hypotheses) and then disorganised schizotypy, based on the positive association between disorganised schizotypy and Creativity in the AUT in both samples. Relatively few studies (Beaty, Silvia, Nusbaum, Jauk & Benedek, 2014; Kane et al., 2016) have explored the relationship between multiple cognitive tasks and multiple creativity tasks in a large sample. This also allows for a rigorous test of the three primary accounts of creative cognition. Given the lack of work done in this area, this is an important gap in the literature that I have the opportunity to address.

As outlined in the general introduction, there are three main theoretical accounts of creativity. An associative processing account posits that creativity is facilitated by diffuse semantic networks, which leads to the generation of more remote, unusual ideas during the creative process. From this view, enhanced associative processing would improve both RAT and AUT performance. An executive control account, on the other hand, states that people who have higher executive control do better at creative tasks. By this account, greater working memory capacity would also facilitate both RAT and AUT performance (although perhaps more strongly for RAT performance, if executive control is especially important for convergent thinking). Finally, a dual process account states that creativity requires both processes to be working effectively, in tandem. Initially, broader associative processing would provide access to more remote, interesting ideas; greater implementation of executive control would then be necessary to maintain the goal and evaluate possible solutions. This model predicts that the relationship between associative processing and

creativity should be moderated by working memory, specifically that associative processing should predict creativity only in those with high working memory capacity.

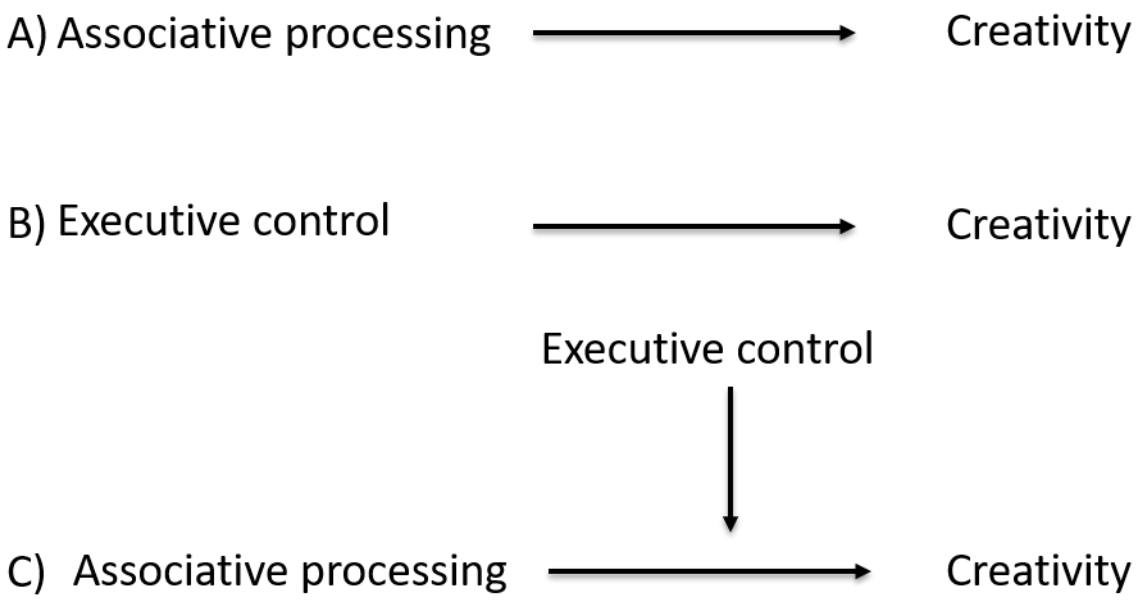


Figure 5.1. The three proposed models for creativity: associative processing model, executive control model and dual process model.

Schizotypy

This study also provides a valuable opportunity to test the associations between schizotypy and core cognitive processes. The literature linking high levels of schizotypal traits to individual differences in areas of cognitive functioning is relatively small (Ettinger et al., 2015; Kane et al., 2016), and somewhat inconsistent in its findings. As described in the general introduction, the evidence for poorer working memory capacity in high schizotypal individuals is mixed. For example, Kane and colleagues (2016) assessed working memory capacity using a number of working memory tasks and extracting a latent variable; working memory capacity did not predict schizotypal traits. This study, while also addressing the additional question of whether schizotypal traits and working memory are related to creativity, will also be an opportunity to replicate the results of Kane and colleagues in a different, yet similarly well-powered sample.

Finally, while there was little evidence for a relationship between schizotypy and creativity, it is still worth testing whether there is a relationship between these two variables that is better explained by underlying differences in cognitive processing. Very few

studies (with a couple of notable exceptions, see Smeekens & Kane, 2016) have tested schizotypal traits, creativity and other cognitive processes in a large sample in an empirically rigorous fashion.

In this next chapter, the first set of analyses will focus on testing the three accounts of creativity. I will test the two single process accounts (the associative processing account and the executive control account) by testing to what extent associative processing abilities or executive control predict creative performance. The second set of analyses will focus on whether any relationship between schizotypal traits and creativity is partially or fully explained by differences in cognitive processing, and will be informed by the results of the creativity analyses.

Study design

Associative processing.

A number of different tasks have been used to assess associative processing in both the schizotypy and creativity literature. Schizotypy researchers primarily use semantic priming tasks, with the assumption that faster or more remote (i.e. indirect) priming is an indicator of enhanced associative processing (Mohr et al., 2001; Gianotti et al., 2001). Creativity researchers, on the other hand, tend to measure associative processing through word association tasks (Benedek & Neubauer, 2013). I chose to use a word association task (WAT) to make my research more comparable to other recent creativity work (e.g., Prabhakaran et al., 2014). Both the task itself and a more detailed description of the data scoring process for the WAT are in Chapter 2. This method is a practical but still effective way to measure associative processing.

Executive control.

As with associative processing, a number of different cognitive tasks have been used to assess the importance of executive control in both schizotypy and creativity. Working memory capacity is a good candidate to explain individual differences in the schizotypy-creativity relationship. First, there is reliable evidence that stronger working memory capacity predicts better creative performance on a number of measures (Kane et al., 2016; de dreu et al., 2012). Secondly, there is evidence that people who are high on schizotypal traits show deficits in working memory tasks (Ettinger et al., 2015). Working memory could therefore be a potential mediator of a negative relationship between schizotypy and creativity, as was observed in the MTurk sample for the RAT.

Complex span tasks assess both the short-term storage of information in memory as well as the active manipulation of information in memory (Conway et al., 2005). I chose to use Foster and colleagues' shortened complex span tasks because they are accessible (all tasks are freely available to researchers online), easy to administer (all tasks come pre-programmed, including detailed instructions for participants), and are relatively short to complete compared to other working memory tasks. Most importantly, research has shown that using multiple shortened versions of the complex span task balances the need to keep testing durations as short as possible, while still reliably assessing working memory capacity. Combining shortened versions of the Operation span and the Symmetry span task predicts 51% of the variance in general intelligence (Foster et al., 2015).

Individual differences research - challenges

Designing a study to examine how individual differences in core cognitive processes might mediate a relationship between schizotypy and creativity raises some challenges. A number of individual differences studies using well-established cognitive psychology tasks have found null results. With an increase in the use of well-established experimental psychology tasks to understand individual variation in performance (as opposed to group differences in performance), there has also been an increase in null findings in this area. As described by Hedge, Powell and Sumner (2017) most cognitive tasks are designed with experimental research in mind. Experimental research and individual differences research have fundamentally different goals; in experimental research, the aim is to reduce individual variation in performance; in individual differences research, however, the opposite is true. Therefore, traditional tasks like the stroop task have good precision to detect between group differences, but poor precision to detect individual differences in performance.

Hedge and colleagues (along with other researchers) interested in individual differences research using cognitive tasks made two useful recommendations (Hedge et al., 2017; Goodhew & Edwards, 2019). The first is to use adequate sample sizes. The second is to combine multiple tasks assessing a construct of interest. In doing so, one can minimise task-specific variability and therefore maximise variability that can be attributed to the underlying cognitive construct. This study uses two related working memory tasks to ameliorate this issue.

Current study

Participants completed three self-report questionnaires (schizotypy, hand preference and creative personality), two performance-based creativity tasks (the RAT and AUT), two working memory tasks, and a word association task. Each testing session was approximately 1.5 hours in duration.

Testing models of creativity.

If the associative processing account of creativity is supported, there will be positive correlations between performance on an associative processing task (the Word Association Task; WAT) and performance on the two performance based creativity tasks in the Lab sample (RAT, AUT). If an executive control account of creativity is supported there will be positive correlations between performance on two working memory tasks (WM) and measures of schizotypy. Finally, if creativity relies on both cognitive skills (as predicted by a dual process model), there will be a relationship between associative processing and creativity that is moderated by working memory capacity. This model reflects associative processing as more important for the idea generation phase and executive control as more important for the idea evaluation phase.

Testing the relationship between schizotypy and creativity.

First, I will determine whether schizotypy is correlated with associative processing and working memory as expected, that is, a positive relationship between schizotypy and associative processing, and a negative relationship between schizotypy and working memory.

I will then test whether any relationship between schizotypy and creativity is mediated by differences in associative processing, which would provide support for an associative account of creativity. I will test whether any relationship between schizotypy and creativity is mediated by differences in executive control, which would provide support for an executive control account of creativity. Finally, I will test whether the mediated relationship between schizotypy and creativity by associated processing is moderated by WM ability, which would provide support for a dual process account of creativity.

Method

The following is a brief outline describing participant and task characteristics for the Lab sample, who completed all schizotypy, creativity and cognitive measures discussed in this thesis. More details are provided in Chapter 2.

Participants.

Participants were 361 introductory psychology students (80 men and 278 women, 1 gender diverse, 1 unclear response) who participated in the study for course credit.

Materials.

Working memory. Working memory was assessed using two complex span tasks: a symmetry span task and an operation span task (Foster et al., 2015). A complex span task requires both engagement in a primary (recall) task while also performing a secondary task. Trial procedure for the two working memory tasks is outlined in Figure 5.2. The final working memory dependent measure was the average performance on both tasks.

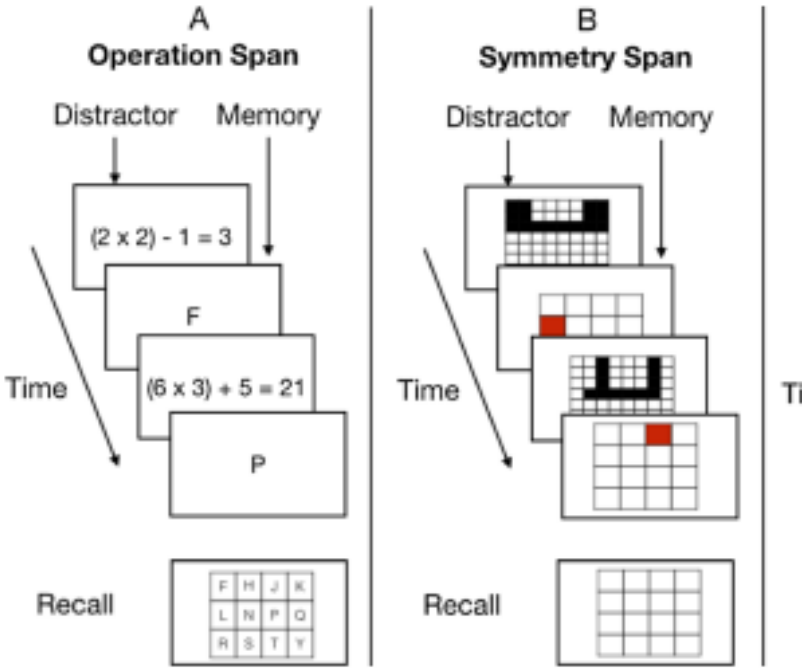


Figure 5.2. Trial diagrams for the two complex span working memory tasks

Word association task. In this task, participants generated words in response to a target word that they determined were associates of the target word. Participants saw six words in total: street, light, red, mountain, lion, and king, and generated responses for each word for 60 seconds each. The Latent Semantic Analysis software (LSA; Landauer, Foltz, & Laham, 1998) calculates a score for each word ranging in value from -.1 to 1, with a value further away from 1 (i.e. a lower value) meaning greater semantic distance between the target word and the response and 1 meaning exactly the same word. The final dependent measure was the average score across all responses, across all six target words. This

measure captures the steepness in the individuals' associative hierarchy across the six words, with higher values reflecting a steeper (i.e., less diffuse) associative hierarchy.

Procedure.

Participants completed the battery of tasks one at a time, in a quiet single occupancy room. The entire session took between 1 hour 15 and 1 hour 30 minutes and tasks were completed in a standardised order. Participants were excluded from the working memory tasks if they were not able to maintain at least 80% accuracy on the secondary task. Overall 324 (of 361) participants' working memory data was included. There were also a number of participants who did not complete the word association task; 347 participants' WAT data was included. Based on these exclusion criteria the sample size for the working memory analyses and the word association analyses differs.

Statistical analysis.

Creativity Models. Any positive correlation between a creativity task and WAT score would support an associative processing account of creativity, while any positive correlation between a creativity task and WM scores would support an executive control account of creativity.

Finally, I will then test the dual process model of creativity by assessing the interaction of associative processing ability and working memory ability on creativity. I predict that the correlation between associative processing ability and creativity will be moderated by working memory ability, in as much as there will be a positive relationship between WAT and creativity only in participants who have high working memory capacity.

Schizotypy and creativity models. Having determined if any of the cognitive models of creativity are supported by the data, I will then determine whether such a model can explain any relationships between schizotypy and creativity. First, I will test the simple correlations amongst schizotypy, WM and WAT ability. This will allow me to determine whether schizotypy is associated with these core cognitive functions as expected. I will then test whether there is any relationship between schizotypy and creativity that is mediated by either WM or WAT ability. If there is support for the dual process model of creativity, I will also follow up with a moderated-mediation analysis. I will test whether there is a mediated relationship between schizotypy and creativity that depends on one's working memory ability.

Results

Descriptive statistics for the cognitive tasks, as well as the descriptive statistics for the creativity task in the Lab sample only are presented in Table 5.1. The correlations between the cognitive tasks are in Table 5.2.

Table 5.1. Descriptive statistics for all cognitive tasks and creativity tasks.

Note. Sample size, means and standard deviations for all cognitive tasks and creativity tasks.

Task	N	M	SD
Working Memory	324	34.04	6.07
WAT	347	.272	.054
WAT (word count)	347	71	20.10
Creativity AUT	346	2.26	.35
Fluency AUT	346	8.53	1.85
RAT	350	10.42	5.56
CPS	350	3.95	3.48

Note. WAT = Word Association Task; AUT = Alternate Uses Task.

Table 5.2. Correlations between cognitive tasks

	WAT	WAT (word count)
WM	.046 (ns)	.119*

Note. WM: Working memory, WAT = Word Association task.

In order to test an associative account of creativity, I tested whether creativity correlates with scores on the WAT. There was a small positive association between RAT performance and WAT scores; better performance on the RAT was associated with generating semantically closer associates on the WAT $r(346) = .114$, $p = .034$ and more words generated during the WAT $r(347) = .177$, $p = .001$. There was no significant correlation between average Creativity in the AUT and scores on the WAT, $r(342) = -.102$, $p = .058$, although greater Creativity was associated with generating more words in the WAT $r(343) = .111$. $p = .04$. Fluency in the AUT was negatively correlated with WAT scores $r(342) =$

-.186, p = .001, i.e. the more words generated in the AUT, the lower the WAT scores/the more diffuse processing shown in the WAT. Fluency was also positively correlated with the number of words generated in the WAT, $r(343) = .292$, $p < .001$, i.e. more words generated in the AUT is associated with more words generated in the WAT.

In order to test an executive control account of creativity, I tested whether creativity correlates with WM performance. There was a small positive association between RAT and WM; better performance on the RAT was associated with better WM scores $r(324) = .199$, $p < .001$. Greater Creativity in the AUT was also associated with better WM scores, although this was non-significant.

Table 5.3. Correlations between cognitive tasks and creativity tasks.

	WM	WAT (average)	WAT (words)
RAT	.199**	.114*	.177*
Creativity AUT	.099, ns	-.102, ns	.111*
Fluency AUT	.011, ns	-.186**	.292**

Note. AUT = Alternate Uses Task, RAT = Remote Associates Test.

Moderation of the WAT-creativity relationship by WM. A described in the introduction, a dual process model of creativity posits that creativity is facilitated by greater associative processing abilities combined with greater executive control. In order to evaluate this model, I tested whether any relationship between WAT and creativity performance is moderated by differences in working memory ability (as outlined in Figure 5.1 in the introduction). I followed Baron and Kenny's (1986) procedure for moderation; the two predictors are entered in separately in the first step, followed by the interaction term in the second step. Moderation is shown if including the interaction term explains significantly more variance than is accounted for by the first step.

The first moderation analysis tested whether any association between WAT and RAT performance was moderated by differences in WM. In the first step, WM and WAT separately significantly predicted RAT performance, $F(2, 314) = 7.607$, $p = .001$, $R^2_{adjusted} = .040$. In the second, step, however, the interaction of both WM and WAT performance did not explain any more variance than either predictor separately, $\Delta F(1, 313) = .047$, $p = .828$, $R^2_{adjusted} = .037$. Individual beta weights are reported in Table 5.4. Figure 5.3 indicates a main effect of both associative processing (WAT performance) and executive control (working

memory performance) on RAT. Note that the positive association between WAT and the RAT means that, contrary to an associative processing account, people with steeper (less diffuse) associative hierarchies solved more RAT problems. Findings for working memory, however, were in line with an executive processing account. There no interaction between associative processing and working memory on RAT performance, providing no support for a dual process model.

Table 5.4. Individual beta weights for multiple regression, WM and WAT by RAT performance

		B	S.E	β	R^2	$R^2\Delta$
Step 1					.046	.040
	WM	.169	.050	.187		
	WAT	9.917	5.551	.099		
Step 2					.046	.037
	WM	.232	.293	.256		
	WAT	18.090	37.953	.180		
	WMxWAT	-.230	1.056	-.110		

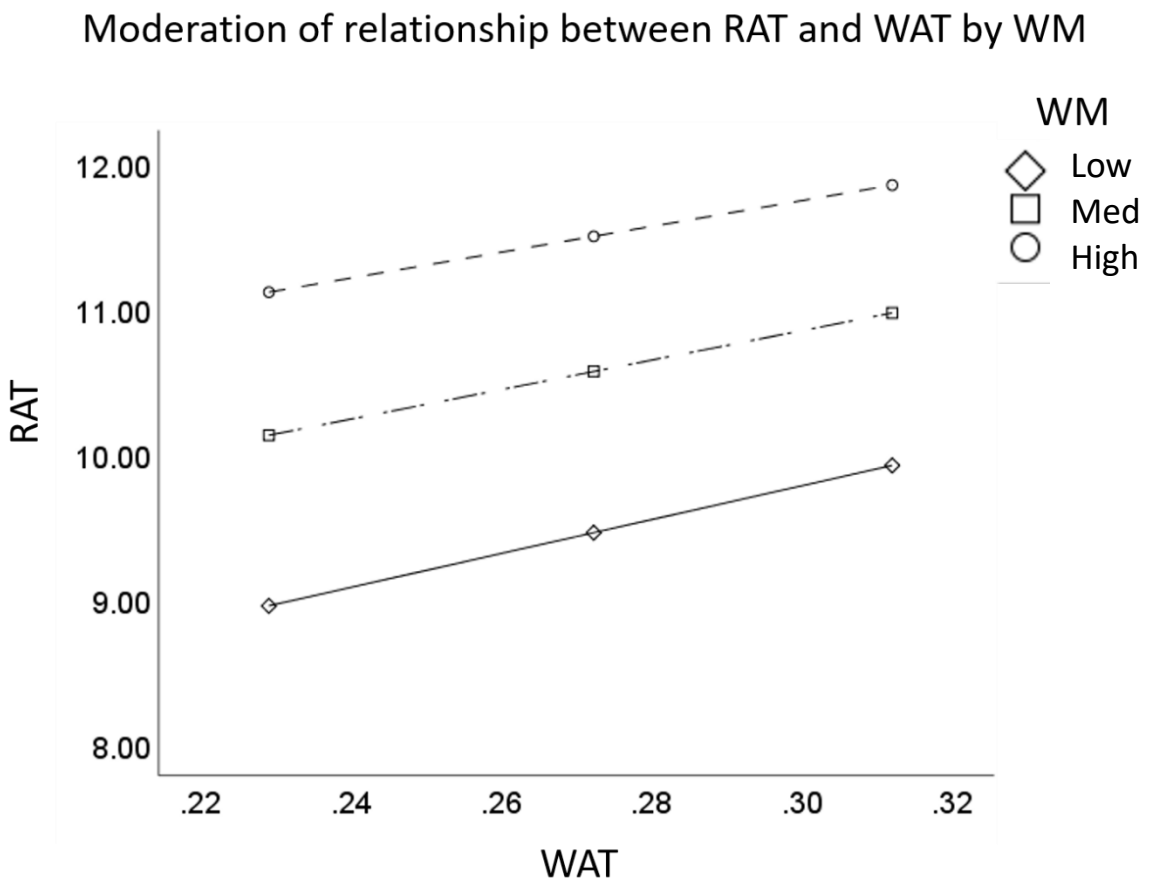


Figure 5.3. Moderation of the relationship between Word association Task scores and Remote Associates Test scores by Working Memory.

The second moderation analysis tested whether any association between WAT and Creativity in the AUT was moderated by differences in WM. In the first step, WM and WAT both separately significantly predicted average Creativity in the AUT $F(2,310) = 3.404$, $p = .035$. In the second step, the interaction of both WM and WAT performance did not explain any more variance in AUT performance than either predictor separately, $\Delta F(1, 309)= 2.322$, $p = .673$. Figure 5.4 indicates a main effect of both associative processing (WAT performance) and executive control (working memory performance) on AUT, but no interaction between the two on AUT performance. In other words, people who show low WAT scores (i.e. more diffuse associative processing) show higher average Creativity in the AUT. People with high working memory capacity also show higher average Creativity in the AUT. These findings are in line with both associative and executive processing accounts of creativity. However, the combination of both more diffuse associative processing and high working memory capacity does not lead to even higher average Creativity in the AUT. There is therefore no support for a dual process model.

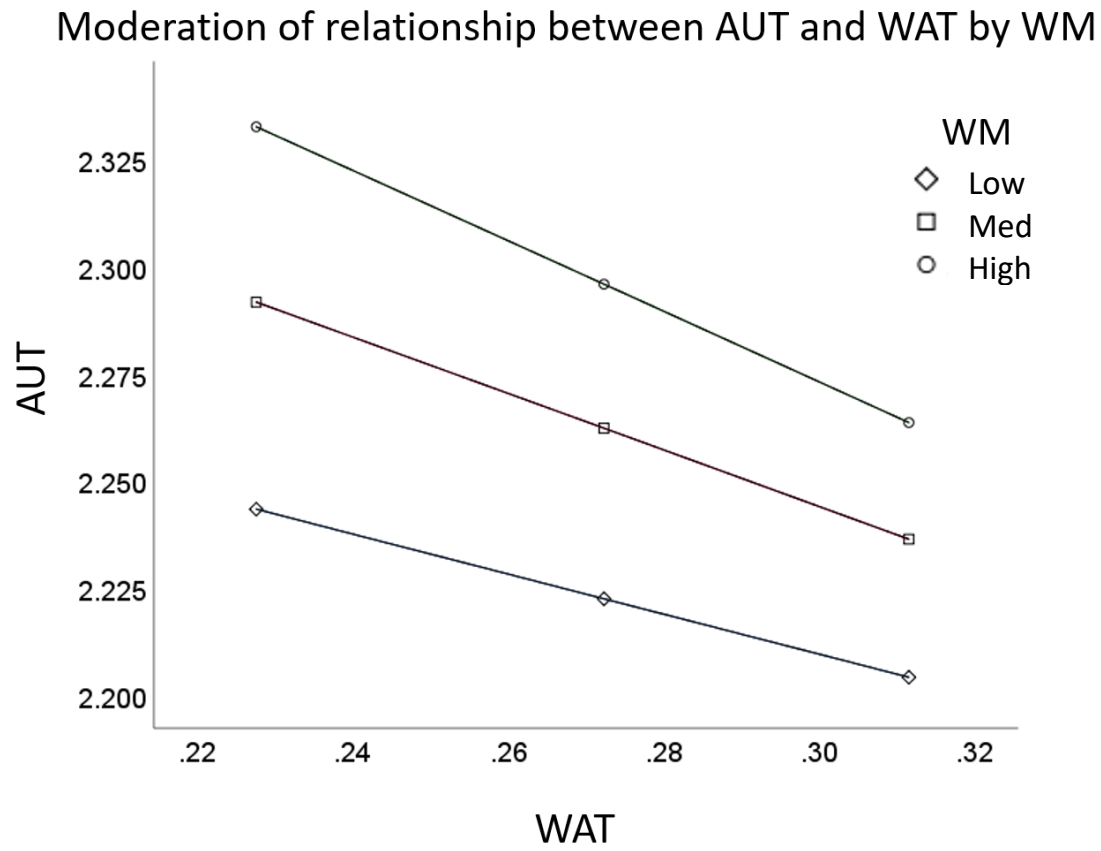


Figure 5.4. Moderation of the relationship between Word association task performance and Alternate Uses task performance by Working memory. High WAT = less creative

Schizotypy and Creativity, mediated by WM and WAT. In order to test how schizotypy might be related to creativity, I first tested whether any factor of schizotypy was correlated with the core cognitive processes of working memory or associative processing. There were no significant correlations between any of the factors of schizotypy and WM, nor with WAT (either semantic distance or the number of words).

Table 5.5. Correlations between cognitive measures and schizotypy.

	WM	WAT (average)	WAT (words)
Positive Schizotypy	-.072	-.061	.085
Disorganised Schizotypy	-.013	.023	.065
Interpersonal Schizotypy	-.010	.016	-.068
Total schizotypy	-.036	.024	.002

I then tested whether there was a relationship between schizotypy and creativity that may be mediated by one or the other core underlying cognitive processes. While Baron and Kenny (date) would state that it is not possible to test for mediation unless all variables are correlated, this is seen by some as a rather statistically conservative view. For instance, it does not take into account the possibility of statistical suppression. A more contemporary perspective would suggest that it is fine to test mediation models when there is not a significant correlation between the two variables.

I first tested whether the hypothesised relationship between positive schizotypy and creativity is mediated by differences in associative processing or working memory, in both the AUT and the RAT using parallel mediation (as outlined in the general introduction). Given that there was a positive association between disorganised schizotypy and Creativity in the AUT, I also tested whether this relationship is mediated by differences in associative processing or working memory. Note that all regression coefficients are standardised.

Parallel mediation - RAT. To test the mediation models, I followed Baron and Kenny's (1986) procedure for mediation. In the first step, a series of regressions were calculated between positive schizotypy scores, RAT performance, WM and WAT scores. In the first regression schizotypy does not significantly predict WAT performance (b = -.0631, s.e. = .0005, ns). This coefficient reflects the direct effect of schizotypy on WAT within the

path model. Schizotypy also does not significantly predict WM performance (b = -.0615, s.e. = .0533).

The next step regresses creativity onto Positive schizotypy and both mediators (WAT and WM). Positive schizotypy is not a significant predictor of creativity (b = -.0056, s.e. = .0475). When WAT is added together with schizotypy, WAT performance does not quite reach significance (b = .0982, s.e. = 5.56, ns). However, working memory is significant (b = 1.862, s.e. = .0501, *p* = .0009.

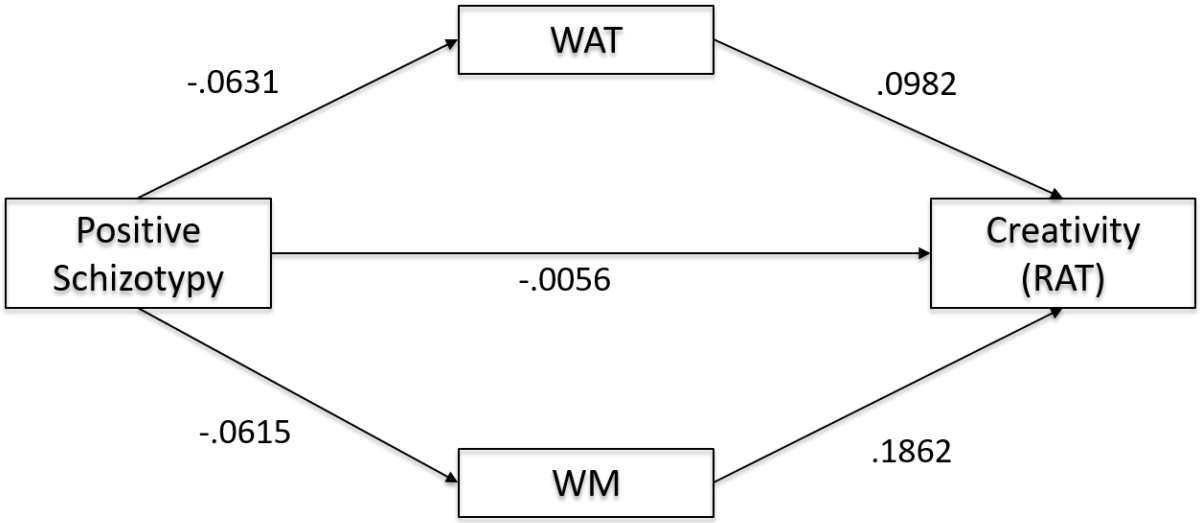


Figure 5.5. Parallel mediation of Positive schizotypy and creativity in the RAT, mediators = Working memory and WAT performance. Scores are standardised.

Finally, the indirect effect of WAT on the relationship between Positive schizotypy and the RAT was not significant (b = -0062, 95% CI = -.0300, .0070). The indirect effect of WM on the relationship between Positive schizotypy and the RAT was also not significant (b = -.0115, CI = -.0399, .0110) as the bootstrapped Confidence Intervals include zero. The total indirect effect of both mediators on the relationship between Positive schizotypy and the RAT was not significant (b = -.0177, CI = -.0531, .0099).

Parallel mediation - AUT. I then followed the same procedure to test the effect of both mediators on RAT performance. In the first step, a series of regressions were calculated between positive schizotypy scores, average creativity in the AUT, WM and WAT scores. In the first regression, schizotypy does not significantly predict WAT performance (b = -.0597, s.e. .0005, ns). This coefficient reflects the direct effect of schizotypy on WAT within the path model. Schizotypy also does not significantly predict WM performance (b = -

.0642, s.e. = .0537). This coefficient reflects the direct effect of schizotypy on WM within the path model.

The next step regresses creativity onto positive schizotypy and both mediators (WAT and WM). Positive schizotypy is not a significant predictor of creativity (b = .0203, s.e. = .0031, *p* = .7189, ns). When WAT and WM are included together with schizotypy in the same model, both WAT and WM no longer reach conventional levels of significance (b_{WAT} = -.1064, s.e. = .3638, *p* = .0602, ns) (b_{WM} = .1067, s.e. = .0033, *p* = .0598, ns).

Finally the indirect effect of WAT on the relationship between positive schizotypy and creativity in the AUT was not significant (b = .0064, CI = .0092, -.0076) as the bootstrapped Confidence Intervals include zero. Similarly the indirect effect of WM on the relationship between positive schizotypy and creativity in the AUT was also not significant (b = -.0068, CI = -.0076, .0297).

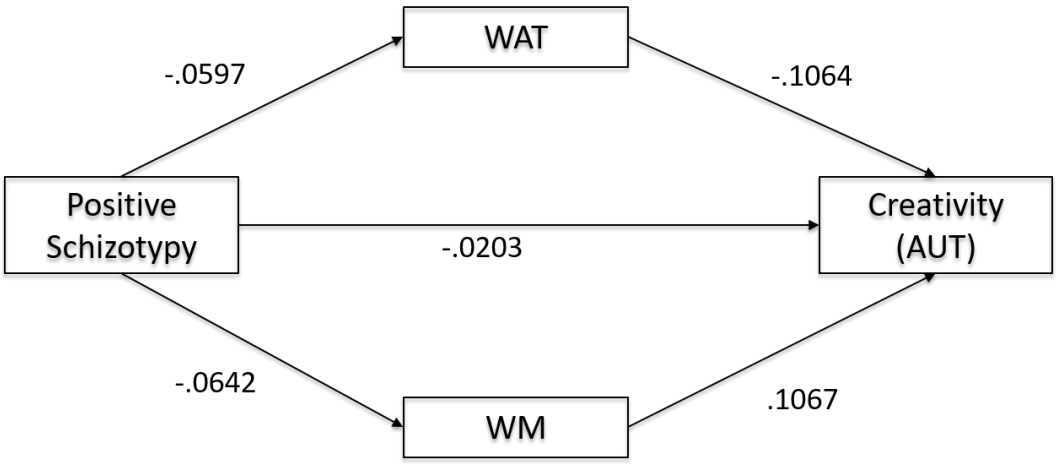


Figure 5.6. Parallel mediation of Positive schizotypy and creativity in the AUT, mediators = Working memory and WAT performance. Scores are standardised.

The total indirect effect of both WAT and WM together on the relationship between Positive schizotypy and creativity in the AUT is non-significant (b = -.0005, CI = -.0230, .0252). Overall, there is no evidence for a relationship between Positive schizotypy and creativity (in the AUT), and there is no indirect effect on this relationship via either working memory or associative processing (WAT).

Exploratory analysis: Disorganised schizotypy and AUT creativity. On the basis of the literature, only positive schizotypy was hypothesised to predict creativity. However, in Chapter 3, there was a positive relationship between disorganised schizotypy and creativity

in the AUT observed in both samples. As an exploratory analysis, I tested whether either WM or WAT performance mediated the relationship between disorganised schizotypy and AUT performance. In the first step, regressions were calculated between disorganised schizotypy scores, average creativity in the AUT, WM and WAT scores. In the first regression, disorganised schizotypy does not significantly predict WAT performance (b = .0282, s.e. .0008, ns), or WM capacity (b = -.0007, s.e. = .0870). This coefficient reflects the direct effect of schizotypy on the hypothesised underlying processes within the path model.

The next step regresses creativity onto disorganised schizotypy and both mediators (WAT and WM). In this model, Disorganised schizotypy is not a significant predictor of creativity (b = .1392, s.e. = .0049, ns). When WAT and WM are included together with schizotypy in the same model, both WAT and WM no longer reach conventional levels of significance (b_{WAT} = -.1115, s.e. = .3599, p = .0602; b_{WM} = .1057, s.e. = .0032, p = .0591).

Finally, the indirect effect of WAT on the relationship between disorganised schizotypy and creativity in the AUT was not significant (b = -.0008, CI = -.0055, .0038) as the bootstrapped Confidence Intervals include zero. The indirect effect of WM on the relationship between disorganised schizotypy and creativity in the AUT was also not significant (b = .0000, CI = -.0042, .0015), as bootstrapped confidence intervals include zero.

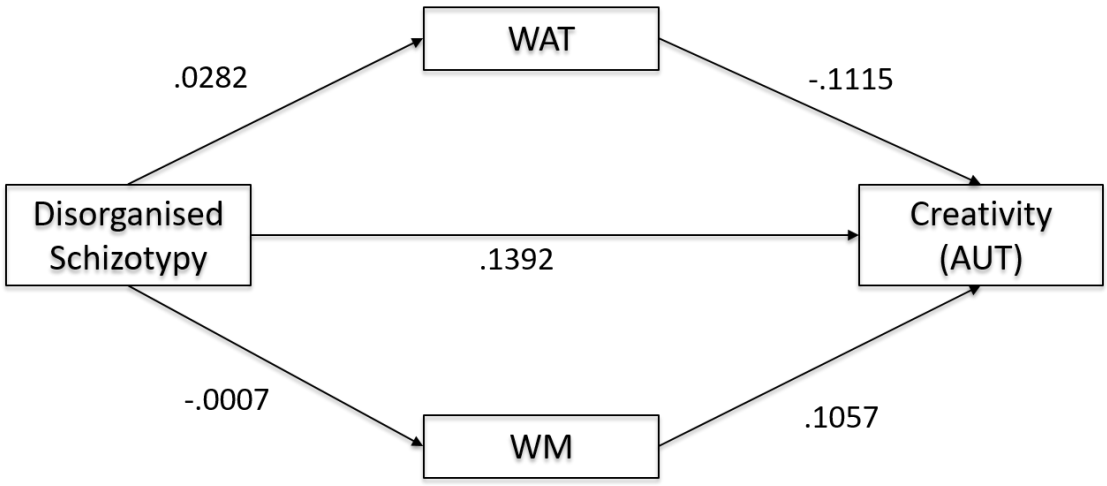


Figure 5.7. Parallel mediation analysis between disorganised schizotypy and creativity in the AUT, mediators = Working Memory, Word Association Task.

The lack of a significant effect in the disorganised schizotypy-creativity mediation model was unexpected, given the finding in Chapter 3 that disorganised schizotypy

positively predicted Creativity in the AUT. Quite possibly the addition of more variables into the model competing to explain variance.

When planning the analyses for the models, I originally intended to first do a parallel mediation analysis between schizotypy and creativity with both Working memory and WAT performance as mediators as a first step. The second step would be to test whether a mediated relationship between schizotypy and creativity by WAT performance would depend on high levels of working memory (i.e. a moderated mediator relationship). However, given that there was no evidence for a moderation of the WAT-creativity relationship by working memory in the original creativity model, this analysis was not completed.

Discussion

The current chapter addresses two questions. The first question concerns the relationship between the core processes of associative processing and working memory as described by the three creativity models outlined in the introductory chapter. The current analyses supported both an associative processing and an executive control account of creativity, but provide no support for a dual process model.

Creativity analyses.

However, the relationship between associative processing and RAT performance was contrary to predictions. As RAT scores improved, people's WAT scores increased. In other words, people with better scores on the RAT showed steeper associative hierarchies. The AUT, however, was negatively correlated in that as scores on the AUT increased, people's WAT scores decreased. In other words, higher Creativity in the AUT was associated with more diffuse semantic processing in the WAT. Working memory predicted performance on both tasks as expected.

While the RAT was originally designed to assess divergent thinking in creativity, as is the AUT, there is no evidence that these two are related in this study – the two tasks are relatively weakly correlated with each other. Both in the current chapter, and in chapters 3 and 4, findings suggests that these two tasks tap very different processes. The RAT in particular correlates much more strongly with working memory, suggesting that not only is it not a particularly useful measure of convergent thinking, but it may not be a good measure of creativity. I will discuss this in more detail in the general discussion.

There was also no evidence for a dual process model account of creativity. If this account was supported, one would predict that the relationship between associative processing and creativity would be moderated by WM ability. The interaction of WAT performance and working memory ability was not significant. This result was unexpected given the considerable interest in dual process models of creativity in the literature. However, as already discussed in the introduction of this chapter, there is currently little direct empirical support. Based on the test of the creativity models, the analyses to test relationships between schizotypy and creativity focussed on testing the two single process accounts of creativity.

Dual process models continue to gain traction in creativity research (Evans, 2008). However, how a dual process model is conceptualised and tested varies considerably, and a careful reading of the literature shows that dual process models are often described, but not tested. For example, according to Nijstad (Nijstad, De Dreu, Rietzschel & Baas, 2010) and Baas (Baas et al., 2013) creative ideation relies on two pathways: a flexible pathway and a persistence pathway. The flexible pathway allows for more activation of distant associates, whereas the persistence pathway allows for increased focus at the expense of more distant associations. A key element of this model is that it is possible to 'activate' a specific pathway by activating certain mood states (de Dreu, Baas & Nijstad, 2008); positive mood is associated with increased flexibility and negative mood associated with increased persistence. While they review a number of studies that find evidence for each pathway separately, they do not test the model directly, or review any research that shows how these two pathways might operate in tandem.

Beaty and colleagues (2014) tested the relative contributions of associative processing and executive control. Associative processing was assessed using a verbal fluency task and latent semantic analysis, similar to that used in the current study. Executive control was assessed by measuring fluid intelligence. Both cognitive processes significantly predicted creative performance on a divergent thinking task. They also found that fluid intelligence significantly predicted creative ability when controlling for associative processing ability. However, they did not test whether the relationship between associative processing and creativity depended on high working memory capacity, and so did not explicitly test a dual process model.

Overall, while there have been a lot of theoretical musings about how a dual process model of creativity works, accompanying empirical support is lacking. The current chapter provided a very explicit test of a dual systems approach. However, other researchers have a very different vision of how a dual process model of creativity might operate. For example, Sowden and colleagues (2015) describe creativity as a two stage process: the initial, idea generation phase and the secondary, evaluation phase. In the current study, the comparison is made between the RAT and the AUT. It would be interesting to break down the process of both tasks further, and look at whether associative processing is associated with the initial idea generation stage for both tasks, and then whether executive control is associated with the final selection process. One possible way to achieve this would be to ask participants to brainstorm a number of ideas without stopping, then to select a few ideas and develop them further.

Schizotypy analyses.

Having tested the relationship between executive and associative processes and creativity, I then determined whether these processes might explain any relationship between schizotypy and creativity. As already described, previous literature has linked schizotypal traits with both broadly diffuse semantic (associative) processing and deficits in executive control. Schizotypy is both an interesting personality trait to study in its own right, while also providing another way to test the models of creativity. An associative processing account predicts that people high in schizotypy will be more creative, whereas an executive processing account predicts that they will be less creative. A dual process account predicts that both skills will be necessary; associative processing will predict creative performance, if and only if the person has high levels of executive control.

In order to test these predictions, I first established whether schizotypy was related to either associative processing or executive control. I then tested whether there was a relationship between schizotypy and creativity that could be better explained by differences in associative processing or executive control.

Schizotypy and associative processing. In the current study, I find no evidence for a relationship between schizotypy and associative processing, using a commonly used paradigm (word association task) and a sound methodology for scoring the responses in a large sample of participants (LSA). This is unexpected, given that a number of studies in the past have linked schizotypal traits with broader associative processing. For instance, studies

using a semantic priming paradigm (Mohr et al., 2001; Gianotti et al., 2001) do find an association between schizotypy and associative processing. However, a recent study using a similar method to the current study (a word association task with LSA) also found no relationship between schizotypal traits and performance on this task (Marggraf et al., 2018). Are the inconsistencies between studies due to differences in methodology?

The word association task has a number of advantages over a semantic priming task in this context. Firstly, it is often used in creativity-associative processing research (Prabhakaran et al., 2014; Benedek & Neubauer, 2013). Furthermore, more recently, it has increased in usage within schizotypy research (Davis et al., in prep, cited in Marggraf et al., 2018). This means that the findings are more comparable across studies.

However, the Word Association Task has some disadvantages. For instance, compared to a semantic priming task, participants have a relatively long window (in this case 60 seconds) in which to generate new words and choose whether to write them down. This may provide participants with more time to consider their word choices. In a semantic priming task, on the other hand, participants are presented with a prime (e.g. DOG), followed (after a short delay) by either a related target (e.g. CAT) or unrelated target (PAN). The participants have to determine whether the target is a word or a non-word. The semantic priming effect is that people are faster to make the judgment when the two words are related versus when they are unrelated. Semantic priming tasks, therefore may be more sensitive to subtle differences in semantic organisation that can be captured in such time-sensitive tasks than in the Word Association Task. A study by Tan and Rossell (2017) demonstrated how semantic priming may happen at shorter, rather than longer intervals. The study compared performance on a lexical decision paradigm with two different stimulus onset times. In one version, the target was presented 50ms after the prime, and in the other version, the target was presented 200ms after the prime. There was a stronger priming effect evident at the short 50ms interval than at the longer, 200ms interval.

The methodology for scoring word association responses, while used in both creativity research (Prabhakaran et al., 2013) and schizotypy research (Margraaf et al., 2018) this method is also still relatively new in this context. Some researchers argue that using LSA in the WAT is not sensitive enough to detect differences that would be more evident in natural speech. Thought disorder, as measured by high levels of disorganised schizotypal traits, is typically evident in observation of natural speech. For instance, LSA can successfully

identify a reduction in semantic coherence in schizophrenia (Elvevag et al., 2007, cited in Bedi et al., 2015). It can also distinguish between first-degree relatives of schizophrenia patients (i.e. likely those with high schizotypal traits) and unrelated healthy individuals (Elvevag, Foltz, Rosenstein & Delisi, 2010). Previous studies that have found differences between those low and high in schizotypal traits have measured natural speech via interview transcripts (Minor et al., 2011, cited in Margraaf et al., 2018). This may be especially important in a high functioning group, as subtle differences in semantic coherence may be more evident in natural speech than in a contrived experimental task where they have more time to think about their responses. Even those in the current samples who are high on schizotypal traits would still be considered high functioning, particularly those in the Lab sample who are all studying at a tertiary level (Marggraf et al., 2018).

In future research, it would be useful to test the associations between schizotypy and multiple associative processing tasks, including a Word Association Task with a number of scoring methods and several different semantic priming tasks. One could then test whether these different methods correlate with each other or differ in their association with schizotypy traits, or creativity.

Schizotypy and working memory. There was also no evidence that schizotypy was related to differences in working memory. While the current results do contradict some findings in the area of schizotypy and working memory (as outlined in the general introduction), two factors inspire confidence in the results of the current study. First, complex span tasks are a well-established, reliable and robust measure for assessing working memory. Unlike other working memory tasks, complex span tasks reflect working memory as both a system for storage and active manipulation of information in the short term, making them ideal for research in all areas, including creativity and schizotypy (Foster et al., 2015). Secondly, while there are a number of studies that have found a negative association between schizotypy and working memory using different tasks, Kane and colleagues found no evidence of a relationship using complex span tasks in a large sample (Kane et al., 2016).

Schizotypy and creativity. Finally, there was no evidence that any relationship between schizotypy and creativity was mediated by either differences in associative processing or working memory. This is unsurprising, for two reasons. There were no

correlations between schizotypy and either cognitive process, and a number of the significant relationships between schizotypy and creativity (in both the correlations and the multiple regression) did not replicate in the Lab sample. This goes against the theoretical predictions, which suggest that an association between schizotypy and creativity can be explained by differences in cognitive processing.

Chapter 6: General discussion

A number of people have drawn links between schizotypal traits and creativity. It was assumed that people who have high levels of schizotypal traits are at high risk of schizophrenia, and therefore share some positive qualities associated with schizophrenia (the ability to make remote connections between ideas) without some of the negative qualities of schizophrenia (severe cognitive deficits). However, despite this common belief, there is a lot of inconsistency in the literature testing this relationship. To that end, my thesis had two overarching goals. The first was to explore, in a scientifically rigorous manner, the relationship between schizotypy and creativity. The second was to explore three cognitive models of creativity and how they relate to schizotypy.

In this final chapter, I will summarise each chapter, and the major findings of the thesis overall. I will then break down the rest of the chapter based on findings related to schizotypy and creativity, and findings related to creativity models. For each of these I will discuss the major findings, implications of my findings, some strengths, limitations and some avenues for future research. I will then close with some final reflections.

Summary of chapters

In chapter 1, I reviewed the current understanding of creativity: what is creativity, creativity measurement, and dominant theories of creative cognition. I then explored what we know about the nature of the relationship between schizotypy and creativity. Lastly, I outlined the aims of the thesis. In Chapter 2, I outlined the methodology for all data collection. In chapters 3 + 4 I tested the relationship between schizotypy and creativity using two distinct statistical approaches. In chapter 5, I tested whether creativity is supported by underlying cognitive processes, as predicted by models of creativity. I then tested whether creativity models explained any relationship between schizotypy and creativity.

Schizotypy-creativity findings

Taking a dimensional approach to measuring schizotypy, Chapter 3 tested whether schizotypal traits are related to creativity as measured by the following creativity tasks (AUT, RAT and the CPS) in two separate samples (MTurk sample and Lab sample). I found no evidence for the predicted effect, a positive association between positive schizotypy and creativity, in either sample. In fact, I found a *negative* association between positive schizotypy and scores on the RAT (but not Creativity in the AUT) in the MTurk sample.

However, this did not replicate in the Lab sample. Only negative schizotypy was positively correlated with RAT performance in the MTurk sample, and disorganised schizotypy was positively associated with AUT creativity in both samples.

In Chapter 4, I took a taxonic approach. I combined the MTurk and Lab sample participants, and used Latent Profile Analysis to identify more homogeneous sub-groups/profiles. The LPA revealed four profiles: a low scoring group (low on all sub-scales), a high positive-interpersonal group, an average scoring group (average on all scales) and a high scoring group (high scores on all scales). In the MTurk sample, higher levels of schizotypal traits (i.e. membership in the high scoring schizotypy group) predicted worse outcomes on the RAT, but not the AUT. This is consistent with the negative associations between schizotypy and the RAT in the MTurk sample found in Chapter 3. In the Lab sample, the high scoring schizotypy group did not show worse performance in either the RAT or the AUT, which also mirrors results in Chapter 3.

There was also no association between schizotypy and either associative processing or working memory. While the literature in both areas is somewhat inconsistent, both findings were unexpected. Based on previous studies I would have predicted that schizotypy would have been associated with more diffuse associative processing, and I would have predicted a negative association between schizotypy and working memory. However, I was only able to test this relationship in the Lab sample, where there was already little evidence for a significant association between schizotypy and creativity. The next section will explore possible explanations for the null findings in this study, firstly in the schizotypy-creativity associations, then in the creativity models.

Schizotypy-creativity associations

The current thesis predicted that schizotypy would be positively associated with creative performance, and this was not supported. In fact, there was evidence for a negative relationship between positive schizotypy and creativity, and only a weak relationship between disorganised schizotypy and creativity. Broadly speaking, this failure to identify hypothesised relationships could be due to four reasons. First, is there a lack of power to detect an effect in my research? Second, are the tasks used reliable measures of creativity? Third, are the tasks valid measures of creativity? Finally, is the original hypothesis wrong?

Power.

A common issue in individual differences research is lack of statistical power. If there is not sufficient power to detect an effect, there is increased risk of both a) finding a spurious effect that is not real, or b) not detecting an effect that is real. There are two main ways to combat this; firstly by increasing the sample size and secondly, by increasing the variability in scores. Both together will decrease the chances of finding effects (null or otherwise) that aren't real. One significant contribution of the current research is a test of the schizotypy-creativity relationship in two samples that have very large sample sizes; therefore, this is unlikely to be a problem. Both samples also showed a range of scores in all measures, particularly in the schizotypy and creativity measures. It is unlikely that lack of power is an explanation for these findings.

Reliability.

Reliability refers to how consistently a task/questionnaire measures the intended construct. Good reliability of measurement encompasses a number of factors; are the components of a measure consistently measuring the same construct (internal reliability)? If I tested the same person at different time points, would I get a similar outcome (test-retest reliability)? If a measure is not reliable, one cannot confidently state that any effects found are because of differences in that construct.

Schizotypy questionnaire reliability. Both the SPQ and the O-LIFE have been found to have good reliability. For instance, Raine and colleagues found that the SPQ has good internal reliability overall (Cronbach's alpha = 0.91), good internal reliability amongst the nine scales that make up positive, interpersonal and disorganised schizotypy (Cronbach's alpha = 0.71-0.78) and good test-retest reliability (r = 0.81). The O-LIFE has good internal reliability (Cronbach's alpha scores ranging from 0.77-0.89) and good test re-test reliability (0.70; Mason & Claridge, 2006).

Creativity task reliability. Both RAT problems and the AUT also have good reliability. Lee and colleagues tested reliability in 30 classic RAT problems and found a Cronbach's alpha of .82. This is likely due to the nature of the task, as there is only predominant response for each problem.

In my thesis, the inter-rater reliability in the AUT across the five raters, as measured by Cronbach's alpha, is good (.8). However, unlike the personality questionnaires and the RAT, the AUT varies both in terms of consistency within a person (as measured by internal reliability and test-retest reliability), but also in terms of consistency in scores across target

items (generating alternative uses for different objects) and consistency in the rating of the ideas by different raters. Using more modern reliability theory (generalisability theory) enables us to account for this more effectively by considering two more relevant sources of error measurement: inconsistency when rating particular items within raters, and inconsistency across raters. Both these sources of error could reduce the reliability of the Creativity score and therefore reduce the ability to measure true variation in individual creative ability. Silvia and Willse calculated a series of dependability scores for a number of different divergent thinking tasks, including several versions of the alternate uses task (2008). The alternate uses task varied by number of raters and number of task items (i.e. the number of items the participant had to generate uses for). Increasing the number of items and the number of raters both independently increased the dependability score for the task. They also compared two different scoring methods. In the first method, the top two scoring procedure, participants circled what they believed were their two most creative options, and only these two were scored for creativity; the average of the two became the final Creativity measure. The second, used in the current study, was the average scoring method, which calculated the average creativity of all responses. Using an average method increased the dependability of the measure. One significant limitation of the current AUT design is the use of only one item (ping pong ball). This means it is not possible to assess consistency across multiple items. For instance, is the same person equally creative in generating uses for a ping pong ball as they are when generating uses for another object? Overall, however, both measures have been shown to have good reliability in the context of individual differences research. I believe that reliability is not a problem for my study.

Validity.

In any psychological research, we use tasks/measures to represent and investigate constructs of interest. The validity of a task determines how well it captures a particular construct. Similar to reliability, there are multiple types of validity of importance. Construct validity refers to how well the task measures the construct. Convergent validity refers to how well a tasks correlates with other measures of this construct, whereas divergent validity refers to how well a task is distinguishable from other tasks that measure a completely different construct. Finally, external validity refers to how well performance on a task reflects people's abilities in everyday life. If a task has poor validity than it is hard to say

with confidence that the task is measuring the construct of interest. A task can be reliable, but still not a valid measure.

Schizotypy measure validity. According to Raine and colleagues, the SPQ has good convergent validity (ranging from 0.59-0.81), discriminant validity (0.63) and criterion validity (0.68). The O-LIFE also has good convergent validity (Fonseca-Pedrero, Ortuno-Sierra, Mason & Muniz, 2015). The current study also supports the validity of these measures, as the two questionnaires are positively associated, suggesting that the two schizotypy questionnaires are measuring the same construct (convergent validity).

Creativity task validity. One strength of my approach is the inclusion of multiple measures of creativity. By including both self-report and performance-based measures, I was able to capture a much broader definition of creativity (useful for improving external validity). The performance based tasks focus on creative process and the creative personality scale focuses on creative traits. In doing so, I was able to test whether these tasks correlated with each other (convergent validity), and the majority did, albeit weakly (significant correlations ranged between .107 and .187). For example, the RAT and the AUT positively correlated with each other. This is consistent with the idea that the RAT and the AUT both reflect creative cognition, but tap into different parts of the creative process; the AUT tends to be associated with the idea generation stage, the RAT tends to be associated with the analytical, idea evaluation stage.

It is also important to note that there is often a trade-off between reliability and validity. While good reliability is vital for good validity, increased reliability beyond a point may increase the rigidity in scoring creative ideas; it starts to look a lot less like the creative skill one might see in a beautiful painting or an elegant mathematic equation. Silvia and Willse, when comparing the two scoring procedures for the AUT, found that the *more reliable* average scoring method was in fact *less valid* as a measure of creativity than the top two scoring procedure (2008). It was less strongly positively correlated with valid measures of creative potential (such as openness to experience) and with measures of creative interests (indicators of commitment to the arts). This is also consistent with the current study's findings; Creativity in the AUT shows a significant, but small correlation with the Creative Personality Scale. However, overall Silvia and Willse concluded that the validity was still good enough to use as a measure of Creativity.

The RAT also prioritises reliability over validity. Lee and colleagues found that RAT performance correlated significantly with measures of intelligence and analytical thinking (including working memory) and less strongly with measures of divergent thinking (unusual uses, AUT). This is consistent with the current findings; in the Lab sample, RAT scores are associated with greater working memory capacity and steeper associative processing; shallow associative processing is hypothesised to be important for creativity. In other words, RAT scores seems to be a more valid measure of intelligence or analytical thinking than creativity. In the current study, higher schizotypy scores are associated with worse performance on the RAT. Furthermore, all factors of schizotypy are negatively correlated with working memory capacity (although none of these correlations are significant). This is consistent with the literature that suggests schizotypy is associated with deficits in other areas of cognitive functioning (Ettinger et al., 2015). The fact that the RAT results are more consistent with cognitive effects in schizotypy research also supports the RAT as a measure of analytical thinking than creativity.

Another concern with validity of the RAT is the idiosyncrasy of the RAT problems. Many of the RAT problems require a specific vocabulary and knowledge set that resonates with individuals of a certain age and from a specific cultural background (middle-older aged, caucasian people from the United states) which is the context in which the majority of the RAT problems were created (Mednick, Mednick & Jung, 1964). Like intelligence, any creativity measure should be independent of any particular knowledge of vocabulary, popular culture or historical references. This project consisted of two samples that differed in age, cultural background and cohort (MTurk sample were slightly older and based in the United States, Lab sample were younger and from New Zealand). Regression analyses showed that age did account for a large proportion of variance in schizotypy predicting creativity. Furthermore, there was a large difference in RAT performance between the two samples (the Lab sample were significantly less accurate in the task). This further weakens the construct validity of the RAT, particularly for the Lab sample; it may be a particularly poor measure of creativity in young adults. If it is solely a measure of creativity, it should be able to assess a broader skill set that is domain general, not domain specific, like intelligence or working memory capacity. Both these concerns regarding the validity of the RAT suggest that the RAT findings may not adequately address the research question in the Lab sample.

Finally, an issue in both creative tasks - research on motivation in creativity suggests that if the participant is less motivated to do their best, it will weaken the construct validity of the task. As an example - if people do not try their hardest when completing an intelligence task, it will not be a fair reflection of their IQ. By the same token, if people don't try hard in a creativity task, then their performance won't necessarily reflect their creative ability. Selart, Nordstrom, Kuvaas & Takemura (2008) found that when participants were given some sort of reward for engagement in a creativity task, they tended to perform better than controls.

Are schizotypy and creativity related?

Ultimately, the tasks could be 100% reliable and valid measures of creativity; however, there could still be no effect of schizotypal traits on creativity. As discussed in the general introduction, the evidence for a relationship is inconsistent; correlation r effects size in the meta-analysis of the research up until 2013 ranged from -.42 to .8. Research from 2013-2019 paints a similar picture. There are a number of potential explanations for this inconsistency.

Firstly, there are such a wide variety of creativity tasks used in the literature. These include convergent thinking performance tasks, divergent thinking performance tasks, creativity preference tasks, verbal fluency tasks, figural fluency tasks and a number of different self-report measures (based on both personality traits and actual behaviour). There is also a lot of variability in the way each study calculates the dependent measure for each task, with some tasks (particularly performance based tasks) having numerous different dependent measures, each with their own rationale for their usage. A good example of this is the Alternate Uses Task. Across the literature, the following different dependent measures are used: originality (subjective and objective), elaboration, fluency and flexibility. This means that the reliability and validity of creativity measures likely varies from study to study.

Second, it gives a lot of room for creativity researchers to use multiple measures of creativity, and to choose to report only those tasks or dependent measures that produce significant findings. Questionable research practices like selective reporting are increasingly the topic of conversation amongst psychological researchers. This practice, in particular, may explain some of the variability in findings, and makes it increasingly difficult to establish whether so called 'robust' effects would stand up to scrutiny.

Given how inconsistent the findings are and the potential for questionable research practices in this field, it is worth challenging the original question - is schizotypy really a significant predictor of creative cognition? In order to do so, I will start with the origins of this question, which can be found both in popular culture and in psychological research, and then evaluate the strength of the claim. Is there reasonable evidence for a link between mental illness and creativity? Where did the idea originally come from?

Theoretical origins of schizotypy-creativity research.

In the field of psychology, the idea that creativity is related to mental illness, and by extension, to schizotypy in particular, comes from the work of Hans Eysenck in the area of psychoticism. Eysenck proposed that the personality trait psychoticism was indicative of early risk for developing schizophrenia. High levels of psychoticism were, in his view, linked to an over-inclusive thinking style, that according to Mednick (1964), was important in creativity. Schizotypy lies on a spectrum that includes risk for psychosis (or psychotic like traits). As a natural progression of this line of thinking, it was assumed by Eysenck that schizotypy must also be related to creativity (Eysenck, 1993). However, since then it has become clear that psychoticism and schizotypy are two different constructs. Furthermore, there is no evidence in the current study that schizotypy is associated with over-inclusive thinking, although other studies do find evidence using slightly different methods (Mohr et al., 2001).

Evidence for the link between mental illness and creativity. The belief that mental illness is related to creativity is prevalent in mainstream discourse; the success of a number of eminent creative people, both currently and historically, have been attributed to mental illness (Redfield-Jamison, 1995). When looking at the biographies of creative people, it is easy to find numerous people over the course of history who appear to have succeeded in creative fields with a history of mental health problems.

Empirical research on the association between schizotypy and creativity originated in biographical work (Ludwig, 1992), which sought to retrospectively understand creative performance by exploring the relationship between creative professions and evidence of mental illness. Ludwig concluded that psychopathology was more commonly experienced by people in creative arts professions, and that certain forms of psychopathology were predictive of creative achievement.

However, there are two major problems with both these types of evidence. First, when people hold a belief (rightly/wrongly) that mental illness is associated with creativity, they will look for cases that confirm this belief. In doing so, they are highlighting only the creative people who have evidence of a mental illness and happen to be creative, and ignore the people that are mentally 'well' and yet still successful in creative fields. Finally, even if the association is robust, it isn't clear from looking at biographical information alone whether they succeeded in spite of or because of their mental illness. Furthermore, more recently Kyaga and colleagues used data from Swedish total population registries and found that people in creative professions were not more likely to suffer from a psychiatric disorder than controls (Kyaga et al., 2013). So overall, there appears to be reason to doubt both the underlying assumptions and the early empirical work that led to the position that schizotypy is helpful in creativity.

Creativity models

In chapter 5, I tested the relationship between creativity and cognitive processes purported to underlie creative cognition (associative processing ability and executive control) in the Lab sample. I also tested how the differences in associative processing or working memory capacity might operate in the context of individual differences in schizotypal traits. In this next section, I will briefly discuss the findings related to the creativity models only; given that there was no significant association between schizotypy and the cognitive tasks.

More diffuse associative processing (as indicated by a lower score on the WAT) and greater working memory capacity predicted greater Creativity in the AUT. Therefore, based on the AUT, there is support for an associative processing account of creativity. Both steeper associative processing (as indicated by a higher score on the WAT) and greater working memory capacity were positively correlated with higher scores on the RAT. Therefore, based on the RAT, there is no support for an associative processing account. Both tasks are correlated with working memory capacity, and therefore both tasks support an executive control account of creativity.

There was also no evidence for a dual process account, i.e. any relationship between associative processing and creativity depending on working memory capacity. People who showed more diffuse activation of semantic networks, plus high working memory capacity, did not show any additional benefit in either task. Similar to the null findings in the

schizotypy-creativity findings, this may be due to one of four reasons: lack of statistical power, poor reliability of measurement, poor validity of measurement and finally, perhaps there is no support for a dual process model of creativity.

Statistical power.

As discussed earlier, power analyses were conducted on the basis of detecting an effect of schizotypy on creative performance. However, the sample sizes for the Lab sample were comparable, if not better powered than other research looking at the associations between associative processing, working memory and creativity (Beaty et al., 2014; Prabhakaran et al., 2014). Fritz and MacKinnon (2007) reviewed a number of studies that tested mediated relationships, and found an average sample size of 142 people, suggesting that the current study was much more highly powered than average. Overall, there appears to be sufficient power to detect a relationship that would support the two single processing accounts of creativity.

Working memory: Reliability.

The shortened complex span tasks have been shown to have good reliability in a number of different studies. They have good test-retest reliability (scores ranging from .77-.83 depending on the type of task; Redick et al., 2012) and good internal consistency (Cronbach's alpha scores ranging from .63-.88; Engle, Tuholski, Laughlin & Conway, 1999; Kane et al., 2004).

Working memory: Validity.

The shortened complex span tasks also have good validity of measurement. For instance, they are highly correlated with other commonly used working memory measures (convergent validity; Broadway & Engle, 2010). They are also highly predictive of measures of fluid intelligence and crystallised intelligence (predictive validity; Unsworth, Heitz, Schrock & Engle, 2005). Overall, there is reasonable evidence to believe that the working memory measures were indeed measuring the intended construct.

WAT: Reliability.

The verb generation version of the task used by Prabhakaran and colleagues found that there was good inter-rater reliability amongst target words. Using a method like latent semantic analysis has also been shown to reduce measurement error (Prabhakaran et al., 2014). However, in the current study individual target words for the WAT only showed moderate internal consistency (Cronbach's alpha = .384). When examining the correlations

between the different target words, there were some targets words that were less strongly associated with the other target words, (particularly the target word street). This suggests one of two things: that it was more difficult to generate words that were reasonable responses to this target word, or that the target word street was not a useful starting word to generate words in a word association task.

WAT: Validity.

LSA values have been shown to have good construct validity (Prabhakaran et al., 2014). The current findings also support the validity of this measure. WAT scores both positively correlate with performance and fluency on the AUT, a divergent thinking measure of creativity. Interestingly, AUT performance negatively correlated with WAT scores (indicating diffuse associative processing), whereas the RAT positively correlated with WAT scores (indicating steeper associative processing). If the associative processing account of creativity is correct, this is further evidence that the RAT is not a useful measure of creativity.

While there is some evidence for the reliability and validity of the WAT, particularly when using LSA to score responses, future work should explicitly test the reliability of the word association task, using a number of different potential target words, and compare it to other measures of associative processing. A measure of associative processing should also correlate with other measures of verbal fluency and intelligence.

Creativity tasks: reliability and validity.

As discussed in the previous section, the AUT does appear to have good reliability and validity. The RAT, however, does not appear to be a good measure of convergent thinking, or creativity in the Lab sample. This suggests that the current study did not fully test the executive control model of creativity (at least in the RAT) or the dual process model of creativity.

Dual process model of creativity.

As discussed in Chapter 5, there has been little direct empirical support for a dual process model of creativity. Testing the dual process model more directly using moderation-mediation analysis was a useful contribution to the creativity literature. I will briefly explore two possible explanations for why there was no support for a dual process model in the current study; in doing so, I will highlight some of the issues with the dual process model literature in general.

In Chapter 5, I discussed a number of conceptualisations of a dual process model of creativity. The majority, including the model as it's conceptualised in this thesis, assume that the two processes are separable. For example, the process of activating information in semantic memory is completely separable from the use of executive control in the creative process. However, the two processes are dependent upon each other. For example, the ability to activate remote concepts in semantic networks when generating ideas is only useful when one is able to inhibit ideas that are irrelevant or truly bizarre. If the two processes are truly separable, then it would need to be tested using tasks that are process pure. An associative processing task arguably always relies on some element of executive control (inhibition of irrelevant responses) in order to be successful.

Finally, it is not clear what aspects of executive control are important in this model. In the current study, I tested only working memory. Working memory made sense from a theoretical perspective as it relates to higher order abilities of executive attention (Engle, 2002), and is highly correlated to measures of overall intelligence. However, it is possible that selecting a more specific measure like cognitive inhibition which is more related to associative processing would have revealed an interaction between associative processing and executive control.

Closing remarks

Overall, this project has taught me a lot about the challenges one faces when trying to understand complex, abstract psychological phenomena. There are a number of future avenues for creativity research. While I have made a number of comments relating to tweaks to study design in future work in this area, I believe that some more significant theoretical work needs to be done in the area of creativity and in schizotypy in order for future empirical research to be informative. Instead of continuing to ask the question, is schizotypy related to creativity, maybe instead we can ask, what is creativity? And how do we measure it in a way that makes sense, and helps explain the experiences of creative people in the real world? The current study has made a small contribution to the theoretical and empirical work in both schizotypy and creativity research, as well as research looking at the relationship between the two. Can I rule out that mental illness confers an advantage in creative thinking? No, but this project suggests that this question is a lot more complicated than a straightforward association between the two. Understanding creativity still proves to be an important, but somewhat elusive goal.

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Appendix A. Full list of databases searched in the literature review of schizotypy and creativity

- ProQuest Central
- SciTech Premium Collection
- Natural Science Collection
- Biological Science Database
- Medline/PubMed
- OneFile
- ProQuest Dissertations & Theses: Global
- ProQuest Health & Medical Complete
- ProQuest Research Library
- Social Science Premium Collection
- Elsevier (CrossRef)
- Agricultural & Environmental Science Database
- ProQuest Environmental Science Database
- Health Reference Center
- ProQuest Science Journals
- ProQuest Social Science Journals
- Directory of Open Access Journals
- PubMed Central
- Sage Journals
- ERIC (U.S. Dept of Education)

Appendix B. Schizotypal Personality Questionnaire. Full list of items.

Please answer each item by circling "Yes" or "No". Answer all items even if unsure of your answer. When you have finished, check over each one to make sure you have answered them.	
1. Do you sometimes feel that things you see on the TV or read in the newspaper have a special meaning for you?	Yes No
2. I sometimes avoid going to places where there will be many people because I will get anxious	Yes No
3. Have you had experiences with the supernatural?	Yes No
4. Have you often mistaken objects or shadows for people, or noises for voices?	Yes No
5. Other people see me as slightly eccentric (odd).	Yes No
6. I have little interest in getting to know other people	Yes No
7. People sometimes find it hard to understand what I am saying	Yes No
8. People sometimes find me aloof and distant	Yes No
9. I am sure I am being talked about behind my back	Yes No
10. I am aware that people notice me when I go out for a meal or to see a film	Yes No
11. I get very nervous when I have to make polite conversation	Yes No
12. Do you believe in telepathy (mind-reading)?	Yes No
13. Have you ever had the sense that some person or force is around you, even though you cannot see anyone?	Yes No
14. People sometimes comment on my unusual mannerisms and habits	Yes No
15. I prefer to keep to myself	Yes No
16. I sometimes jump quickly from one topic to another when speaking	Yes No
17. I am poor at expressing my true feelings by the way I talk and look	Yes No

18. Do you often feel that other people have got it in for you?	Yes	No
19. Do some people drop hints about you or say things with a double meaning?	Yes	No
20. Do you ever get nervous when sometime is walking behind you?	Yes	No
21. Are you sometimes sure that other people can tell what you are thinking?	Yes	No
22. When you look at a person, or yourself in a mirror, have you ever seen the face change right before your eyes?	Yes	No
23. Sometimes other people think that I am a little strange	Yes	No
24. I am mostly quiet when with other people	Yes	No
25. I sometimes forget what I am trying to say	Yes	No
26. I rarely laugh and smile.	Yes	No
27. Do you sometimes get concerned that friends or co-workers are not really loyal or trustworthy?	Yes	No
28. Have you ever noticed a common event or object that seemed to be a special sign for you?	Yes	No
29. I get anxious when meeting people for the first time	Yes	No
30. Do you believe in clairvoyancy (psychic forces, fortune telling)?	Yes	No
31. I often hear a voice speaking my thoughts aloud.	Yes	No
32. Some people think that I am a very bizarre person	Yes	No
33. I find it hard to be emotionally close to other people	Yes	No
34. I often ramble on too much when speaking	Yes	No
35. My “non-verbal” communication (smiling and nodding during a yes / no conversation) is poor.	Yes	No
36. I feel I have to be on my guard even with friends	Yes	No

37. Do you sometimes see special meanings in advertisements, shop windows, or in the way things are arrange around you?	Yes	No
38. Do you often feel nervous when you are in a group of unfamiliar people?	Yes	No
39. Can other people feel your feelings when they are not there?	Yes	No
40. Have you ever seen things invisible to other people?	Yes	No
41. Do you feel that there is no-one you are really close to outside of your immediate family, or people you can confide in or talk to about personal problems?	Yes	No
42. Some people find me a bit vague and elusive during a conversation	Yes	No
43. I am poor at returning social courtesies and gestures	Yes	No
44. Do you often pick up hidden threats or put-downs from what people say or do?	Yes	No
45. When shopping do you get the feeling that other people are taking notice of you?	Yes	No
46. I feel very uncomfortable in social situations involving unfamiliar people	Yes	No
47. Have you had experiences with astrology, seeing the future, UFOs, ESP or a sixth sense?	Yes	No
48. Do everyday things seem unusually large or small?	Yes	No
49. Writing letters to friends is more trouble than it is worth	Yes	No
50. I sometimes use words in unusual ways	Yes	No
51. I tend to avoid eye contact when conversing with others	Yes	No
52. Have you found that it is best not to let other people know too much about you?	Yes	No
53. When you see people talking to each other, do you often wonder if they are talking about you?	Yes	No
54. I would feel very anxious if I had to give a speech in front of a large group of people	Yes	No
55. Have you ever felt that you are communicating with another person telepathically (by mind-reading)?	Yes	No

56. Does your sense of smell sometimes become unusually strong?	Yes	No
57. I tend to keep in the background on social occasions	Yes	No
58. Do you tend to wander off the topic when having a conversation	Yes	No
59. I often feel that others have it in for me	Yes	No
60. Do you sometimes feel that other people are watching you?	Yes	No
61. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?	Yes	No
62. I attach little importance to having close friends	Yes	No
63. Do you sometimes feel that people are talking about you?	Yes	No
64. Are your thoughts sometimes so strong that you can almost hear them?	Yes	No
65. Do you often have to keep an eye out to stop people from taking advantage of you?	Yes	No
66. Do you feel that you are unable to get “close” to people?	Yes	No
67. I am an odd, unusual person	Yes	No
68. I do not have an expressive and lively way of speaking	Yes	No
69. I find it hard to communicate clearly what I want to say to people	Yes	No
70. I have some eccentric (odd) habits	Yes	No
71. I feel very uneasy talking to people I do not know well	Yes	No
72. People occasionally comment that my conversation is confusing	Yes	No
73. I tend to keep my feelings to myself	Yes	No
74. People sometimes stare at me because of my odd appearance.	Yes	No

Appendix C. Oxford-Liverpool Inventory of Feelings and Experiences – full list of items.

Please answer each item by circling "Yes" or "No". Answer all items even if unsure of your answer.

When you have finished, check over each one to make sure you have answered them.

Unusual Experiences sub-scale

1. Do you believe in telepathy	Yes	No
2. Do you ever feel sure that something is about to happen, even though there does not seem to be any reason for you thinking that?	Yes	No
3. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?	Yes	No
4. Do you often have days when indoor lights seem so bright that they bother your eyes?	Yes	No
5. Does your sense of smell sometimes become unusually strong?	Yes	No
6. Have you felt as though your head or limbs were somehow not your own?	Yes	No
7. Have you sometimes sensed an evil presence around you, even though you could not see it?	Yes	No
8. Have you wondered whether the spirits of the dead can influence the living?	Yes	No
9. On occasions, have you seen a person's face in front of you when no one was in fact there?	Yes	No
10. When in the dark do you often see shapes and forms even though there's nothing there?	Yes	No
11. When you look in the mirror does your face sometimes seem quite different from usual?	Yes	No
12. Are your thoughts sometimes so strong that you can almost hear them?	Yes	No
13. Can some people make you aware of them just by thinking about you?	Yes	No
14. Do ideas and insights sometimes come to you so fast that you cannot express them all?	Yes	No
15. Do the people in your daydreams seem so true to life that you sometimes think they are real?	Yes	No
16. Do you sometimes feel that your accidents are caused by mysterious forces?	Yes	No
17. Do you think you could learn to read other's minds if you wanted to?	Yes	No
18. Does it often happen that nearly every thought immediately and automatically suggests an enormous number of ideas?	Yes	No

19. Does a passing thought ever seem so real it frightens you?	Yes	No
20. Does your voice ever seem distant or faraway?	Yes	No
21. Have you ever felt that you have special, almost magical powers?	Yes	No
22. Is your hearing sometimes so sensitive that ordinary sounds become uncomfortable?	Yes	No
23. Do you ever have a sense of vague danger or sudden dread for reasons that you do not understand?	Yes	No
24. Do you feel so good at controlling others that it sometimes scares you?	Yes	No
25. Have you ever thought you heard people talking only to discover that it was in fact some nondescript noise?	Yes	No
26. Have you felt that you might cause something to happen just by thinking too much about it?	Yes	No
27. Have you occasionally felt as though your body did not exist?	Yes	No
28. Have you sometimes had the feeling of gaining or losing energy when certain people look at you or touch you?	Yes	No
29. Are the sounds you hear in your daydreams really clear and distinct?	Yes	No
30. Do your thoughts sometimes seem as real as actual events in your life?	Yes	No
Cognitive Disorganisation sub-scale		
31. Are you easily distracted when you read or talk to someone?	Yes	No
32. Do you ever feel that your speech is difficult to understand because the words are all mixed up and don't make sense?	Yes	No
33. Do you often experience an overwhelming sense of emptiness?	Yes	No
34. Do you often feel lonely?	Yes	No
35. Is it hard for you to make decisions?	Yes	No
36. Are you a person whose mood goes up and down easily?	Yes	No
37. Are you easily hurt when people find fault with you or the work you do?	Yes	No
38. Are you sometimes so nervous that you are blocked?	Yes	No
39. Do you dread going into a room by yourself where other people have already gathered and are talking?	Yes	No
40. Do you easily lose your courage when criticised or failing in something?	Yes	No
41. Do you find it difficult to keep interested in the same thing for a long time?	Yes	No

42. Do you frequently have difficulty in starting to do things?	Yes	No
43. Do you often feel that there is no purpose to life?	Yes	No
44. Do you often have difficulties in controlling your thoughts?	Yes	No
45. Do you often worry about things you should not have done or said?	Yes	No
46. Do you worry about awful things that might happen?	Yes	No
47. No matter how hard you try to concentrate do unrelated thoughts creep into your mind?	Yes	No
48. When in a crowded room, do you often have difficulty in following a conversation?	Yes	No
49. Are you easily confused if too much happens at the same time?	Yes	No
50. Are you easily distracted from work by daydreams?	Yes	No
51. Do you often feel fed up?	Yes	No
52. Do you worry too long after an embarrassing experience?	Yes	No
53. Would you call yourself a nervous person?	Yes	No
54. Do you often hesitate when you are going to say something in a group of people whom you more or less know?	Yes	No
Introvertive anhedonia sub-scale		
55. Can you usually let yourself go and enjoy yourself at a lively party? *negative*	Yes	No
56. Do people who try to get to know you better usually give up after a while?	Yes	No
57. Do you feel that making new friends isn't worth the energy it takes?	Yes	No
58. Do you find the bright lights of a city exciting to look at? *negative*	Yes	No
59. Do you like going out a lot? *negative*	Yes	No
60. Do you prefer watching television to going out with other people?	Yes	No
61. Do you usually have very little desire to buy new kinds of food?	Yes	No
62. Is it fun to sing with other people? *negative*	Yes	No
63. Are people usually better off if they stay aloof from emotional involvements with people?	Yes	No
64. Are there very few things that you have ever really enjoyed doing?	Yes	No
65. Are you much too independent to really get involved with other people?	Yes	No
66. Are you rather lively? *negative*	Yes	No
67. Can just being with friends make you feel really good? *negative*	Yes	No

68. Do you have many friends? *negative*	Yes	No
69. Do you like mixing with people? *negative*	Yes	No
70. Do you think having close friends is not as important as some people say?	Yes	No
71. Does it often feel good to massage your muscles when they are tired or sore? *negative*	Yes	No
72. Has dancing or the idea of it always seemed dull to you?	Yes	No
73. Have you often felt uncomfortable when your friends touch you?	Yes	No
74. Is trying new foods something you have always enjoyed? *negative*	Yes	No
75. On seeing a soft thick carpet have you sometimes had the impulse to take off your shoes and walk barefoot on it? *negative*	Yes	No
76. When things are bothering you do you like to talk to other people about it? *negative*	Yes	No
77. Do you feel very close to your friends? *negative*	Yes	No
78. Do you love having your back massaged? *negative*	Yes	No
79. Have you had very little fun from physical activities like walking, swimming, or sports?	Yes	No
80. Do you enjoy many different kinds of play and recreation? *negative*	Yes	No
81. Is it true that your relationships with other people never get very intense?	Yes	No
	Yes	No
Impulsive non-conformity sub-scale		
82. Do people who drive carefully annoy you?	Yes	No
83. Do you often feel like doing the opposite of what other people suggest, even though you know they are right?	Yes	No
84. Do you often feel the impulse to spend money which you know you can't afford?	Yes	No
85. Do you often have an urge to hit someone?	Yes	No
86. Do you sometimes talk about things you know nothing about?	Yes	No
87. Are you usually in an average sort of mood, not too high and not too low? *negative*	Yes	No
88. Do you at times have an urge to do something harmful or shocking?	Yes	No
89. Do you ever have the urge to break or smash things?	Yes	No
90. Do you often change between intense liking and disliking of the same person?	Yes	No
91. Do you stop to think things over before doing anything? *negative*	Yes	No

92. Do you think people spend too much time safeguarding their future with savings and insurance?	Yes	No
93. Have you ever blamed someone for doing something you know was really your fault?	Yes	No
94. Have you ever cheated at a game?	Yes	No
95. Have you ever felt the urge to injure yourself?	Yes	No
96. When in a group of people do you usually prefer to let someone else be the centre of attention? *negative*	Yes	No
97. When you catch a train do you often arrive at the last minute	Yes	No
98. Would being in debt worry you? *Negative*	Yes	No
99. Would you take drugs which may have strange or dangerous effects?	Yes	No
100. Do you consider yourself to be pretty much an average kind of person? *negative*	Yes	No
101. Have you ever taken advantage of someone?	Yes	No
102. Would you like other people to be afraid of you?	Yes	No
103. Do you often overindulge in alcohol or food?	Yes	No
104. Would it make you nervous to play the clown in front of other people? *negative*	Yes	No

Appendix D. Rating instructions for the Alternate Uses Task.

Alternate Uses Task

In the alternate uses task, participants are required to generate alternative uses for common, everyday objects. In this particular study, participants had to generate alternate uses for a ping pong ball. They were given ten minutes to complete this task.

All Uses are to be rated on a scale of 1-5 for creativity (1 = not at all creative, 5 = highly creative).

Creativity is judged by three main criteria: uncommonness, remoteness and cleverness

1. Uncommon

Creative ideas are uncommon: they will occur infrequently in our sample. Any response that is given by a lot of people is common, by definition. Unique responses will tend to be creative responses, although a response given only once needn't be judged as creative. For example, a random or inappropriate response would be uncommon but not creative.

2. Remote

Creative ideas are remotely linked to everyday objects and ideas. For example, creative uses for a brick are "far from" common, everyday, normal uses for a brick, and creative instances of things that are round are "far from" common round objects. Responses that stray from obvious ideas will tend to be creative, whereas responses close to obvious ideas will tend to be uncreative.

3. Clever

Creative ideas are often clever: they strike people as insightful, ironic, humorous, fitting, or smart. Responses that are clever will tend to be creative responses. Keep in mind that cleverness can compensate for the other facets. For example, a common use cleverly expressed could receive a high score.

Extra Information

- Quickly read all the responses first to get a sense of commonness and uniqueness trends.
- Give low scores to actual intended uses for the objects (e.g., making a fireplace with bricks).
- Use the whole scale. Save the 1s for the really obvious, terrible, and confused responses.
- Overlook spelling mistakes—people are usually typing quickly.
- Please quickly revise your ratings after judging everything. After rating everything, for example, it is a good idea to sort “descending” by your ratings, and see if you want to change any of your higher scores to be even higher. In hindsight, many will look better, and some will look worse.
- Give no score for responses such as ‘no idea,’ a random string of numbers or blank responses

Appendix E. List of Remote Associates Test problems

Problem	Solution
cream skate water	ice
loser throat spot	sore
show life row	boat
night wrist stop	watch
rocking wheel high	chair
reserve ranger tropical	forest
cane daddy plum	sugar
dream break light	day
fish mine rush	gold
political surprise line	party
measure worm video	tape
piece mind dating	game
flower friend scout	girl
river note account	bank

fur rack tail	coat
stick maker point	match
fox man peep	hole
hound pressure shot	blood
light birthday stick	candle
shine beam struck	moon
palm tea house	tree
basket eight snow	ball
bottle paint hair	brush
french car shoe	horn
boot summer ground main sweeper light	camp street
chamber mask natural	gas
office mail hat	box
wagon petrol radio	station
animal back rat	pack

eight skate stick	figure
officer cash larceny	petty
force line mail	air
down question birth	mark
house thumb pepper	green

Appendix F. Creative Personality Scale Items

Instructions: You will see a list of adjectives. Please indicate which of the following adjectives best describe yourself.

Positive adjectives

1. Capable
2. Clever
3. Confident
4. Egotistical
5. Humourous
6. Individualistic
7. Informal
8. Insightful
9. Intelligent
10. Interests wide
11. Inventive
12. Original
13. Reflective
14. Resourceful
15. Self-confident
16. Sexy
17. Snobbish
18. Unconventional

Negative adjectives (reverse coded)

19. Affected
20. Cautious
21. Commonplace
22. Conservative
23. Conventional
24. Dissatisfied
25. Honest

26. Interests narrow
27. Mannerly
28. Sincere
29. Submissive
30. Suspicious

Appendix G. Examples of word corrections in the WAT during LSA

Adjusted words

Colour: changed to American spelling, now ‘color’

Main street: taking out the target word ‘street’, now ‘main’

5th: Numbers changed into actual word, now ‘fifth’

Lamppost: turned into two words, now ‘lamp post’

Beautif: completed, as within 1 or 2 letters of intended word, now ‘beautiful’

Removed words

Non-english names or words

Names of people or places