Is there a relationship between imagination and repetitive behaviours in autistic adults?

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Thesis Summary

This thesis investigated the long held claim that reliance on routines and rituals (restricted and repetitive behaviours [RRB]) is related to a difficulty with flexibly generating novel ideas (imagination) in those with autism spectrum disorder (ASD). The sparse body of previous research into this relationship has yielded equivocal findings. Therefore the main aim of this thesis was to address the question: what is the nature of the relationship, if any, between imagination and RRBs in individuals with ASD?

In order to test this relationship, I developed the first self-report measure of RRBs suitable for use with autistic adults, the Adult Repetitive Behaviours Questionnaire-2 (RBQ-2A), which has since been published in the *Journal of Autism and Developmental Disorders*. In Study One I tested the RBQ-2A with neurotypical (NT) adults and showed that it is a reliable and valid measure of RRB, comprising two components: repetitive motor behaviours (RMB) and insistence on sameness (IS). Study Two showed that autistic adults scored significantly higher on the RBQ-2A compared to NT adults, and in a larger sample of autistic adults (Study Three), three components were identified: RMB, repetitive sensory behaviours (RSB) and IS. In Study Four, significant associations between RBQ-2A score and the imagination subscale of the Autism-Spectrum Quotient were found; although this relationship was unstable. More convincingly, participants who reported *not* playing pretend as a child showed significantly higher levels of IS, and a more limited pattern of self-chosen activities, compared to participants who *did* play pretend. Finally, a range of imagination measures were administered to a small sample of autistic adults (Study Five). There was a great deal of variation in performance on imagination tasks, but none of these measures correlated with each other. There were also no significant relationships between these tasks and the RBQ-2A. However, 89% of participants reported both impoverished past pretend play and a limited pattern of self-chosen activities.

In summary, in this thesis I showed that the conceptualisation of imagination in ASD is incomplete and suggested a conceptualisation of imagination for future research, comprising the key components of generativity, novelty and flexibility. I also showed that the RBQ-2A is a reliable and valid self-report measure of RRBs in autistic adults. Finally, in terms of the nature of the relationship between imagination and RRBs, I provided evidence that this relationship is restricted to IS and past pretend play; that is, individuals with ASD who showed poor pretend play as children go on to behave in a more restricted manner in later life. However, this is a weak relationship, and individuals with ASD may still show high levels of creativity in other domains.

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Abbreviations

AA	Atypical autism
AD	Autistic disorder
ADOS	Autism Diagnostic Observation Schedule
ADI-R	Autism Diagnostic Interview - Revised
ADHD	Attention deficit hyperactivity disorder
APA	American Psychiatric Association
ARI	Adult Routines Inventory
AS	Asperger's syndrome
ASD	Autism spectrum disorder
AQ	Autism-Spectrum Quotient
CAP	Creativity Assessment Packet
CFA	Confirmatory factor analysis
CI	Circumscribed interests
CYBOCS	Children's Yale-Brown Obsessive-Compulsive Scale
DD	Developmentally delayed
DISCO	Diagnostic Interview for Social and Communication Disorders
DS	Down's Syndrome
DSM	Diagnostic and Statistical Manual of Mental Disorders
DV	Dependent variable
EF	Executive function
EFA	Exploratory factor analysis
EFT	Episodic future thinking
EM	Episodic memory
FSIQ	Full Scale intelligence quotient
HFA	High functioning autism
HADS	Hospital Anxiety and Depression Scale
ICD	International Classification of Diseases
IFT	Incomplete Figures Task
IS	Insistence on Sameness
IV	Independent variable

IQ	Intelligence quotient
IQR	Inter-quartile range
KMO	Keiser-Meyer-Olkin measure of sampling adequacy
LD	Learning disability
MA	Mental age
NT	Neurotypical
NVA	Non-verbal ability
NVI(Q)	Non-verbal intelligence (quotient)
OCD	Obsessive-compulsive disorder
PA	Parallel analysis
PCA	Principal components analysis
PDD-NOS	Pervasive developmental disorder – not otherwise specified
PFT	Personal Future Task
PIQ	Performance intelligence quotient
PMT	Pattern Meanings Task
RBI	Repetitive Behaviour Interview
RBS-R	Repetitive Behaviour Scale - Revised
RBQ(-2)	Repetitive Behaviours Questionnaire(-2)
RBQ-2A	Adult Repetitive Behaviours Questionnaire-2
RFT	Repeated Figures Task
RIS	Rigidity/Insistence on sameness
RMB	Repetitive motor behaviours
RSB	Repetitive sensory behaviours
RSMB(/C)	Repetitive sensory and motor behaviours(/compulsions)
RRB	Restricted and repetitive behaviours
SATQ	Subthreshold Autism Traits Questionnaire
SD	Standard deviation
TD	Typically developing
ToM	Theory of mind
TTCT	Torrance Tests of Creative Thinking
UOT	Use of Objects Task

UUCB	Unusual Use of Cardboard Boxes
UK	United Kingdom
VMA	Verbal mental age
VIQ	Verbal intelligence quotient
WASI	Wechsler Abbreviated Scale of Intelligence
WHO	World Health Organisation
WM	Working memory
YBOCS	Yale-Brown Obsessive-Compulsive Scale

1 Chapter One: Introduction

"*Thus, a six-year-old boy had the ambition to collect 1,000 matchboxes, a goal which he pursued with fanatical energy. The mother, however, never saw him play trains with them as other children do.*" (p. 82)

- Asperger (1944)

"*The toddler with autism may spin the wheels of a toy car instead of pretending to park or clean it, while the adult with autism may show no interest in fiction in the form of TV soaps or novels, preferring to read telephone directories…*" (p. 19)

- Happé (1999)

The earliest accounts of autism spectrum disorder (ASD) describe the behavioural inflexibility that characterises autistic individuals to varying degrees (Asperger, 1944; Kanner, 1943). This behavioural inflexibility is reflected in markedly restricted and repetitive patterns of behaviours and actions, coupled with a strong desire to maintain sameness in the environment. These behaviours are now grouped together under one umbrella term: restricted and repetitive behaviours (RRB). However, Happé (1999) noted that early observations of RRB have also been depicted as evidence of impaired imaginative ability (Wing & Gould, 1979). It has been argued that a difficulty with imagination is the central difficulty of ASD (e.g. Harris, 2000; Wing, Gould & Gillberg, 2011), such that autistic individuals find it difficult to symbolically store abstract concepts from their experience and therefore struggle to use such concepts when reacting to daily life or thinking about the future (Wing, Gould, Yeates & Brierly, 1977). This results in an inflexibility of thought as a counterpart to behavioural inflexibility. Indeed, lack of imaginative activity and preference for repetition in ASD have been described as two sides of the same coin (Turner, 1999b).

Traditionally the main criteria for ASD have been conceptualised as a "triad of impairments" (Wing & Gould, 1979), comprising difficulties in social interaction and

communication, with the final component comprising difficulties in imagination co-occurring with RRBs. This formulation of the triad has been generally accepted in the literature (Honey, Leekam, Turner & McConachie, 2007); for example Best, Arora, Porter and Doherty (2015) assert that "the deficit in imagination is manifested as restricted, repetitive patterns of behaviour, interests or activities" (p. 4064). In contrast, imagination is categorised with social and communication difficulties in international diagnostic manuals and according to Jarrold (2003) the reasoning for this is not entirely clear.

Nevertheless, researchers continue to make a theoretical case for the relationship – or shared underlying mechanisms - between RRBs and imagination in ASD (e.g. Begeer, Terwogt, Lunenburg & Stegge, 2009; Boucher, 2007). For example, it has been suggested that a difficulty with imagining the future may explain the elevated presence of RRBs in ASD (Jackson & Atance, 2008; Lind & Bowler, 2010; Lind, Williams, Bowler, & Peel, 2014; Terrett et al., 2013). According to this argument, imagining the future (along with remembering the past) has an evolutionary advantage in that this ability increases behavioural flexibility (e.g. Suddendorf & Corballis, 2007), allowing individuals to imagine different scenarios based on previous experience and plan for new scenarios. If an individual however is not able to imagine or plan for the future, this may lead to a preference for familiar routines and environments. Clinicians maintain the importance of imagination in ASD, particularly in terms of diagnosis. Yet imagination is downplayed in international diagnostic manuals and the apparent relationship between RRBs and imagination in ASD has received little attention in terms of empirical work (see section 1.3, page 50 for a review). Furthermore, the existing evidence base for this relationship is equivocal. Therefore the main aim of this thesis is to further investigate the relationship between inflexibility of thought and behaviour – in other words, imagination and RRBs.

Specifically, I aim to address this relationship in adults with ASD, including Asperger's syndrome (AS). Although adults are generally under-represented in ASD research (Pellicano, Dinsmore & Charman, 2014), there is a particularly striking lack of research regarding imagination in autistic adults. Imaginative difficulties in ASD are generally measured in research and diagnosis in terms of a lack of or impoverished

childhood pretend play (e.g. Charman & Baron-Cohen, 1997; Hobson, Hobson, Malik, Bargiota & Caló , 2013; Rutherford, Young, Hepburn & Rogers, 2007; Wing et al., 1977), which is not the most useful indicator of current imaginative ability for most adults seeking a diagnosis. Moreover, in adult psychiatry, the assessment of a person's sense of reality and inner world forms an important aspect of the diagnosis of overlapping conditions such as bipolar disorder. Given the increasing numbers of individuals who are being diagnosed with ASD as adults, it is important to understand the relationship between imagination and RRBs, and imagination more generally, in autistic adults.

Before the relationship between imagination and RRBs in autistic adults can be assessed, two related issues ought to be addressed. The first issue is the discrepancy between the RRB literature and the imagination literature. RRBs in ASD have been thoroughly researched, and a large body of work has been developed surrounding this phenomenon. Although it should be noted that there are still many issues that are unresolved in RRBs, in comparison the subject of imagination has been somewhat neglected. Much work has focused on the definition, conceptualisation and measurement of RRBs, whereas there have been few attempts to formally conceptualise and define imagination, and imagination has been measured across several contexts using a variety of methods. Furthermore, a review of the literature reveals that the findings from studies of autistic imagination are equivocal (see section 1.1.3, page 22) and while certain tests of imagination are failed by autistic individuals, they succeed in others; indeed there are many autistic individuals who are successful artists, musicians, poets and inventors (e.g. Bogdashina, 2003; Lawson, 2011). This discrepancy between the two literatures may serve as an explanation for why the evidence base is so poor in terms of the relationship between imagination and RRBs.

The second issue concerns how to measure RRBs in autistic adults. I have noted that there has been much work regarding the measurement of RRBs, and I review this in section 1.2 (page 34). However, many of these measures rely on parent-report. As I am investigating the relationship between imagination and RRBs in autistic adults, parent-report is not necessarily the ideal method. For example, parents of adults are more likely to have passed away. In the case of adults who have moved away from home, their parents may be unable to report as accurately on their child's

RRBs. Autistic adults may have also learned to 'mask' their RRBs and therefore they may not be as accessible to any observer. In a similar vein, observational methods are limited in accessing a complete picture of RRBs as they are time-limited and depend on the behaviour manifesting itself during the observational setting. Therefore as an additional aim of this thesis, I developed a self-report measure of RRBs for autistic adults: the Adult Repetitive Behaviours Questionnaire – 2 (RBQ-2A; see Chapter Two, pages 63-64 for an explanation of this decision). I began this work in a Master's dissertation (Barrett, 2013), and I continue it in this thesis, by assessing the reliability and validity of the RBQ-2A.

This chapter will address the first issue, beginning with a conceptual analysis of imagination in ASD research, and the formulation of a working definition for this thesis. I will then briefly review the different methods used to assess imagination and discuss what we have learned from these methods, focussing on two key issues that arise from the initial review; specifically, imagination in adulthood and the different dimensions of the imagination construct. I will then turn to RRB in order to address the second issue discussed above. The literature regarding the conceptualisation and measurement of RRBs will be reviewed, as will the literature regarding the presentation of RRBs in autistic adults, as this may differ from children and adolescents. Finally I will bring these two literatures together and discuss the previous research that has addressed the relationship between imagination and RRBs, what the limitations of the research are, and how I plan to improve upon these limitations. Chapter Two will outline some of the methodological issues that arose from this plan and how I addressed them. Chapters Three and Four will describe the development and testing of the RBQ-2A, including analysing data from this questionnaire using principal components analysis (PCA). Chapters Four and Five will address the measurement and presentation of imagination in autistic adults, and whether imagination and RRBs are related to each other in this population.

1.1 Imagination in ASD

1.1.1 Definition and conceptual analysis of imagination

One of the biggest obstacles in understanding the literature on imagination and ASD is the lack of a standardised definition. Imagination has not been defined

consistently throughout research in ASD, and has been measured across a wide range of contexts using various methods, ranging from pretend play, to thinking about the future, to traditional measures of creativity such as drawing and writing. The combination of the large variety of measures used and lack of a consistent definition has resulted in an incoherent literature. As such, although imagination is generally considered impaired within ASD, the evidence for this is equivocal. Even when a difficulty is found, this is not always ASD-specific (e.g. Craig, Baron-Cohen & Scott, 2001) or due to problems with imagination itself (e.g. Allen & Craig, 2016). Therefore it is important to begin this review of imagination with a conceptual analysis and attempt to define imagination in a way that is relevant to ASD. I will begin by considering the definition of imagination outside of ASD research, such as its everyday use and how it has been defined by developmental psychologists and creativity researchers. I will then discuss how imagination in relation to ASD has been defined by researchers and clinicians, before pulling together these different perspectives in order to formulate a definition of imagination for the purposes of this thesis.

A useful starting point is the use of the word in everyday language. Imagination is defined in various ways, for example the following definitions from the Oxford English Dictionary Online (2015):

> *1. a) The power or capacity to form internal images or ideas of objects and situations not actually present to the senses, including remembered objects and situations, and those constructed by mentally combining or projecting images of previously experienced qualities, objects, and situations. Also (esp. in modern philosophy): the power or capacity by which the mind integrates sensory data in the process of perception.*
>
> *3. The mental consideration of future or potential actions or events.*
>
> *5. The mind's creativity and resourcefulness in using and inventing images, analogies, etc.; poetic or artistic genius or talent. Also: an individual's poetic or artistic genius or talent.*

Therefore, even in its everyday use, the word *imagination* represents a complex construct. The first definition is a more general explanation of what is meant by imagination, and includes a discussion of the origins of imagination; in other words, we construct new thoughts and images by combining our previous experiences. The latter definitions comprise two examples of imagination that have already been mentioned in relation to ASD research: thinking about the future and creativity.

However, in psychological terms, the construct of imagination – or creativity – has not been well-defined. Psychological constructs are inherently abstract concepts and therefore cannot be directly observed or measured, and in some cases they cannot be defined (e.g. Hospers, 1997; Kline, 2000). One way of understanding a construct is to establish examples and counter-examples of the construct by setting up necessary and sufficient criteria for that construct (e.g. Bozeman & Feeney, 2007; Hospers, 1997). There have been few attempts to properly define the construct of imagination or creativity within the literature on imagination in ASD, although ASD researchers have been influenced by developmental psychologists and creativity researchers who have written on the subject. The following sections will briefly examine how imagination and creativity have been defined in research and clinical terms, and will pull out the necessary and sufficient criteria for this construct.

1.1.1.1 Influence outside of the ASD literature

Early psychological theories of imagination focus on symbolic play as the earliest indicator of imagination in children. Vygotsky (1966) argued that play is essential for the development of abstract thought, by separating objects from their meanings. In more general terms, Vygotsky (2004) argued that our brains combine and creatively rework elements of our previous experience and from these generate new ideas and actions by combining them in novel ways. Following on from this, Vygotsky also argued that the older a person and the more varied their experiences then the richer their imagination. This relates to some modern work showing that diversifying experiences increase the creativity of individuals in terms of originality (e.g. Ritter et al., 2012).

Perhaps the most influential individual on our understanding of symbolic play in children was Piaget. Piaget distinguished between two modes of thought:

accommodation and assimilation, arguing that "play is essentially assimilation" (p.87, Piaget, 1962). Assimilation refers to the integration of external percepts and actions into an individual's own limited schemata and cognitive or motor skills (Singer & Singer, 2013). However, this mode of thought is eventually replaced by logic and rationality (Harris, 2000). This account provides some insight into how play influences later cognitive skills, and has some aspects in common with Vygotsky's (2004) description. However, Piaget's account of symbolic play has been criticised as taking a negative stance by Harris (2000), who argued that in Piaget's view pretend play indicates that children have poor objective understanding of reality. In contrast, Harris suggested that in pretend play children actually draw on their causal understanding of the physical and mental world, and that the consideration of alternate realities afforded by pretend play represents a move towards objective reality and is critical for making causal and moral judgements; therefore, this type of thinking is critical throughout an individual's development. Piaget was also criticised by Sutton-Smith (1966; cited in Singer & Singer, 2013) for not addressing the adaptive value of play for an individual's ability to think flexibly. Although these psychological explanations of imagination and creativity vary somewhat in details, all relate the importance of drawing on real-world experience and knowledge in a flexible manner.

Aside from the developmental psychology perspective, early research distinguished creative ability from more traditional concepts of intelligence. Guilford (1959) hypothesised that there are two main strategies to solve a problem: divergent and convergent thinking. Divergent thinking refers to the generation of several relevant ideas to solve a given problem, whereas convergent thinking refers to thought channelled in one direction to reach a single conclusion. Guilford argued that creative individuals are more influenced by divergent thinking which comprises fluency (the generation of relevant ideas), flexibility and originality (analogous to novelty). It has been argued that originality is the most important aspect of creativity (Wallach and Kogan, 1965). Sousa's (2009; cited in Newbold, 2013) definition of creativity expands on Guilford's with the inclusion of elaboration as a dimension.

A more recent conceptualisation of creativity that is commonly referenced is the ability to produce outputs that are *novel* and *appropriate* for the current task or

situation (e.g. Runco & Jaeger, 2012). This is a clear definition of creativity; however, it does not necessarily encapsulate all forms of imagination. A person may daydream about the future without producing any outputs and they can still be said to be *imagining* the future. Therefore although producing an output is a necessary criterion for *creativity*, it is a sufficient but not necessary criteria for imagination. This distinction between imagination and creativity is an important one that has not been fully resolved (e.g. Lawson, 2011; Scott, 2013), but is relevant to the conceptualisation of imagination. I suggest that a compromise can be reached by considering imagination the mental process, and creativity the production of outputs related to these mental processes. Therefore creativity requires imagination, but imagination does not necessarily lead to creativity. Whereas a clear definition relating to creativity has emerged from this literature, the construct of imagination remains ill-defined.

1.1.1.2 How has imagination been defined in ASD research?

Few ASD researchers explicitly define or set out their criteria for imagination, and there is no consensus among those that do. In their seminal paper, Wing and Gould (1979) described the lack of imaginative and symbolic activities, including pretend play, in a group of autistic children. Wing et al. (1977) describe in more detail what is meant by *imaginative activities*: symbolic play; symbolic play with other children; inventing stories; modelling or drawing pictures with imaginative themes; lively discussion of past experiences. Wing et al. (1977) also emphasised the importance of flexibility and variety of activity, which echoes Guilford's (1959) conceptualisation of divergent thinking. However, the originators of the triad of impairments in ASD have since clarified that they specifically refer to *social* imagination; this is the ability to foresee the consequences of their own and others' actions and to act in an appropriate fashion, as well as learning from past experience and mistakes (Wing et al., 2011). This is the clearest example of a definition of imagination in relation to ASD. However, few imagination researchers have referred to this definition, potentially as a result of the overlap between social imagination and other social difficulties such as theory of mind (ToM).

Other ASD researchers have consulted the definitions of imagination in the typical literature, and applied this to ASD populations. According to Scott and Baron-

Cohen (1996), imagination often involves the ability to form a mental representation of entities and situations, specifically those that are non-veridical, and may involve the adaptation or combinations of existing concepts to create new ones. This echoes Vygotsky's (2004) argument that the generation of novelty involves a creative re-combinatorial activity that reworks elements of past experiences. Imagination depends and operates on previous experience, which is reflected in current theories and evidence regarding the relationship between imagination, thinking about the future and episodic memory (EM; e.g. Boucher, 2007; Terrett et al., 2013; Hassabis, Kumaran & Maguire, 2007).

Similarly, creativity is thought to involve the generation, manipulation and transformation of images to produce original representations (Flowers & Garbin, 1989; cited in Craig & Baron-Cohen, 1999 and Scott, 2013); although this can only be applied to certain forms of imagination and not others (Scott, 2013). Less precise definitions of creativity contrast it with conformity (Craig & Baron-Cohen, 1999; Scott, 2013) and relate it to complexity (Lewis & Boucher, 1991). Arguably then, Scott and Baron-Cohen's (1996) description encompasses more forms of imagination and creativity, as it can be applied to many different outputs, such as pretence (e.g. Scott, Baron-Cohen & Leslie, 1999), symbolic play (e.g. Honey et al., 2007), counterfactual reasoning (e.g. Leevers & Harris, 1998) and imagining the future (e.g. Lind & Bowler, 2010). However, several ASD researchers endorse the more concrete conceptualisation of creativity involving generation of ideas that are both novel and appropriate (e.g. Ten Eycke & Müller, 2014; Pring, Ryder, Crane & Hermelin, 2012; Takeuchi et al., 2014). This adds an extra level to the definitions of creativity in ASD research considered thus far, in that a response must be relevant to the task or situation, reflecting the way that creativity has been defined outside of the ASD literature (e.g. Runco & Jaegar, 2012), and further blurring the distinction between imagination and creativity. From this overview however, there are several common elements that appear to be important to imagination: novelty, generativity, flexibility, the use of past experiences and adaptive responses.

1.1.1.3 How has imagination been defined in clinical terms?

In addition to the rearrangement of the diagnostic criteria so that imagination is placed with communication rather than RRBs, international diagnostic manuals tend to downplay the role of imagination in ASD (e.g. Honey et al., 2007) and do not provide a clear definition of imagination for clinical purposes. Within the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5; American Psychiatric Association [APA], 2013) difficulties with shared social play and imagination are listed under social interaction and communication, with the example of age-appropriate flexible pretend play. However, there is not a clear example of how imagination may manifest in adults. One of the International Classification of Diseases, 10th revision (ICD-10; World Health Organisation [WHO], 1993) criteria includes abnormal or impaired development of functional or symbolic play before the age of three years; although this is not a necessary criterion for diagnosis, which highlights what little importance is placed on imagination in formal diagnostic manuals.

Some guidance for clinicians and researchers can be found in diagnostic tools such as the Autism Diagnostic Observation Schedule (ADOS; Lord et al, 2000; Lord, Rutter, DiLavore, Risi, Gotham & Bishop, 2012), the Autism Diagnostic Interview – Revised (ADI-R; Lord, Rutter & Le Couteur, 1994) and the Diagnostic Interview for Social and Communication Disorders (DISCO; Leekam, Libby, Wing, Gould, & Taylor, 2002; Wing, Leekam, Libby, Gould, & Larcombe, 2002). The ADOS does not explicitly define imagination and creativity, but coding guidelines for younger and less verbally fluent participants specify the flexible, creative and representational use of objects beyond their physical properties, particularly in relation to pretend play which provides the predominant indicator of imagination in the ADOS. For older, verbally fluent individuals imagination encompasses any form of creativity or inventiveness shown by the individual throughout the session. While this is a somewhat more detailed description of imagination in ASD compared to the DSM-5 and ICD-10, it remains vague as "creativity and inventiveness" are not explicitly defined or operationalised.

Again, the DISCO does not provide a specific definition of imagination in ASD. However, it does include a relatively detailed description and set of examples for how

imagination may be rated in both children and adults with ASD in its schedule. This focuses on the developmental stages of imaginative play. In addition to pretend play in young children it includes role play, inventing imaginary worlds, and lively, wide-ranging curiosity. However, it is emphasised that some apparently imaginative behaviours in children may be repetitive, or copied. An additional item relates to *shared imagination*: the sharing of imaginative activities with peers. Moreover the DISCO also provides guidance for assessing imagination in autistic adolescents and adults. Some adults with ASD may display similar examples of imaginative activity as children with ASD (such as pretend play), whereas other adolescents and adults may invent imaginary scenarios. According to the DISCO childhood imagination is the precursor to the ability to predict a range of possible consequences arising from past and present events, in other words, social imagination.

Overall, the diagnostic manuals and tools do not provide a consistent picture of the construct of imagination; rather they give vague definitions along with some examples of imaginative and creative behaviour. However, some common themes do emerge: there is an emphasis on flexibility and inventiveness, the latter of which could reflect both generativity and novelty, which complements the key components identified from the previous sections.

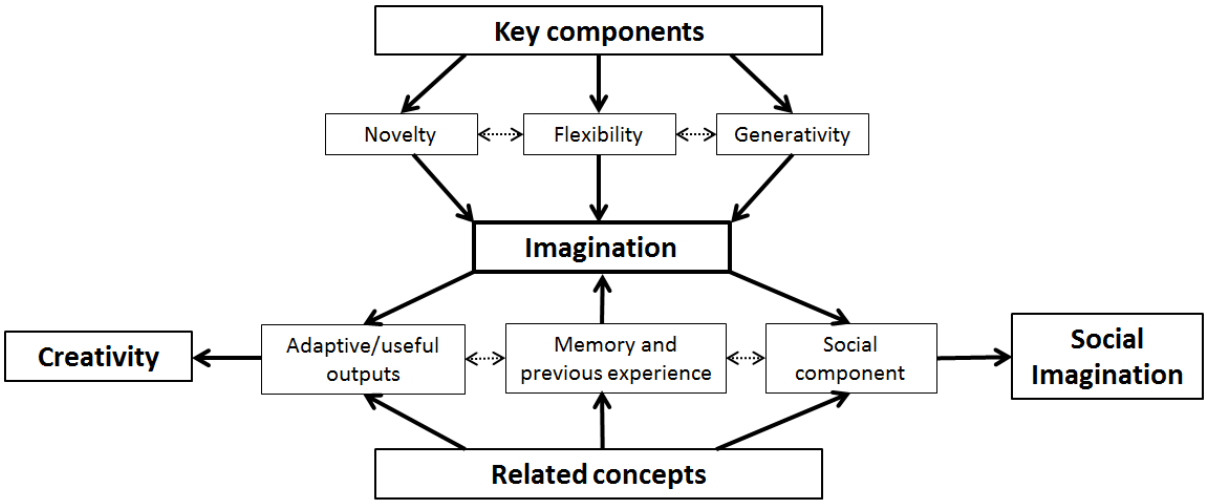
1.1.1.4 Summary and conclusion: Defining imagination

In summary, imagination and creativity have been poorly defined in the case of ASD. As discussed, across the ASD literature, imagination and creativity have been defined in a number of ways, but a certain number of common elements were identified: the *generation* of *novel* mental representations; the *flexible manipulation* of these representations; and the *adaptive* or *relevant* nature of outputs (such as responses to a task). Previous experience has also been identified as very important to imagination and creativity, although not always. Arguably, previous experience contributes to imagination, but is not a component of imagination in the same way as fluency, originality and flexibility. Similarly, whereas the adaptive (e.g. relevant and useful) nature of outputs is arguably very important in creativity, it is not very useful when considering other processes of imagination, such as daydreaming, which do not have an output. In addition, there is the issue of social imagination; the definition on

page 8 can also be reduced into these elements as reacting to social situations relies on being able to flexibly generate appropriate actions based on previous experience, combining generativity, novelty and flexibility along with adaptive responses. Importantly however, imagination and creativity do not have to be socially oriented.

Therefore, I suggest that generativity, novelty, and flexibility form the key components of imagination, with past experience, adaptive outputs and social component as related concepts and creativity as the product of imagination. A working definition of imagination for this thesis is the *generation and flexible manipulation of existing concepts to form novel ideas, which may be rooted in past experience and may result in adaptive outputs (creativity)*, which is illustrated in Figure 1 below, along with the related concept of social imagination.

Figure 1-1 Diagram illustrating my conceptualisation of imagination in relation to research in ASD.



Although this is still not a clear-cut definition of imagination, it encompasses the key components highlighted by previous researchers. These elements have been identified during the literature review process as part of this thesis. When conducting the review, I searched psychological databases for studies and reviews on imagination in ASD, using search terms such as *imagination*, *creativity*, *drawing*, *pretend play*, *thinking about the future*, and *counterfactual reasoning*. These key elements were identified by my reading and reflecting on the literature, comparing different researchers' definitions of imagination and what these definitions have in common. In the previous sections I have provided examples of when researchers have defined

imagination using fluency/generativity (e.g. Craig & Baron-Cohen, 1999; Ten Eycke & Müller), flexibility (e.g. Harris, 2000; Scott & Baron-Cohen, 1996; Vygotsky, 2004), originality/novelty (e.g. Wallach & Kogan, 1965; 2014; Pring et al., 2012; Takeuchi et al., 2014), or all three (e.g. Guilford, 1959). I have also shown that several researchers emphasise the influence of memory or past experience (e.g. Hassabis et al., 2007; Scott & Baron-Cohen, 1996; Wing et al., 2011) and the importance of creative output (e.g. Runco & Jaegar, 2012). These common themes across the literature led me to devise my definition and conceptualisation of imagination. In the next section I consider different methods used to assess imagination and creativity in ASD, and how well they assess the key components of imagination.

1.1.2 Overview of methods used to study imagination in ASD

Imagination in ASD has been measured in a variety of ways, according to the particular definitions of researchers. Possibly the most extensively researched phenomenon has been play (see Jarrold, 2003 for a review). In other studies, researchers have assessed related cognitive abilities such as generativity (e.g. Craig & Baron-Cohen, 1999; Liu, Shih & Ma, 2011; Pring et al., 2012), thinking about the future (e.g. Lind & Bowler, 2010; Lind et al., 2014) and counterfactual reasoning (e.g. Morsanyi & Handley, 2012). Other researchers have drawn on more general creativity tasks such as Torrance Tests of Creative Thinking (TTCT; Torrance, 1968; Torrance, 2008; see pages 14-16 & 18-20 for a discussion) and drawing and writing tasks. These factors, coupled with the variety of definitions used for imagination in ASD research, and lack of guidance across international diagnostic manuals, make it difficult to compare results across studies. Furthermore, many of these studies do not necessarily set out to measure imagination as a whole construct; rather they focus on one aspect of imagination such as generativity. This section will discuss the conceptual strengths and weaknesses of these methods and how they relate to my current definition of imagination in order for me to decide which areas of imagination would be most appropriate to assess in this thesis. This section will focus on the description and evaluation of methods, but see section 1.1.3 (page 22) for a discussion of what we have learned from these methods.

1.1.2.1 Pretend play

Much of the early work relating to imagination in ASD was carried out in studies of pretend play (e.g. Baron-Cohen, 1987; Charman & Baron-Cohen, 1997; Wing et al., 1977) and was heavily influenced by early researchers such as Piaget and Vygotsky. There are thought to be several levels of play in children, although these are not agreed upon by all researchers. Most commonly researchers employ a framework of three levels of play: sensory-motor/exploratory play; functional play; and pretend/symbolic play (e.g. Leslie, 1987; Blanc, Adrien, Roux & Barthélémy, 2005; Rutherford et al., 2007). Pretend/symbolic play is distinct from the earlier two levels of play in that it requires an element of mental representation and acting 'as if' something is the case (e.g. Leslie, 1987; Lillard et al., 2013). This can take many forms: pretending an object is something else (e.g. a banana is a telephone), attributing properties to an object that it does not possess (e.g. a doll is alive) and pretending that an absent object is actually present (Baron-Cohen, 1987). Pretend play may be assessed in terms of parental responses to questionnaires and interviews (e.g. Honey et al., 2007), observation (e.g. Blanc et al., 2005) or a combination of both (e.g. Wing et al., 1977). Most commonly it is assessed by observing participants in either a spontaneous, structured or instructed setting, and is rated on the basis of the frequency, duration and quality of play (Jarrold, 2003).

While much of our understanding of imagination in ASD has arisen from pretend play, it is limited in that researchers are inferring whether or not a child is truly pretending from the child's actions (Jarrold, 2003), and that play behaviours are generally limited to childhood. As this thesis focuses on adults, this limits the utility of pretend play as a measure. However, adults with disabilities, including AS, have been interviewed about their childhood play and they were able to provide rich, retrospective accounts of their play, although this is necessarily influenced by their adult perceptions (Sandberg, Björck-Åkesson, & Granlund, 2004). Nevertheless, pretend play, as the earliest indicator of imaginative ability, is a very useful measure for imagination and creativity and satisfies the necessary criteria of generativity, novelty and flexibility. In order to successfully play pretend, a child must be able to flexibly recombine elements from their schemata into new routines (e.g. Leslie, 1987;

Vygotsky, 2004), and so measurement of pretend play can assess all of these key components to imagination, provided the coding scheme allows for this.

1.1.2.2 Generativity and fluency tasks

Imagination and creativity in autistic individuals have often been assessed using tasks designed to measure generativity; such tasks are known as fluency tasks or divergent thinking tasks. In the previous section I identified generativity as a component of imagination. However, generativity is also an executive function (EF). EF is an umbrella term covering a wide range of abilities. As well as generativity this includes planning, working memory (WM), flexibility/set-shifting, and inhibition. There is evidence that EFs are impaired in children with ASD, although the evidence is mixed (e.g. Hill, 2004). Generativity specifically refers to the ability of individuals to generate spontaneous novel responses to a task. Generativity has been theoretically related to the spontaneous production of pretence in autistic children Turner (1999b) and is thought to underlie imaginative ability (e.g. Low, Goddard & Melser, 2009).

Verbal fluency tasks require participants to say as many words as they can that begin with particular letters (most often F, A and S) or belong to a particular semantic category, such as animals. Ideational fluency tasks go beyond this, by requiring participants to generate new responses in addition to drawing on their semantic memory; although this may be confounded by language ability. Classic ideational fluency tests ask participants to generate novel uses for objects (such as the Use of Objects task [UOT; e.g. Lezak, Howieson, & Loring, 2004; Wallach & Kogan, 1965]) and the Alternate Uses task (Guilford, Christensen, Merrifield & Wilson, 1978). Another popular ideational fluency task is the Pattern Meanings task (PMT; e.g. Wallach & Kogan, 1965), in which participants are asked to interpret six meaningless line drawings in as many different ways as possible. The final category of fluency tasks is the design fluency task (Jones-Gotman & Milner, 1977; Turner, 1999b) in which participants are asked to draw as many different novel designs as possible within a given time limit. As well as individual fluency tasks, there are standardised creativity assessments, such as the TTCT (Torrance, 2008) and Creativity Assessment Packet (CAP; Lin & Wang, 1999). These assessments include a variety of verbal, design and ideational fluency tasks, and each one includes standardised scoring schemes.

Generativity alone is a limited measure of imagination. As mentioned previously, generativity is an EF and therefore difficulties on these tasks may represent global executive dysfunction rather than a specific difficulty with imagination. Moreover, they are most commonly scored on the total output and the total fluency - the number of different, relevant answers a participant generates – which does not assess the key components of novelty and flexibility. Letter and semantic fluency tasks are particularly limited in this regard. Although a participant may be able to generate several different responses to a verbal fluency task, the novelty is questionable as they are retrieving items from memory; although there is an element of novelty in that each time they are required to retrieve new words. However, verbal fluency tasks necessarily do not permit the creation of non-words, and therefore they cannot assess re-combinatorial ability.

Other fluency tasks are better suited to assessing these dimensions. For example, the TTCT and CAP allow for the standardised assessment of fluency, originality, flexibility and elaboration. In creativity research, originality is scored according to how many other participants in the sample generate that particular answer; in the case of standardised tasks, this is derived from population norms. Flexibility is assessed by assigning responses to categories and scoring participants for how many categories are used. It is also important when assessing originality that the answers are *relevant*; giving a nonsensical response could technically be original but does not demonstrate true imagination according to the *novel* and *appropriate* definition used by many creativity researchers (e.g. Runco & Jaeger, 2012). Assessing all of these aspects would provide a fuller picture of a participant's imaginative ability, according to my definition, than fluency alone.

Finally, it has been suggested that tests of divergent thinking are not measures of creativity itself but rather indicators of creative ability (e.g. Runco, 2008). Arguably though, as imagination and creativity are both abstract concepts, they can only be measured through indicators of these constructs, and it would be wise to include more than one measure to obtain a full picture of imaginative and creative ability.

1.1.2.3 Thinking about the future

Several studies examine the ability to think about the future in individuals with ASD. Many researchers specifically investigate episodic future-thinking (EFT), which refers to the ability of an individual to mentally time travel forwards to imagine a specific future event (e.g. Suddendorf & Corballis, 1997). EFT has been assessed in a variety of ways in participants with ASD. Three studies with children used batteries of short tasks to test their participants' knowledge of the future (Hanson & Atance, 2013; Jackson & Atance, 2008; Marini et al., 2016). A study of adults with ASD used a sentence completion task (e.g. *Next year …*); however, this was found to have methodological problems (Crane, Lind & Bowler, 2013; see pages 31-32). In a study with children, Angus, de Rosnay, Lunenburg, Terwogt and Begeer (2015) told participants that they would be having an interview with an unknown experimenter, and then proceeded to ask the participants questions about their anticipation of the event. A more sophisticated assessment of EFT is the analysis of narratives generated by the participants (Lind & Bowler, 2010; Lind, Bowler & Raber, 2014; Lind et al., 2014; Terrett et al, 2013). The exact paradigm varies slightly between tasks; usually participants are presented with a cue word (which may be an object, situation or time period) and asked to generate and recount an imaginary future scenario relating to said cue word. This scenario should be a specific, personal, single event lasting no more than a day for it to qualify as episodic. Again, the precise nature of the scoring varies depending on the study. Lind and Bowler (2010) categorised responses as being episodic or errors (omissions or general images) and Terrett et al. (2013) identified the constituent details of each response and coded them as internal (episodic) or external (non-episodic). The most detailed coding scheme was employed by Lind et al. (2014), who calculated an experiential index based on four subcomponents: the content of the description, participant questionnaires, spatial coherence and independent quality ratings from scorers.

EFT requires imaginative ability in terms of generating novel potential future scenarios by flexibly combining elements from past experience, as per my definition of imagination. Lind and Bowler (2010) specifically argue that the cognitive processing involved in EFT resembles that of imaginative processes in general. As imagining the

future requires the generation of a mental representation of a non-existent situation or experience, this fits well with the definition of imagination discussed earlier. Furthermore, EFT is thought to be related to EM (e.g. Lind & Williams, 2012) by way of flexibly selecting and recombining existing event features from EM (Lind & Bowler, 2010). This relationship fits with the idea that imagination may involve the adaptation, manipulation and transformation of existing concepts as discussed earlier.

1.1.2.4 Counterfactual reasoning

Counterfactual reasoning occurs when a known fact is contradicted (Peterson & Bowler, 2000), such as when reasoning about alternative scenarios to a past event (Begeer et al, 2009). Therefore counterfactual reasoning requires imagination (e.g. Leevers & Harris, 2000) as an individual must be able to mentally represent an alternative scenario to one that actually happened or is happening. Counterfactual reasoning is an important aspect of daily life, as it allows us to learn from mistakes and prepare for the future (Begeer et al., 2009). This form of reasoning is therefore conceptually similar to EFT, and represents the definition of imagination as the ability to imagine non-veridical scenarios, fulfilling the criteria of generativity and novelty. Furthermore, considering more than one scenario (e.g. two possible future scenarios, or comparing what actually happened to what could have happened) requires flexibility. Therefore, testing participants' counterfactual reasoning seems to be a useful measure of imaginative ability according to my definition of imagination; although they are sensitive to methodological issues in terms of the logical structure of the scenarios.

1.1.2.5 Creativity

As I argued previously (page 8), the notion of creativity refers to the outputs that are produced by the process of imagination; and in turn evidence of creativity provides evidence of imaginative ability. Several researchers have therefore assessed imagination in terms of creativity. One of the most obvious examples of creativity is drawing, which is generally associated with creativity. In addition to the design fluency task mentioned previously, other drawing tasks have been used to assess creativity and imagination in children both with and without ASD. For example, Karmiloff-Smith (1990) designed an imaginative drawing task that has since been widely used and

adapted for ASD research (e.g. Craig et al., 2001; Leevers & Harris, 1998; Low et al., 2009; Scott & Baron-Cohen, 1996; Ten Eycke & Müller, 2015). This task involves asking children to draw a house, then asking them to draw another, but one that "*does not exist. An impossible house.*" (p.373, Scott & Baron-Cohen, 1996). They are then asked to draw a man, using similar instructions. Participants are scored according to whether their *real* drawings fulfil all the essential characteristics of a house or man, and whether their *impossible* drawings retain the overall impression of a house or man, but with the addition or deletion of features that render it an impossible representation. Scott and Baron-Cohen and Craig et al. (2001) followed this procedure, but it was adapted by Leevers and Harris (1998) to be a picture completion task under instruction. Low et al. (2009) also adapted this task by presenting participants a picture of a door leading to an alien world of strange, previously unseen people, and asked to draw as many as possible of these "strange and funny-looking" people (see also Allen & Craig, 2016). Generally, the impossible person task fits well with the criteria for imagination according to my definition, as they require the generation of ideas along with creating a novel combination in order to make a person 'impossible' – for example, by replacing a person's arms with tentacles – which requires flexibility and originality.

However, it is worth noting here that not all drawing tasks meet these criteria. For example, Leevers and Harris (1998) also asked children to complete a pair of pictures so that one was real and the other impossible but gave them forced-choice options (e.g. draw stripes or spots on a zebra). This dramatically reduces the imaginative nature of the task as participants do not generate their own ideas. Similarly, Booth, Charlton, Hughes and Happé (2003) asked typically developing (TD) children and children with ASD or attention deficit hyperactivity disorder (ADHD) to copy a drawing twice, including an additional feature the second time, in order to assess drawing and planning rather than the imaginative drawing ability of the children. Other tasks ask participants with ASD to produce drawings and rate them on qualitative aspects, such as how often they draw people and social scenes (e.g. Lewis & Boucher, 1991; Jolley, O'Kelley, Barlow & Jarrold, 2013). This is useful for understanding the distinction between social and non-social imagination, but does not

assess all aspects of imagination and creativity. Another flaw in using drawing tasks to assess imagination in autistic participants is that it measures a type of creativity that many adults do not engage in regardless of diagnosis, and it relies heavily on visuo-spatial ability and fine motor skills.

Another obvious candidate for assessing creativity is the written word. Fictional narratives are thought to build on similar mechanisms and serve similar functions to daydreaming, imagination and pretend play (Barnes, 2012). Some researchers have presented evidence for skill and talent for poetry in autistic individuals that is comparable to neurotypical (NT) poets (e.g. Dowker, Hermelin & Pring, 1991; Lawson, 2011). There is a large body of evidence surrounding the narrative ability of individuals with ASD; for example some studies identify a difficulty with constructing (or retelling) narratives in ASD (e.g. Diehl, Bennetto, & Carter-Young, 2006) whereas others do not (Norbury & Bishop, 2003). Narrative abilities in ASD have also been associated with ToM (e.g. Baron-Cohen, Leslie & Frith, 1986; Capps, Losh & Thurber, 2000). Such studies however do not necessarily assess the imaginative nature of the participants' narrative construction; many such studies ask participants to *retell* a story rather than create a story, or test their comprehension of a narrative. There have been some studies comparing the storytelling ability of children with ASD with TD counterparts (e.g. Angus et al., 2015; Dillon & Underwood, 2012), comparing the fiction preferences of students with ASD and students without ASD (Barnes, 2012) and comparing the generation and comprehension of novel metaphors and similes (Kasirer & Mashal, 2014). As with drawing, writing allows individuals the opportunity to generate novel scenarios that may be recombined from existing concepts or their past experience. However, writing ability is confounded by verbal ability, narrative skills and fine motor skills when writing by hand.

1.1.2.6 Summary

To summarise, imagination and creativity have been assessed in many and varied ways. Although this could represent a strength of the research, there has been little attempt to standardise these tasks (with the exception of formal tests such as the TTCT and the CAP), nor have they been validated against each other. While all of these methods can be used to further our understanding of imagination in ASD, it is difficult

to identify one task that can assess 'pure' imagination, and therefore studies should ideally use more than one method simultaneously in order to obtain a fuller picture of imagination. Of the 49 studies I have summarised in Appendix 1 (Table 8.1, pages 224-242), thirteen measure more than one 'type' of imagination (for example, ideational fluency and the impossible person task [Scott & Baron-Cohen, 1996]). However, just five of these (Angus et al., 2015; Begeer et al., 2009; Lind & Bowler, 2010; Low et al., 2009; Ten Eycke & Müller, 2016) directly assessed the association between the different tasks. It has been found that ideational fluency correlates with storytelling (Angus et al., 2015) and with additive but not subtractive counterfactual reasoning[1] (Begeer et al., 2009) and that thinking about the future correlates with imagination measured by the ADOS (Lind & Bowler, 2010). Low et al. (2009) did find that ideational fluency predicted imaginative drawing; however, this relationship became non-significant when including visuo-spatial planning. Similarly, Ten Eycke and Müller (2016) found that generativity did not predict imaginative drawing in children with ASD. Overall, there is little evidence regarding how these different measures of imagination relate to one another and it is difficult to draw conclusions across different measures; even within specific tasks the results are not always consistent. For example, some studies have found that children with ASD perform poorly on the impossible person task (e.g. Low et al., 2009; Scott & Baron-Cohen, 1996), although this not always ASD-specific (e.g. Craig et al., 2001) and others do not find significant group differences on this task (e.g. Allen & Craig, 2016; Leevers & Harris, 1998).

It is possible to assess the key components of fluency, flexibility and originality across most of the contexts in which imagination and creativity have been assessed in ASD. In terms of specific tasks, I have only argued that verbal fluency *cannot* assess all three key components, as it cannot assess originality. All other tasks have the potential to assess all three key components, and many have also been used to assess the related components of memory (such as in the case of EFT), and creative outputs (such as drawing tasks). However, although these methods all possess the *potential* for assessing these three key components, they have not all been used in this way; for

[1] Additive counterfactual reasoning adds an element to a scenario (e.g. "If only I had done…") and is therefore generative, whereas subtractive counterfactual reasoning removes an element from a scenario (e.g. "if only I had not done…") and is not generative.

example, novelty has never been directly assessed in an EFT study. Section 1.1.31 (page 26) outlines the studies that have assessed several different dimensions of imagination and creativity.

Moreover, their usefulness depends on the exact way the phenomenon is measured and how it is scored. For example the impossible person drawing task is a useful method for assessing creativity via drawing, whereas Leevers and Harris' (1998) forced-choice drawing task is less useful as participants are making a choice between two responses rather than generating their own response, which does not require generativity or novelty (although it relies in part on flexibility). As another example, employing an ideational or design fluency task is more useful when assessing originality and flexibility in addition to fluency. The variety of methods and lack of a clear definition of imagination has resulted in a rather incoherent literature. When researchers write about ASD, it is generally assumed that individuals with ASD have impaired imagination. However, several studies have demonstrated that this is not the case (see the next section) and the diagnostic criteria for ASD do not *require* the presence of imagination impairment; due to the grouping of symptoms (pages 1-2), an individual's communication symptoms along with RRBs may qualify them for a diagnosis, and therefore imagination difficulties are neither necessary nor sufficient for a diagnosis. The following section will describe the key findings that have emerged from the imagination literature, before focussing on the different dimensions of imagination and creativity and research in adults with ASD.

1.1.3 Key findings in relation to imagination in ASD

Since the conceptualisation of ASD as a "triad of impairments" comprising imagination, social interaction and communication, the assumption has generally been that autistic people have a difficulty with imagination. However, across the relatively diverse range of methods of assessing imagination, there have been few consistent findings. An ASD-specific imagination deficit is not always identified, in spite of the fact that impaired imagination is one of the diagnostic criteria for ASD. Appendix 1 (Table 8.1, pages 224-242) provides an overview of studies that have compared the imagination of individuals with ASD with individuals from other populations. Whether or not a study identified a specific ASD difficulty with imagination is displayed in this

table. Of these studies (*N*=49), sixteen (33%) have found that, compared to TD and clinical control groups, individuals with ASD perform worse on imagination and creativity tasks (e.g. Lewis & Boucher, 1991; Lind & Bowler, 2010; Lind et al., 2014; Low et al., 2009; Terrett et al., 2013). However, eight (16%) studies did not find an ASD-specific imagination difficulty (e.g. Crane et al., 2013; Dillon & Underwood, 2012; Dowker et al., 1991; Leevers & Harris, 1998), and in some cases, participants with ASD actually perform better on certain criteria such as originality (e.g. Kasirer & Mashal, 2014; Liu et al., 2011). Finally, 23 studies (51%) resulted in mixed findings (e.g. Bishop & Norbury, 2005; Dichter, Lam, Turner-Brown, Holtzclaw & Bodfish, 2009; Hanson & Atance, 2013; Jackson & Atance, 2012). In addition to comparison with clinical and typical populations, higher levels of ASD traits have been associated with lower scores on imagination tasks in the general population (e.g. Claridge & McDonald, 2009); whereas others have found the opposite (e.g. Best et al., 2015) and others have found mixed or tenuous results (e.g. Rawlings & Locarnini, 2008; Takeuchi et al., 2014).

Some researchers maintain there is a genuine difficulty with imagination in ASD (e.g. Scott et al., 1999), possibly as a result of lack of internal mental representations (e.g. Craig & Baron-Cohen, 1999; Craig et al., 2001), which is often used to explain the finding that children with ASD often show reduced or repetitive pretend/symbolic play (e.g. Baron-Cohen, 1987; Rutherford et al., 2007; Wing et al., 1977). However, there are alternative explanations for why individuals with ASD find imagination tasks difficult. For example, children with ASD are able to understand and imitate pretence (e.g. Kavanaugh & Harris, 1994; Libby, Powell, Messer & Jordan, 1997) and are able to engage in prompted or structured pretend play (e.g. Jarrold, Boucher & Smith, 1996; Lewis and Boucher, 1988), although this is sometimes poor (e.g. Blanc et al., 2005; Sigman & Ungerer, 1984). Therefore it may not be that participants with ASD cannot play pretend, rather they may lack the motivation (Jarrold, 2003). As Lewis and Boucher (1991) noted "it is unsafe to conclude from the fact that an autistic person *does not* do something, that they *cannot* do it" (p.408, my emphasis). In another domain of imagination, there is evidence that individuals with ASD are more likely to prefer non-fictional over fictional narratives (Barnes, 2012), which lends some support to the motivational explanation. In addition, one study found that although children

with ASD did not differ from TD children in terms of formal tests of imagination, they differed in a task of social anticipation (Angus et al., 2015), which may be related to motivation since social difficulties form a core part of ASD.

In order to pass tasks assessing pretence, children with ASD must use internal mental representations. Related to this, researchers have suggested one of two theories that may explain difficulty with EFT in people with ASD. These are the self-projection theory (Buckner & Carrol, 2007), "the ability to shift from one's current perspective to alternative perspectives (temporal, spatial, or mental)" (Lind et al., 2014, p. 56, and the scene construction theory, "the ability to mentally generate and maintain a coherent, *multimodal* spatial representation" (Lind et al., 2014, p. 56). There is some evidence that difficulty with EFT in ASD is specific to the self (e.g. Jackson & Atance, 2008); however, this study was limited as they only considered within- and not between-group differences in a small, very heterogeneous sample. A later study improved on their method and found that both ASD and TD groups performed better at self- compared to non-self-based EFT tasks, and children with ASD performed worse at both types of task (Marini et al., 2016). Evidence from adults suggest that both self-projection and scene construction are important to EFT (e.g. Lind & Bowler, 2010; Lind et al., 2014).

An alternative explanation for why individuals with ASD sometimes perform poorly on imagination tasks is that these tasks are actually tapping into executive dysfunction, which several researchers have set out to test. Scott and Baron-Cohen (1996) found that, children with ASD performed significantly worse on the impossible person task (Karmiloff-Smith, 1990) compared to control groups; but in addition to this, children with ASD were significantly worse than control groups when drawing *unreal* entities under instruction (in order to reduce EF demands), but not when drawing *real* entities. Therefore the authors argue that difficulty with EFs cannot explain their initial findings. The independence of an imagination deficit from executive dysfunction was supported in later studies using different creativity tasks (Craig & Baron-Cohen, 1999; Craig et al., 2001). Studies assessing counterfactual reasoning have also not found evidence of a relationship with EFs (e.g. Begeer et al., 2009; Morsanyi & Handley, 2012) and a study of EFT found that set-shifting did not

make a significant unique contribution to EFT in either children with ASD or TD children (Terrett et al., 2013). This latter finding is unexpected given that set-shifting is a measure of flexibility, which I have identified as a key component of imagination. However, Terrett et al. note that their measure of set-shifting (the Switching task; Korkman, Kirk & Kemp, 2007) only assess one aspect of shifting, and it may be that EFT relies on a different aspect of set-shifting not measured by the Switching task.

In contrast, Leevers and Harris (1998) adapted the impossible person task as employed by Scott and Baron-Cohen (1996) by dramatically reducing the EF demands[2]. Participants were asked to add details to two pairs of incomplete pictures (two houses and two men) so that one in each pair was real and the other impossible. Autistic participants did not perform significantly worse than TD participants or participants with learning disabilities (LDs); from this Leevers and Harris concluded that poor performance on drawing tasks in ASD may be explained by planning difficulties. Booth et al. (2003) later found that children with ASD show more severe planning difficulties in drawing tasks compared to TD children and children with ADHD. Allen and Craig (2016) directly compared cued and non-cued version of the Impossible Person task in one sample of children with ASD and children with LDs matched on age, mental age (MA) and drawing ability. Although children with ASD produced significantly fewer impossible drawings than children with LDs, when a template was provided there was no significant difference between groups, supporting Leevers and Harris' findings. Furthermore, Low et al. (2009) found that for the impossible person task, generativity was a significant predictor of imaginative drawing content for children with ASD but not TD children; however, this relationship was mediated by visuospatial planning, supporting the argument of Leevers and Harris. Also using the impossible person/house task, Ten Eycke and Müller (2016) found that planning and WM (but *not* generativity) predicted imaginative drawing in children with ASD and young TD children, but not older TD children. In contrast, generativity was associated with imaginative drawings of people in TD children only. Therefore, although different EFs may be contribute to imaginative ability, these may vary considerably depending on age and diagnosis. Hanson and Atance (2013) did find that children with ASD who

[2] NB, this is a different task to the forced-choice task described on page 19

scored lower on EFT tasks also scored lower on EF tasks; although unlike Low et al. they did not distinguish between different types of EFs.

Therefore, a clear picture of imagination and creativity in ASD does not emerge from the literature. Although most studies identify either a clear difficulty with imagination in ASD, many are mixed, and several others do not identify an ASD-specific difficulty. Moreover, several studies have demonstrated the presence of creativity in autistic individuals; as creativity requires imagination it is therefore incorrect to assert that all autistic individuals show impaired imagination. However, as I have mentioned before, imagination and creativity studies are sensitive to task differences (page 21). Bogdashina (2003) argues that "imagination in autism is *qualitatively* different from non-autistic imagination" (p. 118, my emphasis). Therefore it is important to consider the type of imagination that is being measured, and how it is being measured. There is conflicting evidence in terms of whether difficulty on certain imagination tasks stems from lack of mental representation, lack of motivation, difficulty with self-projection, difficulty with scene construction, or executive dysfunction. For the purpose of this thesis, I shall review two areas of imagination in ASD in further detail. Firstly I will consider the different dimensions of imagination and creativity, such as novelty and flexibility (see Figure 1) in addition to generativity, as these are the components of imagination that I have identified and may explain conflicting findings across studies. Secondly I will consider what we have learned about imagination in autistic adults, as this is the population I am primarily interested in.

1.1.3.1 Key components of imagination and creativity

My working definition of imagination for this thesis comprises several key components and in the field of creativity research, imagination and creativity can be rated according to several components, the most common being: fluency, novelty (usually referred to as *originality* in the creativity literature), flexibility and elaboration. Certain measures, such as the TTCT, have introduced others, such as abstractness of titles. Yet the majority of imagination and creativity research in ASD have focused on fluency, with a few others including other dimensions such as repetition (e.g. Bishop & Norbury, 2005; Dichter et al., 2009) and accuracy (e.g. Lind et al., 2014). Particularly in the case of pretend play, researchers have noted the presence of repetitive pretend

play (e.g. Wing & Gould, 1979), which may indicate a difficulty with both generativity and flexibility. The focus on generativity/fluency may be an issue considering some studies do not find a strong association between generativity and imagination in individuals with ASD (e.g. Low et al., 2009; Ten Eycke & Müller, 2016).

Asperger (1944) suggested that autistic children show highly original and unusual patterns of thinking. In contrast, Wing (1981) argued that the thought processes of autistic individuals are narrow, literal and logical, but such individuals choose an unusual starting point for their thought processes that would not "occur to a normal person who has absorbed the attitudes current in his culture" (p. 118)". Wing suggested that whereas this may occasionally result in a new insight into a problem, this mode of thinking usually results in an inappropriate response, reflecting earlier discussion that a novel response must also be relevant and appropriate (page 9). However, this disconnect from culture may actually be what gives autistic individuals an advantage in terms of originality; it has been suggested that social-communication difficulties, such as lack of ToM, may foster originality as individuals with ASD are unaware of or less concerned with what others think, the 'correct' way of doing things and how others perceive them or their work (Happé & Vital, 2009), and are not limited by lexicalised knowledge (Kasirer & Mashal, 2016). Autistic adults are more likely to rate themselves as being original compared to NT adults (Kirchner, Ruch & Dziobek, 2016). Liu et al. (2011) assessed divergent thinking in adolescent boys with and without AS using the CAP. Interestingly they found that the boys with AS showed reduced fluency and flexibility compared to their TD peers, but increased originality and elaboration. Their sample however was limited, comprising only males aged between ten and eleven years old.

Kasirer & Mashal (2014) assessed verbal creativity in adults with ASD and NT adults by assessing their generation of different figures of speech (specifically, metaphors and similes). Participants were given ten different concepts as either metaphors or similes (e.g. *love is…* and *feeling worthless is like…*) and asked to create new, comprehensible expressions based on these concepts. A participant's creativity was calculated as their percentage of responses that could be classed as a novel idiomatic response. There was no main effect of group, however all participants

performed worse when generating metaphors. However, there was a significant interaction, in that participants with ASD performed better when generating novel metaphors compared to the NT group, and this was interpreted as the ASD group showing higher originality than the NT group. However, this study did not assess originality in the way it is traditionally measured in creativity research, which is to compare the content of participants' answers against the rest of the sample or a population norm. Furthermore, while two coders rated responses, there was no reference to inter-rater reliability and so there is no indication of the objectivity of the coding system. Kasirer and Mashal (2016) conducted a similar study in children, and these results supported their earlier findings; that is, children with ASD performed better than TD children in terms of generating novel metaphors, whereas TD children performed better in terms of comprehending and generating conventional metaphors. However, Kasirer and Mashal note that the majority of their sample were diagnosed with pervasive developmental disorder – not otherwise specified (PDD-NOS), which could be seen as a limitation of this latter study.

An online survey study (Best et al., 2015) examined the relationship between autistic traits as measured by the Subthreshold Autism Trait Questionnaire (SATQ; Kanne, Wang, & Christ, 2012) and divergent thinking as measured by the Alternate Uses task (Guilford et al., 1978) and PMT. The authors found a significant negative correlation between level of autistic traits and fluency as measured by the PMT but not the Alternate Uses task. However, unusualness of response on the Alternate Uses task was found to be a non-linear predictor of autistic traits. When transformed into a categorical variable, participants who generated four or more unusual responses scored significantly higher on the SATQ. Whereas this is an interesting finding, only 24.1% of participants actually reported having a diagnosis of ASD, and these participants were not analysed separately.

Conversely, strength in originality has not always been found. Craig and Baron-Cohen (1999) administered measures from the TTCT to children with ASD, children with AS, children with LDs and TD children. For one measure, Toy Improvement, children are asked to think of as many different ways to improve a toy as possible; in this task, both ASD groups generated fewer original responses than the control groups.

In line with previous studies, children with ASD also produced less flexible responses. Pring et al. (2012) carried out two drawing tasks from the TTCT along with the Figural Synthesis Task (FST; Finke & Slayton, 1988) – in which participants use an increasing number of shapes to make new representations - with autistic individuals with savant skills, without savant skills, adults with LDs and younger art students. For the TTCT, the art students performed significantly better than all three groups in terms of fluency and originality, and there were no other group differences on these two dimensions; although savants scored significantly higher on elaboration. Therefore having ASD did not result in higher scores in terms of originality. However, there were no group differences on the FST in terms of originality with the exception of at the highest number of shapes; in this case, the art students and savants with ASD showed the most original responses. Whereas these findings are at odds with the previous studies discussed, this study was limited by small group size (*N*=9), and the fact that the art students were deliberately selected from sixth form level and were therefore much younger, in order to avoid the effect of formal training on results. Pring et al. also note that the TTCT measure of originality may be confounded by verbal ability as it is based on the titles rather than the drawings themselves[3]; however, this would not explain Craig and Baron-Cohen's (1999) findings as the ASD and LD groups were matched on verbal mental age (VMA).

Therefore there is some evidence that while imaginative fluency and flexibility may be reduced in ASD, originality and elaboration could be enhanced (e.g. Kasirer & Mashal, 2016; Kasirer & Mashal, 2014; Liu et al., 2011), although this is not always found (e.g. Craig & Baron-Cohen, 1999; Pring et al., 2012). However, these studies have been carried out across several different tasks; it would be beneficial to assess originality and other dimensions of imagination using more than one type of task within the same sample of participants.

1.1.3.2 Imagination in adults with ASD

Most studies investigating imagination in ASD have been conducted with children rather than adults; just six (12%) of the studies listed in Appendix 1 include

[3] However, this is unconvincing as instructions for scoring the TTCT state to focus on the use of the stimulus itself, rather than just the title.

only adults as their participants. As such, little is known about imagination in adults with ASD. Even in diagnostic manuals and tools, there is little provision for how to assess imagination in adults with ASD, with the exception of the DISCO. Barnes (2012) showed that adults with ASD preferred to read non-fiction narratives rather than fiction narratives in contrast to NT adults, who preferred to read fictional narratives about people. However, we can infer little about autistic individuals' ability to imagine from this study, only that they may show a preference for non-fiction. This section will review what we currently know about imagination in adults with ASD.

Several researchers have investigated different aspects of creativity in adults with ASD. Pring et al.'s (2012) study (see page 29) was carried out among adults aged 16 to 43 years and Kasirer and Mashal's (2014) study (see pages 27-28) was carried out among adults aged 18 to 27 years. These two studies found conflicting results, with one suggesting that adults with ASD are more original than TD counterparts (Kasirer & Mashal, 2014) and the other not supporting this (Pring et al., 2012). Kasirer and Mashal interpreted their findings in terms of the weak central coherence bias in ASD and strong attention to detail with narrow focus (Fitzgerald, 2004; Lyons & Fitzgerald, 2013), which may result in the generation of more original ideas. The authors also suggest that their findings relate to ToM, as participants are more likely to focus on their own thoughts which may lead to less conventional responses; although it should be noted that some have argued that ToM may extend to difficulty with theory of own-mind in ASD (Williams, 2010).

Dowker et al., 1991 compared the poetry of an adult with ASD and an NT adult. Although the poet with ASD performed worse on tests of verbal creativity (including the UOT) compared to the NT poet in terms of producing correct responses, the quality of the poetry was comparable, with an independent rater unable to reliably distinguish between the two poets. This discrepancy is a good demonstration of how a formal creativity task may not provide the best measurement of an individual's creative capabilities, as argued by Runco (2008).

A case study of an adult with AS, known as JS, described his patterns of memory and difficulty in generative writing (Boucher, 2007). Specifically, JS struggles

to access and organise what he wants to say, and has poor free recall, EM and event memory. Boucher argues that these three types of memory are important to generativity and contribute to JS' difficulty with creativity. Difficulty with event memory will result in a lack of generalised event scripts that children use in their pretend play, which will then lead to reliance on rote-learned or habitual play sequences; this may translate into routines for adults with ASD. Boucher suggests that as well as difficulty with EM, JS may have difficulties with the EM buffer (Baddeley, 2000), a component of WM which provides temporary storage of information and allows for the combination of information from WM and long-term memory. Boucher argues that if this is disrupted in adults with ASD, this would affect their ability to plan, think about the future, or decide what to do next, and lead to a reliance on RRBs.

Although Boucher's arguments are compelling, these ideas have not been directly empirically tested; there is however some closely related work that has taken place within EFT in adults with ASD. Lind and colleagues analysed short narratives about past and future events generated by autistic and NT adults (Lind & Bowler, 2010; Lind et al., 2014; see pages 17-18 for a description of their paradigms). Overall, autistic individuals tended to generate less specific and detailed accounts of both past and future events compared to their NT counterparts, as well as displaying diminished self-awareness (Lind & Bowler, 2010) and experiencing more fragmented, less vivid mental images (Lind et al., 2014). Notably, the groups in Lind and Bowler's study did not differ in terms of generativity, and Lind et al. (2014) found that general narrative ability did not account for their findings.

In contrast, Crane et al. (2013) administered an EM and EFT sentence completion task to autistic and NT adults, categorising their responses into one of five categories (specific, semantic, extended and categoric events and omissions) and did not identify any significant group differences. However, the authors suggest a number of possible methodological limitations to account for this finding: participants were not explicitly instructed to think of specific events, the coding was not very detailed and responses were computerised which may aid task performance in individuals with ASD. It is notable, however, that Crane et al. were the only authors to control for depressive symptoms; depression affects thinking about the future (e.g. MacLeod & Byrne, 1996;

MacLeod, Rose & Williams, 1993) and is also prevalent in the autistic population (e.g. Leyfer et al., 2006). From their findings, Crane et al. stressed the need to employ mixed methods approaches in studies of ASD, with awareness of demands on the need to socialise and verbalise responses.

As discussed earlier, Boucher (2007) argued for a relationship between generativity and memory on the basis of a case study; imagination has also been more generally associated with memory, as it is thought to involve the manipulation of existing concepts (page 6). Related to this, EFT and EM are significantly associated in the general population, whereas they are not associated with each other in adults with ASD (Crane et al., 2013[4]; Lind & Bowler, 2010). Lind and Bowler (2010) suggest that perhaps individuals with ASD draw from semantic memory rather than EM when imagining the future; this was supported by a later finding with children that semantic knowledge is associated with EFT in children with ASD only (Lind et al., 2014). Lind and Bowler explain their findings in terms of the EM buffer, in line with Boucher's argument. Lind et al. (2014) found that adults with ASD had difficulty with atemporal, non-self-relevant scene construction as well as mental time travel, supporting the idea that EFT (and EM) difficulties in ASD may be related to a general difficulty with binding different elements of a scene. However, these studies have also identified support for the self-projection theory of EFT. For example, Lind and Bowler noted that participants with ASD did not tend to pre-experience the future (or re-experience the past) from their own point of view.

It is difficult to draw conclusions about imagination in adults with ASD given how fragmented the research has been. Generally, studies of adults fall within the categories of creativity (including drawing and writing) and EFT. There are mixed results from creativity studies. Whereas Pring et al. (2012) found that non-savant people with ASD show no particular strengths in creativity, Kasirer and Mashal (2014) showed that people with ASD generate more novel metaphors than NT adults. Presenting mixed findings, Dowker et al. (1991) showed that a poet with AS struggled with formal verbal creativity tests but did well in terms of her own poetry. Therefore it

[4] Although Crane et al. (2013) also did not find a relationship between EFT and EM in their NT adult sample.

may be that performance on creativity tasks relies on what tasks are used and how creativity is assessed. As illustrated by Figure 1 (page 12), creativity requires imagination, but imagination does not require creativity and therefore using creativity as an assessment of imagination has certain limitations. Findings from studies of EFT, which assess imagination more directly as they do not rely on creativity as an output, have been more straightforward, with two studies identifying difficulties in adults with ASD (Lind & Bowler, 2010; Lind et al., 2014) and one finding no group differences (Crane et al., 2013). These studies have also attempted to understand why these difficulties exist in ASD, and have identified problems with EM and the EM buffer, difficulty with self-projection and poor scene construction as potential candidates.

1.1.4 Conclusion: Imagination in ASD

This review of imagination began with a conceptual analysis and an attempt to define the construct. Drawing on previous research, a wide range of definitions has been employed. Following my conceptual analysis I decided upon the following definition of imagination: *generation and flexible manipulation of existing concepts to form novel ideas, which may be rooted in past experience and may result in adaptive outputs (creativity)*. The key components of this definition are fluency, novelty and flexibility. I then reviewed the methods of previous research, contrasting their methods to this definition. Most methods can be interpreted in terms of this framework; however, much of the previous work has focussed on generativity, or fluency, at the expense of novelty and flexibility (although there are some exceptions, such as studies of repetitive pretend play). Therefore while the individual methods are generally strong, there is little attempt to understand how they relate to each other within studies. Again, there are some exceptions to this; five studies assess how different measures of imagination relate to each other (e.g. Angus et al., 2015; Begeer et al., 2009; Lind & Bowler, 2010; Low et al., 2009; Ten Eycke & Müller, 2016). Therefore, the lack of a consistent finding across the literature may be a result of employing different methods. For example, all but one EFT study (Crane et al., 2013) identify an ASD-specific difficulty with imagination, but other methods and measures produce more equivocal results. The lack of a coherent definition of imagination, and agreement regarding its multidimensionality – in terms of subcomponents such as

fluency, flexibility and originality, and in terms of measurement and context such as creativity and thinking about the future – has made it difficult to draw firm conclusions from the imagination literature. It is generally thought that there is a difficulty with imagination in ASD, potentially as a result of a difficulty with internal mental representation (e.g. Craig et al., 2000; Leslie, 1987), and yet ultimately the literature does not support such a straightforward conclusion. Other difficulties such as executive dysfunction (e.g. Low et al., 2009) or a lack of motivation (e.g. Jarrold et al., 1996) may explain poor performance on certain imagination and creativity tasks; indeed, when it comes to autistic individuals' particular interests, they may be motivated to generate *more* original ideas (e.g. Liu et al., 2011). The difference could also be due to the fact that many different approaches are taken to assessing imagination in ASD, and it would be interesting to see how these different measures relate to each other. Having reviewed the relevant literature on imagination in ASD, the following section will address relevant and equivalent areas in the body of research in RRBs in ASD.

1.2 Restricted and repetitive behaviours in ASD

1.2.1 Introduction to RRBs

RRBs form one of the core diagnostic criteria for ASD (APA, 2013; WHO, 1993). This class of behaviours, driven by a desire for sameness and dislike of change (Kanner, 1943), includes a wide range of motor and sensory behaviours and restricted activities that are highly frequent in their repetition and invariant in their manifestation. RRBs have been considered central to the disorder since ASD was first identified (e.g. Asperger, 1944; Kanner, 1943). There is evidence from factor analytic studies and studies of change in ASD symptoms over time that RRB is a distinct construct from social and communication difficulties (Seltzer, Shattuck, Abbeduto, & Greenburg, 2004; Shuster, Perry, Bebko, & Toplak, 2014). The origin of RRBs in ASD is not yet certain, although there is evidence for genetic, neurobiological and neuropsychological causes (e.g. Leekam, Uljarević, & Prior, 2011).

RRB is an umbrella term for a wide and heterogeneous range of behaviours. These can range from motor stereotypies such as repetitive rocking, hand-flapping and kicking to repetitive sensory behaviours such as repeated mouthing or smelling of

objects. In addition, sensory sensitivities are now categorised under RRB according to the DSM-5 (APA, 2013). Complex rituals such as lining up, collecting or carrying around objects also fall under the term RRB. RRBs may also include intense, narrow interest in certain objects, activities or topics, known as circumscribed interests (CI). Finally, routines and extreme dislike of change are also examples of RRB. A dichotomy of RRBs has been proposed, comprising "lower-order" and "higher-order" RRBs (e.g. Prior & Macmillan, 1973; Turner, 1999a). Lower-order behaviours include repetitive sensory and motor behaviours and are thought to be associated with younger children, typical development, children with lower intelligence quotients (IQs) and children with other disorders; in contrast, higher-order behaviours comprise more cognitively complex behaviours such as CI, insistence on sameness (IS) and routines (Turner, 1999a). Whereas many of these behaviours appear distinct from one another, they all have the following in common: high frequency of repetition; invariance in the pursuit of the behaviour or activity; and unusual or inappropriate manifestation of the behaviour. Although it has been established that RRB is independent of social and communication difficulties (Shuster et al., 2014), RRB itself is better thought of as a multi-dimensional construct (e.g. Honey, Rodgers & McConachie, 2012). This will be discussed further in section 1.2.3 (page 42).

However, RRBs are not specific to ASD; in fact, RRBs are prevalent in the development of all children (e.g. Arnott et al., 2010; Leekam et al., 2007). Thelen (1981) suggested that stereotypic movements serve an adaptive function in terms of mastering motor control and postural stability. A cross-sectional study found that the rate of RRBs in TD children increases until around the age of two years, where they remain stable before gradually decreasing after the age of four (Evans et al., 1997). There is little research investigating RRBs in NT adults, and this evidence is generally limited to specific behaviours and situations. For example, there is evidence of pre-sleep rituals and transitional object use in college-age adults (Markt & Johnson, 1993) and of sport-specific rituals in US college athletes (Bleak & Frederick, 1998). Several studies, however, have demonstrated that participants with ASD show higher levels of RRBs than TD participants in terms of both frequency and severity (e.g. Morgan, Wetherby & Barber, 2008; South, Ozonoff & McMahon, 2005). Finally, RRBs are also

associated with other neurodevelopmental disorders and neuropsychological conditions (e.g. Langen, Durston, Kas, van Engeland, & Staal, 2011; Leekam et al., 2011). For example, RRBs are defining features of both obsessive-compulsive disorder (OCD) and Tourette's syndrome (e.g. Scahill et al., 2014; Worbe et al., 2010), as well as being common in individuals with LD (e.g. Bodfish, Symons, Parker, & Lewis, 2000), Williams syndrome (Davies, Udwin & Howlin, 1998), Prader-Willi Syndrome (e.g. Greaves, Prince, Evans & Charman, 2006), and Parkinson's and Huntington's diseases (e.g. Langen et al., 2011).

As with TD individuals, participants with ASD tend to show significantly more RRBs than individuals with other disorders such as Williams syndrome or OCD (e.g. Rodgers, Riby, Janes, Connolly, & McConachie, 2012; Zandt, Prior & Kyrios, 2007). However, there are also qualitative differences between ASD and other groups. For example, there are differences in terms of the types of obsessions and compulsions demonstrated by individuals with ASD compared to OCD (e.g. McDougle et al., 1995). RRBs are associated with anxiety in children with ASD but not children with Williams syndrome (Rodgers et al., 2012), suggesting that the role of anxiety in RRBs is specific to individuals with ASD. Finally, individuals with OCD tend to show distress regarding their RRBs, whereas individuals with ASD often prefer to engage in their RRBs and resist attempts to divert their attention (e.g. Scahill et al., 2014).

As stated, the main aim of this thesis is to assess the relationship between RRBs and imagination, and in order to do this I have developed a self-report measure for RRBs in autistic adults: the RBQ-2A. Therefore the remainder of this section will review evidence regarding the measurement and categorisation of RRBs using other tools, including the precursors to the RBQ-2A. As this thesis specifically examines the relationship between imagination and RRBs in autistic adults, I will also review evidence regarding the presentation of RRBs in autistic adults. This literature will provide the background for the development and the assessment of the RBQ-2A.

1.2.2 Measurement of RRB

RRB tends to be measured with interviews, questionnaires and observation methods. There has been one review of RRB measures (Honey et al., 2012), which identified the three most common measures used in the RRB literature as the ADI-R,

the Repetitive Behaviour Scale – Revised (RBS-R; Bodfish, Symons & Lewis, 1999) and the Repetitive Behaviour Interview (RBI; Turner, 1995, unpublished doctoral thesis) along with its associated questionnaire version, the Repetitive Behaviours Questionnaire (RBQ). Despite the widespread use of these measures, the evidence regarding various indices of reliability and validity remains somewhat incomplete.

The RBS-R (Bodfish et al., 1999) is a 43-item informant-report questionnaire, designed to capture a wide range of RRBs. It has an advantage in that it was specifically designed to assess RRBs and demonstrates good internal consistency, test-retest reliability and construct validity across studies (Honey et al., 2012). The RBQ was derived from the RBI, and again was specifically designed to assess RRBs with a particular focus on ASD, although it has not been used as widely as the RBS-R. The RBQ has since been updated into a more concise form that includes items from both the DISCO and the RBI: the RBQ-2 (e.g. Leekam et al., 2007; Lidstone, Uljarević et al., 2014; see page 65 for a more detailed discussion), which shows good reliability and validity (e.g. Arnott et al., 2010). Other questionnaires have been developed that show promising reliability and validity (e.g. the Behaviour and Sensory Interests Questionnaire; Hanson et al., 2016) although they have yet to be assessed outside of the research groups that developed them.

Questionnaires are advantageous in that they are generally brief and can usually be filled in by the informant with little guidance from the clinician or researcher. Moreover they can be easily administered as global online surveys, which allows for the recruitment of larger and more representative samples. However, questionnaires are limited to closed questions answered on a Likert scale, and may not include a fully comprehensive set of RRBs. It can be difficult for a participant to accurately gauge the frequency of certain behaviours when there are limited options and some behaviours may be highly dependent on the situation. Finally, RRBs can be quite subtle or complex and participants or informants may not understand exactly what is meant by certain RRBs. In contrast, interview measures allow the participants to expand upon their responses to a trained individual, who can also clarify and explain any RRBs of which the participant is unsure. The RBI (Turner, 1995) is a semi-structured interview specifically designed to assess RRBs that asks parents about 50

different RRBs and demonstrates adequate convergent validity and internal consistency along with excellent inter-rater and test-retest reliability (e.g. Honey et al., 2012; South et al., 2005), although it has not been as widely used in research as other measures such as the ADI-R.

Diagnostic interviews are also often used as a measure of RRBs, due to their reliability and validity in measuring autistic traits. The most commonly used interview method (Honey et al., 2012) is the ADI-R (Lord et al., 1994), a semi-structured diagnostic interview for ASD, which covers RRBs along with other ASD traits and relevant development history. Several studies demonstrate the reliability and validity of the ADI-R (e.g. Lam & Aman, 2007; Mooney, Gray, Tong, Sweeney & Taffe 2009). The DISCO (Leekam et al., 2002; Wing et al., 2002) is another diagnostic interview designed to aid clinicians assessing an individual for ASD. The DISCO has good inter-rater reliability, discriminant validity and correlational validity with the ADOS and ADI-R (Leekam et al. 2002; Maljaars, Noens, Scholte & van Berckelaer-Onnes, 2012; Nygren et al. 2009). The DISCO contains 67 RRB items, in contrast to the ADI-R's fifteen. However, to my knowledge there is no published evidence of the DISCO used as an RRB measure and therefore little is known about the psychometric properties of the RRB items outside of the context of the whole interview.

Interviews are limited in practical terms by the fact that they generally require an individual to undergo highly specialised training in order to administer them, and in the case of diagnostic measures are much more time-consuming. They also cannot be simultaneously administered to a large population as easily as questionnaires. Furthermore, the above measures I have discussed rely on informant report, normally from the participant's primary caregiver; even in the case of interviews where the clinician makes ratings, they are generally relying on information from a caregiver. There is disagreement in the literature over whether or not informant-report is reliable (e.g. Fecteau, Mottron, Berthiaume & Burack, 2003; Militerni, Bravaccio, Falco, Fico & Palermo, 2002), although it has been argued specifically in the case of investigator-driven interviews that informant-report is reliable (Seltzer et al., 2004). The reliability of parental report can also be affected by the experiences of the parents. For example, parents of younger children may be more sensitive to their children's RRBs,

whereas parents of older children may have become accustomed to them (e.g. Esbensen, Seltzer, Lam & Bodfish, 2009); moreover parents' judgment and understanding of their child's RRBs may be affected by their understanding of ASD and contact with professionals (e.g. Honey, McConachie, Randle, Shearer & Le Couteur, 2008).

Furthermore there are no self-report measures of RRBs for adults with ASD, which is a particular issue when assessing an adult population. Most of the measures I have discussed may be used to assess RRBs in adults. However, there are certain limitations in that adults may have learned to 'mask' their RRBs, and once an adult leaves home their caregivers may be less aware of their RRBs, particularly if they change. In addition, the parents or caregivers of older adults with ASD may have passed away. On the other hand, it has been argued that self-report measures in general are not suitable for autistic adults. For example, autistic individuals may differ from NT individuals in terms of their understanding of psychological self (e.g. Jackson, Skirrow & Hare, 2012; Williams, 2010), which may impact their ability to report their own mental states and behaviour. Indeed, one of the most widely used self-report measures of autistic traits, the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001), was designed with this potential limitation in mind and participants were asked about their preferences rather than their social and communicative behaviour.

The specific issues regarding both parent- and self-reporting can be avoided by the use of observation methods (e.g. Goldman et al., 2008; Watt, Wetherby, Barber & Morgan, 2008). In this case, participants are filmed and the videos coded for different RRBs. The coding varies from study to study and may be based on an existing measure of RRBs. For example, some studies have also used the ADOS (Lord et al., 2002), an observational diagnostic tool for ASD, to assess RRB. Such methods are useful for measuring the frequency of certain RRBs in an objective and replicable manner. However, while they are effective for measuring motor and sensory behaviours, they have limited use when assessing more complex behaviours such as routines and rituals (e.g., Harrop et al., 2014; Militerni et al., 2002). This may be because such routines

and rituals can be context-dependent or the observation session does not allow enough time for the manifestation of such behaviours (e.g. Honey et al., 2012).

Occasionally the Yale-Brown Obsessive-Compulsive Scale (YBOCS; Goodman et al., 1989) and its associated child-version, the CYBOCS, are used to assess RRBs in ASD (e.g. Anagnostou et al., 2011; McDougle et al., 1995). The YBOCS is a semi-structured interview measure that has its origins in the measurement of OCD. One advantage of this scale is that it can be used as a self-report measure, and even when interviewing parents their children may be encouraged to contribute (Scahill et al., 2014). However, whereas there is overlap between OCD and ASD, individuals with these disorders show different profiles of RRBs (e.g. Cadman et al., 2015) and measures of obsessive-compulsive behaviours do not capture the same construct as RRB. For example, the YBOCS includes questions about intrusive imagery, which is not a feature of RRBs. This criticism has been addressed in CYBOCS by its adaptation into a form suitable for children with ASD (Scahill et al., 2006), but not adults.

As mentioned, some tools that are used to measure RRBs are not actually specific RRB measures, but rather diagnostic measures such as the ADOS and the ADI-R, or questionnaires that cover a range of ASD traits. A notable disadvantage of such measures is the use of diagnostic tools to both classify a child and measure their RRBs in the same study, which results in circularity and has been criticised for non-independence of measurement (e.g. Bodfish et al., 1999; Harrop et al., 2014; Honey et al., 2012). In addition, these measures are not specifically designed to capture RRBs and include a wide variety of other autistic characteristics. This generally results in a narrower range of RRBs that are included; for example, the ADI-R includes just 15 RRB items and has been reported to under-sample RRBs (Lecavalier et al., 2006).

Given the variety of measures used to assess RRB in ASD research, it is important to establish whether these tools are all measuring the same construct. Correlation, or convergent, validity is a measure of whether different measures of the same construct correlate with each other (e.g. Strauss & Smith, 2009), indicating that both tools are measuring the same underlying construct. There has been some attempt to assess the convergent validity of different RRB measures. Honey,

McConachie, Turner and Rodgers (2012) found evidence of significant positive correlations between the ADI-R and the RBQ, although not between the ADOS and the RBQ. This may cast doubt on the RBQ's utility, or it may be a result of the fact that ADOS is a time-limited observational measure (Honey et al., 2012). There is some evidence of correlational validity between the RBI and both the ADOS and ADI-R, although this is not complete; for example the Rigidity scale of the RBI did not significantly correlate with the RRB domains on either the ADI-R or ADOS (South et al., 2005). Militerni et al. (2002) employed both parental report and direct observation and found that the two methods complemented each other well. In addition, they noted a positive correlation between number of observed RRBs and the Childhood Autism Rating Scale (Schopler, Reichler, & Renner, 1988).

Mirenda et al. (2010) found that the sub-scales of the RBS-R significantly correlated with ADI-R total RRB score, with the exception of self-injurious behaviours, although the effect sizes were small to moderate. A later study (Bishop et al., 2013) investigated the sub-categories of both the RBS-R and ADI-R in a large sample of children with ASD (*N*=1825), and found that equivalent sub-scales for repetitive sensory motor behaviours (RSMBs) correlated with each other across measures, and that the self-injury item on the ADI-R correlated with the RBS-R's self-injury subscale; although again the effect sizes were small to moderate. Chowdhury, Benson and Hillier (2010), when investigating the change of RRBs over time, found similar results in the pattern of change across both the ADI-R and the RBS-R. Together these studies represent some convergent validity between the RBS-R and the ADI-R.

A final issue to consider is what aspect of RRBs are being measured. RRBs can be measured in terms of their frequency (i.e. how often the RRB occurs) and/or their severity (i.e. how intense an RRB is, and how much it impacts on the individual and their family). Observation methods are good for determining frequency, but may not provide as much information about intensity or severity. Within the RBQ and RBQ-2, some questions ask about frequency whereas others ask about the impact the behaviours have on others. Cuccaro et al. (2003) argue that whereas the ADI-R provides information about the presence of RRBs it is limited in capturing information about their frequency and intensity. This may explain why Mirenda et al. (2010) and

Bishop et al. (2013) found only moderate correlations, as although the RBS-R and ADI-R both measure RRBs, they measure them according to different criteria. Richler, Huerta, Bishop and Lord (2010) criticised the tendency for research to focus on mean scores as they do not distinguish between prevalence and severity; in their own study, they found that over time although their participants maintained high levels of RRBs, the impact of these behaviours reduced.

In conclusion, there are a wide variety of measures used to assess RRBs in ASD. Whereas these measures tend to have good reliability and validity in and of themselves, there has been little research in terms of how well the measures compare with each other. Few studies include more than one measure, and many use the same tool to both diagnose participants and measure their RRBs. More research is needed to understand how these measures relate to one another.

1.2.3 The factorial structure of RRBs

As mentioned previously (page 35), most researchers now conceptualise RRB as a multi-dimensional construct, but there is not universal agreement upon the precise sub-groups of RRBs. The DSM-5 (APA, 2013) divides RRBs into: stereotyped and repetitive speech, motor movements or use of objects; adherence to routines, rituals and resistance to change; restricted and circumscribed interests; and hyper- and hypo-sensory responsivity and unusual sensory interests. The ICD-10 (WHO, 1993) also sets out four sub-categories which are: motor stereotypies; preoccupations with parts of objects; CI; and adherence to routines. These generally map onto one another, with the exception of the DSM-5's sensory category and the ICD-10's preoccupations with parts of objects. As mentioned previously, RRBs have also been divided in to higher- and lower-order RRBs (e.g. Prior & Macmillan, 1973; Turner, 1999a). However, it can be conceptually difficult to categorise individual RRBs as either a higher- or lower-order behaviour. For example, preferring to wear the same clothes may stem from a desire to maintain sameness, or it could be because other clothes cause sensory discomfort.

Several researchers have attempted to identify the sub-categories of RRB using statistical methods, specifically exploratory or confirmatory factor analysis (EFA or CFA) and PCA. EFA and PCA are used to express datasets arising from measures that

comprise numerous variables as a smaller number of factors or components made up of inter-correlating items (Kline, 2000; Tabachnick & Fidell, 2014). They are an empirical method for determining the number and composition of a construct's sub-categories, as well as assessing conceptual and construct validity (Briggs & Cheek, 1986; Shuster et al., 2014; Williams, Brown & Onsman, 2010). Running these analyses results in a series of factor loadings for each item on each identified factor, which indicate how strongly the item is correlated with the factor (Kline, 2000). They are particularly useful for assessing measures of phenomena that are not directly observable; as is the case for IS behaviours. The range of different factor solutions of RRBs in participants with ASD found across studies is displayed in Appendix 2 (Table 8.2, pages 243-249).

The majority of studies (*N*=17 [63%]) investigating the structure of RRBs in ASD have identified two sub-groups; one comprising RSMBs such as pacing, hand flapping and rocking, and the other comprising more abstract behaviours such as routines and CI, which are collectively referred to as insistence on sameness (IS; e.g. Bishop et al., 2013; Cucarro et al., 2003; Honey et al., 2012; Lidstone, Uljarević et al., 2014; Richler et al., 2010), although the precise naming of factors may vary slightly between research groups. This binary grouping has also been found in studies of TD children (e.g., Evans et al., 1997; Leekam et al., 2007).

However, this is not always the case. Other studies have identified alternative solutions comprising three (Honey et al., 2008; Lam, Bodfish, & Piven, 2008; Mirenda et al., 2010), four (Anagnostou et al., 2011) or five factors (Bishop et al., 2013; Lam & Aman, 2007; Mirenda et al., 2010; Scahill et al., 2014). In the case of three factors, these usually comprise factors equivalent to RSMB and IS, along with an additional factor equivalent to CI (e.g. Honey et al., 2008; Lam et al., 2008) or self-injury factor (Mirenda et al., 2010). There is somewhat more variety within the solutions of four or more subgroups, however they generally map on to the four DSM-5 categories, and may include self-injury (e.g. Bishop et al., 2013; Lam & Aman, 2007; Mirenda et al., 2010; Scahill et al., 2014); with the notable exception of Bourreau, Roux, Gomot, Bonnet-Brilhault, and Barthélémy (2009) who identified four factors equivalent to RSMB and IS and two epiphenomenal factors.

Such differences are likely due to the use of RRB measures that are different in terms of their scope and format; I have already discussed the difficulties of comparing across measures in the previous section. The largest proportion of studies (*N*=14 [52%]) use the ADI-R (e.g. Bishop et al., 2013; Mooney et al., 2009; Shao et al., 2003). All of these studies demonstrate two sub-groups, RSMB and IS, with two exceptions (Honey et al., 2008; Lam et al., 2008). The next most common measure is the RBS-R questionnaire, used in four studies (e.g. Lam & Aman, 2007; Mirenda et al., 2010). Although the RBS-R was conceptually designed with six sub-scales, factor analysis generally results in five sub-scales; although Mirenda et al. (2010) found evidence for both a three- and five-factor model depending on how the scale is to be used, and Georgiades, Papageorgiou and Anagnostou (2010) found two subscales in the Greek version of the RBS-R. Comparing just these two measures, the RBS-R covers a much wider range of behaviours than the ADI-R, which may account for the difference between factor solutions. Most of the factor analysis studies have been conducted on interview/questionnaire measures, with one exception; Bourreau et al. (2009) devised a measure based on observation, supplemented by parental report, the Restricted and Repetitive Behaviour Scale.

As mentioned, there is disagreement over whether or not certain behaviours should be included as RRBs. For example, the RBS-R includes several items on self-injurious behaviours, which may explain why a separate self-injury sub-scale emerges, whereas there is just one self-injury item in the ADI-R and no self-injury item in the RBQ-2 (Lidstone, Uljarević, et al., 2014). Even when different research groups use the ADI-R, there may be considerable variation in terms of what items are included. For example, Lam et al. (2008) did not include unusual sensory interests because at the time they weren't included as part of RRB under the DSM-IV (APA, 2000) and several studies do not include CI as this item is only administered to older children (e.g. Honey et al., 2008; Mooney et al., 2009; Richler, Bishop, Kleike & Lord 2007). There is also evidence that inclusion of different items considerably alters the results; Smith et al. (2009) replicated the usual two-factor model of the ADI-R but found a four-factor model was a better fit when including *verbal rituals*, which falls under the communication domain of the ADI-R. Finally, there is variation in terms of whether

researchers use the *current* or *ever* codes for the ADI-R; although Szatmari et al. (2006) used both and found no difference between the solutions.

Another reason for the variety in factor solutions may lie in the nature of PCA and EFA themselves. There are few hard and fast rules when carrying out factor analytic studies, and a number of decisions need to be made that can affect the outcome of the analysis. These decisions include whether or not to carry out EFA or PCA, what method of rotation to apply to the data, how to extract factors and what cut-off to use for item loadings. These issues are discussed in further detail in the following chapter (page 61). The range of different factor analyses and rotation methods alone can be seen from Appendix 2 and may account for some of the differences between solutions. For example, the majority of studies (*N*=15 [55%]) employ orthogonal rotation only, and *N*=6 (22%) employ oblique rotation[5] only; however, 53% (*N*=8) of studies using orthogonal rotation identify two factors, and 50% (*N*=3) of studies using oblique rotation identify two factors. Therefore differences in rotation may not explain the difference in number of factors identified.

In summary, there is considerable variation in terms of the factor analytic solutions of RRB, due to the variety of measures and methods used. Most commonly, researchers identify a two factor solution comprising RSMB and IS (or equivalently named factors), which maps on to the conceptual distinction between lower- and higher-order RRBs (Turner, 1999a). This is most strongly supported by the fact CFA using the ADI-R supports a two-factor solution (Richler et al., 2007; Richler et al, 2010). However, most of these studies used the ADI-R, so while it seems that RSMB/IS reflects the genuine structure of RRBs, this may not be the case, and further research using other measures is required. The findings from this review highlight the importance of assessing the factor analysis of the RBQ-2A as part of this thesis; especially given the fact that none of these studies were conducted exclusively with adults. The following section will consider evidence from previous research about the presentation of RRBs in adulthood.

[5] See pages 66-67 for an explanation of orthogonal and oblique rotation

1.2.4 RRBs in autistic adulthood

Autistic traits are known to vary over time (e.g. Fecteau et al., 2003; Piven, Harper, Palmer & Arndt, 1996; Seltzer et al., 2004), and therefore when assessing any autistic trait in adults, it is important to understand how they may differ in comparison to children. However, there is markedly less research on RRBs in autistic adults compared with children, especially older adults with ASD (e.g. Chowdhury et al., 2010). To my knowledge there are no studies that compare the profiles of RRBs in autistic adults with NT adults or adults with other conditions, although some studies may include autistic adults in their sample (e.g. Troyb et al. [2014] found that in 8- to 21-year-olds, individuals with ASD showed significantly higher levels of RRBs than TD individuals). Lack of research with autistic adults has implications for the measurement and sub-division of RRBs in this thesis, which focuses on adults. As I have mentioned, other than observation methods, measurements of RRBs tend to rely on parent-report, which may be particularly limited in terms of adults (pages 3-4) and none of the factor analytic studies described previously analyse an exclusively adult sample. Seven of the factor analyses include young adults between the ages of 18 and 23 (e.g. Cuccaro et al., 2003; Hanson et al., 2016; Papageorgiou, Georgiades & Mavreas, 2008; Smith et al., 2009; see Table 8.2) and five include older adults up to the age of 48 years (e.g. Bourreau et al., 2009; Lam et al., 2008; Tao et al., 2016; see Table 8.2). However, when running factor analysis the adults were not separated from the children and therefore we cannot determine whether the factor structure of RRBs differs among adults compared to children. This section will review the evidence regarding RRBs in adults compared to children in order to illustrate the need for a factor analysis of only adults with ASD.

A review paper that examined changes in ASD symptoms and diagnosis over time found evidence that although RRBs do decrease with age in ASD this is at a lower rate than social communication and interaction difficulties (Seltzer et al., 2004). Three studies have compared *current* and *ever* codes from the ADI-R to examine how autistic traits, including RRB, have changed over time (Fecteau et al., 2003; Piven et al., 1996; Seltzer et al., 2003). Piven et al. (1996) included individuals aged 13-28 years and found that there was a significant reduction of symptoms in the social and

communication domains but no changes in the RRB domain across the whole sample, and fewer participants improved in terms of RRBs. Fecteau et al. (2003) sought to replicate Piven et al.'s results in a sample of individuals aged 7-20 years, but instead found significant improvements across all three domains. However, only RRB was significantly associated with chronological age and when looking at individual items there were fewer improvements in RRBs compared to the other two domains. Seltzer et al. (2003) improved on the previous studies by assessing individuals with ASD aged between 10 and 53 years, more than half of whom had an additional diagnosis of LD, and found that RRBs reduced with age across the sample. Adults showed fewer RRBs overall, and in terms of unusual preoccupations and complex mannerisms, adults showed a more pronounced reduction than did adolescents. The greatest reduction was seen in motor behaviours such as repetitive use of objects and complex mannerisms (e.g. rocking), whereas the least improvement was seen in unusual preoccupations, unusual sensory interests, verbal rituals, compulsions/rituals and CI.

Findings from the ADI-R are therefore mixed, with two studies showing a reduction of RRBs with age (Fecteau et al., 2003; Seltzer et al., 2003) and Piven et al. (1996) not finding this. However, as I have discussed, this tool does not exclusively measure RRBs and is limited with relation to RRBs (see page 40). This may explain the inconsistencies across studies as the ADI-R does not give a complete, detailed picture of RRBs. Georgiades et al. (2010) found that youths and adults aged 13-48 years scored significantly higher in terms of Compulsive Ritualistic Sameness Restricted Behaviours scores on the RBS-R compared to children under the age of 12 years, but there was no difference in terms of Stereotyped and Self-Injurious Behaviours. Also using the RBS-R, Esbensen et al. (2009) focused solely on the relationship between age and RRBs in a cross-sectional design. They found that age was significantly negatively correlated with total RBS-R score and all of its subscales, with adults showing fewer RRBs than children, even when controlling for age, psychotropic medication and presence of an LD. Age-related reduction in RRBs was most pronounced in the subscales of restricted interests and stereotyped movements. Additionally, stereotyped movements reduced less with age in participants with both ASD and LD compared to participants with ASD only. Overall these findings support those of

Fecteau et al. and Seltzer et al., but there is some evidence from both studies that in cognitively able participants, the reduction in terms of RSMBs are more pronounced than those of IS.

Although it is useful to understand the differences between RRBs in adults and children, none of these studies look exclusively at adults. Chowdhury et al. (2010) examined RRBs in a small sample of individuals with ASD aged 19 to 28 years using both the ADI-R and the RBS-R (informants rated their child on both *current* and *lifetime* presence of RRBs). There was improvement across all aspects of RRB, in particular for the repetitive use of objects according to the ADI-R and compulsive behaviour (which includes repetitive use of objects) subscale of RBS-R. The least improvement was seen in CI on the ADI-R and restricted behaviour (including restricted interests) on the RBS-R. The only behaviour that did not change over time was self-injurious behaviour, although it was also the behaviour that was least endorsed overall. These findings suggest that IS behaviours are more prevalent than RSMBs in adults compared to children, supporting Esbensen et al. (2009) and Georgiades et al. (2010). The sample was however limited in that the oldest participant was 28 years and there was only one female participant. A study of a wider age range (20-78 years) of adults with ASD and LD found that there was no difference between younger (<49) and older (>49) age groups, suggesting that once participants have reached adulthood RRBs remain stable in this population (Hattier, Matson, Tureck & Horovitz, 2011). However, it should be noted that this study is limited in terms of analysis, as the correlation between RRBs and age was not assessed. Furthermore, the authors used the Stereotypies subscale of the Diagnostic Assessment for the Severely Handicapped-Second Edition (Matson, 1998); although Hattier et al. (2011) state this measure has good reliability and validity, it is unclear how this measure performs compared to more standard measures of the RRB in ASD. Finally, the profile of RRBs may differ within autistic adult samples. A study of 827 adults (aged 18-75) diagnosed with an ASD found that men scored significantly higher than women in terms of RRB according to the ADI-R regardless of diagnostic group; although the authors argued it may be that women showed 'different' rather than 'fewer' RRBs, and these RRBs are not picked up by standard diagnostic tools (Wilson et al., 2016).

It is the case that RRBs continue to be present in adults with ASD and are related to other behavioural, sensory and cognitive functions (e.g. Kargas, López, Reddy, & Morris, 2015; Miller, Ragozzino, Cook, Sweeney, & Mosconi, 2015; Minassian, Paulus, Lincoln & Perry, 2007; Travers, Kana, Klinger, Klein & Klinger, 2015). However, the findings reviewed here indicate that RRBs in adulthood may present differently than in childhood; not just in terms of overall frequency and severity, but in terms of which behaviours are prevalent. Specifically, the findings of Chowdhury et al. (2010) and Esbensen et al. (2009) suggest that RSMBs decrease with age at a greater rate than other RRBs, whereas Georgiades et al. (2010) found that IS behaviours were higher in adults compared to children. In addition, there is evidence across studies that the developmental trajectory may depend on intelligence quotient (IQ; e.g. Esbensen et al., 2009). This has implications for clinical practice, in that when assessing participants for RRBs it must be borne in mind that adults may present somewhat differently to children and that a reduction of RRBs is a natural part of the developmental trajectory (e.g. Fecteau et al., 2003; Piven et al., 1996). There are also implications for research, in that care should be taken when drawing conclusions from across a range of ages. This may account for the variability in findings among the factor analytic studies; as I have noted, there has not been a single factor analysis carried out among only adults with ASD. Given that RSMB and IS have in some cases been determined by factor analysis and appear to present differently in adults compared to children, there is a need to analyse the factor structure of adults with ASD separately as it is not unreasonable to expect that the factor structure may vary across ages. This reinforces the importance of assessing the factor structure of a new measure of RRBs (in this case, the RBQ-2A).

1.2.5 Conclusion: RRBs in ASD

In this section I have reviewed the literature on measuring and categorising RRBs in ASD, as well as the literature on RRBs in autistic adulthood. There are several tangential issues not been covered here, as the literature is relatively large and complex, and several questions are beyond the scope of this thesis (e.g. the cause of RRBs). In terms of measurement, there are several methods for assessing RRBs in ASD, and as is usually the case, they have complementary strengths and weaknesses and so

use of more than one measure is recommended. From the factor analytic evidence, it seems that RRBs can generally be divided into RSMBs and IS, although the exact solution depends on the measurement and type of analysis employed. Finally, although adults do present with fewer RRBs than children, these remain an important aspect of ASD. Having reviewed the imagination and RRB literatures separately for ASD, the following section will review evidence regarding the relationship between these two constructs.

1.3 The relationship between imagination and RRB in ASD

This section will focus on previous research that has explored the relationship between imagination and RRB. Several researchers have argued for the existence of a relationship between generativity and RRBs, and between imagination and RRBs (e.g. Hanson & Atance, 2013). Indeed, it has been suggested that executive dysfunction, such as generativity and inhibition, are the cause of RRBs; although the evidence for this is mixed (e.g. Leekam et al., 2011). Generativity is particularly relevant here as I have identified it is a key component of imagination, although they are not synonymous. Generally, it is argued that there is a negative relationship between imagination and RRBs, in that imaginative difficulty results in high rates of RRBs. Early observations of autistic children noted the limited behavioural repertoires coupled with lack of spontaneous imaginative activity (Wing & Gould, 1979). Turner (1999b) later drew a more direct link between high rates of RRBs and dislike of change in autistic children with difficulty in spontaneously generating novel ideas and behaviours. Happé (1999) noted that children with ASD tended to engage in obsessive, repetitive sensory and motor actions with toys and objects rather than playing pretend; she argued that these obsessive rituals give way to obsessional interests in autistic adults. As such a link was made between a lack of early pretend play and restricted interests in both childhood and adulthood. Similarly, Boucher (2007) argued that difficulty with memory results in difficulty with generativity and imagination, which in turn leads to a reliance on routines. Furthermore the majority of this work suggests that it is specifically the routines, rituals and restricted interests of autistic people that is related to imagination. This suggests that this relationship is specific to IS rather than RSMBs; although Happé's (1999) suggestion that RSMBs

replace pretend play suggests some degree of relationship between imagination and RSMBs. Regardless, this relationship has received very little empirical attention (Honey et al., 2007; Leekam et al., 2011). In typical populations, there is little evidence related to this relationship; although Kloosterman, Keefer, Kelley, Summerfeldt, and Parker (2011) noted that imagination as measured by the AQ correlated with communication/mindreading abilities but not resistance to change in an undergraduate NT population.

Honey et al. (2007) compared RRB, play and communication in children with and without ASD aged between two and eight years old. They examined these using the Activities and Play Questionnaire Revised, an original parental questionnaire based on the RBQ and DISCO, which assesses RRB and play behaviours (including symbolic play) in children. Although there were two age groups for both TD and ASD children, the older TD children were excluded as their language reached ceiling level, and the ASD groups were collapsed into one due to a lack of variation in language ability. For children with ASD, there was a significant negative correlation between total RRB and total play, and both expressive language and RRB significantly predicted play. However, for the TD children RRB was not a significant predictor, nor did it correlate with play; the latter was only predicted by expressive language. The authors interpreted this as a three-way relationship between RRB, imagination and communication specific to ASD.

This finding lends some support to the argument that difficulties with imagination are reflected by excessive RRB. However, Honey et al.'s (2007) results also support the placement of imagination with communication in the DSM; a three-way relationship is difficult to reconcile with the distinction between RRBs and social interaction/communication, although these two are somewhat related. It may be that imagination is related to both but this association is stronger with either RRBs or communication. The finding that expressive language predicts play in TD children supports Kloosterman et al.'s (2011) later finding that imagination and communication/mindreading are associated in a large NT population (*N*=222). There are some limitations to Honey et al.'s (2007) work. Most notable is the fact that different types of play and sub-types of RRB were not separately measured and

analysed. The different sub-types of RRBs may associate markedly differently with other variables, such as age and IQ (e.g. Militerni et al., 2002; Richler et al., 2010; Moore & Goodson, 2003). In terms of imagination, this is especially important given that it is specifically symbolic play which is thought to be an indicator of imagination, and these findings assess all play behaviours but have been interpreted in terms of imagination. Honey et al. also used a questionnaire to assess play and RRB, which has inherent limitations, and just two DISCO questions to measure language. In addition, there was also no information about specific ASD diagnosis or symptom severity for the participants. Nevertheless these findings provide preliminary evidence of the relationship between imagination and RRB, which may be expanded by using more detailed measures of both RRB and imagination.

A later study (Harrop et al., 2014) of TD and autistic children (aged between two and five years) assessed the developmental trajectory of RSMBs, measured observationally by coding the frequency of RSMBs in a free play session; however, the authors also assessed correlations between the ADOS algorithm measures and frequency of RSMBs at the first time point. Harrop et al. found a significant positive association between frequency of observed RSMBs and the ADOS-G imagination algorithm, which is primarily based on a structured play scenario as well as free play. As higher scores on the ADOS indicate more difficulties with imagination, this indicates that a higher level of RSMBs was associated with more imagination difficulties, supporting the findings of Honey et al. and demonstrating convergence across different methods while having the advantage of confirmed diagnoses of ASD for all the participants. Harrop et al.'s finding also supports the suggestion by Happé (1999) that RSMBs may replace pretend play in autistic children. This observational study specifically measured only RSMBs, and while an association was found, it is not possible for this method to assess IS behaviours. The study also focused on younger children who mostly engage in RSMBs rather than IS (e.g. Militerni et al., 2002; Moore & Goodson, 2003).

Several studies have examined the relationship between generativity – as measured by fluency tasks - and RRB (Turner, 1997; Bishop & Norbury, 2005; Dichter et al., 2009). Although generativity is just one aspect of imagination, and fluency tasks

have their methodological flaws, these studies may provide some insight into the relationship between imagination and RRBs. Turner (1997)[6] assessed four groups of individuals (ASD, ASD with LD, LD only and non-ASD clinical control participants[7]) using the UOT, PMT, a design fluency task and the RBI. A significant negative association was observed between performances on both ideational fluency tasks with sameness behaviour and CI for both ASD groups, but not for the clinical control groups. This was supported by median split comparisons; autistic individuals who produced few novel responses on the UOT showed significantly more extreme sameness behaviour and CI. Importantly, there were no significant correlations between ideational fluency and stereotyped movements or repetitive use of language, suggesting that generativity is only associated with certain sub-categories of RRB, which are equivalent to IS. Performance on design fluency tasks was also related to CI. This study is somewhat limited by the large age range of participants (between six and thirty-two years) within relatively small group sizes (*N*=21/22). Moreover, an online study of ASD traits and divergent thinking reported a significant negative correlation between fluency score on the PMT test and the rigidity subscale of the SATQ (Best et al., 2015). However, they did not find a relationship between rigidity and the Alternate Uses task, and their sample included both NT and autistic participants.

Turner's (1997) findings have not always been replicated. Bishop and Norbury (2005) compared children with different language impairments with children with ASD. In particular, children with pragmatic language impairment share some of the communicative difficulties of children with an ASD but fewer social difficulties and fewer RRB. Bishop and Norbury found that children with pragmatic language impairment performed at the same level on the UOT and PMT as children with ASD; they interpreted this to mean that the poor performance on fluency tasks was not due to RRB. Furthermore, generativity (percentage correct) on both tasks was significantly related to the pragmatic language composite (measured by the Children's Communication Checklist; Bishop, 1998) and the ADOS communication scale, but not

[6] NB Participants performance on these fluency tasks were also reported later by Turner (1999b), but the latter paper did not include the RRB results.

[7] These were participants referred to psychiatry services for reasons other than ASD, including attentional problems, anxiety, depression and eating disorders.

RRB. Bishop and Norbury treat their own results with caution as they did not use a complex measure of RRB, which was assessed using the ADOS and the Social Communication Questionnaire (Berument, Rutter, Lord, Pickles & Bailey, 1999), and did not distinguish sub-categories of RRB which may have masked any relationships. Finally, levels of RRB were generally low, even within the ASD group. Dichter et al. (2009) assessed ASD and TD children using an Animals Fluency task, UOT, the Children's Communication Checklist and the RBS-R. When controlling for non-verbal intelligence, there were significant relationships between communication and the number of total and correct responses on the Animal Fluency task for participants with ASD but not TD participants. In contrast to Turner's (1997) findings, there was no significant correlation between measures of generativity and RRB or its sub-scales. Dichter et al. argue these findings support those of Bishop and Norbury (2005) while using a more detailed measure of RRB. These findings are not entirely consistent however, as UOT was not significantly related to communication. In another domain of imagination, Lind et al. (2014) did not find evidence of a significant relationship between EFT and RBS-R total scores; although they did not report correlations from the subscales.

The studies considered thus far have looked at generativity, the frequency of different play behaviours (Honey et al., 2007) and the imagination algorithm from the ADOS (Harrop et al., 2014). Therefore this research has focused only on the *fluency* aspect of imagination rather than other aspects such originality, flexibility and elaboration; although fluency is important to imagination, it is just one component according to my definition of imagination (page 12). Liu et al. (2011; see page 27) measured these dimensions in boys with AS and found that they scored significantly higher than matched TD boys in terms of originality and elaboration. The authors noted that boys with AS tended to draw pictures within idiosyncratic restricted interests; for example one child was interested in biology so only drew microscopic organisms such as dust mites, viruses and bacteria. Liu et al. suggested that the tendency to draw within unusual special interests contributed to the ASD group's significantly higher score on originality compared to the TD group. Conversely, this also may have negatively affected their flexibility score, as it reduced the number of

categories that the ASD group used. This pattern of findings illustrates how RRB - in this case CI – could both positively and negatively affect imagination. Unfortunately Liu et al. did not include a measure of RRBs so this relationship cannot be evaluated from these results. However, the suggested relationship between restricted interests and originality contrasts with the more common hypothesis that imagination and RRBs are negatively associated in ASD. Therefore Liu et al.'s study highlights the importance of considering different types of imagination, such as originality, as they may be differentially associated with RRBs in ASD. In a similar vein, some previous research has indicated a positive relationship between the level of RRBs and the presence of "savant" skills or special talents in both ASD and non-ASD populations (e.g. Lyons & Fitzgerald, 2013; O'Connor & Hermelin, 1991; Vital, Ronald, Wallace & Happé, 2009), although it should be noted that such abilities are not always creative.

A related issue is how the different subtypes of RRBs are associated with imagination. Two of the above studies examined the relationship between imagination (as measured by generativity or play) and RRBs without taking subtypes into account (Bishop & Norbury, 2005; Honey et al., 2007). When there is evidence that a construct is multi-dimensional, it is misleading to only assess a composite of said construct, as this obscures which dimension accounts for any effects (Briggs & Cheek, 1986; Strauss & Smith, 2009). As described in section 1.2.3 (page 42), there is evidence that RRBs divide into at least two subtypes, RSMB and IS. There is scarce empirical evidence showing how the subtypes of RRBs relate to imaginative ability. Only two studies to my knowledge have assessed a full range of RRB subtypes, and these only measured generativity rather the whole construct of imagination (Dichter et al., 2009; Turner, 1997).

Turner (1997) identified significant relationships between generativity and sameness and CI, but not stereotyped movements. This supports the hypothesis that relationship between RRBs and imagination is specific to IS. Similarly, Best et al. (2015) found a significant association between one of their creativity measures and the rigidity subscale of the SATQ. However, the rigidity subscale of the SATQ is the only subscale that corresponds to RRBs and does not include any RSMBs and so no conclusions can be drawn from this study about the specificity of the relationship. It

should be noted that Harrop et al. (2014) investigated RSMBs in ASD and discovered a significant positive association with imagination on the ADOS, although the authors did not test IS. In contrast, Dichter et al. (2009) found no association between any RRB subscale and generativity. This inconsistency may be partially explained by the fact that the sub-grouping of RRBs varies across measures (see Appendix 2, Table 8.2, page 243). Given the existing conflicting evidence, it is important to consider the different subtypes of RRBs when investigating the relationship between RRB and imagination. Theoretically, it is specifically IS that drives the potential relationship between imagination and RRBs rather than RSMBs; this is supported by evidence from Turner and Best et al. This is not supported by the finding that RSMBs are also related to imagination (Harrop et al., 2014). Turner's participants were aged from six to thirty-two and Best et al.'s participants were all adults, whereas the children in Harrop et al.'s study were aged from two to five years. As Happé (1999) argued, pretend play is replaced by RSMBs that may become obsessive rituals, and in adults this may be replaced by restricted interests. Therefore in younger children the relationship with imagination may be driven by RSMBs, and in older children and adults it may be driven by IS.

1.3.1 Conclusion: Imagination and RRB

In summary, the precise nature of the relationship between RRB and imagination in ASD has not been definitively established. The empirical evidence is equivocal; there is some evidence that related constructs – generativity and play – are indeed associated with RRB (Best et al., 2015; Harrop et al., 2014; Honey et al., 2007; Turner, 1997); however, this is not a consistent association (Bishop & Norbury, 2005; Dichter et al., 2009). There is some evidence that this relationship is specific to IS (Turner, 1997), although this is not definitive (e.g. Harrop et al. [2014] found a relationship between imagination and RSMBs). Furthermore, there is some evidence that imagination is related instead to communication (Dichter et al., 2009; Honey et al., 2007; Kloosterman et al., 2013), reflecting the placement of imagination in international diagnostic manuals. Part of the difficulty in establishing this relationship lies within methodological issues, particularly in terms of assessing subtypes of both constructs. So far, most of the studies have focussed on fluency and generativity,

rather than other aspects of imagination such as originality and flexibility and researchers do not always take into account the different sub-types of RRB. Therefore the potential relationships between imagination and RRB may be 'masked' by using composites of variables. This issue is exacerbated by the fact that the imagination literature is relatively underdeveloped and has not satisfactorily established whether or not imagination is a multi-dimensional construct. Little consideration has also been given to the potential positive effects of RRBs on imagination, in particular restricted interests (e.g. Liu et al., 2011; Vital et al., 2009). Importantly for this thesis, only two out of the six studies investigating this relationship in ASD included adults (Best et al., 2015; Turner, 1997). Furthermore, what we can conclude from these studies in terms of the relationship between imagination and RRB in autistic adults is limited by the fact Best et al. did not separate out ASD participants from NT participants in their analyses, and Turner tested generativity only. Therefore the relationship between RRBs and imagination has yet to be fully explored in an adult ASD population.

1.4 Summary and Aims of the Thesis

This chapter began by considering the overlap between behavioural inflexibility in ASD – now conceptualised as RRBs – and the more elusive concept of imagination that may be related to it. My overall goal was to examine the relationship between imagination and RRBs in autistic adults. However, before this issue can be properly considered, there are a number of obstacles to overcome; the first being arriving at a definition of imagination. I began this literature review by undertaking a conceptual analysis of imagination, resulting in the following definition: *generation and flexible manipulation of existing concepts to form novel ideas, which may be rooted in past experience and may result in adaptive outputs (creativity)*. In reviewing the imagination literature, I described a wide variety of measurements and evaluated their usefulness in relation to this definition, and also found that few studies took into account different dimensions of imagination. Most studies focus on fluency to the neglect of originality and flexibility, including studies that examine the relationship between imagination and RRBs, and so most previous research does not assess a complete picture of imagination in ASD. Related to this, few studies have measured

imagination in autistic adults, and therefore very little is known about this construct in adulthood.

Reviewing the literature regarding the measurement and categorisation of RRBs in ASD, the lack of empirical information about RRBs in autistic adults became apparent. RRBs have been measured in a variety of ways, and generally can be categorised into RSMB and IS, but little effort has been made to assess RRBs in autistic adults. Many of the measures that have been developed are unsuitable for use with autistic adults, as they focus on child behaviours and rely on parent-report, which leads me to the next issue that should be addressed before assessing the relationship between imagination and RRBS. At the time of designing the studies for this thesis there was no published measure of self-reported RRBs suitable for autistic adults. The YBOCS, described earlier (page 40), can be used as a self-report measure but it has not been adapted for use with adults with ASD, unlike the child version (Scahill et al., 2006) and was originally designed for use with individuals with OCD, which as I have described may not be useful for assessing the presentation of RRBs in ASD (page 40). The AQ (Baron-Cohen et al., 2001) includes items related to RRBs (e.g., *It does not upset me if my daily routine is disturbed*). However, the original sub-scales of the AQ do not include RRBs, and only two factor analyses have identified an RRB subscale (Kloosterman et al., 2011; Lau, Kelly, & Peterson, 2013) and therefore it is not suitable as a measure of RRBs. Finally, there is an adult version of the Childhood Routines Inventory (Evans et al., 1997); however, this had not yet been published at the time of designing the studies for this thesis[8]. Therefore I developed the RBQ-2A in order to provide a self-report measure of RRBs in autistic adults. As a major part of assessing the RBQ-2A's reliability, I analysed its structure using PCA in Chapters Three and Four. As with imagination, different sub-categories of RRBs should be assessed when examining the relationship between RRBs and imagination, due to previous evidence that this relationship is specific to IS (Turner, 1997). Therefore assessing the factor structure of the RBQ-2A is not only important for reasons of psychological validity (see Chapter Two, page 61), but also to distinguish items that relate to IS from items that relate to RSMBs, in order to assess whether or not the relationship between RRBs and

[8] However, I did choose to include this measure in Chapter Five of this thesis.

imagination is specific to IS. The RBQ-2A's other psychometric properties in terms of reliability and validity are assessed in Chapters Three to Five.

Having developed and assessed a satisfactory measure of RRBs for autistic adults, I sought to address the primary question of this thesis in Chapters Four and Five. That is: what is the nature of the relationship, if any, between imagination and RRBs in autistic adults? Previous research is inconsistent; however, there is preliminary evidence that RRBs are related to imagination in ASD (e.g. Harrop et al., 2014; Honey et al., 2007) and this may be specific to IS (Turner, 1997; although see Harrop et al., 2014). Specifically I investigated the relationship between the different RRB subscales and imagination in accordance with the three key components of imagination that I identified at the beginning of this chapter (fluency, originality, and flexibility).

My definition of imagination informed my decision making in terms of what types of imagination to assess and what tasks to use (see Chapter Two, page 75 onwards for more detail). Given that autistic individuals may show very different profiles of imagination (i.e. low fluency and high originality [Liu et al., 2011]), it was important to assess all three components as part of this thesis. In Study Five, *fluency* is assessed across three tasks (design fluency, ideational fluency and thinking about the future), *originality* across two (design and ideational fluency), and *flexibility* in one (ideational fluency). Study Four's imagination measures do not map onto these components, as I used questions about past pretend play and the imagination subscale of the AQ. Both measures have their weaknesses (see Chapter two, pages 75-77), and the use of the AQ subscale was opportunistic (page 77); however, I decided it was important to include a measure of pretend play as this is one of the most commonly used methods for assessing imagination in ASD. It was not possible to measure the three key components of imagination from the pretend play questions, as I did not have enough detailed information from my participants. However, pretend play is a construct which could be measured according to these three components using observational methods and this is discussed in Chapter six (pages 183-184).

No study to my knowledge has investigated the relationships between different scales of RRBs *and* different dimensions of imagination in a single sample with ASD; as I have mentioned, Best et al. (2015) did not separate out their participants with ASD, nor were they able to confirm diagnoses. As well as being able to assess the relationship between imagination and RRB in a more detailed fashion, this strategy enabled me to assess a wide range of imaginative abilities in autistic adults for the first time. The relationship between imagination and RRBs in autistic adults is directly addressed in Chapters Four and Five of this thesis, along with the relationship *between* the three components of imagination in Study Five. The next chapter describes the main methodological issues that arose while carrying out the work for this thesis and how they have been addressed.

2 Chapter Two: Methodological Considerations

In the previous chapter, I reviewed evidence relating to imagination, RRBs and their relationship in ASD. The main aim of this thesis was to further examine this relationship, with the additional aims of developing a self-report measure of RRBs and exploring imagination in autistic adults. I have chosen to carry out these aims by developing a new measure of RRBs and assessing various aspects of its reliability and validity, in conjunction with measuring imagination using a range of tools. Several methodological considerations arose in designing the studies for this thesis, including the most effective way of assessing RRBs in this population, the effect of self-report in autistic individuals, the procedure for running factor analyses, the selection of appropriate imagination measures that can be compared to the RRB measures, and finally the characteristics of participants. This chapter will summarise the methods used to address the aims of this thesis before discussing the main methodological considerations and the decisions I have made in relation to them.

2.1 Overview of methods and relevant issues

As described at the end of the previous chapter, I began the empirical work of this thesis by developing a self-report measure of RRBs suitable for use with autistic adults. The first methodological issues arose here: what is the best method of assessing RRBs in this population, given that they may be assessed using observation, questionnaire and interview methods? This will be discussed in more detail in the next section, with particular consideration of the limitations of using self-report measures with autistic individuals, as this is relevant to the chosen measure (the RBQ-2A). Throughout this thesis I assessed the reliability and validity of the RBQ-2A across several studies in several different ways. Reliability is an assessment of how consistently a tool measures a construct (Field, 2013). One way of assessing this is by assessing a scale's internal consistency; whether or not each of the items on a scale measures the same construct as the rest of the items. This can be assessed by calculating the correlation coefficients between different items on a measure (Cronbach, 1951; Field, 2013), resulting in Cronbach's alpha values, and I will report these for the RBQ-2A in Studies One to Five. Another useful indicator of reliability is

test-retest reliability; that is whether or not an individual's answers on a measure remain similar over time, which will be assessed in Study Five (Chapter Five).

Construct validity means that a tool measures successfully its intended construct in a meaningful way and may be assessed in several ways. One method is by examining its factor structure (e.g. Williams et al., 2010). In Study One (Chapter Three) and Study Three (Chapter Four) I assessed the RBQ-2A's factor structure in two samples, one comprising undergraduate students and the other autistic adults, comparing these with previous factor analytic studies. The next methodological issue arose here, as there are several different ways of carrying out factor analysis, which may affect the outcome of results. Construct validity can also be assessed by testing hypotheses derived from the construct being measured. The most obvious hypothesis regarding RRBs is that a valid measure of RRBs should discriminate between ASD and NT groups, and I assessed this in Study Two. Finally, a valid measure of RRBs should also be associated with *other* theoretically associated constructs and assessed this in Studies One, Two, Three and Four by assessing the RBQ-2A's relationship with a measure of general autistic traits (page 84) and anxiety (page 146). In a similar vein, correlational validity (sometimes called convergent validity) is a subtype of construct validity, which is demonstrated when different tools that aim to measure the same construct correlate with each other, which was tested in Study Five.

The main aim of this thesis was addressed with Studies Four and Five. In Study Four (Chapter Four), the relationship between RRBs and imagination was tested by assessing group differences in terms of autistic adults who reported playing pretend games as a child with autistic adults who reported *not* playing pretend games as a child and by assessing the correlation between the RBQ-2A and a questionnaire measure of imagination as part of a large online survey. In Study Five, I tested this relationship in a smaller sample by administering several tasks designed to tap into various imaginative abilities, and testing their correlation with scores on the RBQ-2A and an RRB item from the DISCO. I also examined their relationship with each other, to see to what extent the different measures all tap into the same construct. This represents another major issue in designing studies for the thesis: given how many measures there are to assess imagination, which is an elusive construct, which measures should be chosen to assess

it? The final methodological issues concern whether or not questionnaires and experimental tasks may be reliably compared to one another, and the characteristics of participants to be recruited. The issues of diagnosis, age and ability should all be considered in relation to the different studies of this thesis. The following sections address these methodological considerations in more detail.

2.2 Assessing RRBs in autistic adults

In Chapter One, I outlined the variety of methods that have been used to assess RRBs in children and adults with ASD (pages 36-42). To summarise this discussion, RRBs tend to be measured using questionnaires, interviews, and observation methods. The former two methods may be used as self-report measures with the individual themselves, or as an informant measure. The first methodological issue that arises for this thesis therefore is how best to measure RRB. All of these measures have advantages and disadvantages; however, I would argue that the most limited are the observation methods, due to the fact they are poor tools for assessing complex behaviours such as routines and rituals that comprise the RRB subtype IS. Given that the relationship between RRBs and imagination may be specific to IS in older children and adults, it is vital that the chosen measure is able to tap into both RSMBs and IS. It is difficult to assess rituals and routines in an efficient manner other than by asking the individual themselves or a person who knows the individual well.

The subsequent decisions then are whether to use questionnaires or interviews, and whether to use self- or informant-report. The main advantage of questionnaires is that they can be completed independently, data may be collected online or by post and therefore they are able to reach larger audiences of participants simultaneously, in contrast to interviews where either the researcher or participant must travel, and only one participant can be seen by a researcher at a time. Given that it can be difficult to recruit autistic adults, in order to maximise my recruitment potential, I decided that the initial study with autistic adults would be conducted online and as such a questionnaire rather than interview would be more appropriate. However, in order to avoid confounding effects from the disadvantages of questionnaires (e.g. misunderstanding or misinterpreting the questions, limited response options), I also chose to use an interview method in conjunction with the

questionnaire measure in a face-to-face study. This will allow for comparison between the two methods and assure that valid conclusions may be drawn from the initial online study.

Finally, in terms of the source of the information, I have described the potential advantages of self-report measures regarding the assessment of RRBs in adults (Chapter One, page 39) and I therefore chose to assess participants using self-report measures. However, there are certain specific disadvantages to using self-report in autistic individuals. I have noted that autistic individuals may differ in terms of their understanding of their psychological self (e.g. Jackson et al., 2012; Williams, 2010). Empirical research addressing the reliability and validity of self-report measures in ASD has been mixed. The AQ itself demonstrates good test-retest reliability and good agreement between self- and parent-report in adults (e.g. Baron-Cohen et al., 2001). Furthermore, Berthoz and Hill (2005) demonstrated good comprehension, convergent validity, test-retest reliability and discriminant validity in questionnaires assessing alexithymia in autistic adults and Hesselmark, Eriksson, Westerlund and Bejerot (2015) demonstrated good internal consistency in a personality measure, along with a high correlation between self-reported neuroticism and clinician ratings in autistic adults. In contrast, a study of autistic traits in children and adolescents (aged 9-18 years) did not find significant associations between self- and parent-reports on the AQ or related measures, the Empathising Quotient and Systemising Quotient (Johnson, Filliter, & Murphy, 2009). Similarly, Dewrang & Sandberg (2011) found that no significant differences in self- and parent-report on the Child Obsessive Compulsive Impact Scale (Piacentini, Peris, Berman, Chang, & Jaffer, 2007) for TD young people, but parents of ASD young people scored their children significantly higher than the young people did themselves. Given these conflicting findings, it is important to consider the reliability and validity of different self-report measures in ASD individually, and this was taken into account throughout this thesis (Chapters Three to Five). Additionally, in Chapter Five I assessed the self-report measure against scores on the DISCO, as an attempt to assess whether or not there is an effect of self-report.

Having decided on assessing self-reported RRBs using a questionnaire, it was then necessary to determine what questionnaire to use. At the time of designing the

studies for this thesis, there was no published self-report measure of RRBs suitable for autistic adults (see page 39 in the previous chapter). Therefore I aimed to develop the first such measure. I decided to adapt an existing parent-report measure rather than designing an entirely new measure in order to ensure that the items chosen were reliable and valid measures of RRBs in ASD. As described in the previous chapter (page 37) there are two widely used questionnaires for RRBs, the RBS-R and the RBQ. However, both of these measures are relatively long and contain several items that refer to behaviours that are less relevant to an older, more able population such as self-injurious behaviours, particularly the RBS-R. Therefore the short-form of the RBQ, the RBQ-2, was chosen as the measure to adapt. The original purpose of the RBQ-2 was to describe a profile of RRBs that may change with age. The RBQ-2 has its origins in two interview measures, the DISCO and the RBI and comprises 20 RRB items including examples of both RSMB (e.g. rocking, pacing, and fiddling) and IS (e.g. arranging objects, resistance to changes in the environment, and routines). Thirteen of these items are common to both the RBI and DISCO, five items are unique to the DISCO and two are unique to the RBQ-2 (Leekam et al., 2007). The reason for choosing to adapt the RBQ-2 rather than other measures of RRBs lies in the fact that the RBQ-2 is a brief measure that still taps into a range of RRBs, from stereotyped movements and sensory symptoms to more complex behaviours. As 18 of the RBQ-2 items are based on DISCO items, and the design of the DISCO itself is based on Wing and Gould's (1979) triad, the RBQ-2 seemed conceptually the most appropriate tool to use. Moreover, although the item content is drawn from a diagnostic interview method, its original design as a questionnaire to measure RRBs in TD children avoids the problem of circularity in using items which have been already used to decide the diagnosis of the person. In comparison to the RBS-R and RBQ, there are few changes that need to be made to make the RBQ-2 age- and ability-appropriate for adults, preserving the comparability between the parent- and self-report versions. As part of assessing the RBQ-2A's reliability and validity, I conducted factor analysis on the data collected for this thesis. The following sub-section discusses issues relating to the process of factor analysis.

2.3 Methodological considerations in relation to PCA and FA

Factor analysis is a useful method of assessing the construct validity of a measure, and as such I conducted factor analyses on both the undergraduate and ASD questionnaire data. As mentioned in the previous chapter (page 45), there are several decisions that need to be made when conducting factor analyses, and these decisions impact the resultant solution of the analyses. Due to the fact there are a variety of ways to conduct factor analyses, the differing approaches across analyses may mask the 'true' structure of RRBs. In order to avoid these issues, I decided to analyse the two datasets using the same approach, so that any differences between analyses is not attributable to analytic strategy.

There are few hard and fast rules for running factor analyses, although there are some guides available (e.g. Osborne & Costello, 2009; Tabachnick & Fidell, 2014; Williams et al., 2010). One important decision is whether to use exploratory (EFA and PCA) or confirmatory analyses (CFA). Both EFA and PCA are exploratory techniques and are particularly useful when a construct or measure has not yet been assessed. EFA estimates the factor structure using a mathematical model and is therefore helpful when assessing a construct that cannot be observed. In contrast, PCA reduces the actual dataset into a number of components and is a better tool for reducing data and removing redundant items (Field, 2013; Kline, 2000). On the other hand, CFA statistically tests a hypothesised model which may be based on theoretical knowledge or previous research (Kline, 2000; Williams et al, 2010). As such one can test multiple models and determine which one is the best fit for the data, so this would be the best analysis to choose for a well-tested measure such as the RBS-R or ADI-R. If one factor/component solution for RRB can be replicated using different techniques and different measures, this lends support to the validity of the identified sub-categories and to the validity of the measures (Briggs & Cheek, 1986).

Having made the decision to use EFA, PCA or CFA, it is then important to decide what rotation to use. Rotation of the data maximises high factor loadings and minimises low loadings, which simplifies and clarifies the data, resulting in a more easily interpreted factor solution (e.g. Osborne & Costello, 2009; Williams et al., 2010). There are two main categories of rotation: orthogonal (e.g. Varimax, Quartimax),

where the factors are independent of one another; and oblique (e.g. Direct Oblimin, Promax), where the factors correlate with each other. There is a preference for orthogonal rotation as it results in more interpretable results; however, this is unsatisfactory for most research involving human participants, since behaviour is rarely partitioned in such a way and therefore orthogonal rotation may result in a loss of information if the factors are indeed correlated (Osborne & Costello, 2009).

Other decisions include the number of factors to extract and what constitutes a significant loading. The number of factors to extract has traditionally been decided on the basis of Kaiser's criterion and Scree plots (Cattell, 1966). However, these are limited by not being stringent or objective enough (e.g. Tabachnick & Fidell, 2014). Statistical techniques, such as parallel analysis (PA; Horn, 1965) or checking the goodness-of-fit statistics, are preferable but not always used. Whether or not an item significantly loads on to a factor is most often decided on by employing a cut-off. There is very little guidance on how to decide the cut-off, and this varies considerably among researchers.

2.3.1 My decisions in relation to these methodological considerations

Prior to data analysis, a number of data screening decisions were made in addition to testing the usual assumptions of factor analysis: the Keiser-Meyer-Olkin (KMO) measure of sampling adequacy; multicollinearity; and factorability. To maintain consistency with previous research (Leekam et al., 2007; Lidstone, Uljarević et al., 2014) item 20 was removed before FA as its response scale differs to the other items (Leekam et al., 2007); for a more detailed discussion see Chapter Three (page 84). In addition, items were removed before analysis if 80% or more of the sample responded *never or rarely* to any question. Finally, a Little's Missing Completely at Random test was conducted on the samples to ensure there was no pattern to missing data.

I decided to not analyse the data using CFA for two reasons. Firstly, CFA ideally involves the use of two samples, one for carrying out an initial exploratory analysis and a second sample on which to perform the CFA itself, and I did not anticipate recruiting sufficient participants in either study (although see Chapter 4, page 107) to allow for this type of analysis. Secondly, although the RBQ-2A is an adult version of the RBQ-2, it is a new measure and the theoretical structure of RRBs has not been universally

agreed upon, therefore it is more appropriate to carry out EFA. The decision between PCA and EFA was a less clear-cut one. Although PCA is advantageous as its solution is based on the actual data, EFA is useful for identifying latent constructs. Ultimately I decided to analyse using PCA as the RBQ-2A is in the early stages of development and assessment.

It is possible to specify components in advance of PCA and therefore I could have specified two components, consistent with previous research. However, I decided to use statistical methods, given the variety of numbers of factors/components identified in previous RRB research (Appendix 2, pages 243-249), and in order to increase objectivity. I therefore decided on the number of components using PA (Horn, 1965) with the Monte Carlo PCA for Parallel Analysis program. PA is a more stringent criterion for component extraction than Kaiser's criterion or the Scree plot (Tabachnick & Fidell, 2014), and occurs before data analysis, unlike goodness-of-fit models. To carry out PA, an initial PCA is first run on the data with no rotation and no fixed number of components to obtain Eigenvalues for each component. The Monte Carlo program is then run, specifying the number of participants, variables and replications of the data (in this case, 100). This calculates criterion Eigenvalues for several components. These criterion Eigenvalues are then compared to the actual Eigenvalue. If the actual Eigenvalue is higher than the criterion Eigenvalue, the component is accepted. Once the criterion Eigenvalue is larger than the actual Eigenvalue, the comparison ends and the analysis is re-run specifying the number of components equal the number of actual Eigenvalues that were larger than their respective criterion Eigenvalues.

The method of rotation can largely depend on the outcome of the analysis itself; that is, it is better to use orthogonal rotation if the correlation between factors does not reach .32 (e.g. Tabachnick & Fidell, 2014). However, there can also be a theoretical basis to this decision. If the sub-categories of a construct are related to each other, this should be reflected in research and theory, and oblique rotation should be used. There is some evidence of correlation between sub-scales of RRB measures; however, this is not found across all studies (e.g. Bishop et al., 2013; Cuccaro et al., 2003). In addition there is evidence for the familial aggregation of IS but

not RSMB (e.g. Lam et al., 2008; Szatmari et al., 2006) and that RSMB and IS are differentially associated with certain variables (e.g. Militerni et al., 2002; Moore & Goodson, 2003), therefore representing distinct constructs (Bishop et al., 2013). This suggests orthogonal rotation is more appropriate as these constructs are independent of each other. However, all RRBs are defined by the same essential criteria (see Chapter One, page 35), and when considering ASD traits as a whole, RRBs group together independently of social and communication criteria (Shuster et al., 2014). Therefore I deemed it most appropriate to employ oblique rotation in the first instance, but to be mindful of the correlation not reaching the threshold of .32.

A final important decision to make is the threshold for an item loading on to a component. Previous research in the ASD RRB literature uses several different cut-offs ranging from .3 (e.g., Bishop et al., 2013; Cuccaro et al., 2003), .35 (e.g. Shao et al., 2003), .38 (e.g., Leekam et al, 2007; Lidstone, Uljarevic et al, 2014) to .4 (Honey et al, 2008; Szatmari et al, 2006). According to Guadagnoli & Velicer (1988) loadings above .3 or .4 are usually considered salient to that component (regardless of direction [Tabachnick & Fidell, 2014]). Before analysis, .4 was chosen as the cut-off in order to be more conservative, given the relatively small sample size of the first sample (Study One); and therefore the same cut-off was applied in Study Four.

2.3.2 Summary

This section has provided an overview of my reasons for choosing to adapt the RBQ-2 into an adult self-report measure for the work presented in this thesis, as well as my analytic strategy in terms of carrying out PCA on these data. In this thesis I analysed the data using PCA, as the RBQ2-A is still in its exploratory and development phase. Following initial data screening and testing of assumptions, the number of components was determined using PA as it is the most objective measure. Oblique rotation was prioritised in order to allow the components to be correlated with each other. The following section describes the decisions made when recruiting participants for the studies in this thesis.

2.4 Participants

It is important to consider the characteristics of participants to be targeted for recruitment in each study of the thesis. For the first study assessing the RBQ-2A, the

aim was to test whether the questionnaire is reliable in a typical population. University students were targeted as it is easy to recruit large numbers from this population and they form the starting point in the development of many questionnaires. This population is of course inherently limited by the fact they tend to be young and, in the case of psychology students, female. For the second study a more representative sample that included participants with ASD was analysed in order to provide a brief test of the reliability and validity of the RBQ-2A in autistic compared to NT individuals. The third and fourth studies were conducted with participants reporting a clinical diagnosis of ASD. The data collection for these studies was conducted online in order to maximise the number of participants that could be recruited. Initially this sample was intended to include only participants from the United Kingdom (UK); however, issues with recruitment resulted in individuals from other countries taking part (see Chapter Four, page 107 for further explanation and discussion of this). As the original intention was to only recruit participants from the UK, and the survey's demographic questions were aimed at British individuals, only the UK participants have been included in this thesis; however, this dataset does provide the opportunity to analyse the RBQ-2A in other national populations in the future.

The final study of this thesis involves conducting a range of imagination tasks with participants. For this study, another group of autistic individuals ranging in age and gender were recruited, and were asked to provide some evidence of their diagnosis (the DISCO was also used to confirm diagnoses). When initially designing this study and selecting the imagination tasks to be used, I intended to recruit a control group. However, due to time constraints this was not possible and so I intended to use population norms available for the standardised creativity measures (described in the following section) in lieu of a control group. Unfortunately, it later transpired that the publishers of these creativity tests do not make the norms for individual subtests available to administrators, and therefore it was not possible to use norms as only subtests were used (see page 77 for a discussion). Lack of a control group is not necessarily an issue for the central question of this thesis; namely, the relationship between imagination and RRBs in autistic adults. The most important role for a control group in this thesis is in testing the reliability and validity of the RBQ-2A, and a control

group was available in Study Two. In terms of understanding the profile of imagination in ASD, the lack of a control group does limit this somewhat, but only in the sense of how imagination may differ from the general population. However, it has been argued that studies employing a matched control group design are limited in terms of what they can tell us about the autistic population as a result of its heterogeneity (Jarrold & Brock, 2004).

In terms of inclusion and exclusion criteria, Study One specifically targeted university students across several waves of recruitment, and in one of these waves male students were targeted in order to address the gender imbalance of the sample. Other than this study, there were no inclusion or exclusion criteria in terms of gender. In Study Two both autistic and NT participants were recruited. Studies Three-Five targeted only autistic participants. The only exclusion criterion for age that was implemented across studies was that participants should not be younger than eighteen years as I was specifically targeting adults; the exception is for Study Two. Study Two consists of a secondary analysis of data collected as part of a study on the role of cortisol and melatonin in sleep disturbance in ASD. As such participants' ages were restricted to between 25 and 39 years due to the distinct developmental pattern of the melatonin rhythm cycle across the lifespan.

A more pertinent issue relating to selection of participants is ability. Ability in terms of IQ and independence varies greatly within the autistic population, ranging from people who are non-verbal and require a high level of support in their daily lives, to those who score extremely highly on IQ tests and need less support. Research tends to focus on participants who are verbal with higher cognitive ability, which is a weakness of the ASD literature. Due to the nature of the questionnaire and tasks implemented in this thesis, participants were required to be fluent in both written and spoken English to take part; although this was the only specific criterion relating to IQ or ability, this would result in a sample that is heavily skewed towards cognitively able participants (although many of my participants did have other support needs, for example in terms of social skills). For the final study I also tested the IQs of participants to ensure that they met the cut-off of 70 for average intelligence (Wechsler, 1999), and participants who did not meet this criterion were excluded from

analysis. As the characteristics of the target population limits the generalisation of any findings from the thesis to a cognitively able adult population of autistic adults, I will take this into account when interpreting the results from all of the studies. The following section discusses methodological issues in terms of assessing imagination in ASD, as well as how these imagination measures may be used in a satisfactory way with the RBQ-2A given that the latter is a questionnaire and not an experimental task.

2.5 Measuring imagination in ASD

As described in Chapter One, there are several measures of imagination that have been used to assess this construct in ASD, ranging from pretend play to counterfactual reasoning. In Chapter One I evaluated these methods against my working definition of imagination: the *generation and flexible manipulation of existing concepts to form novel ideas, which may be rooted in past experience and may result in adaptive outputs (creativity)*. I concluded that most of the measures I discussed in Chapter One did meet my definition, in the sense that these concepts can in some way be assessed through them; the one exception was verbal fluency tasks which only measure fluency or generativity. Given the importance of dimensions other than fluency to imagination, I decided to assess fluency, novelty and flexibility in this work. However, it was then necessary to decide what 'types' of imagination to assess, and what exact measures to use within these types. I have demonstrated that the findings related to imagination can be very sensitive to choice of task, so it was important to carefully consider these issues. Another issue to be cautious of is the fact that I have chosen to assess RRBs using a self-report questionnaire whereas almost all measures of imagination discussed in Chapter One were experimental tasks. Therefore this discrepancy may add noise to the comparison of imagination and RRBs, causing any relationship (or lack thereof) to be more difficult to interpret. This is in some ways an inevitable problem, as RRBs are difficult to measure other than through self- or informant-report, and imagination (or creativity) tends to be measured using experimental tasks. This potential problem will be addressed by the use of at least one self-report method to assess imagination in this population.

As a starting point, I decided to assess pretend play as this is the basis of most of the imagination literature in ASD, and the only relevant criterion in the international

diagnostic manuals. I decided to assess *past* pretend play (using self-report methods) in my participants to examine whether or not this has any effect on current RRBs. Asking participants about their past pretend play has inherent limitations; for example they are limited by the issue of self-report that I have already discussed. There is also the issue of memory; however, there is some evidence of the reliability of retrospective recall of childhood in the general population (for a discussion see Lillard & Smith, 2012). As mentioned in Chapter One (page 14), Sandberg et al. (2004) interviewed adults with disabilities including AS about their childhood pretend play and were able to gain detailed insight into these experiences; although they noted that recall of childhood experiences reflects the adults' current perceptions, and that the relationship between perception and reality in memories is not clear. Indeed, some research indicates that autistic individuals have difficulty with episodic and autobiographical memory (e.g. Bowler, Gardiner & Grice, 2000; Crane & Goddard, 2008; Goddard, Howlin, Dritschel, & Patel, 2007), although there is evidence that this is difficulty is limited to speed and specificity and that patterns of recall are similar to NT adults (e.g. Crane, Pring, Jukes, & Goddard, 2012). Regardless, the comparison between retrospective recall of childhood pretend play with current RRBs may be conflated with the individual's current perception of reality. However, I decided to include questions about past pretend play as the diagnostic criteria for ASD only list pretend play as an example of imagination, and in turn pretend play is the focus of much of the imagination literature in ASD. As adults generally no longer play pretend in the same way as children do (although see page 75), it is difficult to gauge their level of pretend play other than by questioning themselves or an informant. This information was elicited in two ways for this thesis, and these methods are discussed in section 2.5.2 (page 76). As I intended to measure imagination using a variety of methods, it was necessary to determine which other aspects of imagination should be assessed. In order to assist with this decision making process, I ran a short consultation study to gain insights and opinions about the suitability and the relevance of different types of task. This study is outlined in the sub-section below.

2.5.1 Consultation with experts

I consulted with three autistic individuals, and two professionals with extensive experience in ASD. I discussed drawing tasks such as design fluency and the impossible person task, tasks related to imagining the future and also pretend play questions with each participant. In each case the tasks were explained rather than demonstrated to each participant, and each participant was able to ask for clarification on the tasks. In most cases, the design fluency task was accompanied by an example of the meaningless line stimuli used in such tasks. I asked them whether or not they thought these tasks were suitable for autistic adults, whether or not they were relevant to imagination in ASD, and whether or not they thought that imagination was an important aspect of ASD. I had already started gathering responses to the pretend play questions at this point, and so this part of the interview was for evaluation purposes only. Table 2.1 below provides an overview of participants' responses.

Table 2-1 Overview of participants' opinions about imagination tasks and relevance of assessing imagination in ASD; Y=Yes, N=No, M=Maybe/Probably/Depends

	Drawing		Future thinking		Pretend play		Imagination
Participant	Suitable	Relevant	Suitable	Relevant	Suitable	Relevant	Relevant
Autistic individual	N	Y	M	M	M	M	Y
Autistic individual	Y	Y	Y	Y	Y	Y	Y
Autistic individual	Y	Y	Y	Y	M	Y	M
Professional	M	N	M	M	N	N	Y
Professional	Y	Y	Y	Y	N	Y	Y

Importantly, four out of the five participants felt that imagination was an important area to explore in ASD. In terms of these three particular areas, opinions were relatively mixed. None of the tasks were dismissed outright, but also none of the tasks was universally praised. The task that elicited the most concern was the pretend play questions, with concerns mostly due to understanding of the term pretend play (although examples were given) and the memories of individuals. The first issue is addressed by collecting this information using both questionnaire and interview method (see the following sub-section), as interviews allow for more detailed explanation of what is meant by 'pretend play' and other specialised terms, and I have already considered the effect of memory on this task in the previous sub-section.

Thinking about the future was criticised as it may be confounded with both routines and anxiety; however, the former is not necessarily a problem for this thesis as I am interested in the relationship between imagination and RRBS. Drawing tasks were mostly criticised in terms of measuring just one very specific part of imagination. There was an emphasis on having 'starting points' or prompts for tasks, in order to reduce the demands on the participant; open questions and tasks were seen as too demanding.

I decided not to assess general measures of creativity such as drawing or writing ability as these could be affected by individual differences that are not unique to ASD, and may be too sensitive to confounding variables such as motor skills and narrative ability. In a similar vein, I chose not to assess counterfactual reasoning as this confounds with logical ability. I also wanted to use tasks that are easily adapted to have cues, which were deemed important by the individuals with whom I consulted. I decided to measure a wide range of types of imagination in order to balance the advantages and disadvantages identified by my consultants; therefore I chose to measure both design fluency and thinking about the future as discussed with my participants. In addition, I included ideational fluency, to further ensure I was assessing a wide range of imaginative abilities. I opted to assess drawing and future thinking using fluency tasks as these are a more 'pure' measure of imaginative ability since the task demands are simple; they only require participants to generate and produce ideas. These tasks can also be scored in such a way as to assess flexibility and originality. It should be noted that these tasks are still limited by confounding factors; the design fluency may be affected by motor skills, and the ideational and future thinking fluency tasks by verbal ability. In the following sub-sections I shall describe in more detail why I chose the specific measures that I did.

2.5.2 Specific imagination tasks used in this thesis

2.5.2.1 Retrospective reports of pretend play

Pretend play was included as this is a very important area of research in ASD. However, this is obviously more difficult to study in adults who likely no longer engage in pretend play – although two of the participants that I consulted raised the point that some autistic adults do engage in a form of pretend play such as pretending to be

another person "in their head" or by taking part in live action role play. I have already discussed the issues surrounding the retrospective recall of pretend play, such as the effect of memory and self-perception (page 73).

The relationship between childhood pretend play and RRBs was assessed in two studies. The first, Study Four (Chapter Four, page 119), was carried out on data from an online survey of adults with self-reported clinical diagnoses of ASD. The second, Study Five (Chapter Five, page 139), was carried out in a group of adults with ASD with diagnoses of ASD confirmed by clinical reports and/or the DISCO as administered by myself. Since Study Four was designed as an online survey study I developed pretend play questions based on the DISCO (see Chapter Four, page 120). These were piloted with seven autistic individuals (see Chapter Three, page 82) who were able to answer them satisfactorily and did not report any specific problems with the questions. These questions were taken from the DISCO as this interview is based on the early work of Wing and Gould (1979), and assesses imaginative abilities in more detail than other diagnostic tools such as the ADOS. For Study Five, I administered the abbreviated form of the DISCO (see page 143), which includes the items on which I based Study Four's pretend play questions as part of its schedule. One disadvantage of this approach is the fact this makes it more difficult to compare the findings from Study Four (questionnaire items) with the findings from Study Five (interview). However, this disadvantage is balanced by the fact that administering these questions in interview format removes some of the issues surrounding the use of questionnaires as the interviewer is able to respond to participants' queries directly, provide further explanation and examples for specialised terms, and elicit more information from participants.

2.5.2.2 The AQ imagination subscale

As Studies One and Three were conducted online and there are no diagnostic tools for ASD that can be administered entirely online and anonymously, I included the AQ (see page 85 for more details) in order to check that participants identifying as autistic met the clinical cut-off for ASD, and to ensure that participants in Study One did *not* meet this cut-off. The AQ is not a screening or diagnostic tool, but it is useful as a measure of autistic traits. The AQ is divided into five subscales, including one that

represents imagination. Therefore, although I did not initially intend to measure imagination in this way, I used the AQ data as an additional assessment of imagination.

However, the subscales of the AQ, in particular imagination, have certain weaknesses. In their original paper, Baron-Cohen et al. (2001) did not use factor analysis to determine the subscales; these were instead determined conceptually. Several factor analyses have failed to find support for the proposed subscales (e.g. Austin, 2005; Hoekstra, Bartels, Cath & Boomsma, 2008; Kloosterman et al., 2011; Stewart & Austin, 2009). The internal consistency of an imagination subscale is usually low (Hurst, Mitchell, Kimbrel, Kwapil, & Nelson-Gray, 2007; Kloosterman et al., 2011; Stewart & Austin, 2009) and not all factor analyses even identify an imagination subscale (Austin, 2005). Nevertheless, it is the only measure of ASD traits that includes several items relevant to imagination that are not solely concerned with ToM or empathy. As such, the AQ was used as a measure of imagination but I will interpret findings from this scale with caution. Notably, this will also address the issue I raised earlier of comparing questionnaire and task measures, as this enables the RBQ-2A to be compared to a questionnaire measure of imagination.

2.5.2.3 Design and ideational fluency: The Torrance Tests of Creative Thinking

I initially chose to use two subtests from the TTCT (Torrance, 2008) to assess design fluency. The TTCT is available in two Forms, A and B; these subtests were taken from Form A as these particular subtests have been used in previous studies with ASD participants (e.g. Pring et al., 2012). The main reason I chose to use this version of the design fluency task was because they are standardised tests with normative data available. However, I only included two subtests rather than the whole test in order to reduce the length of time for participants, given the amount of other measures included in the study (see pages 140-147).

As discussed earlier, standardised norms were unfortunately not available for the TTCT tasks. However, these tasks are still useful as they are similar to other measures of design fluency with the benefit of standardisation in terms of administration and scoring; such that originality scoring is based on normative data rather than the responses of the sample, which could lead to circularity in measurement. These two design fluency subtests have also been used in previous

studies with ASD participants (Pring et al., 2012; Craig & Baron-Cohen, 1999). Having decided to include these two design fluency tasks, I also chose to include an ideational fluency measure from the TTCT, equivalent to a use of objects task but with written rather than spoken responses. I considered including a more conventional use of objects task; however, I decided upon this task to complement the figural TTCT subtests. There were two available ideational fluency tasks, one based around unusual uses for a cardboard box (Form A) and one based around unusual uses for a tin can (Form B). I initially planned to include both forms of the task; however, when piloting Study Five with an autistic individual, the study session was overly long. I therefore decided to only include the cardboard box task as this originates from the TTCT Form A along with the chosen design fluency tasks.

2.5.2.4 Thinking about the future: The personal future task

When deciding on what tasks to include in this thesis, I reviewed a wide range of future thinking tasks that have been used both within and outside the ASD population. Having chosen fluency tasks for two other measures of imagination, I identified a widely used future thinking fluency task that has not yet been used with autistic individuals, to the best of my knowledge; the personal future task ([PFT] e.g. MacLeod & Byrne, 1996; MacLeod et al., 1993). The PFT asks participants to generate positive and negative future events across different time periods (see page 270 for task instructions). This task has been used in other clinical populations and is conceptually similar to an ideational fluency task, so is a good analogue for that particular task.

One potential limitation of the personal future task is the fact that previous studies have found that anxiety and/or depression affects performance on the PFT; for example individuals with anxiety generate more negative events than non-anxious participants, whereas those with both anxiety and depression generate fewer positive events than those with anxiety alone (e.g. MacLeod & Byrne, 1996; MacLeod, Pankhania, Lee & Mitchell, 1997). This may present an issue given that mental health problems are elevated in the ASD population (e.g. Leyfer et al., 2006) and so participants may generate more negative events and/or fewer positive events as a result of their mental health rather than ASD traits. Previous research using other

methods has demonstrated that depression does not account for differences between autistic and NT participants' performance on future thinking tasks (Crane et al., 2013). However, Crane et al. (2013) did not distinguish between positive and negative future thinking as the PFT does and did not include a measure of anxiety; therefore I decided to include a measure of both anxiety and depression for this sample in order to test whether there was any relationship between mental health symptoms and performance on this task.

The time given for each condition varies across studies from thirty seconds (e.g. MacLeod et al., 1993) to three minutes (e.g. Quoidbach, Hansenne & Mottet, 2008). Initially I planned to allow two and a half minutes time limit, which is commonly used in the UOT to which the PFT is analogous. However, the autistic individual I piloted this study with suggested it was too long and so was reduced to two minutes per condition. Finally, as I am interested in the relationship between imagination measures, and both the PFT and ideational fluency tasks are verbal (albeit one spoken and the other written), any relationship between the two may be entirely explained by verbal fluency. Therefore I included a verbal fluency measure to control for this, based on previous studies (Benton, 1968; Lezak et al., 2004; Turner, 1999b).

2.5.3 Summary of imagination measures

Study Four and Five include a wide variety of imagination measures, in order to assess as much of the construct as possible. Study Four and Five will include the pretend play questions and AQ subscale. These were chosen in part because they are easily administered online; however, as I have noted, they have their limitations. Therefore the imagination measures for Study Five, covering pretend play, design fluency, ideational fluency and thinking about the future were chosen to improve upon Study Four's measures, and to examine a wider range of imaginative abilities. The latter three were also chosen to provide objective rather than subjective measures of imagination. These measures also allow for the exploration of the three components of imagination identified in Chapter One (page 12). Table 2.2 overleaf shows how these different measures relate to these components of fluency, originality and flexibility. Note that the pretend play questions do not map on to these components, which should be addressed in future research (page 183).

Table 2-2: Relationship between imagination tasks in Study Five and the three key components of imagination identified in Chapter One.

Component	Task
Fluency	Incomplete and Repeated Figures
	Unusual Use of Cardboard Boxes
	Personal Future Task
Originality	Incomplete and Repeated Figures
	Unusual Use of Cardboard Boxes
Flexibility	Unusual Use of Cardboard Boxes

2.6 Summary

At the beginning of this chapter I identified several methodological issues that arose over the course of this body of work. Firstly there was the issue of how to assess RRBs in an adult autistic population. I decided upon a self-report questionnaire, specifically an adapted version of the parent-report RBQ-2. Secondly there was the issue of the best procedure for running a factor analysis. I have addressed this by considering how previous research has approached this and deciding on one analytic strategy that I shall use throughout this thesis. There was then the issue of how to measure imagination, given there is no one preferred measure of imagination that purports to measure the entire construct. A related issue arose with the use of questionnaire methods to assess RRBs and experimental tasks to assess imagination. Therefore I addressed both issues by assessing imagination using a variety of methods, including both interview and questionnaire measures. This in and of itself presents a limitation as it means in-depth evaluation of each measure is not possible; however, for the purpose of this thesis I decided the priority should be on capturing as much of the imagination construct as possible. Finally I have discussed some of the issues relating to the recruitment of participants, which I shall take into consideration when interpreting findings from this thesis. The next chapter presents the early development and testing of the RBQ-2A.

3 Chapter Three: The Development of the Adult Repetitive Behaviours Questionnaire -2

The main aim of this chapter is to develop a self-report measure suitable for use with autistic adults. In order to achieve this aim I adapted an existing parent-report measure of RRBs, the RBQ-2 (Leekam et al., 2007), into a version suitable for adults and assessed this questionnaire using PCA in a sample of undergraduate students, and then assessed group differences between NT adults and adults with confirmed diagnoses of ASD. Studies One and Two reported in this chapter have been published in the *Journal of Autism and Developmental Disorders* (Barrett et al., 2015). The RBQ-2A is free available to download online[9].

3.1 Background

As described in the previous chapter (page 65), the RBQ-2 was chosen as the measure to develop into an adult self-report questionnaire. The RBQ-2 was originally tested in a large sample (*N*=679) of TD two-year-olds (Leekam et al., 2007). There was satisfactory endorsement of all RRBs, and EFA supported both a four- and two-factor solution. The four-factor solution comprised: repetitive motor movements, adherence to routine, restricted interests, and unusual sensory interests. The two-factor solution comprised RSMB, which corresponded to repetitive motor movements and unusual sensory interests, and IS, which corresponded to adherence to routine and restricted interests. The reliability and validity of the RBQ-2 has since been further supported in TD 15-month-olds (Arnott et al., 2010).

The RBQ-2 has also been assessed in children and adolescents with ASD (*N*=120; Lidstone, Uljarević et al., 2014). Reflecting Leekam et al.'s (2007) findings, PCA for this ASD sample also resulted in two components: RSMB and IS, with good internal consistency across the whole scale (α=.86) and for both RSMB and IS (α=.79, α=.83, respectively). Overall, the similarity of results across studies, satisfactory endorsement of items and good internal consistency support the construct validity of the RBQ-2 in children.

[9] The RBQ-2A can be downloaded here: http://sites.cardiff.ac.uk/rbq2a/download/

The RBQ-2A was initially developed as part of a Master's dissertation (Barrett, 2013). The original RBQ-2 was adapted for use with adults by editing the phrasing of questions. The phrase "*does your child*" was changed to "*do you*", and question 20 was changed from "*what sort of activity will your child choose if they are left to occupy themselves?*" to "*what sort of activity will you choose if you are left to occupy yourself?*" Child-specific words such as *toys* were either replaced with other similar concept words (e.g., *objects*) or removed entirely from items 1, 2, 11 and 14. In addition to piloting with NT participants (see Barrett et al., 2015), the RBQ-2A was also piloted with a small group of adults with ASD (N=7; 5 male, 1 female, 1 agender) aged 20-44 (M=27.61, SD=7.95). The total mean score for the RBQ-2A ranged from 1.3 to 2.35 (M=1.97, SD=.51) with a Cronbach's α of .94, indicating excellent internal consistency. Five participants provided feedback and reported finding the questions easy to understand and answer. This chapter continues this research and assesses the RBQ-2A in terms of reliability and validity across two different samples.

In Study One of this thesis reported below, I followed the pattern taken by previous RBQ-2 research by assessing the new RBQ-2A initially only with NT adults. In contrast to research on RRBs in NT children, research on the full range of RRBs in NT adults is sparse and generally this research is limited to particular behaviours (e.g. Markt & Johnson, 1993). Therefore, new evidence on self-reported RRBs in NT individuals will enable comparison with evidence from adults with ASD, providing further insight into the presentation of these behaviours in adults both with and without ASD. Beyond comparison purposes, it will be useful to further our understanding of the pattern of RRBs in an adult NT population. In Study Two, I then carried out additional assessments of internal consistency and construct validity with a smaller sample of adults in collaboration with colleagues in Australia.

3.2 Study One: Principal Components Analysis of undergraduate students

In this study, the RBQ-2A was administered to a university student sample and the structure of the RBQ-2A assessed using PCA. It was expected that two components would emerge, which would be consistent with most previous research, and that they

would be broadly similar to that found in the original RBQ-2 (Leekam et al., 2007; Lidstone, Uljarević et al., 2014) and show good internal consistency. However, it should be borne in mind that some researchers have found evidence for models with three or more components (e.g. Honey et al., 2008; Bishop et al., 2013). Indeed, Leekam et al. found evidence for both a two- and four-factor solution for the RBQ-2. The internal consistency of the RBQ-2A was also assessed using Cronbach's alpha. Finally, the AQ was included (Baron-Cohen, et al., 2001), which has been used widely to assess the presence of a variety of autistic traits in the general population (e.g., Hurst et al., 2007; Kloosterman et al., 2011; Stewart & Austin, 2009). It was expected that scores on the RBQ-2A would be significantly correlated with scores on the AQ, demonstrating construct validity.

3.2.1 Method

3.2.1.1 Participants

One hundred and sixty three UK university students were recruited, aged between 18 and 50 years (*M*=21.32 years, *SD*=4.67; 5 female, 67 male, 1 unreported). Participants were undergraduate and postgraduate students recruited via the university and social media. The first wave of participants (*N*=76) were recruited for my Master's dissertation, and the remainder were recruited during my PhD. In order to increase the number of male participants, male non-Psychology students (*N*=20) were also specifically targeted via the university Notice Board. Psychology undergraduates (*N*=120) received course credits in exchange for participation. Two participants scored at or above the clinical cut-off of 32 on the AQ and were removed from further analyses, resulting in a new sample (*N*=161) comprising 95 women and 65 men (1 unreported) with a mean age of 21.28 years (*SD*=4.69). The majority (*N*=136) were aged 18-22 years.

3.2.1.2 Materials

3.2.1.2.1 The RBQ-2A

The twenty items comprising the RBQ-2A are presented overleaf (Table 3.1) and these items are presented with full response options in Appendix 3 (pages 250-253). For thirteen items, there are four available responses, corresponding to *never or rarely* (1), *mild or occasional/one or more times daily* (2), *marked or notable/15 or*

more times daily (3), and *serious or severe/30 or more times daily* (4), with additional information given regarding the effects of behaviour for eight items. For the remaining seven items, only the first three response levels are offered.

Table 3-1 Full list of RBQ-2A items and number of responses per item.

Item	Full question	Shorthand	Response options
1	Do you like to arrange items in rows or patterns?	Arrange	4
2	Do you repetitively fiddle with items? (e.g. spin, twiddle, bang, tap, twist, or flick anything repeatedly?	Fiddle	4
3	Do you spin yourself around and around?	Spin	4
4	Do you rock backwards and forwards, or side to side, either when sitting or when standing?	Rock	4
5	Do you pace or move around repetitively? (e.g. walk to and fro across a room, or around the same path in the garden?)	Pace	4
6	Do you make repetitive hand and/or finger movements? (e.g. flap, wave, or flick your hands or fingers repetitively?	Hand/ finger	4
7	Do you have a fascination with specific objects? (e.g. trains, road signs or other things?)	Fascination	3
8	Do you like to look at objects from particular or unusual angles?	Angles	3
9	Do you have a special interest in the smell of people or objects?	Smell	3
10	Do you have a special interest in the feel of different surfaces?	Feel	3
11	Do you have any special objects you like to carry around?	Carry	3
12	Do you collect or hoard items of any sort?	Collect	3
13	Do you insist on things at home remaining the same? (e.g. furniture staying in the same place, things being kept in certain places, or arranged in certain ways?)	Home	4
14	Do you get upset about minor changes to objects? (e.g. flecks of dirt on your clothes, minor scratches on objects?)	Change	4
15	Do you insist that aspects of daily routine must remain the same?	Routine	4
16	Do you insist on doing things in a certain way or re-doing things until they are “just right”?	Redoing	4
17	Do you play the same music, game or video, or read the same book repeatedly?	TV/Music	4
18	Do you insist on wearing the same clothes or refuse to wear new clothes?	Clothes	4
19	Do you insist on eating the same foods, or a very small range of foods, at every meal?	Food	4
20	What sort of activity will you choose if you are left to occupy yourself?	Activities	3

As mentioned in the previous chapter (page 67), item 20 is typically removed from factor analytic studies of the RBQ-2. This is because it has a non-quantitative response scale that is distinct from the other items (Leekam et al., 2007). Although all of the RBQ-2A’s response scales are ordinal, the first nineteen items focus on the *frequency* or *severity* of a behaviour and therefore have a natural order (e.g. *one or more times daily* is clearly lower than *thirty or more times daily*). In contrast, item 20 asks about the *quality* of activities (e.g. a restricted range of activities, or a flexible and

varied range of activities); whether or not these items represent the higher or lower end of a scale is determined by the researcher. That is, a high score could reflect more restricted behaviours, or a high score could reflect more flexible behaviours depending on the design of the survey. In the case of the RBQ-2A, high scores on this item reflect more restricted behaviours. As a result of its removal from factor analysis, item 20 is usually included only in the total score rather than the subscale scores. Therefore item 20 has been neglected in previous research despite containing a potentially rich source of information regarding RRBs; I shall return to this item in Chapter Four (page 119).

The most extreme responses are rarely endorsed and so in order to make all items comparable with each other, the two most extreme responses for items 1-6 and 13-19 are collapsed into one, resulting in a three-point scale in accordance with previous research (Leekam et al., 2007; Lidstone, Uljarević et al., 2014). Mean scores are used when analysing the RBQ-2A so as to counteract the effects of missing data, calculated by dividing the participant's total score (out of 60) by the number of items actually answered, resulting in a mean total score between 1 and 3 for each participant. Subscale scores may then be calculated according to previous research, or as is the case here by running PCA in order to determine components.

3.2.1.2.2 The AQ

The AQ (Baron-Cohen et al., 2001) is a self-report questionnaire assessing the presence of autistic features in the general population. It comprises 50 statements based on the original triad of impairments (social interaction, social communication and social imagination; Wing & Gould, 1979), and other aspects of cognitive processing in ASD and was originally divided into five subscales (imagination, social skills, attention switching, attention to detail and communication) although this was not on the basis of empirical evidence. Each item is answered on a four-point scale ranging from *definitely disagree* to *definitely agree*. The questionnaire is then scored in a dichotomous manner, such that for half of the items the *agree* responses represent an autistic trait that is scored 1, and the *disagree* responses are scored 0; and vice versa for the remaining half of the items. The total number of 1s and 0s are then calculated and each participant receives a score out of 50, with higher scores indicating greater endorsement of autistic traits. In most studies, a score of 32 is considered the clinical

cut-off for ASD in accordance with the original paper (Baron-Cohen et al., 2001). Later research has recommended a more stringent cut-off of 26 (Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005). Here I chose to implement the the original cut-off score of 32 in order to preserve a larger sample size and greater variation in responses.

In order to assess the correlations between the individual AQ subscales and the RBQ-2A, the full range of scores (from 1 to 4) were analysed rather than the traditional dichotomous scoring described above (e.g. Kloosterman et al., 2011; Stewart & Austin, 2009). This was to increase the amount of information captured by the AQ and so that the AQ responses were more comparable to the RBQ-2A. The necessary items were reversed so that a higher score on the AQ subscales indicated a higher level of autistic traits; that is, a higher score on the AQ imagination subscale indicates more difficulties with imagination.

3.2.1.3 Procedure, data screening and statistical analyses.

Ethical approval was obtained from the university's School of Psychology Ethics Committee, and informed consent was obtained from the participants before they completed the questionnaires. The online questionnaires were presented on Google Documents, with the RBQ-2A presented first followed by the AQ[10]. The data were analysed using SPSS 20. The PCA was run according to the analytic strategy outlined in the previous chapter. The internal consistency for the whole scale and each of the resultant components was also assessed by calculating Cronbach's alpha (α) values. The correlations between age and RBQ-2A score, and between AQ and RBQ-2A scores, were also assessed. Finally, the difference in scores between resultant sub-scales were also tested, along with the correlations between the sub-scales.

3.2.2 Results

Table 3.2 on the next page shows the endorsement, mean total scores and standard deviations (SDs) for all 20 RBQ-2A items (see Appendix 3 [page 250] for the full RBQ-2A questions and responses). For every item, at least 14.9% of the sample

[10] At the time of designing this study, Google Documents was the only tool available to me that was free to use without restricting the amount of responses that could be collected; however, it does not allow for randomisation of question blocks and therefore there was a fixed order for questionnaires. The RBQ-2A was presented first as it is the primary measure for this study.

endorsed *mild or occasional* or higher. However, 81.9% of participants responded with *never or rarely* to item 18 (clothing), which resulted in this item being excluded from the analysis. The mean total score for all RBQ-2A items for the sample (*N* = 161) ranged from 1 to 2.55 (*M*=1.51, *SD*=.30). The internal consistency of the whole scale was good (Cronbach's α=.83).

*Table 3-2 Study One: Frequencies, percentages, means and SDs of NT participants' responses to all twenty RBQ-2A items (*N*=161).*

	Never or rarely	Mild or occasional/one or times daily	Marked or notable/15 or more times daily	Mean (SD)
1. Arrange	90 (55.9%)	69 (42.9%)	2 (1.2%)	1.45 (.52)
2. Fiddle*	31 (19.4%)	70 (43.8%)	59 (36.9%)	2.18 (.73)
3. Spin **	121 (76.1%)	33 (20.8%)	5 (3.1%)	1.27 (.51)
4. Rock ***	83 (52.5%)	53 (33.5%)	22 (13.9%)	1.61 (.72)
5. Pace *	99 (61.9%)	49 (30.6%)	12 (7.5%)	1.46 (.63)
6. Hand/ finger	65 (40.4%)	59 (36.6%)	37 (23%)	1.83 (.78)
7. Fascination	120 (74.5%)	39 (24.2%)	2 (1.2%)	1.27 (.47)
8. Angles*	120 (75.0%)	34 (21.3%)	6 (3.8%)	1.29 (.53)
9. Smell	125 (77.6%)	27 (16.8%)	9 (5.6%)	1.28 (.56)
10. Feel*	97 (60.6%)	54 (33.8%)	9 (5.6%)	1.45 (.6)
11. Carry*	124 (77.5%)	30 (18.8%)	6 (3.7%)	1.26 (.52)
12. Collect	106 (65.8%)	48 (29.8%)	7 (4.3%)	1.39 (.57)
13. Home**	74 (46.5%)	68 (42.8%)	17 (10.7%)	1.64 (.67)
14. Change	86 (53.4%)	60 (37.3%)	15 (9.3%)	1.56 (.66)
15. Routine	96 (59.6%)	54 (33.5%)	11 (6.8%)	1.47 (.62)
16. Redoing	72 (44.7%)	70 (43.8%)	19 (11.8%)	1.67 (.68)
17. TV/Music*	57 (35.6%)	74 (46.3%)	29 (18.1%)	1.83 (.71)
18. Clothes*	131 (81.9%)	24 (15.0%)	5 (3.1%)	1.21 (.48)
19. Food*	118 (73.8%)	35 (21.9%)	7 (4.4%)	1.31 (.55)
20. Activities	53 (32.9%)	91 (56.5%)	17 (10.6%)	1.78 (.62)

* *N* = 160; ** *N* = 159; ***N* = 158; Percentages given as valid percentages

3.2.2.1 Principal components analysis

Several participants had missing data (*N*=13) across the 18 RBQ-2A items being included in the analysis. A Missing Value Analysis was conducted on the dataset for these 18 items. As Little's Missing Completely at Random test was non-significant (*Z*[227]=194.60, *p*=.94) and the percentage of participants with missing data was small (8.07%) it was appropriate to exclude these participants from the analysis (Tabachnick & Fidell, 2014).

The final sample used for the PCA comprised 148 participants (87 female, 60 male, 1 unreported) with a mean age of 21.3 years (*SD*=4.79) and a mean total RBQ-2A score of 1.52 (*SD*=.30), and 18 items were entered into the analysis. The mean total RBQ-2A scores of the participants were significantly positively skewed, as found in the analysis of other RRB questionnaires in the typical population. Age was also positively skewed with five outliers. However, age was not significantly correlated with RBQ-2A score (r_s=.01, *p*=.88). Therefore, to preserve variation and sample size these five outliers remained in the PCA. Mean total AQ score was 13.82 (*SD*=5.99), which was normally distributed. Initial screening indicated that the assumptions of sampling adequacy (KMO=.79), multicollinearity and factorability (*Z*[153]=643.61, *p*<.001) were all met. The initial PCA solution resulted in six components with eigenvalues greater than one, explaining 62.03% of the variance. PA indicated that two components should be retained, so the analysis was re-run specifying two components.

Table 3-3 Study One: Pattern matrix for PCA of NT data, percentage of variance explained, internal consistency and descriptive statistics for each component

Rotated item loadings:	Component 1 Repetitive Motor Behaviour (RMB)	Component 2 Insistence on Sameness (IS)
1. Arrange	**.45**	.14
2. Fiddle	**.61**	.05
3. Spin	**.71**	-.08
4. Rock	**.87**	-.21
5. Pace	**.72**	-.07
6. Hand/finger	**.69**	.03
7. Fascination	.39	.26
8. Angles	.23	.22
9. Smell	.18	.31
10. Feel	.38	.25
11. Carry	.18	**.42**
12. Collect	-.08	**.50**
13. Home	.00	**.70**
14. Change	-.10	**.70**
15. Routine	-.10	**.72**
16. Redoing	.18	**.51**
17. TV/Music	.16	**.51**
19. Food	-.04	**.44**
Percentage of variance explained:	25.67%	10.16%
Cronbach's alpha (α):	.78	.73
Mean (SD)	1.65 (.46)	1.54 (.37)
Median (IQR)	1.50 (.67)	1.50 (.47)

When running the PCA with oblique rotation (Direct Oblimin), the correlation between the two components was above .32, confirming that this was an appropriate method of rotation (Tabachnick & Fidell, 2014). This solution explained 35.83% of the variance after Direct Oblimin rotation. Table 3.3 on the previous page shows the rotated item loadings (from the pattern matrix), percentage of variance explained and Cronbach's alpha values for each of the components.

There were no cross-loading items, but four items did not load sufficiently on to either component. The first component corresponds approximately to RSMB but with no sensory items; therefore it is named Repetitive Motor Behaviours (RMB). The second corresponds to insistence on sameness IS as in previous research. The internal consistency (Cronbach's alpha) of both scales is acceptable (> .70).

3.2.2.2 Correlations and subscale analyses.

For the following analyses, non-parametric statistics were used where the data were not normally distributed. Mean total scores on both RMB and IS were significantly positively skewed, although there were no outliers. Table 3.3 on the previous page shows the means, standard deviations, medians and interquartile ranges (IQRs) of the two components. There was a significant correlation between the two components (r_s=.35, p<.001). A Wilcoxon's signed ranks test indicated that participants scored significantly higher on RMB than IS (Z=-2.79, p=.005). These results indicate that there is a small but significant difference between sub-scale scores.

Mean total score on the RBQ-2A was significantly and positively correlated with mean total score on the AQ (r_s=.57, p<.001), which remained significant when removing two outliers on RBQ-2A (r_s=.56, p<.001). Mean total AQ score was also significantly positively correlated with both RMB (r_s=.35, p<.001) and IS (r_s=.54, p<.001). The social skills and communication subscales were positively skewed, with four outliers; however, removal of these outliers did not affect the pattern of results so they remained in the analyses. Table 3.4 overleaf shows the correlations of the AQ and RBQ-2A subscales with each other. All of the subscales of the AQ were

significantly correlated to the RBQ-2A and its subscales, with the exception of the imagination subscale.

Table 3-4 Study One: Spearman's ranked correlation coefficients between the RBQ-2A and the subscales of the AQ.

	Social skills	Attention switching	Attention to detail	Communication	Imagination
Total RBQ-2A	r_s=.33**	r_s=.52**	r_s=.43**	r_s=.36**	r_s=.15
RMB	r_s=.19*	r_s=.28*	r_s=.34**	r_s=.30**	r_s=.13
IS	r_s=.34**	r_s=.58**	r_s=.37**	r_s=.25**	r_s=.12

**Significant at the .01 level; *Significant at the .05 level

3.2.3 Discussion

This chapter represents the first stage of meeting my aim to develop a self-report measure of RRBs for adults in order to assess the relationship between imagination and RRBs in autistic adults. The specific aim of Study One was to test the RBQ-2A in NT adults. In addition to being a useful stage in the development and testing of RBQ-2A, Study One provided new data on the pattern of RRBs in NT adults. An adapted version of a parent report measure of RRBs, the RBQ-2A, was administered to a university student sample. PCA resulted in a two-component structure, one comprising motor behaviours, RMB, and the other behaviours related to routines and a preference for sameness, IS. As predicted, scores on the RBQ-2A were also correlated with another measure of autistic traits, the AQ (Baron-Cohen et al., 2001); in addition all of the AQ subscales, with the exception of imagination, were significantly associated with the RBQ-2A and its subscales. Finally, undergraduates scored significantly higher on RMB than IS.

The RMB component identified in Study One is similar to a component that is commonly found in previous research, RSMB (e.g., Cucarro et al., 2003; Leekam et al., 2007; Lidstone, Uljarević et al., 2014; Richler et al, 2010). Five of the six RMB items consistently load onto the factor that in previous research included motor and sensory items (RSMB), the exception being item one, *arranging objects*, which loaded here and in Leekam et al.'s (2007) analysis but not in Lidstone, Uljarević et al.'s (2014) analysis. Whereas it was predicted that the RBQ-2A would form two components, the results here were not entirely in line with predictions. The major difference between RMB

found here and RSMB in previous research is the lack of sensory items loading onto this component, which was not predicted. The second component corresponded to IS. This result was more comparable to previous research using the RBQ-2 in an ASD sample, with five items (13-17) loading in exactly the same way as in Lidstone, Uljarević et al.'s study.

In summary, the components yielded by the present PCA are similar to previous research with NT children and autistic children using the RBQ-2, with the exception of sensory items. Items two to six[11] load onto RSMB in the child version of the questionnaire (Leekam et al., 2007; Lidstone, Uljarević et al., 2014) and RMB in the present study, and items 13 to 17 load onto IS across all three studies, supporting the construct validity of the questionnaire.

To my knowledge this the first study to look at the component structure of RRBs in NT adults, and so there are no analogous populations to compare them against. Therefore the most probable reason for the difference between the present PCA solution and previous research is that the present sample comprised NT adults whereas previous research examined NT children (Leekam et al., 2007) and children and adolescents with ASD (Lidstone, Uljarević et al., 2014). Certain types of behaviours may be associated with younger children or children with ASD rather than NT adults. For example, mean scores on items 3 (spinning) and 11 (carrying around objects) were higher in NT children (Arnott et al., 2010; Leekam et al., 2007) than in the present study. Moreover, autistic individuals show higher levels of sensory symptoms than NT individuals (e.g., Ben-Sasson et al., 2009; Kern et al, 2006; Leekam, Nieto, Libby, Wing, & Gould, 2007; Rogers & Ozonoff, 2005) and these items were not well endorsed by the present sample. Interestingly however, the participants scored themselves significantly higher in terms of RMB than in terms of IS. This may be because these items are tapping into behaviours associated with fidgeting and fiddling that are relatively common in typical populations.

[11] These are: fiddling, spinning, rocking, pacing and repetitive hand/finger movements. See Appendix 3 (pages 250-253) for a complete list of RBQ-2A items.

The different loading of certain items may also reflect the fact that certain behaviours do not clearly fall into one particular category. For example, eating a small range of foods (item 19) formed part of IS in the present study but has previously loaded on to RSMB (Lidstone, Uljarević et al., 2014) as well as IS (Leekam et al., 2007); eating a small range of food may be a result of sensory issues or insistence on sameness and is therefore conceptually related to both subscales. The fact that these sensory items do not load in this analysis may reflect the slightly different wording of the questions. In particular, the sensory items 8 and 9 both ask about a *special interest* which is not a common or everyday term. As a result participants may be more reluctant to endorse these items. However, the wording is the same for the parent version of the questionnaire in which sensory items do load onto a component (Lidstone, Uljarević et al.; Leekam et al.). It is not obvious why the wording of the sensory items would affect self-reporting NT adults differently to parents reporting on their children. Furthermore, in the next chapter, I present data from an online study of autistic adults in which the sensory items do load onto a component (page 112). Finally, of the eighteen items included in the analysis, the four items that did not load onto any component were answered on a three-point rather than a four-point scale. Given that the responses are collapsed before any analysis takes place, it is unlikely that this had any effect on the analysis; although it may be the case that the lack of a fourth response option resulted in more participants endorsing the mild/occasional response option as the less 'extreme' response. However, these same items are scored on a three-point scale in the parent-report version of the RBQ-2, and therefore this does not seem a likely explanation.

Although the primary goal of Study One was to assess the RBQ-2A's reliability and validity in an undergraduate sample, the inclusion of the AQ allowed me to assess the relationship between imagination and RRBs, bearing in mind the criticisms I raised in the previous chapter regarding the imagination subscale of the AQ (page 77). Interestingly, in this sample the only subscale *not* associated with any of the RBQ-2A subscales was imagination. This supports Kloosterman et al.'s (2011) previous finding that imagination as measured by the AQ is associated with communication/mindreading abilities but not resistance to change in an

undergraduate population. This does not necessarily impact negatively on the case for a relationship between RRBs and imagination; indeed Honey et al. (2007) identified a relationship between RRBs and play that was specific to autistic children.

There are some limitations in terms of the sample. Firstly, the sample comprised only university students and is therefore limited in age and IQ distribution. However, this will be addressed by assessing more representative samples later in this chapter (page 94). A second limitation lies in the relatively small sample size for a PCA. There are no concrete rules for how large a sample size is needed for PCA (e.g. Hogarty, Hines, Kromey, Ferron, & Mumford, 2005). Some argue that at least 100-300 cases are needed, whereas others recommend a specific ratio of cases to variables, ranging from 3:1 to 10:1 (e.g. Guadagnoli & Velicer, 1988; Tabachnick & Fidell, 2014; Williams et al, 2010). However, such rules of thumb have been found to be unreliable (e.g. Guadagnoli & Velicer, 1988; MacCallum, Widaman, Shaobo & Hong, 1999).

PCA was deemed appropriate here for the following reasons. First and foremost, the KMO measure of sampling adequacy was .79 which is well above the acceptability criterion of .5 (Field, 2013). The PCA also met all other assumptions of the analysis. Secondly, if communalities are above .5 then samples between 100 and 200 are adequate as long as there are few factors with a small number of salient variables (MacCallum, et al., 1999). Here there are two components with six and eight variables each, and all communalities were greater than .5 before rotation (M=.62). Finally, it is desirable for a component to have five or more loadings at .5 or greater (Osborne & Costello, 2009); however, if a component has four or more loadings greater than .6 then the pattern may be interpreted whatever the sample size (Guadagnoli & Velicer, 1988). Here RMB has 5 item loadings above .6, suggesting it is reliable, although IS has just 3 loadings above .6 so does not meet this criterion. Nevertheless, both components meet Osborne and Costello's (2009) criterion. Therefore, although the sample size is relatively small for PCA, given these strengths and the overall similarity of the PCA solution to previous research (with the exception of the sensory items), it presents only a minor limitation. Furthermore, the RBQ-2A was assessed in a larger sample, comprising participants with ASD, which will be reported in Chapter Four.

As part of collaboration with researchers in Melbourne, Australia, RBQ-2A data were available from adults with ASD diagnosed by a clinician and confirmed by the researchers, along with a group of NT adults matched on IQ. This enabled me to assess group differences with adults confirmed to have a diagnosis of ASD. In addition, the effects of IQ could be ruled out. Furthermore, when recruiting the NT control group, diagnoses of ASD were screened for as well as anxiety and mood disorders, allowing us more confidence in describing this group as NT. The next study assessed the differences in RBQ-2A between these two groups as an additional measure of criterion validity.

3.3 Study Two: Comparison between ASD and NT participants

In Study Two, we assessed the group differences between a sample of adults confirmed to have an ASD diagnosis and an NT sample. It was hypothesised that the ASD sample would score significantly higher than the NT group on the RBQ-2A. If the expected group differences are found, then this supports the construct validity of the RBQ-2A. This study also explored the reliability of the subscales found in Study One in a more representative NT sample.

3.3.1 Method

3.3.1.1 Participants

Data were collected from two groups of adults who were participating in a larger study of the roles of melatonin, cortisol and psychopathology in sleep disturbance in adults with ASD being carried out in La Trobe University, Melbourne, Australia[12]. All participants completed a screening questionnaire that included first language, ASD diagnosis or family history of ASD, comorbid diagnoses, employment and marital status, living arrangements and medication. To be accepted into the study, ASD adults needed to have a confirmed clinical diagnosis of ASD (clinical reports were provided), while NT adults all had an AQ score <26 (Woodbury-Smith et al., 2005). Any individual with a diagnosis of schizophrenia was also excluded from the study. Furthermore, NT adults were excluded if they had a first degree relative with ASD, or if they had an anxiety or mood disorder. All participants had at least average

[12] The sharing of this data was approved by both Cardiff University School of Psychology Research Ethics Committee and by La Trobe University's Human Ethics Committee.

intellectual ability (IQ > 80) and the NT and ASD samples were group-wise matched for Performance IQ (PIQ), Verbal IQ (VIQ) and Full Scale IQ (FSIQ), as shown in Table 3.5 (page 96).

The ASD group (*N*=29) comprised 15 women and 14 men aged 21.86 to 44.23 years (*M*=34.27, *SD*=6.29). The NT group (*N*=37) comprised 23 women and 14 men aged 21.90 to 43.32 years (*M*=30.75, *SD*=6.21). For the NT group, 48.6% were employed on a full time basis, 24.3% worked part-time, 24.3% were students and 2.1% were unemployed. For the ASD group, 27.6% were employed full time, 24.1% worked part-time, 6.9% were home keepers, 13.8% were students and 27.6% were unemployed. ASD participants were recruited through various Australian Autism Associations, the research centre's Research Participant Registry as well as flyers displayed at clinics specialising in ASD. The NT participants were recruited primarily through the School of Psychological Science participant registry, social media, and flyers placed around the university and in the general public. This study received ethical approval from La Trobe University's Human Ethics Committee. Informed consent was obtained for all participants.

3.3.1.2 Materials

As in the previous studies all participants completed the RBQ-2A and the AQ as part of an online survey comprising several different questionnaires. The subscales of the AQ were not assessed in this study.

As noted above, all ASD participants provided a copy of their clinical report confirming their diagnosis. They were also assessed using the ADOS-2 (Lord et al., 2012), a semi-structured observation schedule that is used clinically to diagnose ASD and confirm diagnoses for research purposes. ADOS-2 data were available for 27 of the ASD group; the remaining two participants were recruited interstate and funds were not available to travel to assess them. The total ADOS-2 score ranged from 4 to 19 for this sample (*M*=11.59, *SD*=4.23). Six participants (21%) did not meet the criteria for ASD according to the recently revised ADOS-2 algorithm (Lord et al., 2012), which is similar to the rate reported by Bastiaansen et al. (2011). However, when removing participants who did not meet ADOS-2 criteria for ASD from the analyses, the pattern of results did not change (with the exception that RMB no longer significantly

correlated with the AQ). Therefore, as these participants had a confirmed clinical diagnosis of ASD they remained in the analysis to preserve statistical power.

Twenty-three (79%) of the ASD participants and 34 (92%) of the NT participants completed the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2008) to gain estimates of VIQ, PIQ and FSIQ. Four of the ASD participants had recently completed the Wechsler Adult Intelligence Scale – III as part of their diagnostic assessment and IQ scores were obtained from their diagnostic reports. Participants who were not assessed lived interstate (2 ASD, 3 NT). No participants scored below 89 on any of the IQ measures. Participants who did not complete an IQ assessment held, or were in the process of completing, a diploma or undergraduate degree and thus were considered high-functioning. The means, SDs and ranges for all three IQ scores for both groups are shown in Table 3.5 below.

Table 3-5 Study Two: VIQ, PIQ and FSIQ ranges, mean scores and SDs and correlation with mean total RBQ-2A scores for both NT and ASD groups.

	NT				ASD			
	Mean (SD)	Range	N	Correlation with RBQ-2A	Mean (SD)	Range	N	Correlation with RBQ-2A
VIQ	115.06 (8.77)	97-130	34	r_s = -.17 p = .34	118.92 (11.64)	95–143	25	r = .07 p = .73
PIQ	115.74 (9.93)	96-134	34	r_s = -.06 p = .75	116.48 (13.68)	89–150	25	r = -.07 p = .74
FSIQ	117.44 (8.61)	99-133	34	r_s =-.10 p = .59	120.22 (12.08)	96-145	27	r = .03 p = .90

3.3.1.3 Data screening and statistical analyses

The age of the NT group was positively skewed, so square root transformation was applied to the ages of both samples; the ASD group was significantly older than the NT group (t[1, 60.26]=5.08, p=.03). Therefore any group differences may be confounded by age. However, age was not significantly correlated with participants' mean total score on the RBQ-2A in either the NT (r_s=.08, p=.645) or ASD group (r=-.02, p=.94). Welch's t-tests, which correct for unequal sample sizes, showed no significant

differences between the two groups in terms of VIQ (t[1, 42.8)=1.94, p=.17), PIQ (t[1, 41.64]=.05, p=.82) or FSIQ (t[1, 45.39=1.02, p=.32). Furthermore, mean total score on the RBQ-2A was not significantly correlated with VIQ, PIQ or FSIQ in either of the participant groups (see Table 3.5). These data were assessed by testing the between-group differences, the within-group differences for each group separately, and the correlations between the RBQ-2A and AQ, along with the correlations amongst the sub-scales.

3.3.2 Results

The means, SDs, medians and interquartile ranges (IQRs) for the RBQ-2A across the two groups are shown in Table 3.6 below. Mean RBQ-2A total scores ranged from 1 to 1.8 in the NT group and from 1.05 to 2.75 in the ASD group. Participants in the ASD group scored significantly higher on the RBQ-2A than participants in the NT group (Z=-5.43, p<.001, r=-.67), indicating a large effect size. No significant sex differences were found in mean RBQ-2A score in either the NT or ASD group. There were significant positive correlations between mean total RBQ-2A score and mean total AQ score in both ASD participants (r_s=.56, p=.002) and NT participants (r_s=.42, p=.01). Finally, the internal consistency of the RBQ-2A was acceptable in the NT group (α=.73) and excellent in the ASD group (α=.91).

Table 3-6 Study Two: Means, SDs, medians and IQRs for the mean total RBQ-2A score and the components RMB and IS

	ASD group		NT group	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Total RBQ-2A score	1.84 (.45)	1.90 (.78)	1.25 (.19)	1.20 (.25)
RMB score	1.59 (.45)	1.50 (.58)	1.26 (.28)	1.17 (.33)
IS score	2.04 (.55)	2.0 (1.0)	1.29 (.25)	1.25 (.25)
RSMB score	1.64 (.47)	1.60 (.70)	1.20 (.24)	1.10 (.30)

3.3.2.1 Subscale Analysis

Mean scores on the two subscales identified in Study One, RMB and IS, were calculated for all participants. The means, SDs, medians and IQRs of the mean scores

on each component for the two groups are shown in Table 3.6. The ASD group scored significantly higher than the NT group on both RMB (Z=-3.32, p=.001, r=-.41) and IS (Z=-5.51, p<.001, r=-.68), indicating medium and large effect sizes respectively. Unlike the findings from Study One, there were no significant differences between scores on RMB and IS for the NT group (Z=-.90, p=.37). However, in the ASD group participants scored significantly lower on the RMB subscale compared to the IS subscale (t[28]=-5.62, p<.001). There were also no significant sex differences in either of the subscales in both groups (p>.05). In the ASD group, the internal consistency was acceptable for RMB (α=.75) and good for IS (α=.87). For the NT group internal consistency was questionable for RMB (α=.65) and poor for IS (α=.55). In addition, RMB and IS were significantly correlated in the ASD group (r=.64, p<.001) but not in the NT group (r_s=.15, p=.37).

The subscales of the RBQ-2A as identified from Study One exclude the sensory items as defined by Lidstone, Uljarević et al. (2014; items 7, 8, 9 and 10[13]). As sensory atypicalities are a behavioural feature of ASD, an RSMB variable was created with these items, comprising the RMB and sensory items (items 1-10, see Appendix 3, page 250). The mean RSMB score of the NT group was 1.20 (SD=.24; α=.76) and the mean RSMB score for the ASD group was 1.64 (SD=.47; α=.85). The medians and IQRs are displayed in Table 3.6. The ASD group scored higher than the NT group in terms of RSMB (Z=-4.20, p<.001, r=-.52), with a large effect size. There was no significant within-participant difference between RSMB and IS for the NT group (Z=-1.68, p =.09) but there was for the ASD group (t[28]=-5.11, p<.001). Again there were no significant sex differences in terms of RSMB in either group (p>.05).

3.3.2.2 Subsidiary analyses

The RBQ-2A scores of the Study One sample were also compared to the NT group from Study Two. In order to create matched groups, only the older participants from each group (aged 23 years and older) and those with an AQ score <26 were selected. This resulted in two NT groups: one from Study One (N=20) and one from Study Two (N=34), which did not significantly differ in terms of age (Z=-1.68, p=.09) or

[13] Lidstone, Uljarević, et al. (2014) also included items 18 and 19 as sensory items. However, these were not included here as 18 was excluded from the PCA and 19 loaded with IS.

AQ score (t[1, 36.77]=3.54, p=.07). The mean age, RBQ-2A and AQ scores are displayed in Table 3.7 below. RBQ-2A scores were positively skewed in the Study Two sample, so the RBQ-2A scores of both were transformed using natural logarithm for this analysis. Group comparison of RBQ-2A total scores showed that the Study One NT group scored significantly higher on the RBQ-2A than the Study Two NT group (t[1, 27.83]=12.04, p=.002). The Cronbach's alpha of the older participants from Study One was good (α=.87), lending further support to the internal consistency of the RBQ-2A in older adults. In addition, when this Study One NT subgroup was compared with the Study Two ASD participants aged 23 years and older (N=26; M age=35.64 [SD=5.03]; M RBQ-2A score=1.83 [SD=.44]), the Study Two ASD participants still scored significantly higher than the Study One subgroup (t[1, 44]=8.02, p=.007).

Table 3-7 Study Two: Means, SDs, medians and IQRs for the mean total RBQ-2A and components scores for the two NT groups

	Study One NT group		Study Two NT group	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Age (years)	30.0 (8.59)	25.51 (12.04)	31.52 (5.88)	30.01 (10.12)
Total RBQ-2A	1.51 (.33)	1.40 (.39)	1.24 (.17)	1.20 (.25)
Total AQ	14.4 (5.09)	-	11.79 (4.60)	-

3.3.3 Discussion

This study explored the difference in RBQ-2A scores between NT and adult ASD participants. In line with the hypothesis, participants with ASD scored significantly higher on the RBQ-2A than IQ-matched NT participants, in terms of both total score and scores on the subscales identified in Study One. This supports the construct validity of the RBQ-2A in adults as it is able to detect differences in RRBs between autistic and NT groups. Additionally, the internal consistency of the RBQ-2A was further supported in this study, with the exception of the IS subscale in the NT group. Although the RMB subscale was <.70 which is generally interpreted as questionable, it can be argued that when assessing psychological constructs, values below .70 can be expected and accepted (Field, 2013). It may be that the internal consistency is higher

for the ASD group as the items are more relevant for this group than the NT participants.

These results indicate that the RBQ-2A is able to distinguish between NT and ASD participants at a group level, as NT participants rate themselves lower on RRBs. However, this finding would be strengthened by assessing the accuracy of self-report, by testing the correlation between the RBQ-2A and another type of measure such as parent-report or observation. Some argue that individuals with ASD find introspection and reporting their symptoms difficult (e.g., Williams, 2010). Nevertheless, group differences were detected, indicating that adults with ASD are able to self-report RMB and IS behaviours with accuracy.

Interestingly, while there is no significant difference between both versions of RMB and IS in the NT sample, participants with ASD rate themselves significantly higher on IS compared to RMB. This suggests that among older adults with ASD, reported IS behaviours are particularly high compared to RMB. This is supported by some research that indicates whereas RSMBs have reduced by adulthood, levels of IS remain high, although this distinction is not always found (e.g. Esbensen et al., 2009). This pattern was repeated when including sensory items in the RMB factor to create RSMB. In addition, the NT group scored themselves significantly lower compared to the ASD group on all subscales. For both groups, addition of sensory items increased the internal consistency compared to RMB. For the NT group, addition of sensory items slightly reduced the mean (from 1.26 to 1.20) whereas for the ASD group, addition of sensory items increased the mean (from 1.59 to 1.64), increasing the difference between the two groups established on the RMB subscale. This reflects previous research that found autistic individuals show higher levels of sensory symptoms than NT individuals (e.g., Kern et al. 2006). Given these results, it is important to retain the sensory items in the RBQ-2A when it is administered to an ASD sample. However, there is a caveat with this analysis in that this version of the RSMB subscale is theoretically driven rather than based on previous empirical evidence. The issue of whether or not to include sensory items in the RBQ-2A will be returned to in Chapter Four, which describes a larger sample of autistic adults.

Scores on the RBQ-2A were higher in Study One compared to the NT group from Study Two. Interestingly, the students in Study One also rated themselves higher in terms of RMB compared to IS, whereas there were no within-group differences in the Study Two sample; this may reflect a different pattern of RRBs as well as different levels of RRBs. However, when matching the two NT groups in terms of age and total AQ score, the Study One university students still scored higher on the RBQ-2A than the Study Two sample. Therefore it seems unlikely that either differences in age or AQ score account for the differences in RBQ-2A scores of both two NT groups. Although the two samples were recruited from different countries, both are Western countries, making country of origin an unlikely explanation for the difference in RBQ-2A score. A more plausible explanation might be that in Study Two, NT participants with anxiety or mood disorders were excluded, while this did not occur in Study One. Furthermore, the participants in Study One were university students and it has been shown that university students have high levels of anxiety symptoms compared to the general population (e.g., Andrews & Wilding, 2004; Stallman, 2010). Anxiety may be related to RRB, for example via rituals in university students (Markt & Johnson, 1993) and in children and adolescents with ASD (e.g., Lidstone, Uljarević et al., 2014; Rodgers et al., 2012).

3.4 General Discussion

Overall, these results indicate that the RBQ-2A is a useful new self-report measure for assessing RRBs in adults. Study One found a two-component structure in an NT university student sample that approximately corresponds to previous research using other measures of RRBs, with the exception of sensory items. Study One also supported previous research (Kloosterman et al., 2011) by failing to show a relationship between the AQ imagination subscale and RRBs. Study Two, using a more representative sample of adults, found that participants with ASD score significantly higher than IQ-matched NT participants on the RBQ-2A total and subscale scores, which would be expected from an accurate measure of RRBs. The internal consistency of the RBQ-2A and its subscales was high for adults with ASD in Study Two, providing further support to its reliability as a measure of RRBs for adults with ASD; both studies also support the use of the RBQ-2A as a measure of RRBs in NT adults. Additionally,

both studies showed that RRBs are significantly associated with AQ score (with the exception of the imagination subscale in Study One), supporting the construct validity of the RBQ-2A. Subsidiary analyses in Study Two also indicated that although the university sample in Study One had higher levels of RRB than the adults in Study Two, this was unlikely to be due to differences in age. Given the potential relationship between RRBs and anxiety, it can be speculated that the higher incidence of anxiety in university populations (Andrews & Wilding, 2004; Stallman, 2010), alongside the screening for significant psychopathology in the Study Two NT sample, may have biased the Study One group to relatively higher scores[14]. Further research is needed to explore both the association between psychopathology symptoms and RRBs, and whether the RBQ-2A can accurately distinguish between ASD and psychological disorders that involve high levels of RRB, such as OCD and other specific anxiety disorders.

An unexpected finding from Study One is that most sensory items from the RBQ-2A did not load onto either component; although it should be noted that this was the first PCA carried out on an adult NT sample of RRB data. Therefore it is not known whether this reflects a genuine finding, or reveals a weakness in the RBQ-2A, as discussed in this chapter (pages 91-92). It may be that the RBQ-2A does not capture a wide enough range of sensory behaviours, as it includes just six items from the original set of 25 items in the DISCO (corresponding to items 7, 8, 9, 10, 18 and 19 in the RBQ-2A[15]) and these items do not cover all sensory modalities. Other questionnaires are more detailed, for example the Glasgow Sensory Profile (Robertson & Simmons, 2013) covers seven modalities, including auditory, vestibular and proprioceptive, which are not included in the RBQ2-A. Another explanation could be that the participants in the present studies may report an unusually low number of sensory behaviours. The Glasgow Sensory Profile has provided evidence of a wider range of sensory behaviours in the general population (Robertson & Simmons, 2013). Furthermore, 45% of an NT sample (*N*=20) reported at least one marked sensory atypicality on the Sensory

[14] However, see Study Five for a failure to show a relationship between the RBQ-2A and anxiety (pages 158-159).

[15] Note that in Study One, item 18 was excluded due to too few endorsements (page 87), and item 19 loaded on to IS (see page 92 for a discussion).

Preferences Questionnaire (Kent, 2014, unpublished doctoral thesis). In contrast only 15.54% of the participants entered into the PCA in Study One responded to items 7-19 with *marked or notable* and no NT participant endorsed *marked or notable* on any of these items in Study Two. These findings indicate that sensory symptoms are not common in the NT participants across both studies, whereas they are highly prevalent within the autistic population (e.g., Boyd et al., 2010; Kern et al., 2006; Leekam et al., 2007) and in Study Two's ASD sample.

3.4.1 Limitations

There are some important limitations to consider for the studies reported here. As the RBQ-2A was adapted from a measure for children, it may be missing certain items that are applicable only to adults; for example, IS behaviours may increase with age (e.g. Bishop et al., 2013; Moore & Goodson, 2003), and therefore more detailed questions in relation to IS may improve an adult measure. In addition, the RBQ-2A as a self-report measure is currently suitable only for more able adults. Therefore the RBQ-2A, and any associated findings, are only generalizable to this population. In both studies, there was significant positive correlation between the AQ and the RBQ-2A. However, this correlation might be partly explained by the fact both are self-report measures. As mentioned, it is therefore important to compare the RBQ-2A with other measures of autistic traits such as interviews or informant-report questionnaires. In Chapter Five of this thesis, the abbreviated DISCO (Carrington, Kent, et al., 2014) was administered to participants alongside the RBQ-2A, so the relationship between self-report and researcher ratings can be assessed. Similarly, the RBQ-2A should be assessed alongside an independent measure of RRBs, as it is closely related to the DISCO, which will also be addressed in Chapter Five.

A general criticism of the RBQ-2A is the fact that it is a self-report measure, which is a somewhat contentious issue in ASD literature, as I noted in Chapters One and Two. There is some evidence that self-report is not reliable in autistic populations (e.g. Dewrang & Sandberg, 2011; Johnson et al., 2009). However, in the case of the RBQ-2A, ASD participants scored higher in terms of internal consistency than NT participants and the RBQ-2A successfully discriminated between ASD and NT participants, supporting the use of the RBQ-2A in this population. As exemplified by

the AQ (Baron-Cohen et al., 2001), certain RBQ-2A items do ask about *preferences* rather than actual behaviours (e.g. item 1: "*Do you like to arrange items in rows or patterns?*"). Other questions ask about behaviours which may present more of a difficulty; however, these questions do not explicitly address psychological states. During piloting, participants were asked for feedback on questions and none reported any particular difficulty with the RBQ-2A questions, although two participants with ASD found it difficult to respond to the AQ. The effect of self-report will be further examined in Chapter Five.

3.4.2 Conclusion

Chapter One described previous factor analytic studies of RRBs in ASD and research relating to adults with ASD, concluding that a self-report measure of RRBs for autistic adults is needed. Therefore the studies presented here represent an important new contribution with the development of an adult self-report measure of RRBs, which can be used with both ASD and NT populations. The need for such a measure is indicated by the findings of the studies, which indicate that self-reported RRBs in adulthood may present slightly differently than carer-reported RRBs in childhood. In particular, although the subtypes of RRBs remain the same, the specific behaviours that are endorsed differ. The potential clinical applications of the RBQ-2A include its use as a signposting questionnaire or as a supplement to diagnostic interviews such as the DISCO. Its utility may be especially helpful given that the AQ does not give an adequate or reliable assessment of RRBs across typical populations (e.g., Kloosterman et al., 2011; Lau et al., 2013). It may also be useful for other clinical conditions that show RRBs, such as OCD, Gilles de la Tourette syndrome and Parkinson's disease (Langen et al., 2011). From a research perspective, the RBQ-2A allows for the opportunity to accurately and reliably explore RRBs directly in adults both with and without ASD. Overall, these results show that the RBQ-2A is a promising self-report measure of RRBs in adults. However, further research should involve older and more diverse NT participants that include representation of a range of ethnic and socio-economic statuses, as well as a larger sample of adults with confirmed diagnoses of ASD. Although the RBQ-2A is a descriptive questionnaire that can only identify a profile of behaviours as perceived by self-informants, further research comparing self-

and other-informant RBQ-2A questionnaires and its use with clinical interviews may help to assess how well the RBQ-2A complements and streamlines the diagnostic process in clinical practice. Chapter Four addresses some of these issues and builds on this chapter by assessing the factor structure of the RBQ-2A in a larger sample of adults with ASD. In addition, Chapter Five further tests the RBQ-2A's reliability and validity in adults with ASD by assessing the RBQ-2A against additional measures of RRBs. Both of these chapters also use the RBQ-2A as the primary measure of RRBs when addressing the main question of the thesis ("what is the nature of the relationship, if any, between imagination and RRBs in autistic adults?").

4 Chapter Four: Assessing the RBQ-2A and its association with reported pretend play in autistic adults

In Chapter Three, I described the development and initial testing of the RBQ-2A in two samples, and showed the RBQ-2A to have acceptable reliability and validity. In this chapter, I will extend these findings by analysing the component structure of the RBQ-2A in a sample of adults with ASD. This chapter will also address any differences that arise when assessing the component structure of the RBQ-2A with an NT or ASD sample. Finally, I will test the possible association between RRB and imagination in autistic adults using self-reported measures of imagination in childhood and adulthood as part of the main aim of the thesis. A large online survey of RRBs, ASD traits and history of childhood pretend play in autistic adults was conducted for both studies.

4.1 Background

In the previous chapter, a PCA carried out on NT undergraduate student data (Study One) revealed a two-component structure of RRB when assessed using the RBQ-2A. Although the identification of two components is common in previous research (e.g. Leekam et al., 2007; Lidstone, Uljarević et al., 2014), the items comprising these two components were somewhat unusual; specifically, the sensory items did not load onto either component. However, as this was the first PCA carried out on RRB data from NT adults, it cannot be said for certain whether or not this finding is an anomaly or a reflection of the actual structure of RRBs in an NT population. Study One also found that in an undergraduate population, imagination is the only AQ subscale not associated with RRBs. In line with predictions, autistic adults scored significantly higher on the RBQ-2A and its two components compared to NT adults (Study Two). This provides the first evidence that the RBQ-2A is suitable for use in research with autistic adults, which is the intended use for this questionnaire. The next stage of the research was to assess the RBQ-2A in a larger sample of adults with ASD.

A survey comprising the RBQ-2A, the AQ, and a series of questions about participants' childhood pretend play was distributed online. As I have noted (see Chapter Two, page 73), there are issues regarding the reliability of retrospective recall of childhood experiences, as they can be affected by the adult's current perspective

and episodic recall can be poor in ASD; however, I decided it was important to include a measure of pretend play as it is the most common context in which imagination is assessed in ASD. The intent was to recruit only adults with ASD and it was indicated in the information sheet and consent form that only individuals with a clinical diagnosis of ASD should participate. The survey did not explicitly exclude non-UK participants; however, it was designed for a UK audience (for example, participants were asked about British qualifications) and the initial recruitment was based in the UK (e.g. British charities). Following publication of the RBQ-2A (Barrett et al., 2015), a successful press release resulted in international media interest. However, some international websites misrepresented the study as a self-diagnostic test of ASD. As a result, an extremely wide range of people took part in the survey globally (*N*=2593) reporting diagnoses of ASD, other conditions or no diagnosis at all. Appendix 4 (Table 8.3, pages 254-257) describes the breakdown of the whole sample according to country. In order to analyse a more homogeneous group, the decision was made to analyse only those reporting a clinical diagnosis of ASD and those either living in or originally from the UK (*N*=352) for the thesis. Care was taken to remove participants who indicated in any way that they thought the survey was a test. However, the remaining data should be analysed in the future, particularly as it allows for confirmation of component structure and cross-sectional comparisons.

The main question addressed in this thesis is the potential relationship between imagination and RRB. Although there is a sound theoretical case for a negative association between imagination and RRB (Chapter One, page 50), the little research examining this relationship has produced inconsistent findings. The inconsistency may be due to methodological differences between studies, in particular only examining one or two aspects of each construct. For example, not all studies examine the different subtypes of RRB (Bishop & Norbury, 2005; Honey et al., 2007) and there is evidence that this relationship may be specific to IS (Turner, 1997). Another issue is relying on one type of assessment in each study, for example relying only on one imagination task, or only assessing pretend play or future thinking. Both of these limitations are addressed in this chapter. The RBQ-2A can be divided into subscales using PCA, and each are examined separately in relation to imagination. In

addition to the RBQ-2A's subscale, I assessed the relationship between imagination and RRBs measured by item 20. Item 20, as described in Chapter Three (pages 84-86), is generally excluded from factor analytic studies as its responses represent a non-quantitative scale[16]. However, this represents a potentially important source of information regarding RRBs. There is no statistical evidence for what subtype of RRBs it falls under; however, given its focus on restricted interests and activities, it seems likely to be related to IS and therefore it is important to test its relationship with imagination.

Moreover, as part of this online survey study, data were collected regarding two aspects of imagination. The main measure of imagination was a series of questions regarding past pretend play activities derived from the DISCO (e.g. *When you were a child, did you play pretend?*). I assessed whether or not participants who reported playing pretend as a children show lower levels of RRBs. An alternative measure of imagination in adulthood comes from the inclusion of the AQ. As I explained in Chapter Two (pages 76-77), the primary purpose of including the AQ in this study was to check levels of autistic traits in the sample as confirming diagnosis was not possible; however, the AQ does include an imagination subscale and so scores on this subscale were compared with scores on the RBQ-2A. This is considered a subsidiary measure of imagination rather than the primary measure in this study given limitations regarding this subscale (see Chapter Two, page 77).

4.2 Study Three: PCA of RBQ-2A data from autistic adults

In this study, a PCA was carried out on the RBQ-2A data from the online survey. It was hypothesised that there would be at least two components corresponding to RSMB and IS as in previous research with participants with ASD. It was thought that in contrast to in Study One, the sensory items would load together with the RMB items.

4.2.1 Method

4.2.1.1 Participants

Participants were recruited through the Wales Autism Research Centre's website and Research Recruitment Register, the RBQ-2A website, and several UK ASD

[16] Summary of response options: one (*range of different and flexible activities*), two (*some varied and flexible activities*) and three (*restricted and repetitive activities*).

charities, along with the media attention described above which directed individuals to the websites. There were 352 participants aged between 18 and 66 (*M*=37.0, *SD*=12.32) who reported a diagnosis of an ASD and were living in or originally from the UK. There were 132 men, 215 women and 5 participants with a non-binary gender identity[17]. The majority reported a diagnosis of AS (*N*=198, 56.25% of the sample). The majority of participants were white (92.6%), 41.8% had studied to degree level and 57.1% were employed. Table 4.1 below shows the proportions of all the ASD diagnoses for this sample. Of the participants who reported the age of diagnosis (*N*=341), 251 (73.6%) were diagnosed as an adult and 90 (26.4%) were diagnosed as a child. Eleven participants did not report age at diagnosis (*N* ASD=8; *N* AS=2; *N* HFA=1).

Table 4-1 Study Three: Frequency and percentage of diagnoses reported by participants in Chapter 4 by age of diagnosis (N=341)

Diagnosis	Child (*N*=90)	Adult (*N*=251)
AS	46 (51.11%)	150 (59.76%)
ASD*	27 (30.0%)	61 (24.3%)
High Functioning Autism (HFA)	10 (11.11%)	22 (8.76%)
Autistic Disorder (AD)	6 (6.67%)	8 (3.19%)
Other*	1 (1.11%)	10 (3.98%)

*Two of these participants (diagnosed as adults) reported a diagnosis of ASD Level One.
**Other diagnoses include: "HFA or AS", PDA, Childhood Autism, Atypical Autism, and PDD-NOS.

Total scores on the AQ ranged from 5 to 50 (*M*=36.09, *SD*=8.34) and were positively skewed (*SW*[352]=.95, *p*<.001). For this study, the more conservative cut-off of 26 was implemented so participants scoring below 26 were removed before analysis. Forty-three participants were removed as they had scores below 26[18].

In addition, the structure of the RBQ-2A determined by the PCA in this study differed to the solution found in Study One (see results, pages 86-88). Therefore further secondary analyses were carried out on the data from the Study Two ASD and NT groups to check the reliability and validity of this alternative solution (see Chapter Three, pages 94-95, for a description of this sample).

[17] These include: agender, non-binary, and intersex.
[18] These participants all reported a diagnosis of ASD, however the AQ was employed here as a way of confirming that participants scored in line with other autistic individuals, and so participants scoring below the cut-off were not included in the analysis. However it should be noted that the AQ was not originally intended to be a screening or diagnostic tool.

4.2.1.2 Materials

All participants completed demographic information, including their diagnostic status, educational attainment, their employment information and ethnicity. All participants completed the RBQ-2A, the AQ and a series of open-ended questions about past pretend play and current imaginative activities (these are described in Study Four, page 120).

4.2.1.3 Procedure, data screening and statistical analyses

Data were collected using Google Documents. Participants were first presented with an information sheet and consent form and could not progress to the next page until they had confirmed they had read both of these. Participants were then asked for their age, gender and diagnostic information and the RBQ-2A was then presented, followed by the AQ, the pretend play questions and finally the remaining demographic questions. After completing the survey participants were presented with a debrief sheet. This study was approved by Cardiff University School of Psychology Ethics Committee. The PCA was run according to the analytic strategy outlined in Chapter Two (pages 66-69). As with Study One, internal consistency was assessed by calculating Cronbach's alpha (α) values, along with the correlations between age and RBQ-2A score, AQ and RBQ-2A scores, and the RBQ-2A sub-scales and the within-group differences among sub-scales.

4.2.2 Results

4.2.2.1 PCA

Table 4.2 on the next page shows the endorsement, mean total scores and *SD*s for all 20 RBQ-2A items. For every item, at least 18.2% of the sample endorsed *mild or occasional* or higher, and there were no items excluded on the basis of endorsement. There were 34 (11.0%) participants with missing data across the relevant nineteen items[19]. Little's Missing Completely at Random test was non-significant ($\chi^2[369]=400.39$, $p=.125$) so it was appropriate to remove these participants from the analysis.

[19] As discussed (Chapter Two, page 67), item 20 is not included in the PCA of RBQ-2A data.

Table 4-2 Study Three: Frequencies, percentages, means and standard deviations of ASD participants' responses to all twenty RBQ-2A items (N=309)

	Never or rarely	Mild or occasional/One or more times daily	Marked or notable/15 or more times daily	Mean (SD)
1. Arrange	69 (22.3%)	182 (58.9%)	58 (18.8%)	1.96 (.64)
2. Fiddle**	38 (12.4%)	73 (23.8%)	196 (63.8%)	2.51 (.71)
3. Spin*	236 (76.6%)	56 (18.2%)	16 (5.2%)	1.29 (.56)
4. Rock *	125 (40.6%)	98 (31.8%)	85 27.6%)	1.87 (.82)
5. Pace*	96 (31.2%)	121 (39.3%)	91 (29.4%)	1.98 (.78)
6. Hand/finger**	95 (30.9%)	83 (26.9%)	129 (41.7%)	2.11 (.85)
7. Fascination**	45 (14.7%)	117 (38.1%)	145 (47.2)	2.33 (.72)
8. Angles****	75 (24.6%)	144 (47.2%)	86 (28.2%)	2.04 (.73)
9. Smell***	132 (43.1%)	106 (34.6%)	68 (22.2%)	1.79 (.78)
10. Feel****	94 (30.8%)	105 (34.4%)	106 (34.8%)	2.04 (.81)
11. Carry*****	124 (40.1%)	97 (31.4%)	83 (27.3%)	1.87 (.82)
12. Collect**	51 (16.6%)	93 (30.3%)	163 (53.1%)	2.36 (.75)
13. Home**	18 (5.9%)	65 (21.2%)	224 (73.0%)	2.67 (.58)
14. Change***	34 (11.1%)	88 (28.8%)	184 (60.1%)	2.49 (.69)
15. Routine**	20 (6.5%)	92 (30.0%)	195 (63.5%)	2.57 (.61)
16. Redoing*	16 (5.2%)	66 (21.4%)	226 (73.1%)	2.68 (.57)
17. TV/Music**	30 (9.8%)	83 (27.0%)	194 (63.2%)	2.53 (.67)
18. Clothes****	74 (24.3%)	106 (34.8%)	125 (41.0%)	2.17 (.79)
19. Food**	67 (21.8)	89 (29.0%)	151 (49.2%)	2.27 (.80)
20. Activities	11 (3.6%)	117 (37.9%)	181 (58.6%)	2.55 (.57)

*Missing=1 **Missing=2, ***Missing=3, ****Missing=4, *****Missing=5; Percentages given as valid percentages

The final sample comprised 275 participants, aged from 18-66 years (M=36.56, SD=12.24; positively skewed [SW(275)=.96, p<.001] with no outliers). The total AQ score ranged from 26 to 50 (M=38.51, SD=5.88) and was positively skewed (SW[275]=.98, p<.001) with no outliers. The mean score for all RBQ-2A items for the sample ranged from 1.15 to 2.95 (M=2.21, SD=.36), which was positively skewed (SW[275]=.98, p=.002) with no outliers. The internal consistency of the whole scale was good (α=.84).

Initial screening indicated that the assumptions of sampling adequacy (KMO=.85), multicollinearity and factorability (χ^2[171]=1306.10, p<.001) were all met. The initial PCA solution resulted in five components with eigenvalues greater than one, explaining 56.06% of the variance. PA indicated that three components should be retained and the PCA was re-run with Direct Oblimin rotation. However, the correlation between components run during the PCA was less than .32, which suggests

that orthogonal rotation is more appropriate (see Chapter Two, pages 68-69). Therefore the PCA was re-run with Varimax rotation (see Appendix Five, Table 8.4, page 258); however, the pattern of loadings remained the same regardless of rotation. Table 4.3 below shows the pattern matrix from the Direct Oblimin rotation.

Table 4-3 Study Three: The pattern matrix for the PCA of the ASD sample, after Direct Oblimin rotation (N=275)

Rotated item loadings:	Component 1 Insistence on Sameness (IS)	Component 2 Repetitive Motor Behaviours (RMB)	Component 3 Repetitive Sensory Behaviours (RSB)
1. Arrange	.24	.21	-.34
2. Fiddle	.04	**.67**	-.03
3. Spin	-.11	**.63**	-.02
4. Rock	-.07	**.68**	-.18
5. Pace	.11	**.66**	.15
6. Hand/finger	-.01	**.56**	-.23
7. Fascination	**.44**	.17	-.16
8. Angles	.13	.12	**-.55**
9. Smell	-.05	-.13	**-.79**
10. Feel	-.04	.11	**-.76**
11. Carry	.24	.20	**-.44**
12. Collect	**.55**	.07	-.16
13. Home	**.78**	-.20	-.01
14. Change	**.69**	-.22	-.20
15. Routine	**.69**	.04	.09
16. Redoing	**.67**	-.15	-.11
17. TV/Music	**.45**	.32	.00
18. Clothes	**.45**	.34	-.00
19. Food	**.54**	.13	.19
Percentage of variance explained:	26.72	10.44	7.32
Cronbach's alpha (α):	.79	.70	.67

The final rotated solution explained 44.47% of the variance. Table 4.3 above and Table 4.4 overleaf show the percentage of variance explained, Cronbach's alpha values, the means and SDs, and the medians and IQRs for each of the three components. The first component corresponds to IS, and the second component resembles the RMB component from Study One. The final component mostly comprises sensory items and was therefore named Repetitive Sensory Behaviours

(RSB)[20]. The internal consistency (Cronbach's alpha) of the IS and RMB subscales were acceptable (≥ .70), whereas it was questionable for RSB (although see the note in Chapter Three, page 99 regarding α values below .70). The mean inter-item correlation for each subscale ranged from .31 to .34. The full RBQ-2A scale significantly correlated with AQ (r_s=.39, p<.001), but not with age (r_s=-.01, p=.84).

Table 4-4 Study Three: The ranges, means and SDs, and medians and IQRs for each of the three components (N=275)

	IS	RMB	RSB
Range	1.0-3.0	1.0-3.0	1.0-3.0
Mean (SD)	2.46 (.42)	1.96 (.50)	1.94 (.56)
Median (IQR)	2.56 (.56)	2.0 (.80)	2.0 (.75)

4.2.2.2 Subscale analyses

All three components were positively skewed. There was one outlier who scored more than three SDs below the mean on IS; however, removing this participant from analyses did not affect the pattern of findings so the following results are reported from the full sample (N=275). A Friedman's test indicated a significant difference between scores on the three subscales (χ^2[171]=183.63, p<.001). Follow-up Wilcoxon Signed Ranks Test demonstrated significant differences between IS and RMB (Z=-11.78, p<.001) and between IS and RSB (Z=-11.96, p<.001) but not between RMB and RSB (Z=-.56, p=.58).

Finally, Table 4.5 overleaf shows the correlations between the three components and the full RBQ-2A scale, the AQ and age. Although the correlation matrix resulting from the PCA did not reach the threshold of .32, Spearman's correlation analyses did find significant associations between each of the three components, all above .32[21]. The three components were all significantly correlated with the full RBQ-2A scale and with the total AQ score. The only component significantly correlated with age was RMB, which had a negative association with age (r_s=-.24, p<.001). There were no significant gender differences, with the exception that

[20] The PCA was also run only on participants scoring 32 or above on the AQ (N=236). IS and RMB remained the same, whereas RSB varied slightly depending on the method of rotation. Therefore (PTO) the findings from the full sample (N=275) were used for the rest of the analyses given the consistent pattern of loadings across rotation.

[21] This difference is likely due to the fact that the PCA is run on a Pearson's correlation matrix in SPSS.

women scored significantly higher than men on the AQ (Z=-2.16, p=.031) and RSB (Z=-2.23, p=.026)[22].

Table 4-5 Study Three: Correlations between the subscales of the RBQA, the AQ and age (N=275)

	RMB	RSB	RBQ-2A	AQ	Age
IS	.36**	.45**	.84**	.42**	.07
RMB	-	.38**	.70**	.23**	-.24**
RSB	-	-	.73**	.20**	.05

*Significant at the .05 level **Significant at the .01 level

4.2.2.3 Secondary analyses of data from Study Two

The present study identified a distinct component solution from that identified in Study One. Therefore the ability of the current solution to distinguish between ASD and NT participants was assessed in the IQ-matched samples described in Chapter Three (see pages 94-95). Mean scores on the three components identified in the present study were calculated for all participants. The means, SDs, medians and IQRs of the mean scores on these three subscales for the two groups are shown in Table 4.6 below.

Table 4-6 Study Three: Means, SDs, medians and IQRs on the mean total RBQ-2A score and the components IS, RMB and RSB for the participants from Chapter Three, Study Two (N=66)

	ASD group (Study Two; N=29)		NT group (Study Two; N=37)	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Total RBQ-2A score	1.84 (.45)	1.90 (.78)	1.25 (.19)	1.20 (.25)
IS score	2.05 (.54)	2.11 (.89)	1.26 (.24)	1.22 (.22)
RMB score	1.57 (.50)	1.40 (.60)	1.24 (.28)	1.20 (.40)
RSB score	1.66 (.66)	1.50 (1.25)	1.14 (.26)	1.0 (.25)

All variables, with the exception of IS for the ASD group, were positively skewed. There were four outliers across the three variables in the NT group. However, removal of these outliers did not affect the pattern of results, so they remained in the analyses. The ASD group scored significantly higher than the NT group on all three components: IS (Z=-5.67, p<.001); RMB (Z=-3.08, p=.002); and RSB (Z=-3.73, p<.001). Friedman's test was significant for both the NT group (χ^2[2]=10.60,

[22] Participants who identified as another gender identity were not included in gender difference analyses as the N was too small.

p=.005) and the ASD group (χ^2[2]=21.17, p<.001), indicating that there were significant within-groups differences between the three components. For the NT group, there was no significant difference between RMB and IS (Z=-.60, p=.55) but there were significant differences between IS and RSB (Z=-2.22, p=.026) and between RSB and RMB (Z=-2.37, p=.018). Conversely, for the ASD group there were significant differences between IS and RMB (Z=-4.10, p<.001) and between IS and RSB (Z=-3.23, p=.001) but not between RMB and RSB (Z=-.46, p=.65). For the ASD group, all three components were significantly associated with each other (IS and RMB: r_s=.66, p<.001; IS and RSB: r_s=.56, p=.002; RMB and RSB: r_s=.46, p=.012). In contrast, only RMB and RSB were significantly associated for the NT group (r_s=.40, p=.015). However, there were no significant gender differences in either group for any of the subscales.

4.2.3 Discussion

This study repeated the procedure for Study One in a larger sample of adults with diagnoses of ASD, and represents the first PCA of RRB data from an entirely adult ASD sample. The larger sample size and wide age range addresses Study One's limitations while testing the RBQ-2A in a clinical population. Overall, the results support the reliability and validity of the RBQ-2A in terms of internal consistency and correlation with AQ for the whole scale. Study One was partly replicated in terms of the components IS and RMB, and the group differences in Study Two were replicated here. However, there is some inconsistency, in that sensory items did not load in Study One, whereas in Study Three they formed their own component.

Three components were identified. Two of these, IS and RMB, closely resemble those identified in Study One. The IS component closely resembles that of most previous research using the RBQ-2; items 13-18 of the RBQ-2 have always previously loaded onto IS (Lidstone, Uljarević et al., 2014; Leekam et al., 2007). The IS component is fairly similar to Study One, with the exception that item 11 (*carrying objects*) did not load on to this component, and that items 7 (*fascination with objects*) and 18 (*wearing same clothes*) did load; although item 18 was not included in Study One's analysis due to poor endorsement. The second component, RMB, very closely resembles that found in Study One. The only difference was that item 1 (*arranging objects*) did not load onto this component.

The biggest difference lies in the loading of the sensory items. In Study One, items 7-10 did not load sufficiently onto any component. However, in the current study, items 8-11 formed their own component. This is logical for items 8-10 as they are all sensory behaviours. More unusual is the fact that item 11 (*carrying objects*) also loaded onto RSB, and item 7 (*fascination with objects*) loaded onto IS instead – although item 7 has previously loaded on to IS (Lidstone, Uljarević et al., 2014). This may reflect the point raised in previous chapters that it is not always clear where an RRB may lie. In terms of item 7, the source of one's fascination with an object may be sensory (e.g. liking the look of an object), but it may also reflect a particular interest; restricted or circumscribed interests tend to fall in the category of IS rather than RSMB. Similarly, item 11 refers to *carrying around special objects*. The reason for carrying around an object maybe because that object is related to a particular interest; or it may be because of a sensory preference (e.g. liking the feel of an object). It is important to note here that in some studies with other measures, such as the ADI-R, three factors or components are identified (e.g. Mirenda et al., 2010). In two of these cases, the third factor or component specifically represents CI (Honey et al., 2008; Lam et al., 2008). It may be then that items relating to special interests do not always fall neatly into the category of RSMB or IS. In contrast, the three components found here are unique to the RBQ-2A[23]. This may reflect an inherent weakness in terms of the sensory items, as these are the items that differed across the two samples. Notably items 8 to 11, which are the items that load onto RSB, are also among the seven items that are answered on a three-point rather than four-point scale. However, as I noted in Chapter Three (page 92), these items are also answered on a three-point scale in the parent-report RBQ-2, and these items neither fail to load nor do they form their own component in the parent version. Therefore it is unlikely that this is an explanation for the unusual behaviour of these items.

Relevant to the above discussion is the fact that the internal consistency was acceptable (and near to the threshold for good, .80) for IS and RMB but questionable for RSB. This may, however, be a result of the fact that four items is relatively small for

[23] Lam et al., (2008) named one of their three subtypes RMB, however, they excluded unusual sensory interests from the analysis as their study was conducted prior to sensory symptoms' inclusion under RRB in DSM-5.

a component; it is preferable for a component to comprise 5 or more items loading ≥.5 (Osborne & Costello, 2009). In addition, as discussed in Chapter Three (page 99) an α value below .70 may be acceptable for psychological constructs (Field, 2013). As in Study One, the RBQ-2A and its subscales are significantly associated with AQ score, supporting the construct validity of the RBQ-2A.

However, the most important difference between the two studies is the diagnostic status of the two samples; Study One was conducted on an NT sample whereas Study Three was conducted on an ASD sample. Therefore the differences in terms of sensory items may be due to genuine structural differences in RRB between ASD and NT individuals. It has been suggested that RSMBs serve the purpose of developmental mastery in TD children and hence they reduce over time (Thelen, 1981); in contrast, they are much more pervasive in ASD development and are associated with anxiety (e.g. Lidstone, Uljarević et al., 2014) and there is anecdotal evidence for the enjoyment of RRBs in individuals with ASD.

An additional difference between Study One and Study Three is the different methods used to rotate the data. In Study One, I applied direct oblimin rotation as the correlation coefficient between the two components was >.32 (Tabachnick & Fidell, 2014) when running the PCA. Conversely, in Study Three, this was not the case and so varimax rotation was applied. As discussed in Chapter Two, the type of rotation applied to EFA and PCA is important in RRB research as there is some disagreement over whether or not the sub-groupings would be correlated. However, there was no difference between the two rotations in Study Three, and therefore this is unlikely to account for the differences between Study One and Study Three.

A notable finding in this study is that RMB was significantly negatively correlated with age. In addition ASD participants in both studies scored higher on IS than either RMB or RSB. Previous research has shown that RRBs reduce across the lifetime, although they remain more stable than social and communication traits (e.g. Esbensen et al., 2009; Fecteau et al., 2003; Piven et al., 1995). However, there is also some evidence that RSMBs are particularly associated with younger individuals and individuals with LDs (e.g. Esbensen et al., 2009; Militerni et al., 2002; Moore &

Goodson, 2003). The findings from the present study support the possibility that whereas all RRBs reduce over time in an ASD population, RSMBs reduce at a faster rate than IS behaviours.

In order to further assess whether Study Three's alternative component structure was reliable and valid, I tested whether or not the new subscales were able to distinguish between ASD and NT groups by returning to the data from Study Two. As before, the Australian ASD group scored significantly higher than the IQ-matched NT group on the components identified in Study Three. Moreover, there were no within-group differences for NT participants in terms of RMB and IS, replicating Study Two. However, the NT group scored significantly lower on RSB compared to both of the other components. This supports the discussion of the previous chapter relating to the fact that sensory symptoms are not particularly prevalent in the NT population. It is known that people with ASD show higher levels of RRBs than NT individuals, but arguably this difference is even more pronounced in terms of sensory items. This could explain why in Study One, none of the sensory items loaded onto any component. In contrast, in both the online survey ASD sample and the Australian ASD group, there was no significant difference between levels of RMB and RSB. This suggests that RMB and RSB are more closely related in people with ASD compared to NT individuals. Indeed, it is common for RMBs to include an element of sensory feedback (e.g. Leekam et al., 2011).

Finally, there were significant gender differences found in terms of both the AQ and the RBQ-2A in the Study Three ASD sample but not the Study Two ASD sample. Unusually, autistic women scored significantly higher on the AQ and the RSB subscale than autistic men. Gender differences in terms of autistic traits are not found in every study; however, a meta-analysis found that from six years of age, autistic girls and women show significantly fewer RRBs then autistic boys and men, with no differences in social or communication traits (Van Wijngaarden-Cremers et al., 2014). This finding may then indicate that the women in this sample are not representative of the female ASD population as a whole.

Although there are many similarities between the two PCA solutions in Study One and Study Three, there is a clear difference in terms of sensory items. Therefore it is necessary to decide which of these two PCA solutions is the most appropriate to use for the rest of the analyses in this thesis. It is also necessary to judge which of these solutions more closely reflects the 'true' construct of RRBs, if the RBQ-2A is to become a useful research tool. This will be discussed at the end of this chapter (page 130). The analyses for Study Four were conducted on the same dataset for Study Three, and therefore the subscales as identified in Study Three were used.

4.3 Study Four: Assessing imagination and RRB in the online survey

Having carried out the PCA of the online survey data in Study Three, these data were then analysed in Study Four to assess the relationship between RRB and both childhood and adult imagination. Firstly, correlation analyses were run to test whether there is a relationship between the RBQ-2A subscales and adult imagination as measured by the AQ. As described in Chapter One (page 56), it is specifically IS which I have hypothesised to drive the relationship between RRBs and imagination in older children and adolescents (e.g. Turner, 1997), although there may be a relationship between imagination and RSMB in younger children (e.g. Happé, 1999; Harrop et al., 2014). Therefore, I hypothesised that there would be a significant positive association (as higher scores on both questionnaires indicate higher levels of ASD traits) between imagination and total RBQ-2A score and IS, but not with RMB and RSB. Although I hypothesised a relationship between the total RBQ-2A score and imagination, it was anticipated that this relationship may be masked by the hypothesised lack of correlation between RMB/RSB and imagination, and so this is a tentative hypothesis. In terms of item 20, I hypothesised that participants who scored themselves higher on item 20 would also score higher on the AQ imagination subscale.

Secondly, participants were split into two groups on the basis of their responses to questions about their past pretend play as children. These two groups were: those who reported playing pretend as children and those who did not. The difference between the groups in terms of scores on the RBQ-2A and its subscales were then analysed. It was hypothesised that participants who reported that they did not play pretend as children would show significantly higher levels of RRB than those

who did; specifically they would show higher levels of IS rather than RMB or RSB. I also hypothesised that there would be a relationship between pretend play group and responses to item 20, in that participants who reported not playing pretend would also be more likely to report a restricted range of self-chosen activities.

4.3.1 Method

4.3.1.1 Participants

These analyses were carried out on the same UK sample used for Study Three (*N*=275). Participants were aged from 18-66 years (*M*=36.56, *SD*=12.24), 100 were men and most participants (57.8%) were diagnosed with AS. This sub-sample was used as they had no missing data on the RBQ-2A.

4.3.1.2 Design

For the analysis of the pretend play question, the independent variable (IV) was whether or not the participant played pretend as a child. The dependent variables (DVs) were mean total score on the RBQ-2A and the mean subscale scores for each of the three components identified in Study Three (IS, RMB and RSB).

4.3.1.3 Materials

In addition to the RBQ-2A, AQ and demographic information, participants were asked a series of questions related to their past pretend play and current imaginative activities. The first question was closed ("*When you were a child, did you play pretend?*") whereas the subsequent questions were open-ended. Table 4.7 below shows the full set of questions presented to each participant.

Table 4-7 Study Four: Pretend play questions

1. When you were a child, did you play pretend?
(Answers: Yes/No/I don't remember)
2. What kind of pretend games did you play?
For example, did you feed dolls, play with toy cars or pretend to be someone else?
3. What kind of pretend objects, people or animals did you play with?
4. Now, as an adult, what imaginative or creative activities do you enjoy?
5. What are your favourite interests?

4.3.1.4 Procedure, data screening and statistical analyses

As in Study One (Chapter Three, page 86), for the analysis of the AQ subscales, the full range of scores (from 1 to 4) were analysed rather than dichotomous scoring and a higher score on the AQ imagination subscale indicates more difficulties with imagination. All five subscales were non-normally distributed. There were outliers present on two subscales (*social skills* and *communication*); removal of these outliers did not affect the pattern of results so they remained in the analysis. Non-parametric (Spearman's correlation) analyses were used to account for the non-normality of the AQ subscales and the three RBQ-2A subscales.

In order to assess whether participants who played pretend as children differed on the RBQ-2A and its subscales (IS, RMB and RSB) compared to participants who did not play pretend, a MANOVA was carried out on the participants who answered *yes* or *no* to this question. Participants who did not answer this question (*N*=3), or responded with *I don't remember* (*N*=53), were not included. This resulted in a smaller sample size (*N*=219) for the MANOVA (aged from 18 to 66 [*M*=36.54, *SD*=12.22]; 81 male; 134 female; 4 non-binary). This sample met the following assumptions of MANOVA: no univariate outliers; no multivariate outliers according to Mahalanobis' Distance; and homogeneity of variance-covariance matrices according to Box's M test. However, there were some issues in that each of the DVs were skewed, the relationships between RMB and RSB were not linear in either group, and there was some evidence of multicollinearity. Specifically, whereas the three subscales were moderately correlated (0.3-0.6) which is necessary for MANOVA, the RBQ-2A correlated very highly with each of the subscales, reaching the threshold for multicollinearity (0.8) with IS (see Table 4.8 below).

Table 4-8 Study Four: Spearman's rank order correlation coefficients between the DVs for the MANOVA (N=219).

	RBQ-2A	RMB	RSB
RMB	**.686****	-	
RSB	**.717****	.354**	-
IS	**.843****	.354**	.433**

**Significant at the .01 level

This is unsurprising given that the three subscales are all derived from the RBQ-2A (although the total score includes items 1 and 20, which are not represented in the subscales). This high level of correlation suggests it is not appropriate to include the RBQ-2A mean total score in a MANOVA with the other three DVs. Therefore it will be analysed separately using non-parametric analyses due to the fact that the data is not normally distributed. To address the other assumptions not met, Pillai's trace criterion will be used to determine significance as it is more robust to violations of assumption.

Finally, participants were grouped in terms of how they responded on item 20, and non-parametric analyses were used to test group differences in terms of AQ imagination. In order to address whether or not item 20 varied according to pretend play group, a chi-square analysis of item 20 and pretend play group was carried out on the sub-sample described above.

4.3.2 Results

4.3.2.1 Imagination in adulthood: The AQ

Table 4-9 Study Four: The means and standard deviations for the five subscales of the AQ (N=275).

	Imagination	Social Skills	Attention Switching	Attention to Detail	Communication
Mean	2.81	3.33	3.40	3.09	3.17
SD	.59	.43	.38	.49	.47

Table 4.9 above shows the means and SDs for the AQ subscales of the sample (*N*=275; See Tables 4.3 and 4.4 for the means and SDs for the RBQ-2A and its subscales). There were three outliers across social skills and communication; however, removal of these outliers did not affect the pattern of findings. All five AQ subscales were significantly associated with the RBQ-2A (see Table 4.10 below). The internal consistency of the imagination subscale was acceptable (α=.74).

Table 4-10 Study Four: The correlations (r_s) between the RBQ-2A and subscales of the AQ (N=275).

	Imagination	Social Skills	Attention Switching	Attention to Detail	Communication
RBQ-2A	.16 (*p*=.007)	.29 (*p*<.001)	.38 (*p*<.001)	.33 (*p*<.001)	.36 (*p*<.001)

There was no significant difference between male and female participants in terms of imagination (Z=-.71, p=.478). Of the RBQ-2A subscales, imagination was only significantly associated with IS (r_s=.23, p<.001) and RMB (r_s=.14, p=.022) but not RSB (r_s=-.04, p=.567). When running partial correlations controlling for the RMB and RSB subscales, the association between IS and imagination remained significant (r_s=.25, p<.001). When controlling for IS, the association between imagination and RMB became non-significant, whereas the association with RSB became significant (r_s=-.16, p=.009). When controlling for the other AQ subscales, the only significant relationship that remained was between imagination and RSB (r_s=-.18, p=.004).

In terms of item 20, only nine participants responded with option one (*range of different and flexible activities*) and therefore these participants' responses collapsed into option two (*some varied and flexible activities*). When collapsing responses, participants who responded with option one or two (N=113) had a mean score of 2.71 (SD=.56) on the AQ imagination subscale and those who responded with option three (*restricted and repetitive activities*; N=162) had a mean score of 2.87 (SD=.61); mean scores were positively skewed with no outliers for either group. There was no significant difference between the two groups in terms of score on the imagination subscale (Z=-1.95, p=.052) [24].

4.3.2.2 Imagination in childhood: Pretend play

4.3.2.2.1 Descriptive statistics

Table 4.11 overleaf shows the gender distribution, age and AQ score for participants responding *Yes*, *No* and *Don't Remember* when asked about pretend play. Chi-Squared analysis indicated no significant relationship between gender and reported pretend play (χ^2(4)=3.75, p=.441). This relationship remained non-significant regardless of whether participants responding *I don't remember* or identifying as another gender identity were excluded.

[24] When removing participants responding with option one instead of collapsing them into option two, the difference remained non-significant (Z=-1.94, p=.053).

Table 4-11 Study Four: Gender distribution, means and SDs for age and total AQ score according to pretend play group (N=272).

Pretend Play	Gender	Age	Total AQ Score
Yes (*N*=144)	48 Male 93 Female 3 Other gender identity*	37.22 (12.44)	37.17 (5.69)
No (*N*=75)	33 Male, 41 Female 1 Other gender identity*	35.24 (11.76)	41.31 (5.66)
I don't remember (*N*=53)	18 Male 35 Female	36.7 (12.42)	38.06 (5.37)

*Includes the following gender identities: agender; non-binary; and intersex

4.3.2.2.2 Group differences

For the smaller sample (*N*=219) described above, 144 (65.8%) reported playing pretend as a child and 75 (34.2%) reported not playing pretend as a child. There was no significant difference between the two groups in terms of age (Z=-1.04, p=.297) but the group that did not play pretend scored significantly higher on the AQ (Z=-4.85, p<.001). Participants who reported playing pretend scored significantly lower on the AQ imagination subscale (M=2.60, SD=.55) than participants who reported not playing pretend (M=3.20, SD=.50; Z=-6.92, p<.001). Table 4.12 below shows the mean scores and standard deviations of the two groups on the RBQ-2A and its subscales.

Table 4-12 Study Four: Means and SDs on the RBQ-2A mean total score and mean subscale scores, grouped according to whether or not participants played pretend as a child (N=219).

Pretend Play	RBQ-2A total	IS	RMB	RSB
Yes (*N*=144)	2.22 (.36)	2.43 (.42)	2.0 (.48)	2.02 (.55)
No (*N*=75)	2.21 (.33)	2.57 (.38)	2.0 (.53)	1.93 (.53)

As explained previously, (page 122) the total RBQ-2A score was not included in the MANOVA due to high correlation with its subscales. For the whole RBQ-2A scale, a Mann-Whitney test showed that there was no significant difference between the groups (Z=-1.19, p=.23). The MANOVA was then carried out with pretend play group as the IV and the RBQ-2A subscales as DVs. There was a significant difference between the two groups (F[3,215]=4.24, p=.006, η_p^2=.056) with a borderline medium effect size. When examining the DVs individually, Bonferroni correction was applied to adjust for multiple comparisons (.05/3), resulting in an alpha level of .017. The only subscale to reach significance was IS (F[1,217]=6.40, p=.012, η_p^2=.029) with a small effect size.

Neither of the others reached significance (RMB: $F[1,217]=.01$, $p=.941$; RSB: $F[1,217]=1.22$, $p=.271$).

Table 4.13 below shows the number of participants endorsing options one (*range of different and flexible activities*), two (*some varied and flexible activities*) or three (*restricted and repetitive activities*) on item 20 according to whether or not they answered *yes* or *no* to the pretend play question. A chi-square analysis determined that these two variables were significantly related to each other ($X^2[2]=6.4$, $p=.041$). However, given the low number of respondents for option one, options one and two were collapsed as before (page 123) and the relationship then became non-significant ($X^2[2]=3.52$, $p=.06$).

Table 4-13 Study Five: Responses to pretend play question and RBQ-2A item 20 data from Chapter Four data (N=219).

		Restricted and repetitive activities (3)	Some varied and flexible activities (2)	Range of different and flexible activities (1)
Pretend play = No	Count	50 (66.67%)	25 (33.33%)	0
	Expected count	43.5	28.8	2.7
Pretend play = Yes	Count	77 (53.47%)	59 (40.97%)	8 (5.56%)
	Expected count	83.5	55.2	5.3

4.3.2.2.3 Re-categorisation of pretend play answers

As mentioned, participants were asked more than one question about pretend play (see Table 4.7, page 120). The subsequent questions were open-ended so some participants chose to write descriptions of play activities as children. All participants' answers were checked for consistency with how they answered the first question, and in some cases participants were re-categorised. For example, some participants answered *No* to pretend play, then gave an example of playing pretend as a child (e.g. "*I liked pushing my mother's make-up around in a small tray as if they were people in a car*"). Several participants who answered *I don't remember* also gave examples of pretence such as having an imaginary friend or role-playing. Participants who did not provide enough detail for re-categorisation were left in their original category. Overall, 26 (9.5%) participants were re-categorised. The majority ($N=16$) of re-categorisations

occurred in the *Don't Remember* group. This resulted in 73 participants in the *No* group and 160 in the *Yes* group. The above MANOVA was re-run in the same way on this newly re-categorised data. However, there was no difference in the pattern of results. The overall MANOVA was significant (F[3,229]=4.24, p=.006, η_p^2=.053) , with the only significant subscale being IS (F[1,231]=6.43, p=.012, η_p^2=.027). The chi-square analysis above was also re-run using the re-categorised answers and remained significant (X^2[2]=7.43, p=.024), including when response options one and two were collapsed X^2[2]=5.25, p=.022).

4.3.3 Discussion

The aim of Study Four was to assess the relationship between RRBs and imagination in both childhood (pretend play) and adulthood (the AQ). The RBQ-2A, AQ and a series of imagination and pretend play questions were administered as an online survey to a large sample of participants. The majority of participants reported playing pretend games as a child; although in their descriptions of pretend play, some participants noted that their games were repetitive, socially isolated and/or different to that of their peers. Reflecting the inconsistent nature of the previous research in this area, the findings from this study are mixed, although there is reasonably strong evidence for a relationship between IS and childhood pretend play.

As hypothesised, there was a significant association between RRBs and the imagination subscale of the AQ. Specifically, there was a significant association between the imagination subscale and IS, although there was also a significant association with RMB. However, these findings became more complex when controlling for other variables. As higher scores on any of the AQ subscales indicate higher levels of ASD traits, a higher imagination score actually indicates more difficulty with imagination. Therefore participants with higher levels of IS and RMB showed more difficulty with imagination. In the case of IS, this relationship remained significant when controlling for the effects of RMB and RSB, supporting the hypothesis that the relationship between RRBs and imagination is specific to IS. A significant relationship between RMB and imagination was not hypothesised; however, it is not an unprecedented finding, as one study did find a significant relationship between imagination and RSMBs (Harrop et al., 2014), in that greater frequency of RSMBs

significantly correlated with a higher score on the imagination difficulties algorithm of the ADOS; although this previous study was carried out with young children. However, when controlling for IS, the relationship with RMB was no longer significant, so it may be the case that RMB correlated with imagination due to shared variance with IS. Taken together with findings from Study One and previous research (Kloosterman et al., 2011) that imagination as measured by the AQ is *not* associated with RRBs in a typical undergraduate population, Study Four's findings indicate there may be a relationship between imagination and RRBs that is specific to the autistic population and to IS.

However, when controlling for the other AQ subscales score, imagination as measured by the AQ was no longer significantly related to either IS or RMB. The results of the latter analysis suggest that there is not a relationship specific to imagination but instead participants who score higher on any of the AQ subscales will also score higher on the RBQ-2A and its subscales. Given that the two measures correlate and both measure autistic traits, this is not surprising. What is more unusual is that when controlling for the other AQ subscales or IS, the relationship between imagination and RSB became significant and *negative*. Indeed, when controlling for the AQ, there was a significant *negative* relationship between imagination and total RBQ-2A score, presumably driven by the relationship with RSB. The direction of this relationship indicates that participants who engage in more sensory behaviours have less difficulty with imagination. In terms of general creativity, a possible explanation is that those who have heightened sensory symptoms may be able to utilise their sensory sensitivity or sensory seeking behaviours to aid the creative process. However, not all of the AQ imagination items refer to imagination in that sense, and none refer to actively being creative, so further exploration of this potential relationship is required in order to understand it. Finally, participants' scores on the imagination subscale of the AQ did not significantly differ depending on their response to item 20. However, when interpreting these findings it is important to bear in mind certain limitations of the AQ. The imagination subscale of the AQ has limited reliability in that it is not always identified by factor analyses, and often shows poor internal consistency (e.g. Austin, 2005; Hurst et al., 2007; Kloosterman et al., 2011; Stewart &

Austin, 2009). Therefore any findings using the subscale must be interpreted with caution. This may explain why the findings are somewhat inconsistent and unusual when using this scale. However, it should be noted that in this particular sample, the internal consistency of the AQ imagination subscale was acceptable.

I originally hypothesised that childhood imagination as measured by pretend play would be related to RRBs, in that there would be a significant difference between those who reported playing pretend and those who reported not playing pretend for total RBQ-2A score. However, this was a tentative hypothesis (page 119) and indeed there was no significant difference between pretend play groups for the total RBQ-2A score. As hypothesised, participants who did not play pretend scored higher in terms of IS, while there was no difference between groups for RMB and RSB, which may explain why there was no association between pretend play and overall RRBs as measured by the RBQ-2A total score. This remained even after re-categorisation of some of the participants.

There was also evidence of a significant relationship between pretend play response and response to item 20, such that a higher percentage of participants saying *no* to pretend play also endorsed the *restricted and repetitive activities* response to item 20; although when collapsing the scores to take into account the small number of participants endorsing option one, this result became non-significant. However, when analysing the relationship between item 20 and the re-categorised pretend play items, this relationship remained significant regardless of whether or not the responses were collapsed. Taken together, these findings support previous research showing a significant negative relationship between imagination and IS (e.g. Turner, 1997), in that a lack of imaginative play is associated with increased preference for routines and rituals. This study expanded on previous research by showing that this association exists between imaginative behaviours in childhood, and IS behaviours in adulthood. However, limitations of this study should be borne in mind and are discussed in the following general discussion section.

4.4 General Discussion

This chapter described two studies carried out using online survey data from adults with ASD in the UK. Firstly a PCA was carried out on the data to determine the component structure of the RBQ-2A in a sample of adults with ASD, which to my knowledge is the first time RRBs have been assessed this way in an adult ASD sample. Support was found for three components, which were named IS, RMB and RSB. Secondly the relationship between imagination and RRB was tested using retrospective reports of pretend play and the imagination subscale of the AQ. It was found that participants who reported not playing pretend as a child showed significantly higher levels of IS only, and there was some evidence that participants' score on item 20 (*activities*) from the RBQ-2A differed depending on whether or not they reported pretend play as a child. These findings support the hypothesised relationship between IS and imagination. Some support was found for this relationship using data from the imagination subscale of the AQ; however, this relationship was not stable and also extended to RSB.

Together with the findings from the previous chapter, it can be concluded that the RBQ-2A is a reliable and valid tool for assessing RRB in adults either with or without a diagnosis of ASD. As well as being a useful tool in its own right, this allows for the assessment of the relationship between RRBs and imagination in autistic adults. For both developing an RRB measure and assessing this relationship, it is important to separate out different types of RRB, as these sub-categories have been shown to be differentially related to variables such as IQ and age (e.g. Militerni et al., 2002; Moore & Goodson, 2003) and I have hypothesised that imagination is specifically related to IS (page 57) as explanations of the relationship between RRBs and imagination specifically focus on routines and inflexible activities (e.g. Boucher, 2007; Wing & Gould, 1979), and there is some evidence for this being the case (Turner, 1997). Although the precise nature of the RSMB components of the RBQ-2A is not yet clear, the IS component remains relatively stable across studies. From Study Four, it is not yet clear whether there is a relationship between RRB and imagination. A weak but significant effect was found in terms of pretend play, but the relationship was less clear-cut in terms of the relationship with imagination in adulthood as measured by

the imagination subscale of the AQ; although this may be due to methodological issues with the AQ. However, this small effect is worth exploring in more depth using a wider range of imagination measures and is the focus of the next chapter.

As discussed at the end of Study Three, this thesis has now identified two potential component structures for the RBQ-2A. They are somewhat different to one another, particularly in terms of sensory items; however, the IS subscale comprises similar items in each solution. The principal aim of this thesis is to assess whether or not RRBs are related to imagination in adults with ASD, along with developing and testing a self-report measure of RRB suitable for adults (the RBQ-2A). The hypothesis is that IS will specifically be related to imagination and so it is important to determine which of these two PCA solutions best reflect the structure of the RBQ-2A in order to accurately assess the specificity of the relationship between imagination and IS. EFA and PCA are useful tools for determining the reliability and validity of a measure (e.g. Kline, 2000; Shuster et al., 2014; Strauss & Smith, 2009), but are also known for being subjective statistical methods (e.g. Osborne & Costello, 2009; Williams et al., 2010). However, as explained in Chapter Two (page 66), the same PCA approach was adopted for both analyses so that any differences should not be explained by differences in in analytical approach.

Appendix 6 (pages 259-263) comprises a detailed discussion of the differences between the two solutions in terms of reliability, validity and similarity with previous research. To summarise this discussion, the solution identified by Study Three is more reliable in terms of internal consistency, includes sensory items (which are important to consider in an ASD sample) and is also more similar to previous research than Study One's solution. In addition, given that the analysis presented in this chapter was carried out on a sample that was larger and comprised autistic adults, the Study Three solution appears to be the most logical solution to use for the final chapter. Therefore I have chosen to perform the remaining analyses of the thesis using the PCA solution from Study Three (Table 4.3).

4.4.1 Limitations

There are a number of limitations shared by both studies. Firstly, all of the measures used are self-report, the limitations of which I have already discussed

throughout this thesis in relation to RRBs (e.g. page 64). Although there is evidence of both NT and autistic adults successfully reporting on their past pretend play (Lillard & Smith, 2012; Sandberg et al., 2004), this may be affected by their current adult perceptions (Sandberg et al., 2004). Therefore, the comparison between retrospective recall of childhood pretend play with current RRBs may be conflated with the individual's current perception of reality. This relates to the fact that the participants have an ASD diagnosis and may therefore be aware that a lack of pretend play is an early indicator and a possible diagnostic criterion for ASD. However, it could then be argued that participants will assume they did not play pretend. Given that the majority of the ASD sample did report pretend play, this indicates they were answering honestly. Moreover, participants who responded *Yes* to pretend play scored significantly lower on the AQ imagination subscale (indicating fewer difficulties with imagination) than those who responded *No*. This provides some support for the convergent validity of the two measures, although both have their limitations. This will be addressed in the following chapter which includes standardised measures of imagination and an interviewer-rated measure of RRBs.

Secondly, the study was conducted online and so it was not possible to confirm the diagnoses of participants. Although AQ scores were checked, the AQ has limited diagnostic use (e.g. Ketelaars et al., 2008; Murphy, Beecham, Craig, & Ecker, 2011) and it would be preferable to confirm ASD diagnoses using a diagnostic measure. There were some participants who reported a self-diagnosis. Although many individuals are now being diagnosed as adults, which presumably requires some level of self-diagnosis, participants were only included if they reported a clinical diagnosis of ASD. However, simply reporting a clinical diagnosis of ASD is not sufficient proof of diagnosis; again this will be addressed in the following chapter. Third, although data was not collected on participants' IQs, completing the online survey relies on the participants having the necessary cognitive resources to complete the questionnaires. This results in a sample that may not be representative of the ASD population, which includes a relatively high proportion of individuals with learning difficulties (e.g. Charman et al., 2011; Fombonne, 2003). As such findings from this study are not

generalizable to all individuals with ASD, which is a common problem with studies of adults with ASD.

The majority of participants included in the survey were diagnosed as adults and not as children. Generally, individuals with ASD are diagnosed as children (Howlin & Asgharian, 1999). Therefore this sample is not representative of the ASD population. I report group differences in terms of age at diagnosis in Appendix 7 (page 264). There were no significant relationships between gender or pretend play and age of diagnosis; however, participants who were diagnosed as adults scored significantly higher in terms of AQ and RBQ-2A total score, as well as IS and RSB. This is unusual, as it would be expected that individuals with higher levels of autistic traits would have been identified and diagnosed earlier in life. This could reflect masking in the early years; difficulty with IS and RSB may be less noticeable than RMB, which was not significantly different between groups. It could also be explained by greater awareness of their autistic traits as individuals are likely have been more involved in their diagnosis as an adult than as children.

Similarly, the majority of participants identified as female. ASD is diagnosed much more commonly in boys and men (e.g. Begeer et al., 2013; Szatmari et al., 2011; Werling & Geschwind, 2013). Therefore it is somewhat unusual that an ASD study has a higher proportion of women compared to men. This is particularly pertinent for the pretend play findings, as there is evidence that pretend play occurs at higher rates in girls with ASD compared to boys with ASD (e.g. Knickmeyer, Wheelwright, & Baron-Cohen, 2008), although this is not always the case (e.g. Baron-Cohen, 1987). However, there were no sex differences in terms of childhood pretend play or adult imagination measured by the AQ in the present sample.

It is not clear whether the higher rate of ASD in boys and men represents genuine gender differences or is instead due to gender bias in diagnostic tools, misdiagnosis of girls and women, and the 'masking' of symptoms (e.g. Van Wijngaarden-Cremers et al., 2014; Wing et al., 2011). Outside of ASD, it may be that women are generally more likely to volunteer for research studies than men. In traditional studies, women form on average 71-77% of the sample, but just 57% in a

large web-based survey (*N*=361,703; Gosling, Vazire, Srivastava, & John, 2004); however, there is some evidence that women are more likely to participate in health-related questionnaires (e.g. Eysenbach & Wyatt, 2002). Regardless of the reason, the gender imbalance of Studies Three and Four also affects the generalisability of the findings, especially when considering the unusual finding in Study Three that the women in the survey sample scored significantly higher in terms of the AQ and RSB.

4.4.2 Conclusion

To summarise, Study Three presents the first PCA, to my knowledge, of RRB data exclusively from autistic adults. I identified a three-component structure of the RBQ-2A comprising RMB, RSB and IS that differs somewhat from previous research that has always included children and adolescents. Study Three also supported the internal consistency and construct validity of the RBQ-2A in a larger sample of autistic adults. In addition, Study Four provided evidence for a relationship between imagination and RRB, in particular a small but significant effect between IS in adulthood and retrospective reports of pretend play. The next chapter describes a subsequent study of RRBs and current imaginative abilities, in which I was able to overcome some of the limitations of this study by carrying out several measures of imagination and confirming the diagnoses of participants. The DISCO was also included as a measure which asks participants about their pretend play as a child. As the DISCO is a researcher-led semi-structured interview, more detailed information is elicited from the participant and is interpreted by the researcher. This enables a more objective judgment of level of pretend play achieved. In addition the parents of participants, who may have more reliable and objective memories, were able to provide additional information about their children's pretend play. Therefore there is the opportunity to replicate the pretend play findings in a smaller but richer dataset. In addition, I administered several other measures of imagination to test the hypothesis that imagination and RRB, specifically IS, are related. These measures objectively assessed creativity and thinking about the future at the time of data collection. The standardised creativity measures also allowed for the assessment of novelty and flexibility in addition to fluency, test whether or not these variables associated differentially with RRBs.

5 Chapter Five: The Relationship between RRBs and Imagination

5.1 Summary of findings in relation to aims of the thesis

The overall aim of this thesis is to answer the question: what is the nature of the relationship, if any, between imagination and RRBs in autistic adults? Based on previous research and theory, I expect that there is a relationship between the two, but that it is specific to IS; in that routines, rituals and other examples of IS that are prevalent in ASD are associated with imaginative difficulties. I also aimed to develop a self-report measure of RRBs suitable for use with autistic adults, and to assess a variety of different aspects of imagination in autistic adults, including the three key components of imagination I identified in Chapter One; generativity/fluency, novelty/originality and flexibility.

Most of the thesis until this point has focused on the aim of developing a self-report measure of RRBs, as this is crucial in enabling the testing of the relationship between imagination and RRBs. In Chapters Three and Four I described the development and assessment of the RBQ-2A as a reliable and valid self-report measure of RRBs in both autistic and NT adults in terms of component structure, internal consistency and construct validity. Two potential component structures were identified through PCA; however, the most reliable was identified in Study Three; a three-component structure comprising IS, RMB and RSB. This chapter will build upon the previous findings by conducting further assessment of the reliability and validity of the RBQ-2A, specifically its test-retest reliability and correlational validity, in order to confirm its utility as a measure of RRBs.

A clear picture has not yet emerged in terms of imagination. In Chapter Four I assessed autistic participants' past pretend play and current imaginative ability. I demonstrated evidence for a small but significant association between IS and retrospective childhood pretend play. There was also some evidence that the quality of self-chosen activities (as measured by item 20 of the RBQ-2A) in autistic adults is related to childhood pretend play, although this relationship was not entirely stable. Similarly, the evidence regarding imagination as assessed by the AQ was somewhat equivocal. There was no relationship with restricted activities, whereas there was some evidence of a relationship with IS even when controlling for RRBs. Unusually,

there was also evidence of a relationship with RSBs. Further exploration and testing of the relationship between imagination and RRBs is required in order to draw more firm conclusions regarding the aims of this thesis.

The aim of Study Five was to build on findings from earlier in the thesis in order to test whether or not IS is specifically related to imagination in autistic adults, along with exploring the profile of imaginative abilities in autistic adults and further testing the reliability and validity of the RBQ-2A. For this study, the participants were seen in person allowing for direct assessment of their imaginative abilities and RRBs, rather than solely relying on self-report as in the previous chapters.

5.2 Issues addressed in this chapter

5.2.1 Issues relating to imagination

The main focus of this chapter is to assess imagination in autistic adults in a more detailed way in order to examine their relationship with RRBs, with particular focus on different components of imagination (generativity, novelty and fluency). The penultimate section of Chapter One (page 50) discussed the potential relationship between imagination and RRBs, as well as the methodological difficulties that have impeded a definitive conclusion being drawn, which should be addressed before further examining this relationship.

Firstly, evidence for the relationship between imagination and RRBs has been drawn from a wide range of contexts: play behaviours, ideational and verbal fluency and thinking about the future. These represent very different areas of imagination, and although they are all compatible with my definition of imagination (*the generation and flexible manipulation of existing concepts to form novel ideas, which may be rooted in past experience and may result in adaptive outputs [creativity]*), it is not clear how these areas relate to one another and exactly what they are measuring. Few studies (*N*=13) have assessed different types of imagination in one sample of individuals with ASD, and even fewer (*N*=5) have directly correlated the different types of imagination; overall significant associations have been found between different measures of imagination (Angus et al., 2015; Begeer et al., 2009; Lind & Bowler, 2010), although the relationship between generativity measures (e.g. UOT and design

fluency) and the impossible person task has been shown to depend on planning (Low et al., 2009) or limited to TD children (Ten Eycke & Müller, 2016). As the literature comprises such a variety of measures, the nature of imagination in autistic adults is not yet clear (see discussion in Chapter One, page 29). Understanding imagination in autistic adults has a twofold purpose; in the context of this thesis, it is important to understand both imagination and RRB in order to draw conclusions regarding the relationship between them, and as I have noted (page 3), RRBs are currently better defined than imagination. In a broader context, it is important to improve our understanding of imagination in autistic adults as it provides useful information for diagnosis.

In order to address this first issue, I decided to include a variety of measures simultaneously, covering four domains of imagination: ideational fluency, design fluency, thinking about the future and retrospective reports of childhood pretend play. All of these domains have been previously explored in the context of understanding their relationship with RRBs, with the exception of drawing/design fluency, which forms a large part of the imagination literature in ASD. These aspects were chosen as they all fit my working definition of imagination, and they encompass a range of imaginative activities (for a more detailed discussion, see Chapter Two). Ideational and design fluency are measured by three subscales from the TTCT. Thinking about the future is measured by the PFT, a fluency task that has not yet been tested in an autistic population. Performance on this task may be affected by anxiety and/or depression (see Chapter Two, pages 78-79), and therefore the Hospital Anxiety and Depression Scale (HADS) was included. Given that two of the imagination measures depend on verbal fluency, a verbal fluency measure was included to control for this in any significant associations. Finally, a short form of the DISCO (see page 143) was administered which allows for the retrospective assessment of childhood pretend play. Measurement of several different aspects of imagination in a single sample may reveal how these different constructs relate to one another to form the single construct of imagination in autistic adults.

Related to this, there are several different dimensions of imagination that could be measured, relating to novelty, generativity and flexibility as shown in Figure 1 (page

12). I have noted that ASD researchers often measure fluency while neglecting other dimensions of imagination such as originality or flexibility (e.g. page 26). Although fluency is an important part of imagination, it may be confounded with EF difficulties – such as a difficulty with generativity - and it is therefore important to consider other ways of measuring imagination. It is also important as RRBs may be differentially related to separate constructs; for example there may exist a negative relationship with fluency, but a positive one with originality (page 55). As discussed previously in Chapter One, Wallach and Kogan (1965) consider the most important aspect of imaginative ability to be originality, which is conceptually equivalent to novelty in my definition of imagination. This refers to thinking of ideas that are unusual or even unique to a participant. Originality is usually scored in terms of how many other participants responded in the same way; for example, an idea may be original if no more than 5% of the sample had the same idea. In addition to originality, flexibility may be an important reflection of imaginative ability. The inflexibility of thought may also be logically related to a person's RRB, which can be characterised at least in part as inflexible behaviour. The TTCT allows for originality and flexibility to be scored in a standardised manner. This represents the first time the relationship between RRBs and originality and flexibility have been assessed in an exclusively ASD sample.

5.2.2 Issues relating to RRBs

The main measure of RRBs in this study for assessing the relationship with imagination was the RBQ-2A. As this study was carried out in a smaller sample, and it is therefore wise to reduce the number of analyses conducted, the total RBQ-2A score will not be used in this chapter to assess the relationship between imagination and RRBs. This is especially pertinent considering the findings from the pretend play data in Study Four and in previous research (Turner, 1997) that the relationship with RRB is specific to IS. Instead in terms of imagination analyses, the focus will be on IS only, using RMB and RSB as the control subscales[25].

An important issue with regards to RRBs has been the reliance on self-report thus far. This is also true for imagination, but will be addressed in this chapter by the use of standardised measures. As I have mentioned, a short form of the DISCO (page

[25] The total RBQ-2A scale will still be analysed for reliability and validity checks

143) was administered as part of this study. Usually the DISCO is carried out with the parents of an individual, but in this case participants were interviewed directly, although they were offered to bring a parent with them. Therefore the DISCO still relies in part on self-report, however, it allows for the trained interviewer to interpret the participant's answers and code items accordingly. The DISCO includes several items relating to RRBs. As mentioned in Chapter One, the DISCO's RRB items have not yet been validated as a standalone measure of this phenomenon, so caution is needed when interpreting them; nevertheless these items may help to validate self-report findings from the RBQ-2A. Of particular interest here is the item *limited pattern of self-chosen activities*, which codes whether an individual has a wide range of activities and interests that they spontaneously engage in, or prefers to engage in repetitive tasks and routines, and is analogous to the RBQ-2A's item 20 which was found in Study Four to be related to past pretend play.

One of the aims of this study was to assess aspects of the reliability and validity of the RBQ-2A that I have not yet tested. Firstly I aimed to assess the test-retest reliability of the RBQ-2A, by having participants complete the RBQ-2A at two time points and then assessing the correlations between their scores at each time points. Secondly, I aimed to assess the correlational validity of the RBQ-2A by comparing it with two measures, the RRB items from the DISCO and a recent questionnaire, the Adult Routines Inventory (ARI; Evans, Uljarević, Lusk, Loth & Frazier, 2017). The ARI is an adult version of the Childhood Routines Inventory (CRI; Evans et al., 1997) that I noted in Chapter One (page 58) as being unpublished at the time of carrying out the work from this thesis. Finally, I explained in Chapter Two (page 62) that construct validity is also demonstrated when a measure of a construct is associated with measures of *other* constructs to which it is theoretically related. It has been suggested that RRBs both serve to alleviate anxiety, and are a consequence of feeling anxious (e.g. Lidstone, Uljarević, et al., 2014; Rodgers, Glod, Connolly, & McConachie, 2012). In line with this, there is evidence that anxiety and RRBs are positively associated with each other (e.g. Joosten, Bundy & Einfeld, 2009; Stratis & Lecavalier, 2013); although there is some evidence that this is specific to IS rather than RSMBs (e.g. Rodgers et al., 2012). Indeed IS as measured by the parent-report RBQ-2 is significantly associated

with anxiety (Lidstone, Uljarević, et al., 2014). Therefore, if the RBQ-2A is associated with a measure of anxiety in accordance with previous research and theory, this would support the construct validity of the RBQ-2A.

5.3 Study Five: Assessing the relationship between self-reported RRBs and different aspects of imagination

This study assessed the internal consistency and test-retest reliability of the RBQ-2A as well as its correlations with the ARI, DISCO and HADS. The correlations between the different measures of imagination with each other and with the IS, RMB and RSB subscales of the RBQ-2A were also assessed. Finally, this study also aimed to replicate findings from Study Four that IS and a limited pattern of activities is associated with childhood pretend play, using the *imaginative activities* and *limited pattern of self-chosen activities* items from the DISCO along with the RBQ-2A. Participants were seen in two sessions, and took part in several measures of imagination and RRBs, along with the DISCO, measures of IQ and a measure of mental health.

It was expected that there would be significant associations between the imagination measures and RRBs. It was generally expected that poor performance on imagination tasks would be associated with higher levels of RRBs; however, in the case of originality, this relationship may be reversed. I hypothesised on the basis of previous research and Study Four that this relationship would be specific to the IS subscale of the RBQ-2A and the *limited pattern of self-chosen activities* item of the DISCO. It was also expected that the different measures of imagination would be significantly associated with each other. Finally, I expected that the RBQ-2A would be significantly and positively associated with both the ARI and RRB items from the DISCO, along with anxiety symptoms. I also expected that the RBQ-2A would show good test-retest reliability and continue to show good internal consistency.

5.3.1 Method

5.3.1.1 Participants

Participants were recruited in a variety of ways: from the Wales Autism Research Centre's Research Recruitment Register; through local charities in the South Wales area; personal contact; and the Cardiff University Noticeboard. Inclusion

criteria for the study were: having a clinical diagnosis of any ASD, being aged 18 or older, with the ability to read and write English fluently. The only exclusion criterion was having an IQ below 70 as the study was cognitively demanding. Initially 29 participants were recruited; however, one participant withdrew and another participant was excluded due to having an IQ below 70.

The final sample comprised 27 participants, aged between 19 and 63 at the first time point (*M*=35.69, *SD*=12.71), seventeen (63%) of whom identified as male. All participants reported receiving a diagnosis of ASD from a clinician. The majority of participants (*N*=20) were diagnosed with AS. The remaining participants were diagnosed with ASD (*N*=4) or HFA (*N*=3), and eighteen participants were diagnosed as adults. Twenty-two participants provided evidence of their clinical diagnosis in the form of reports or letters. Twenty-three participants reported whether or not they had a diagnosis of anxiety or depression (*N* anxiety=5; *N* depression=2, *N* both=10, *N* neither=6). Seven participants were currently attending college or university, eleven participants were employed and twenty-three participants identified as being white.

5.3.1.2 Materials and measures

5.3.1.2.1 Demographics

The following demographic information was collected: date of birth; gender; ASD diagnosis; age at diagnosis; anxiety and/or depression diagnosis if applicable; college/university status; age of leaving education; qualifications; employment status; current job; and ethnicity. Where available, participants were also asked for proof of diagnosis (e.g. diagnostic report, letter from diagnosing clinician).

5.3.1.2.2 RRBs

5.3.1.2.2.1 RBQ-2A

The RBQ-2A as described in Chapters Three and Four and Appendix 3 (page 250). Total score and the subscales (IS, RMB and RSB) from Study Three were used for reliability and validity checks, and the subscales were assessed for their relationship with imagination.

5.3.1.2.2.2 Adult Routines Inventory

The ARI; Evans et al., 2017) is the adult self-report version of the Childhood Routines Inventory (Evans et al., 1997). The ARI comprises 55 items covering a wide variety of RRBs, scored on a 5-point scale: *Not at all/Never* (1); *A little/Rarely* (2); *Somewhat/Sometimes* (3); *Quite a lot/Often* (4); *Very much/Always* (5). See Appendix 8, pages 265-269 for a list of items. Factor analysis of the ARI results in two factors: Repetitive Sensory-Motor Behaviours/Compulsions (RSMBC), equivalent to RSMB; and Rigidity/Insistence on Sameness (RIS), equivalent to IS.

5.3.1.2.3 Imagination and related constructs (generativity, novelty and flexibility)

Chapter Two (page 75) lists the different measures of imagination used in this thesis and the reasons for selecting them. Generativity/fluency were measured using two verbal fluency tasks, the PFT, and the TTCT. Originality and flexibility were also assessed by the TTCT. Finally, the DISCO includes several items that code for the quality of childhood pretend play.

5.3.1.2.3.1 Measures of generativity only

5.3.1.2.3.1.1 Verbal fluency

As a baseline measure of generativity, participants completed letter and semantic fluency tasks (Benton, 1968; Lezak et al., 2004; Turner, 1999b). In the letter fluency task, participants were first asked to name as many words they could possibly think of beginning with the letter T as a practice. Once they named three correct words, they were asked to name as many different words as they could beginning with the letters F, A and S in one minute. For the semantic fluency task participants were asked to think of words belonging to the category *items of clothing* as a practice task; once they named three correct words they were then asked to name as many *animals* and as many *foods* as they could in one minute without repetitions. Participants' responses were scored in terms of total correct responses (fluency), excluding non-words, repetitions and responses that did not begin with the correct letter or belong in the given category.

5.3.1.2.3.1.2 Personal future task

This task was adapted from the PFT paradigm developed by MacLeod and colleagues (e.g. MacLeod & Byrne, 1996; MacLeod et al., 1993). For this task,

participants were given two minutes to name as many possible future events that may happen to them as they could. They were instructed that the events could be trivial or important, but either definitely going to happen or quite likely to happen. There were two conditions: positive (*things that you are looking forward to, in other words, things that you will enjoy*) and negative (*things that you're worried about or not looking forward to, in other words, things that you would rather not be the case or rather not happen*). The exact instructions given to participants are provided in Appendix 9 (page 270). In each condition there were three time periods: next week (including today); next year; and next five to ten years. As with the verbal fluency tasks, participants were scored in terms of total output and total valid responses. Responses were counted as correct if they were a future event, not repetitions of a previous event in any timeframe of a condition, and were the correct emotional valence for the condition.

5.3.1.2.3.2 Measures of generativity, novelty and flexibility

5.3.1.2.3.2.1 Torrance Tests of Creative Thinking subtests

Three subscales from the TTCT (Torrance, 2008) were included to further assess imagination. Two subtests were taken from Figural Form A: *Incomplete Figures* and *Repeated Figures*. For the Incomplete Figures task (IFT), participants were given ten minutes to complete ten meaningless line drawings and give each one a title. For the Repeated Figures task (RFT), participants had ten minutes to create as many drawings as possible from thirty stimuli consisting of a pair of parallel lines, again giving each one a title. The third subtest was taken from Verbal Form A and was *Unusual Uses of Cardboard Boxes*. In this test, participants were given ten minutes to think of as many new and unusual uses for cardboard boxes as possible and write down their answers.

For the IFT and RFT, participants were scored in terms of fluency (generativity) and originality (novelty). The fluency score comprised the number of drawings completed and titled, excluding repetitions and uninterpretable responses. This results in two total scores out of 10 and 30 respectively. Only responses that were counted under the fluency score could be coded in terms of originality. To assess originality, participant responses were compared against the most common responses

per stimulus derived from population norms by the authors of the TTCT. Each participant response that was included under the common responses was given a score of 0, and all other responses a score of 1. As originality may confound with fluency, the proportion of original responses was calculated by dividing the number of original responses by the fluency score.

For the Unusual Uses of Cardboard Boxes (UUCB) task, fluency and originality were scored in the same way. In the case of fluency, any interpretable response that was not an impossible use (e.g. make a live dog) or a repetition was counted as a valid response. Unlike for the figural TTCT, there was not a strict upper limit in terms of how many uses a participant could generate (although the booklet provided 50 lines). The UUCB task was also scored in terms of flexibility. Each response was given a particular category, and the total number of unique categories generated formed the flexibility score for each participant.

Due to the potential subjectivity of scoring participants in terms of originality and flexibility rather than just fluency, two additional researchers coded participants' responses on the TTCT. One coded all participants' responses to the figural TTCT, and the other coded seven participants' responses to the verbal TTCT.

5.3.1.2.4 DISCO-Abbreviated

The DISCO – Abbreviated, a shortened form of the DISCO, was used in this study for three purposes: firstly, to assess ASD traits and confirm diagnoses in the sample; secondly as an additional measure of imagination; and finally as an additional measure of RRBs. The use of the DISCO in this study is particularly important since much of the work regarding the importance of imagination and its relationship with RRBs in ASD is derived from Wing and Gould's early observations, which also served as the basis for the DISCO. Therefore this interview provides a rich source of information regarding imagination in ASD, compared to other tools which neglect imagination.

The full DISCO is an effective tool for diagnosing ASD that assesses the frequency, severity and impact of an individual's behaviours and demonstrates good inter-rater reliability and discriminant validity (Leekam et al., 2002; Maljaars et al., 2012; Nygren et al., 2009; Wing et al., 2002) and has been validated in Swedish

(Nygren et al., 2009), as well as showing strong agreement with outputs from the ADI-R and ADOS (Maljaars et al., 2012; Nygren et al., 2009). The items comprising the DISCO-Abbreviated were selected from the full interview on the basis of their predictive validity and ability to discriminate between ASD and non-ASD clinical diagnoses (Carrington, Kent et al., 2014).

As mentioned (page 138), participants were interviewed directly in this study, although they were offered to bring a parent with them. If a participant was unable to recall or did not know the answer to an item, they were asked to consult their parents or a close relative after the interview and inform the research team of the answer if possible. For most DISCO items, participants are given two codes; one for whether they show the behaviour *currently* and another for whether they have *ever* shown the behaviour. For the purposes of diagnosis, the *ever* codes are used. Most DISCO items are coded in the following way: *marked problem* (0), *minor problem* (1) or *no problem* (2), although some items have their own specialised coding systems.

5.3.1.2.4.1 Confirmation of diagnoses

There are several algorithms available for determining whether or not an individual should be diagnosed with ASD. In contrast to the full DISCO, to date the only published algorithm for the DISCO-Abbreviated is based on DSM-5 criteria (Carrington, Kent et al., 2014). DSM-5 criteria have been criticised for not being sensitive or specific enough, particularly in terms of excluding more cognitively able individuals (e.g. McPartland, Reichow & Volkmar, 2012; Taheri & Perry, 2012), which represents a specific problem for the present study; although the DSM-5 algorithm for the *full* DISCO has been found to show good sensitivity and specificity across age and ability level (Kent, Carrington et al., 2013). Another issue that may be pertinent for the present sample is the fact that the DSM-5 requires the presence of symptoms before the age of three, and such information is not always possible to obtain for adults depending on the age and health of their parents. Nevertheless, as the only published algorithm for the DISCO-Abbreviated, I chose to implement the DSM-5 algorithm.

In light of the potential issues with the DSM-5 algorithm, I also chose to implement Wing and Gould's ASD algorithm. This algorithm requires evidence for the following criteria: social impairment; communication impairment; imagination

impairment; and repetitive activities, but does not specify that symptoms have to be present in early childhood. Therefore it represents a useful check of diagnosis that does not rely on information which may not be available to my participants.

5.3.1.2.4.2 Imagination items

Item 38 on the DISCO–Abbreviated is *imaginative activities*, and for this the interviewer asks participants "Does/Did [name]/you have any pretend play or imaginative activities?" Unlike most DISCO items, *imaginative activities* is rated on a six point coding scheme (Table 5.1 below). For adults, this item is coded in terms of the highest level reached by the individual. The first three codes (0-2) represent not having imaginative pretend play in the DISCO DSM-5 algorithm, whereas the last three (3-5) represent having imaginative pretend play. Therefore this item is conceptually similar to the pretend play question asked of participants in the previous two studies.

Table 5-1 Study Five: Scoring guideline for imaginative activities from the DISCO.

No pretend play	0	No play with model toys e.g. no interest in the function of trains, cars and dolls, although A may handle them in the same way as any other objects.
	1	Plays with real household equipment using it for its real purpose. No interest in miniatures e.g. sweeps with real broom, digs with real spade.
	2	Holds doll, toy animals as if real, e.g. hugs and kisses toys.
Pretend play	3	Goes through simple sequences of actions with toys as if they are real e.g. pushes toy trains and cars along floor as if real, and makes appropriate noises, or tucks doll in bed.
	4	Will pour and give a pretend cup of tea to other person spontaneously (if A only drinks from cup rate 3).
	5	Goes through longer sequences of actions with toys e.g. has a doll's tea party, sets up a garage, road and road bridges for play with toy cars.

Three other measures of childhood pretend play are also relevant. Individuals are coded in terms of *delayed* pretend play (whether or not pretend play was so delayed as to cause concern), *shared* pretend play (whether or not pretend play was shared, and if it was shared, whether the child dominated the play), and *repetitive* pretend play (whether the play was varied and flexible, or repetitive). Delayed pretend play is coded at two levels, whereas shared and repetitive pretend play are

coded at three levels corresponding to marked, minor or no problem. Participants who are scored between 0 and 2 on *imaginative activities* are necessarily delayed in terms of pretend play, and are not scored in terms of repetitive and shared pretend play as they do not show pretend play.

5.3.1.2.4.3 RRB items

There are twenty-three items that are coded under RRBs in the DISCO - Abbreviated DSM-5 algorithm (Appendix 10, Table 8.9, page 271). However, as higher scores on the RBQ-2A indicate higher levels of RRBs, and *lower* scores on the DISCO indicate marked difficulties, the coding of RRB items in the DISCO was reversed and recoded in line with RBQ-2A scoring (i.e. *marked problem* [0] became *marked problem* [3]). As the RBQ-2A measures current behaviour, the *current* codes from the DISCO were used as the measure of RRBs. Of particular relevance is the DISCO item *limited pattern of self-chosen activities*. *Limited pattern of self-chosen activities* codes whether an individual has a wide range of activities and interests that they spontaneously engage in, or prefers to engage in repetitive tasks and routines. It is analogous to item 20 (*what sort of activity will you choose if you are left to occupy yourself?*) of the RBQ-2A and was used here to replicate the finding from Study Four[26].

5.3.1.2.5 Other measures

5.3.1.2.5.1 Hospital Anxiety and Depression Scale

The HADS (Zigmond & Snaith, 1983) was included to assess anxiety for the purpose of assessing construct validity as described in Chapter Two (page 62), and also because performance on the personal future task may be related to both anxiety and depression (page 78). The HADS was originally designed for use with physically ill patients but is now widely used as a measure of mental health symptoms, and demonstrates good reliability and validity (e.g. Bjelland, Dahl, Haug, & Neckelmann, 2002; Mykletun, Stordal, & Dahl, 2001). The HADS comprises 14 items measured on a 4-point Likert scale from 0-3. Seven items relate to anxiety and seven relate to depression, resulting in a total possible score on each scale of 21; for each scale, the clinical cut-off point is eight.

[26] This item was used rather than item 20 of the RBQ-2A, so that the two items were drawn from the same measure (the DISCO), and because two participants had missing data on item 20.

5.3.1.2.5.2 Wechsler Abbreviated Scale of Intelligence

FSIQ, VIQ and PIQ were measured using the WASI (Wechsler, 1999), which comprises the Vocabulary, Block Design, Similarities and Matrix Reasoning subtests.

5.3.1.3 Procedure and statistical analyses

This study was approved by the Cardiff University School of Psychology Ethics Committee. Once contact had been established, the participant was sent the information sheet to read before taking part. The study was conducted in two sessions at one of two locations; the university or a local charity. At the start of the first session, the participant was offered another chance to read the information sheet. Once the participant had provided written informed consent, they filled in their demographic information. The first session comprised the imagination and creativity tasks (verbal fluency, PFT and the TTCT subtests), followed by a break and then the WASI and questionnaires. Nine participants completed the questionnaires digitally, and seventeen completed paper copies, depending on the available resources at the testing site. The length of time between the two sessions varied depending on the availability of the participant. The second session comprised the DISCO – Abbreviated interview, followed by filling in the RBQ-2A for a second time. Following completion of the second session, the participant was then debriefed. Participants were paid at the end of each session and their travel costs reimbursed.

5.3.1.3.1 Counterbalancing in first session

All participants completed the demographics first. They then completed the imagination and creativity tasks, the order of which was counterbalanced so that half the participants completed the verbal fluency and future thinking task first, and the other half completed the TTCT first. Verbal fluency always came before the PFT, but the conditions of the PFT (positive and negative) were also fully counterbalanced. IFT always came before RFT as they are presented this way in the TTCT; however, whether participants completed the figural TTCT subtests before the verbal TTCT subtest was also counterbalanced. After a break, participants then always completed the WASI in the standardised order (Vocabulary, Block Design, Similarities and Matrix Reasoning) and then the questionnaires. Half the participants completed the RBQ-2A first, and half completed the ARI first. All participants finished with the HADS.

5.3.1.3.2 Statistical analyses

In order to address the issues of reliability and validity set out at the start of this chapter, test-retest reliability for the RBQ-2A was assessed by testing the correlations between total RBQ-2A score and scores on its subscales across the two time points. The correlations were also tested while controlling for the time between sessions. The correlational validity of the RBQ-2A was assessed by testing its correlations with the ARI and with relevant items from the DISCO - Abbreviated. Inter-rater reliability was assessed using intra-class correlations. Correlation analyses were also conducted to test whether or not the HADS anxiety and depression scales were associated with the RBQ-2A.

To address the main aim of this study, correlation analyses were conducted to test the association between the RBQ-2A's subscales only (not the total score) and the different measures of imagination. Correlation analyses were also conducted to test whether or not the HADS anxiety and depression scales were associated with the PFT, as both anxiety and depression affect performance on the PFT. I also compared scores on the RBQ-2A subscales and *limited pattern of self-chosen activities* from the DISCO between participants who reported pretend play with those who reported not playing pretend, in order to further test the association found in Study Five. As I expect any relationship between RRBs and imagination to only occur with IS and not RSMB (see page 57 for a fuller discussion), only the three RBQ-2A subscales were used for this aim and not the total score. Due to the relatively small sample size and to counteract the effect of multiple testing, the alpha level was set to .01 for the analyses involving the imagination measures. Finally, the associations between the different measures of imagination were also assessed.

5.3.2 Results

5.3.2.1 Data screening and descriptive statistics

Age at time one (M=35.69, SD=12.71) was positively skewed with no outliers (SW[27]=.89, p=.009). One participant attended the DISCO session with a parent, one parent completed the full DISCO interview on behalf of their child and fourteen participants provided supplementary information about past behaviour from their parents. Only eight participants met the DSM-5 criteria for ASD using the DISCO-

Abbreviated. Of the five participants who did not provide evidence for their ASD diagnosis, only one met the DSM-5 criteria using the DISCO-Abbreviated. However, twenty-two participants met Wing and Gould's criteria for ASD. Each of the five participants who did not meet these criteria were able to provide evidence for their diagnosis and their exclusion did not alter the pattern of results, with three exceptions[27]. Questionnaire data were available from twenty-six participants. Participants' scores on the WASI ranged from: FSIQ=80.0-126.0 (*M*=107.81, *SD*=13.80); VIQ=75.0-120.0 (*M*=102.52, *SD*=14.35); PIQ=86.0-137.0 (*M*=111.96, *SD*=14.38).

5.3.2.2 Reliability and validity of the RBQ-2A

5.3.2.2.1 Test-retest reliability

RBQ-2A data were available for twenty-six participants at Time 1 and for twenty-five participants at Time 2. Table 5.2 below shows the scores and Cronbach's alpha values for the RBQ-2A total and subscale scores at Time 1 and Time 2.

Table 5-2 Study Five: Range, mean, SDs, Medians, IQRs and Cronbach's α values for the RBQ-2A subscales at Time 1 and Time 2

	Range	Mean (SD)	Median (IQR)	Cronbach's *α*
Time 1				
RBQ-2A Total	1.25-2.95	2.15 (.47)	2.18 (.74)	.93
RBQ-2A RMB	1.00-3.00	1.84 (.62)	1.80 (1.10)	.88
RBQ-2A RSB	1.00-2.75	1.92 (.51)	2.00 (.75)	.71
RBQ-2A IS	1.33-3.00	2.40 (.50)	2.56 (.72)	.87
Time 2				
RBQ-2A Total	1.11-2.75	2.02 (.47)	2.0 (.73)	.90
RBQ-2A RMB	1.0-2.80	1.74 (.55)	1.80 (1.10)	.80
RBQ-2A RSB	1.0-3.0	1.91 (.57)	2.0 (.88)	.76
RBQ-2A IS	1.0-3.0	2.24 (.54)	2.44 (.72)	.88

Mean scores on the total RBQ-2A were normally distributed at both time points. At Time 1, RMB and IS scores were positively skewed with no outliers, whereas RSB scores were normally distributed. At Time 2, all three subscales were normally

[27] The relationship between the RBQ-2A IS subscale and the ARI RIS subscale was no longer significant (r_s=.39, p=.08). The relationship between negative responses on the PFT and the HADS anxiety scale approached significance (r_s=.49, p=.025) as did the relationship between RFT and IFT fluency (r_s=.45, p=.035); however, as explained (page 148) the alpha level was set at .01 for the imagination analyses due to the small sample and large number of analyses.

distributed. Mean scores on the RBQ-2A at Time 1 and Time 2 were significantly correlated (r=.93, p<.001). Time 1 and Time 2 were also significantly correlated for RMB (r_s=.82, p<.001), RSB (r=.82, p<.001), and IS (r_s=.86, p<.001). The amount of time between the two sessions varied considerably between participants, ranging from 1 to 47 weeks (M=9.45, SD=10.57). There were two outliers in terms of time between sessions; however, their removal did not affect the pattern of results. All associations remained significant when controlling for the time between two sessions: RBQ-2A, (r_s=.92, p<.001), RMB (r_s=.83, p<.001), RSB (r_s =.78, p<.001), and IS (r_s=.89, p<.001).

5.3.2.2.2 Correlational validity

Table 5.3 below shows the scores on the ARI and its subscales, which were all normally distributed. The ARI and RBQ-2A were significantly correlated with each other (r=.82, p<.001). In addition, the ARI RSMBC subscale was significantly correlated with both the RMB (r_s=.75, p<.001) and RSB sub-scales (r=.64, p<.001), and the ARI RIS subscale was significantly correlated with the IS subscale (r_s=.51, p=.008).

Table 5-3 Study Five: Range, mean, SDs, Medians and IQRs for the ARI and its subscales

	Range	Mean (SD)	Median (IQR)	Cronbach's α
ARI Total	1.53-4.45	3.31 (.67)	3.34 (.75)	.90
ARI RSMBC	1.30-4.50	3.19 (.76)	3.36 (1.12)	.88
ARI RIS	1.73-4.61	3.51 (.80)	3.57 (1.15)	.90

There are twenty-three items listed under RRB in the DISCO according to the DSM-5 criteria (see Appendix 10, Table 8.9, page 271). Mean total scores were calculated for the *current* codes of all twenty DISCO RRB items, and these ranged from 1.12 to 2.37 (M=1.67, SD=.32). These items showed excellent internal consistency α=.90[28]. These items were significantly correlated with the mean total scores from the RBQ-2A (r=.80, p<.001). However, participants scored significantly higher on the RBQ-2A compared to the DISCO (t[25]=-8.57, p<.001).

[28] Due to low variance, *repetitive acting out roles* and *twisting hands or objects near eyes* were not included in this analysis.

5.3.2.2.3 Construct validity

Total scores on the HADS anxiety subscale ranged from 3 to 21 (*M*=12.08, *SD*=4.71) and were normally distributed. Nineteen (84.6%) participants scored at or above the suggested clinical cut-off of 8 for both scales in terms of anxiety. Anxiety was not significantly associated with any of the RBQ-2A subscales (see Appendix 11, Table 8.10, page 272).

5.3.2.3 The relationship between RRBs and imaginative abilities

As the RBQ-2A and its subscales were significantly correlated at both time points, and most of the imagination measures were taken at Time 1, the RRB subscales from Time 1 were used in this study.

5.3.2.3.1 Relationship between RRBs and verbal fluency

For the Letter Fluency task, valid responses ranged from 21 to 74 (*M*=42.11, *SD*=15.01) and from 19 to 63 (*M*=37.93, *SD*=11.10) for the Category Fluency task, and both were normally distributed. These two measures were also significantly associated with each other (r_s=.71, *p*<.001). Neither of these measures was significantly associated with any of the RBQ-2A subscales (see Appendix 11, Table 8.11, page 272).

5.3.2.3.2 Relationship between RRBs and the Torrance Tests of Creative Thinking

5.3.2.3.2.1 Descriptive statistics

Table 5-4 Study Five: Ranges, means (SDs), and medians (IQRs) for the TTCT data.

	Fluency			Originality*			Flexibility*		
	Range	Mean (SD)	Median (IQR)	Range	Mean (SD)	Median (IQR)	Range	Mean (SD)	Median (IQR)
Incomplete Figures (*N*=24)	3-10	7.67 (2.24)	8.0 (4)	.50-1.0	.74 (.16)	.73 (.26)	-	-	-
Repeated Figures (*N*=24)	0-29	12.08 (6.75)	10.0 (8)	.50-1.0	.80 (.16)	.83 (.24)	-	-	-
Unusual Uses of Cardboard Boxes (*N*=27)	4-39	16.26 (8.63)	16.0 (11)	.47-1.0	.72 (.13)	.76 (.21)	.39-1.0	.65 (.17)	.63 (.21)

*As a proportion of fluency.

The range of scores, means and standard deviations of the TTCT sub-tests are displayed in Table 5.4 on the previous page. Two participants did not complete either the RFT or IFT. One additional participant did not complete the IFT, and another did not complete the RFT. Of the participants who did complete the tasks, out of a total of ten drawings on the IFT, participants completed a mean of 7.67 and a median of 8 drawings, and for each participant at least 50% of their drawings were rated as original. For the RFT, participants completed a mean of 12.08 and a median of 10 drawings, and again for each participant at least 50% of their drawings were rated as original. For the UUCB task, participants generated a mean of 16.26 and a median of 16 uses, and at least 47% of participants' responses were rated as original. Table 5.5 below shows examples from the participants in this study to illustrate original and non-original responses.[29]

Table 5-5 Study Five: Examples of original and non-original responses on the TTCT subtests

	Not original	Original
Incomplete Figures (Titles)	"Happy stickman" "Birds in the sky" "Mountain top view" "Heart"	"Here comes summer" "Falling to Earth" "I'm not a ghost I'm a phantom" "Out to sea in umbrella" "Mr Cloud was content"
Repeated Figures (Titles)	"House with 4 rooms" "Front door" "Trees" "Book"	"Curious llama" "Inter-dimensional gateway" "Finally I'm tall ☺" "Get off your high horse" "Coconut halves clapping"
Unusual Uses of Cardboard Boxes	"Improvised furniture" "Draw or write on the cardboard" "Building a fort" "Toys"	"Lunar eclipse pinhole" "Tobogganing" "Use as a wormery" "To illustrate how to build bridges – outer framework"

[29] Due to copyright restrictions, only the titles of the figural TTCT responses are shown here. However, it should be noted that the TTCT emphasises the use of the *stimulus* when judging the originality of a response.

5.3.2.3.2.2 Relationship with RRBs

Fluency scores were normally distributed on the RFT, but positively skewed on the IFT (*SW*[24]=.88, *p*=.007) with no outliers. The mean proportion of original responses on both the IFT and RFT were normally distributed. Inter-rater reliability was excellent for all four measures (ICC ranged from .998 to 1.0, *p*<.001), therefore the first coder's (SB) scoring was analysed. There were no significant associations between fluency or originality on the Figural TTCT and any of the RBQ-2A subscales (see Appendix 11, Table 8.12, page 272). Fluency on the RFT and IFT were not significantly associated with each other (r_s=.28, *p*=.205). The proportion of original responses on the IFT and the RFT were also not significantly associated with each other (*r*=.094, *p*=.669).

Fluency, originality and flexibility were all normally distributed in the UUCB. Inter-rater reliability was good or excellent for all three measures (ICC .89-.98, *p* range from 0.11 to <.001) and so the first coder's scoring was analysed. There were no significant associations between any of the UUCB scores and any of the RBQ-2A subscales (see Appendix 11, Table 8.12). Fluency on the UUCB was not associated with the other TTCT fluency scores, and neither was originality associated with the originality scores on the Figural TTCT (see Appendix 11, Table 8.12).

5.3.2.3.3 Relationship between RRBs and the Personal Future Task

5.3.2.3.3.1 Descriptive statistics

Table 5-6 Study Five: Range, means (SDs) and median (IQRs) for the three conditions of the PFT.

	Range	Mean (SD)	Median (IQR)
Total	5-85	37.22 (22.23)	34.0 (22)
Positive	1-59	19.70 (12.49)	16.0 (13)
Negative	4-54	17.52 (12.63)	15.0 (11)

Table 5.6 above shows the range, means, SDs, medians and IQRs for responses to the PFT. All participants were able to complete this task, although several (*N*=7) expressed a difficulty with thinking about the future. There was a large amount of variation in the amount of responses to this task; Table 5.7 overleaf shows some examples of the events that participants generated.

Table 5-7 Study Five: Examples of participant responses across all six conditions of the PFT.

	Positive	Negative
Next Week	"Some time at the weekend to get into the garden" "Finishing a sewing box that I'm making for fiancée" "Spending time with my child"	"My neighbours making a lot of noise" "On Saturday night my room-mate's having a party" "Paying for the work that's being done"
Next Year	"This year I'm hoping to pass all my exams" "I might get a job" "Getting to know my great nieces and nephew better"	"My mother getting ill… or even dying" "There's always the elections next year" "PIP assessment"
5-10 Years	"Buying a house" "I would like to be a chiropractor one day" "I think it's the kids growing up more than anything and seeing how they're gonna change"	"I may have met somebody, but they'll have broken up with me, that's a possibility" "I suppose losing my parents, that's a good possibility" "Well I'll have even more benefit assessments"

5.3.2.3.3.1.1 Relationship with RRBs and anxiety

Responses in all three conditions were significantly positively skewed, and there were two outliers in terms of positive and negative events. However, the removal of these outliers did not alter the pattern of results so they remained in the analysis. There was no significant difference between the number of positive and negative valid events (Z=-.74, p=.461). None of the three conditions of the PFT were associated with either anxiety or depression as measured by the HADS (see Appendix 11, Table 8.13, page 273). Again there were no significant associations between total valid FTT responses and any of the RBQ-2A subscales (Appendix 11, Table 8.13).

5.3.2.3.4 Relationship between RRBs and DISCO pretend play items

5.3.2.3.4.1 Descriptive statistics

Participants' scores on the *imaginative activities* item from the DISCO ranged from 0 to 5 (see page 145 for scoring details). Scores between 0 and 2 indicate that participants showed no evidence of pretend play as a child, and scores of 3 or above

indicate evidence of pretend play as a child. Sixteen participants in total reported playing pretend as a child, and eleven indicated not playing pretend as a child. Participants who are scored 3-5 on *imaginative activities* are then scored in terms of whether or not the pretend play was *delayed*, *shared* and/or *repetitive.* Table 5.8 below shows the different patterns of scores that participants received on these variables, in terms of whether or not play was delayed, whether or not it was shared, and whether or not it was repetitive. One participant had missing data on all three additional variables and is not included in the table.

Table 5-8 Study Five: Patterns of scores for participants on the DISCO past imagination items; "-" indicates missing data.

Imaginative Activities	Delayed	Shared	Repetitive	*N*
No pretend play	Yes	N/A	N/A	11
Pretend play	-	No	Yes	7
	-	Yes	Yes	1
	Yes	No	Yes	2
	No	Yes	Yes	1
	No	No	Yes	4

5.3.2.3.4.2 Relationship with RRBs

Participants were split into two groups in line with Study Four's analysis, such that scores of 0-2 were recoded as 'no pretend play' and 3-5 were recoded as 'pretend play'. Table 5.9 overleaf shows the means and standard deviations for IS, RMB and RSB of each group. All scores were normally distributed with the exception of RMB in the pretend play group, which was positively skewed with no outliers. Participants who did not report playing pretend as a child scored between 1.33 and 3.0 (M=2.44, SD=.49) in terms of IS and participants who did report playing pretend as a child scored between 1.44 and 3.0 (M=2.37, SD=.52) on IS; however, there was no significant difference between the two groups in terms of IS (t[1,22.39]=.137, p=.715) or in terms of the other two RBQ-2A subscales (RMB: Z=-.37, p=.721; RSB: t[1,20.06]=.68, p=.419).

Table 5-9 Study Five: Means and standard deviations for IS, RMB and RSB, according to whether or not the participant showed evidence of pretend play.

		IS	RMB	RSB
Imaginative Activities	0-2 (No pretend play) (*N*=11)	2.44 (.49)	1.87 (.57)	2.02 (.55)
	3-5 (Pretend play) (*N*=15)	2.37 (.52)	1.81 (.67)	1.85 (.49)

Finally, chi-squared analyses were carried out to assess the relationship between *imaginative activities* and *limited pattern of self-chosen activities* from the DISCO. The two less extreme options of the latter item were collapsed together as in Study Four[30]. Table 5.10 below displays the frequencies and percentages of participants' scores on *limited pattern of self-chosen activities* according to whether or not they reported playing pretend. The chi-squared analysis was not significant[31] (χ^2[1]=.004, *p*=.952); however, the expected count for one of the cells was below five, suggesting that chi-squared analysis should not be run.

Table 5-10 Study Five: Frequencies and percentages of participants' scores on the limited pattern of self-chosen activities items from the DISCO, grouped according to whether or not they played pretend.

		Limited pattern of self-chosen activities	
		Marked problem	No / Minor problem
Imaginative activities	0-2 (No pretend play)	7 (63.6%)	4 (36.4%)
	3-5 (Pretend play)	10 (62.5%)	6 (37.5%)

5.3.2.4 Relationships between the TTCT, PFT and DISCO results

Appendix 11, Table 8.13 (page 273) shows the correlation coefficients between equivalent scores on each of the imagination measures: figural TTCT (RFT and IFT), verbal TTCT (UUCB) and all three conditions of the PFT. The figural TTCT measures were not correlated with the PFT.

Total, negative and positive PFT scores were significantly and positively associated with fluency on the verbal TTCT task. However, when controlling for overall

[30] Not collapsing the RRB items did not affect the significance of the analyses.
[31] This analysis remained non-significant regardless of whether the *current* or *ever* codes were entered for *limited pattern of self-chosen activities*.

verbal fluency, the only association that remained significant at the .01 level was between negative PFT responses and fluency on the verbal TTCT task (r_s=.55, p=.005).

There were no significant correlations between participants' scores on the DISCO imaginative activities item and any of the imagination fluency measures (Appendix 12, Table 8.14, page 274). Table 8.14 also shows performance on the imagination fluency tasks in terms of participants' scores on the DISCO pretend play items for descriptive purposes only; these were not statistically analysed due to the small sample size.

5.3.3 Discussion

The main aim of this study was to test the hypothesis that IS behaviours are associated with imagination in autistic adults, while also assessing additional measures of the reliability and validity of the RBQ-2A. This study extended the previous chapter and previous research, by measuring several aspects of imagination (design fluency, ideational fluency, thinking about the future and childhood pretend play) in one sample with ASD. The findings presented here further support the reliability and validity of the RBQ-2A, along with demonstrating a varied profile of imagination and creativity in autistic adults. However, there was no statistical evidence of a relationship between imagination and RRBs.

5.3.3.1 Reliability and validity of the RBQ-2A

The RBQ-2A continued to demonstrate good reliability and validity in this study. Internal consistency was excellent for the scale as a whole at both time points (α≥.90) and good or acceptable for the subscales. The RBQ-2A and its subscales show good test-retest reliability with all correlations at .82 or higher. One potential issue is the large variation in terms of time between completing the RBQ-2A among participants; however, controlling for this and removing outliers did not alter the strong correlations between the two time points. Finally, the whole RBQ-2A scale was strongly correlated with the whole ARI scale, and their equivalent sub-scales (RMB/RSB and RSMBC; IS and RIS) also correlated with each other. These findings add strength to the use of the RBQ-2A as a measure of RRBs in autistic adults.

However, the positive association between the ARI and RBQ-2A may be explained by the fact they are both self-report measures. Therefore the RRB items from the researcher-rated DISCO were also compared with the RBQ-2A. There was a strong positive correlation between responses on the RBQ-2A and scores on the RRB items from the DISCO, although participants tended to score themselves higher on the RBQ-2A than they were scored on the DISCO. There are some limitations to using the DISCO in this manner. Firstly, the DISCO RRB items are not currently a recognised scale of RRB items; although their internal consistency in this study was excellent, which suggests that they may warrant further assessment. Secondly, given that most items from the original parent-report RBQ-2 were derived from the DISCO, the two measures are closely related, and this may account for the strong association. However, eleven of the twenty-three DISCO items do *not* have direct RBQ-2A analogues, which suggests that this is not necessarily an issue. Third, the researcher making ratings still relies on self-reported information to score the participant (although information was available from sixteen parents in total). A more reliable assessment of the effect of self-report would be to have a parent or other informant to fill in the RBQ-2A on behalf of the participant, which should be addressed in future research. Finally, the questions on each measure are also qualitatively different, in that the DISCO tends to focus on more 'extreme' behaviours as a result of its purpose as a diagnostic tool, whereas the RBQ-2 (on which the RBQ-2A is based) was designed to assess a profile of RRBs that would be seen in both typical and atypical development. Moreover, eleven of the RBQ-2A's items are initially answered on a four-point scale that is later collapsed, compared to the DISCO items which are all rated on a three-point scale. These two differences may explain why participants tended to rate themselves higher on the RBQ-2A compared to how they were coded during the DISCO. In summary, the comparison with the DISCO provides some evidence of the correlational validity of the RBQ-2A, but this evidence should be treated with some caution.

As discussed in Chapter Two (page 62) and the start of this chapter (page 138), construct validity can be assessed by testing a measure's relationship with a theoretically related construct. As a final assessment of construct validity, the correlation between the RBQ-2A and the HADS was tested, as there is substantial

evidence from previous research that RRBs and anxiety are related in ASD (e.g. Joosten et al., 2009; Rodgers et al., 2012; Stratis & Lecavalier, 2013). Unusually, none of the RBQ-2A subscales significantly associated with anxiety. Therefore this casts some doubt on the construct validity of the RBQ-2A. Although the HADS is widely used as a measure of anxiety and depression, more recent studies have questioned its suitability for measuring these two distinct constructs (Cosco, Doyle, Ward & McGee, 2012; Norton, Cosco, Doyle, Done, & Sacker, 2013). Therefore it may be an issue with the HADS rather than the RBQ-2A that results in a lack of correlation; for example, several previous studies that find a relationship between RRBs and anxiety (Lidstone, Uljarević, et al., 2014; Rodgers et al., 2012; Wigham, Rodgers, South, McConachie & Freeston, 2015) have used the more detailed Spence Children Anxiety Scale (Spence, 1998).

5.3.3.2 Performance on imagination tasks

In terms of imagination, there was a wide variety in performance on the TTCT. Most participants completed ten drawings on the IFT (*N*=9); although performance was more varied on the RFT, however, this may be due to the fact that the same stimulus is presented repeatedly, which may have made the task difficult for some participants. Some participants (*N*=3) were unable to complete the drawing tasks, with one participant describing it as too "*abstract*". One previous finding has been that participants with ASD generate more original ideas than TD children (e.g. Liu et al., 2011). Although there is no comparison group, it is worth noting that across all three TTCT tasks at least 47% of each participants' responses were original, which is a high proportion for a group that is thought to struggle with imagination. Two participants also linked the different stimuli in their responses and created stories, which according to the TTCT scoring guidelines should be considered highly original.

Fluency showed markedly more variation, although 33.3% of participants completed all ten drawings on the IFT. As noted above, there were some particular difficulties with fluency on the figural form of the TTCT. Fluency ranged from 3 to 10 drawings on the IFT, 0 to 29 on the RFT and 4 to 29 unusual uses of cardboard boxes. Flexibility was measured in the UUCB by summing how many different categories a participant's responses fall into, and then calculating the number of unique categories as a proportion of a participant's fluency score. For this sample, the scores ranged

from .39 to 1.0 and the mean score was .66; this is somewhat unexpected as previous research has shown difficulty with flexibility in autistic individuals (e.g. Craig & Baron-Cohen, 1999; Liu et al., 2011); although Pring et al. (2012) did not find a difficulty in flexibility in design fluency. Considering the variation in fluency with the high proportion of original responses, this pattern is compatible with the hypothesis that whereas some autistic individuals with ASD have difficulty with generating ideas, the ideas that they do generate tend to be original. Further assessment of these constructs and comparison with a control group of NT individuals is necessary to test this hypothesis, and to explore flexibility in ASD.

It is more difficult to assess the profile of responses on the PFT as it is not a standardised task. To my knowledge, this is the first study to employ the PFT in ASD, and so it cannot be compared to previous research with this population. It is also a qualitatively different task compared to other future thinking tasks, as the quality of participants' responses are not coded in terms of how specific and detailed the event is, or whether the event is categorical (e.g. going shopping) or extended (e.g. going on holiday). Some participants expressed a difficulty with thinking about the future, making comments such as "*I don't really think forward*", "*You can't tell what's gonna happen*", and "*That's a difficult one, I don't tend to think that far into the future*". However, it was definitely not the case that all participants struggled with thinking about the future; indeed, one participant commented "*I've always thought into the future*" and enjoyed entertaining 'what if?' questions in their writing.

Seventeen participants reported a clinical diagnosis of anxiety and/or depression, and the majority of participants scored above the clinical cut-off for anxiety on the HADS in the current sample. Given the high levels of anxiety and depression in the present sample, it would be expected that the sample would follow the pattern of a clinical group with both anxiety and depression as described in Chapter Two (page 78); that is, positive events may be reduced due to depression, and negative events may be increased due to anxiety. However, neither anxiety nor depression were significantly associated with performance on the PFT, supporting previous research in terms of depression (Crane et al., 2013) and there was no within-group difference in terms of positive and negative events. This lack of association may

be due to weakness of the HADS (see earlier discussion, page 159) or the low power of the study; or it may be that anxiety and depression do not affect future thinking in autistic individuals in the same way as they do NT individuals. It would be interesting to directly compare groups of individuals with anxiety/depression either with or without ASD to see how performance on the task differs between these two groups.

In terms of pretend play, more than half of the sample (*N*=15) reported playing pretend games as a child, which may reflect the relatively able nature of the sample. However, Table 5.9 (page 156) showed that all participants who did play pretend played repetitively as children, and additionally most participants indicated another difficulty (e.g. lack of *shared* play). This is particularly notable given that diagnosis of ASD in the UK follows ICD-10 criteria which do not *require* difficulties in pretend play for a diagnosis, yet the entire sample showed some difficulty with past pretend play[32]. These difficulties with past pretend play are notable when considering the range of responses to the different imagination tasks included in this study; supporting the idea that imagination is a complex, multi-dimensional construct. Indeed, there were no significant correlations between *imaginative activities* from the DISCO and the other imagination tasks. Finally, this may provide some evidence that difficulties with certain aspects of imagination are central to ASD despite not being included as necessary diagnostic criteria in the ICD-10 or DSM-5.

The findings presented here may inform how the imagination literature in ASD should be approached. As discussed earlier (page 21), there has been little research addressing the correlational validity of different imagination methods. Notably, neither of the design fluency measures here were significantly associated with future thinking; whereas the ideational fluency task was associated with future thinking, although this was mostly due to the fact that both depend to some extent on verbal fluency. Moreover, the *imaginative activities* item from the DISCO was not significantly correlated with the other imagination measures. Table 8.14, Appendix 12 (page 274) shows the pattern of performance on the TTCT and PFT depending on how participants were coded on the pretend play items. Due to existing issues with low power and

[32] With one exception of a participant who scored 5 on imaginative activities but for whom there was no information on whether this play was delayed, shared or repetitive.

sample size (page 161) I did not run statistical analyses on these data; however, a strong qualitative pattern does not emerge when inspecting the table. The lack of relationship between these measures suggests that although all of these measures ostensibly assess some facet of imagination, they are all measuring distinct constructs.

This may also reflect the distinction between imagination and creativity that I discussed in Chapter One (page 8). Specifically, thinking about the future and generating novel uses for objects do not actually *require* an output, whereas drawing and playing pretend are outputs of imagination. If an individual shows difficulty in terms of creativity, they do not necessarily have difficulty with imagination; however, if they are able to generate novel responses – as the majority of the sample did here – this implies they have imaginative ability. This further highlights how estimates of imaginative ability are sensitive to task differences, and a range of measures should be used when assessing imagination. Furthermore, careful consideration should be given to where the line is drawn between imagination and creativity in future research.

Overall, the lack of relationship between different measures of imagination may explain why across the previous research, there is equivocal evidence across different methods. Given the wide range of studies of imagination in ASD employing a variety of methods, this highlights how difficult it is to draw conclusions about imagination in ASD from the available literature. Further research should assess imagination in more than one way in their studies, and explore how different measures of imagination may be related to allow for a better interpretation of the current literature.

5.3.3.3 Relationship between imagination and RRBs

Previous findings regarding imagination and RRB in ASD have been equivocal. Some studies find evidence of a relationship (Best et al., 2015; Harrop et al., 2014; Honey et al., 2007), and others find evidence that this relationship is specific to IS (Turner, 1997). However, these findings have not always been replicated (Bishop & Norbury, 2005; Dichter et al., 2009; Lind et al., 2014). Previous research into this relationship has focused almost exclusively on fluency and not assessed originality or flexibility as components of imagination (e.g. Bishop & Norbury, 2005; Turner, 1997), and tends to measure one type of imagination (e.g. Dichter et al., 2009; Honey et al.,

2007) and/or not analyse the different subtypes of RRBs (e.g. Bishop & Norbury, 2005; Honey et al., 2007), which has limited the conclusions that can be drawn about this relationship. The present study aimed to address these weaknesses by simultaneously assessing the different subscales of RRBs and assessing different types and dimensions of imagination. I expected there to be evidence that imagination and RRBs are significantly associated with each other, and that this is specific to IS and limited self-chosen activities as in Study Four.

In line with hypotheses, there was no relationship between imagination and either RMB or RSB. Study Five is the first to my knowledge to explore this relationship in terms of RRBs and the drawing tasks from TTCT (equivalent to design fluency). Contrary to hypotheses, IS was not associated with any of the measures of imagination, and in contrast to Study Four, there was no difference in IS between participants who did and did not play pretend. Also in contrast to Study Four, there was no relationship between imaginative activities and a limited pattern of activities as measured by the DISCO (ever and current codes). This is despite the fact that, as demonstrated in Table 5.11 below, twenty-four participants (89%) showed a difficulty with both imagination and limited pattern of self-chosen activities from the DISCO.

Table 5-11 Study Five: Patterns of scores for participants on the DISCO past imagination items and limited pattern of self-chosen activities from the DISCO (N=26); "-" indicates missing data.

Imaginative Activities	Delayed	Shared	Repetitive	Limited Pattern of Activities	*N*
No pretend play	Yes	N/A	N/A	Yes	9
	Yes	N/A	N/A	No	2
Pretend play	-	No	Yes	Yes	7
	-	Yes	Yes	Yes	1
	Yes	No	Yes	Yes	2
	No	Yes	Yes	Yes	1
	No	No	Yes	Yes	4

It may be that the power and variation of the sample, in contrast to Study Four's large sample, was too low to detect any relationship. However, as can be seen from Table 5.11, all participants either showed no pretend play, or only showed

pretend play that was repetitive. Therefore it is possible that a significant association with pretend play was not found in terms of IS or limited pattern of self-chosen activities because the participants with pretend play still showed some sort of imaginative difficulty. This difficulty may have masked any group differences that might be present between a group of autistic participants who did show pretend play and a group of autistic participants who either show no pretend play, or their pretend play was limited in some way.

As discussed in Chapter One (page 53), there is some evidence that RRBs are associated with ideational fluency (e.g. Turner, 1997); however, these findings are not supported here and in some previous research (Bishop & Norbury, 2005; Dichter et al., 2009). The present results also support the one previous study that has tested the relationship between RRB and future thinking (Lind et al., 2014); although the present study extended upon Lind et al.'s work by analysing the subscales of the RBQ-2A rather than a single RRB construct. Few studies have reported the relationship between RRBs and other types of imagination such as originality and flexibility, with the one exception of Best et al. (2015), who only found an association with fluency, although they did not separate ASD participants from NT participants. However, in the present study there was not a significant association between these variables and any RRB.

In summary, I noted in Chapter One that the inconsistency of the research regarding the relationship between imagination and RRBs in ASD may result from the fact that researchers tend to not separate out the subtypes of RRBs in their analyses; this was supported by a specific relationship with IS identified in the previous chapter. However, I was unable to replicate the findings from the previous chapter, or identify any other significant associations between imagination and RRBs. This may be as a result of insufficient sample size and power to detect what is potentially a subtle effect unique to IS and pretend play, or floor effects in terms of the childhood pretend play of the sample. In the next chapter, I shall discuss the directions that future research should take regarding the relationship between imagination and RRBs in ASD.

5.3.3.4 Limitations

One limitation of this study is that this sample may have been a particularly imaginative sample, given that the study was advertised as an imagination study in

order to be open about the purpose of the study and to generate interest. This may have attracted a disproportionate number of participants who considered themselves imaginative or creative; however, it should be noted that this was not the case for all participants. Another major limitation lies in the fact that, out of the 27 participants, only eight met the DSM-5 criteria according to the DISCO. Whereas 22 participants were able to provide some evidence of a diagnosis by a clinician, five were not, and only one of these met DSM-5 criteria on the DISCO. This may be because the present sample is relatively cognitively able; some have criticised the DSM-5 criteria for excluding individuals who are older or more able (e.g. McPartland et al., 2012; Taheri & Perry, 2012). This may also explain why there were no significant findings, due to the lack of variation within the sample. However, the lack of DSM-5 diagnoses may simply reflect the fact that use of just one diagnostic measure in a research setting may not be enough to diagnose a participant. Indeed, Lind et al. (2014) argue that clinical judgment is a more reliable and valid inclusion criterion for research. Another possible explanation for the discrepancy may come back to the issues of self-report and EM in ASD. Although the administrator of the interview has to make their own judgment about whether or not a particular behaviour is a marked problem, and receives specialised training in this, the participant is still required to remember and report on their own behaviour. This is particularly difficult in the case of older adults when asking about their childhood experiences, and when asking anyone about infancy. Where possible, participants asked their parents about particular behaviours, but not everyone provided this information. Therefore it was difficult in many cases (*N*=9) to ascertain whether or not there were any setbacks or delays in very early development, and this is essential for the DSM-5 criteria (APA, 2013; Carrington, Kent et al., 2014). However, twenty-two participants did meet Wing and Gould's ASD criteria according to the DISCO; those that did not were able to provide evidence of their diagnosis.

Finally, there is a limitation in terms of the issue of statistical power. A priori power analyses were not conducted as the previous research is sparse and inconsistent, and therefore I was not able to predict effect sizes for the correlation analyses. Autistic adults can be a difficult group to identify and recruit, and although

27 is a respectable sample size compared to many other experimental studies conducted with autistic adults, it is a small sample size for conducting a large number of analyses across several variables. I attempted to control for the effect of multiple testing by interpreting only those correlations that were significant at the .01 level. I also conducted post-hoc power analyses on the data, the results of which are presented in Appendices 11 and 12 (pages 272-274). Unsurprisingly, these analyses were greatly underpowered, in some cases to a value of .01. Therefore, it is a possibility that significant associations were not found because of lack of power.

5.3.3.5 Conclusion

This chapter aimed to assess how RRBs as measured by the RBQ-2A are related to imagination in ASD, along with further testing of the reliability and validity of the RBQ-2A. The reliability and validity of the RBQ-2A was strongly supported in this study, with the exception that the RBQ-2A was not associated with anxiety. Limitations of previous research into imagination and RRBs were addressed assessing imagination in several ways, both in terms of method (drawing/design fluency, novel use of objects, and thinking about the future) and scoring (fluency, originality and flexibility). Overall, the participants in this study performed well on the measures of imagination employed here, casting further doubt on the notion of autistic people not being imaginative. Furthermore, it would be expected that if the same underlying construct was responsible for all types of imagination employed by these different tasks, there would be some correlation between the different measures, which has been found in some of the few studies to have explored this (e.g. Begeer et al., 2009; Lind & Bowler, 2010). However, only one association was found, between the verbal TTCT measure and the PFT, and this was mostly explained by performance on the verbal fluency task. Therefore this suggests that different measures of imagination are measuring quite distinct constructs (e.g. being able to come up with new ideas, and being able to create different drawings), and that general conclusions about imagination should not be drawn from studies investigating just one type of imagination, for example thinking about the future. In addition, the different sub-categories of RRBs were examined, as this has not always been the case in previous studies of imagination and RRBs in ASD. However, thorough examination of the

different relationships among the imagination and RRB variables did not reveal any significant relationships, although there is a strong pattern in that difficulty with pretend play is almost always present with a limited pattern of self-chosen activities (Table 5.11). The next and final chapter of this thesis will address what the difficulties of identifying an association with RRBs means for the construct of imagination and its importance to ASD, and discuss directions for future research.

6 Chapter Six: General Discussion and Conclusion

"*Their unswerving determination and penetrating intellectual powers, part of their spontaneous and original mental activity, their narrowness and single-mindedness, as manifested in their special interests, can be immensely valuable and can lead to outstanding achievements in their chosen areas*" (p.88)

- Asperger (1944)

The focus of this thesis is the relationship between inflexibility of thought and behaviour in autistic adults. These have been conceptualised as imaginative ability and RRBs, respectively. Theoretical arguments have been put forward for the replacement of flexible, imaginative thought and action with restricted and repetitive patterns of behaviour (e.g. Happé, 1999; Turner, 1999b; Wing & Gould, 1979). However, research on this subject has yielded equivocal results; some find evidence for this negative association between the two (e.g. Honey et al., 2007), whereas others do not (e.g. Dichter et al., 2009), and it has also been suggested that certain RRBs may foster aspects of imagination such as originality (Liu et al., 2011). Given this conflicting theory and evidence, the question arises: what is the nature of the relationship between imagination and RRBs in ASD?

Throughout this thesis I have aimed to address this question and further our understanding of the relationship between RRBs and imagination in autistic adults by measuring these constructs in detail. Having noted the lack of suitable measures of RRBs for adults, I also aimed to develop a self-report measure of RRBs suitable for use with autistic adults. Finally, I aimed to provide a detailed profile of imagination in autistic adults, since a supposed difficulty with imagination as part of a 'triad of impairments' in ASD has informed most psychological research into ASD to some extent; and yet our understanding of imagination in autistic adults is under-developed (see Chapter One, section 1.1.3.2, page 29). The preceding empirical chapters addressed these aims, firstly by developing and testing a self-report measure of RRBs for autistic adults (the RBQ-2A), and then by measuring several different aspects of imagination in order to test its relationship with RRBs and to describe the profile of

imagination in autistic adults. Overall I was able to develop a reliable and valid measure of RRBs for autistic adults, and have provided evidence of a variety of imaginative abilities in autistic adults. However, only one study (Study Four) demonstrated any strong evidence of the relationship between imagination and RRBs, and as expected, this was specific to IS, including a limited pattern of activities. This final chapter summarises the findings and implications from these studies, reflects on why this relationship has been so difficult to tease apart in this thesis and in previous research, and offers suggestions for the directions of future research regarding this relationship between RRBs and imagination.

6.1 Summary of findings

Before assessing the relationship between imagination and RRBs, I aimed to develop a self-report measure of RRBs suitable for use with autistic adults as the existing measures for this purpose were limited. The goal of Chapter Three was to present the development and initial testing of the RBQ-2A, in order to demonstrate that it is a useful measure of RRBs for both autistic and NT adults. This was achieved over two studies. In Study One I conducted a PCA on RBQ-2A data from undergraduate students, and found that most items grouped into factors equivalent to RSMB and IS, with the notable exception of sensory items. The level of internal consistency was good for the whole questionnaire and acceptable across its subscales. Additionally, I found that imagination as measured by the AQ is not associated with the RBQ-2A in an undergraduate sample. In Study Two, I compared scores on the RBQ-2A and its subscales between a group of autistic adults and a group of NT adults matched on IQ. As expected, autistic adults scored higher on the full questionnaire and subscales, supporting the construct validity of the RBQ-2A. Therefore in Chapter Three I was able to show preliminary evidence that the RBQ-2A is a reliable and valid measure of RRBs in both autistic and NT populations, although there were still some issues remaining. Firstly, the fact that sensory items did not load on any component presents an important limitation given that sensory symptoms form part of the criteria for ASD. Secondly, the RBQ-2A had not yet been assessed in a large sample of autistic adults. Finally, there was the issue of the fact that the RBQ-2A relies on self-report. I addressed the first two issues in the following chapter.

Chapter Four sought to further test the RBQ-2A in autistic adults, while also beginning to address the relationship between imagination and RRBs. Study Three built on the findings of Study One and Two by assessing the RBQ-2A in a large sample of adults with ASD, representing the first time that the factor structure of RRBs has been assessed in an exclusively adult autistic sample. Again the internal consistency of the whole scale was good. However, the factor structure was distinctive, with sensory items forming their own component in addition to RMB and IS; although this factor structure is somewhat unusual, this solution includes sensory items, which presents an advantage over Study One's solution. In Study Four, I carried out the initial analyses exploring the relationship between imagination and RRBs. In terms of the relationship between imagination and RRB, a small but significant association was found between retrospective reports of childhood pretend play and current scores on the IS subscales of the RBQ-2A in Study Four. There was also a significant relationship between childhood pretend play and scores on RBQ-2A item 20 (*activities*), suggesting that participants who did not play pretend as a child then went on to have more restricted patterns of activities and interests as an adult; although this relationship was not significant when collapsing responses on item 20. The associations between pretend play and both IS and item 20 remained significant when re-categorising participants' pretend play answers. Some significant association was also found between IS and RSB with the imagination subscale of the AQ, in contrast to Study One, suggesting that there is an ASD-specific relationship between the imagination subscale of the AQ and the RBQ-2A; however, this was not a wholly stable relationship. In summary, Chapter Four met the goal of demonstrating the reliability of the RBQ-2A in a larger sample of autistic adults and beginning the exploration of the relationship between imagination and RRBs.

The final empirical chapter aimed to bring together all three goals of this thesis within a small sample of autistic adults: examining the relationship between imagination and RRBs; developing and testing a measure of RRBs for autistic adults; and describing the profile of imagination in autistic adults. With regard to testing the RBQ-2A, Study Five found that the RBQ-2A demonstrated good test-retest reliability as well as correlational validity with the ARI. I assessed the correlation of the RBQ-2A

with items from the DISCO, a non-self-report measure, in order to address the potential critique of the use of self-report measure in ASD I raised earlier; this correlation was strong and positive, supporting the use of the RBQ-2A. However, construct validity in terms of relationship with anxiety was not supported, potentially due to limitations with the chosen anxiety measure. Overall, there is now strong evidence for the following types of reliability and validity in support of this measure and its subscales: internal consistency; test-retest reliability; construct validity (distinguishing ASD and NT participants); and correlational validity.

Study Five also revealed important information about the presentation of imagination in adults with ASD. Imagination was assessed in terms of ideational and design fluency (measured by the TTCT), thinking about the future (measured by the PFT), and past pretend play (measured by the DISCO). Although there was no comparison group, the proportion of original responses across the TTCT measures ranged from .47 to 1.0, which suggests that some participants were highly original in their thinking. Several participants expressed a difficulty with thinking about the future; however, in general participants were able to generate several future events, although the specificity of these events was not assessed unlike in previous studies (e.g. Lind et al., 2014). Finally, more than half of the sample reported playing pretend as children, although this was always repetitive. Overall, the idea that autistic adults are impaired across all forms of imaginative thinking was not supported, as there was great variation in performance on the imagination tasks; all participants showed some difficulty with past pretend play, however many performed very well in terms of creativity. On a related note, scores on these imagination tasks were not associated with one another, suggesting that the construct of imagination is multi-faceted.

In terms of the main aim of Chapter Five and this thesis, Study Five aimed to replicate findings from Study Four, in that a lack of pretend play (measured by the DISCO) should be associated with increased scores on IS (as measured by the RBQ-2A) or a limited pattern of self-chosen activities (as measured by the DISCO). Study Five failed to replicate these findings in terms of significance, although it should be noted that all but two participants did show both a difficulty with pretend play and a limited pattern of activities according to the DISCO. The lack of replication may be due to low

statistical power as a result of the small sample size, or it may be the fact there was not enough variation in the group in terms of pretend play; all participants reported some difficulty with pretend play in the past, which may have masked any significant group differences. Considering imagination *other* than pretend play, Study Five failed to find a significant association between scores on the RBQ-2A and a) design fluency, b) ideational fluency, or c) thinking about the future, regardless of whether fluency, originality or flexibility were being assessed. It may be that there is a relationship between RRBs and imaginative ability but this is a small effect (hence only seen in Study Four's larger sample and not the relatively small sample of Study Five) that is limited to pretend play, or childhood imagination in general. These results may also reflect a genuine finding that RRBs in adulthood do not relate to imagination in adulthood.

In summary, the goals of the thesis were: to develop a self-report measure of RRBs and test its reliability and validity; to examine the profile of imaginative ability in autistic adults; and finally to assess the nature of the relationship between imagination and RRBs in autistic adults, which I hypothesised would be specific to IS. The empirical work presented in this thesis addressed my goals in the following ways. Firstly, across two PCAs of RBQ-2A data and numerous tests of reliability and validity, and over four different samples of participants, I have demonstrated that the RBQ-2A is a reliable and valid measure of RRBs in both NT and autistic adults, albeit with some caveats in terms of unusual factor structure and lack of a correlation with anxiety. I measured several aspects of imagination in autistic adults and assessed the relationships of the different tasks with each other. Imagination in autistic adults varies widely depending on the task used; for example, there was a wide variation in the sample in terms of creativity, but almost all participants showed some difficulty with childhood pretend play. Different imagination tasks also do not correlate well with each other, highlighting the multidimensional nature of this construct. Finally, across Studies Four and Five I found some evidence of a relationship between imagination and RRBs. However, this was limited to childhood pretend play and imagination measured by the AQ; none of Study Five's other measures of imagination correlated with RRBs. Nevertheless, I have identified evidence of a specific relationship between reports of

childhood pretend play and IS, in particular limited patterns of activities, although these findings were limited to Study Four. The following section shall consider the implications of these findings.

6.2 Implications of findings

As I have described in the previous section, in terms of the main goal of this thesis, I have found evidence for a specific relationship between IS, including limited patterns of activities, and past pretend play. I began this thesis with the premise that behavioural inflexibility in ASD is related to inflexible thought, or difficulty with imagination. Following a review of the previous theory and evidence relating to this claim, I further narrowed down the relationship as being between imagination and a class of RRBs known as IS – comprising, for example, rigidity, rituals and restricted interests – rather than between imagination and the other major class of RRBs, RSMBs. Yet the evidence for this remained sparse and I did not find such a relationship with most of my measures of imagination. This raises the question of why it is so difficult to uncover convincing evidence of this relationship. It is notable that the only significant evidence came from a measure of *childhood* pretend play; perhaps there is a relationship between RRBs and imagination, but this relationship is more robust in childhood compared to adulthood. The simplest answer is that there is no such relationship. However, it seems intuitive that an individual who finds it difficult to flexibly consider alternative scenarios, or who is not motivated to do so, may prefer to engage in the same activities on a daily basis and dislike change. Conversely, someone who prefers their environment and activities to remain the same may avoid thinking about change or alternative scenarios in order to avoid anxiety-provoking thoughts, which would then reduce the flexibility of their thinking.

An answer to this conundrum may lie in our conceptualisation of imagination. Imagination has several dictionary definitions, and has been defined in several different ways by creativity researchers, developmental psychologists and the authors of international diagnostic manuals and diagnostic tools. In addition to the issue of definition, the concepts of imagination and creativity have been measured using several different tools across a wide range of contexts, including pretend play, thinking about the future and drawing ability. Therefore, our understanding of imagination in

the ASD literature is underdeveloped compared to RRBs. There are still unanswered questions regarding RRBs in ASD, but there is a large body of work specifically focussing on the conceptualisation and measurement of RRBs, unlike with imagination. Therefore this makes it difficult to explore the specifics of a potential relationship between imagination and RRBs. I concluded in Chapter One that imagination is not necessarily a unidimensional construct. The evidence presented in this thesis supports this conclusion given that Study Five showed little correlation between different measures of imagination, even when measured using a similar scoring method such as fluency, with the exception of the UUCB and the PFT tasks; although this relationship became weaker when controlling for verbal fluency, implying that any relationship may be more to do with EF rather than a shared construct of imagination. From these findings it is unwise to draw conclusions about one type of imagination on the basis of evidence from another type, or indeed to make conclusions about imagination as a whole. Therefore it follows that a relationship would not exist between RRBs and imagination as a single construct, and that there may be differential relationships between RRBs and different imaginative behaviours (e.g. pretend play, thinking about the future) and different components of imagination (e.g. novelty, flexibility).

Not only does the type of imagination that is being measured matter, the type of RRB measured when exploring this relationship is equally important. In the larger sample of autistic adults in Study Four, I found evidence of a relationship between past pretend play and IS measured by the RBQ-2A, as well as with item 20, *what sort of activity will you choose if you are left to occupy yourself?* The latter is important as this item is not included within the overall IS subscale[33], and therefore the IS subscale and item 20 may be independently related to imagination; however, it should be noted that item 20 is conceptually related to IS. In the Study Five sample, I qualitatively demonstrated a similar pattern using analogous DISCO items, although neither this nor the relationship with IS were significant. However, this lack of replication may be due to power issues or floor effects in terms of pretend play. From this evidence, I conclude that there is a specific relationship between impoverished past pretend play

[33] As explained in Chapter Two, this is due to the fact item 20's response scale is non-quantitative, unlike the other nineteen RBQ-2A items.

and IS, including a restricted range of repetitive activities, but that this is a small effect. Again, this appears to be an intuitive relationship; if an individual has difficulty in enacting complex pretend scenarios which require a degree of novelty and flexibility, this may later manifest as a preference for routines, a narrow, unvaried range of interests/activities and other behaviours related to IS. However, the direction of this relationship cannot be assessed in this thesis due to the retrospective nature of the studies' design.

The specificity of this relationship may suggest why definitive evidence for the relationship between imagination and RRBs has been difficult to ascertain. It may be that previous research into this relationship has been too broad, whereas focussing on specific aspects of imagination and RRB allows for a clearer understanding of this relationship. From this thesis, the only aspect of imagination that appears to be related to RRBs is childhood pretend play, albeit this is a weak relationship. Previous evidence of a relationship between other creativity measures and RRBs (Best et al., 2015; Turner, 1997) may arise from shared features of different aspects of imagination; although my imagination measures were not related to each other, a lack of power may have masked some small relationships based on the fact that these measures all tap into generativity, novelty and flexibility, the key components of imagination. It is unclear which aspect of childhood pretend play is driving this relationship, as pretend play relies on the ability to generate novel events or sequences of events in a flexible manner. In comparison to the various creativity measures I employed, I did not assess pretend play in as much detail, due to the fact I was interested in autistic adults. Further exploration of this construct in relationship to RRBs may reveal whether one or all of the components of generativity, novelty and flexibility relate to RRBs. Moreover, this relationship was specific to IS including a limited pattern of self-chosen activities, rather than overall measures of RRBs. The weakness of a relationship that is specific to pretend play and IS may explain why this relationship is not always supported (e.g. Bishop & Norbury, 2005; Dichter et al., 2009; Lind et al., 2014).

6.3 Strengths, contributions and limitations

6.3.1 Strengths

The main strength of this body of research has been to analyse a wide range of types of imagination for the first time in a single sample of autistic adults, including measurements of pretend play, thinking about the future, ideational fluency and design fluency, and assessing imagination in terms of fluency, originality and flexibility. As such this is the first study to present a detailed picture of imagination in autistic adults and to show the variety of performance on both standardised and non-standardised measurements of imagination and creativity. I was also able to include a wide range of ages and genders in my studies, which is sometimes difficult in ASD research. Unlike most other previous research, originality and flexibility were assessed along with fluency, which represents a strength of the research in that a fuller picture of imagination was assessed.

6.3.2 Contribution of the thesis

6.3.2.1 Contribution to researchers

In terms of the main question of this thesis - whether or not there exists a relationship between imagination and RRBs in ASD - I have provided evidence of a small but significant relationship between retrospectively reported pretend play and IS in ASD. This thesis has made a theoretical contribution to researchers working in the field of imagination and ASD. In Chapter One I identified several issues regarding the imagination literature in ASD, which need to be addressed by current and future researchers. Firstly, there is no clear, agreed upon definition of imagination and it is vital for researchers to consider this carefully before carrying out imagination research. In Chapter One I presented a possible candidate: the *generation and flexible manipulation of existing concepts to form novel ideas, which may be rooted in past experience and may result in adaptive outputs (creativity)*. The key components identified here were: generativity, flexibility and novelty, and related (but not necessary) components are the connection with memory and past experience, and the production of adaptive outputs. Although my conceptualisation of imagination is by no means definitive, it may provide a clearer starting point for researchers wishing to explore this construct.

Related to this, I noted that the imagination literature in ASD research is limited in terms of scoring imagination, and researchers should take into consideration the imagination and creativity literature outside of ASD research, which places more emphasis on aspects of imagination such as originality (e.g. Runco & Jaeger, 2012). Dimensions of imagination such as originality and flexibility are increasingly the subject of research studies (e.g. Best et al., 2015; Pring et al., 2012) and this trend should continue. Similarly, more research is needed regarding the relationships between different measures of imagination and creativity, as our lack of knowledge in this area limits our ability to draw conclusions across different studies. I attempted to address this in Study Five, however it is unclear whether or not my findings are a result of low power. Finally, I have suggested that it is important to also consider the strengths of imagination in ASD as well as difficulties. The findings from Study Five that autistic adults show a varied profile in terms of imagination support this, and researchers should also build upon the findings of Liu et al. (2011) and Kasirer and Mashal (2014; 2016) that autistic individuals show high levels of originality rather than focusing on difficulties with imagination.

The main concrete contribution of the work contained in this thesis is the development of a reliable and valid self-report measure of RRBs in autistic adults, the RBQ-2A. This is an important contribution to the field as many measures of RRBs tend to be parent-report or rated by a researcher or clinician. However, these types of measures, while advantageous in their own right, are limited in measuring RRBs that cannot be easily observed by others, or that are masked by adults who may have been encouraged or trained to hide their traits from others. Therefore, self-report from an autistic individual may provide useful information that cannot be accessed through other means. In other cases, parents may be unable or unwilling to take part in research on behalf of their child, and therefore it is necessary to have good RRB measures that do not rely on parent report. Although the RBQ-2A is by no means a perfect or comprehensive measure of RRBs and further research is needed to assess its utility, the findings in this thesis represent a strong starting point for this tool. The RBQ-2A is freely available to download online[34] and may be a useful addition to sets of

[34] The RBQ-2A can be downloaded here: http://sites.cardiff.ac.uk/rbq2a/download/

questionnaires for research purposes. Section 6.4 (page 181) suggests some potential avenues for future research.

6.3.2.2 Contribution to clinicians

The contribution of this thesis to clinicians is limited by the fact that the studies presented here are not specifically related to the work of clinicians such as diagnosis or intervention. For example, the diagnostic utility of the RBQ-2A has not yet been assessed, but given that several of the RBQ-2A's items have their origin in a diagnostic tool (the DISCO) it may prove to be a useful additional measure when diagnosing individuals. The self-report nature of the RBQ-2A allows for individuals to report on their own RRBs, which could be important for diagnosis in the case of adults where there is no available informant. However, it is important to note that the RBQ-2A can never be a diagnostic tool on its own as it only measures one set of criteria for ASD, although it may provide useful supplementary information for tools that might be limited in capturing RRBs, such as the ADI-R (Lecavalier et al., 2006). Moreover, the RBQ-2A may be a useful outcome measure when assessing the performance of interventions for autistic individuals.

In terms of imagination and the role it plays in diagnosis, a particular issue with diagnostic manuals – especially the DSM-5 – is that the importance of imagination in ASD has been relatively downplayed. Although initially centred as one of the 'triad of impairments' in ASD (Wing & Gould, 1979), as I described in Chapter One, there is little guidance from diagnostic manuals about how to evaluate imagination in autistic individuals in relation to a diagnosis (pages 10-11). Again, this thesis does not present any evidence relating to imagination in a clinical context, however findings from Study Four demonstrate that a lack of retrospectively reported pretend play is associated with increased IS in autistic adults, and Study Five showed that past difficulty with pretend play is common in autistic individuals. These findings highlight the importance of considering past pretend play when making a diagnosis of ASD, if possible. Finally, the detailed imagination profiles of a small number of autistic individuals in Study Five highlight the variety of imaginative strengths and difficulties in autistic individuals. This information may prove useful for clinicians who are considering whether or not to use creativity-based therapies and interventions, as well as using interventions to

foster creative skills and improve imaginative difficulties such as thinking about the future.

6.3.2.3 Contribution to the autism community

Given that research into ASD should ultimately benefit the autism community, it is important to consider the contribution to the autism community when evaluating research. To my knowledge there is no universal definition of the autism community, and there are many individuals who could be captured by this term. Here I use this term to refer to autistic individuals, relatives and friends who offer support, and professionals that work with autistic individuals and their families, such as charity organisations.

Although the development of the RBQ-2A primarily benefits researchers (see page 176), this in turn may have indirect benefits for the autism community as the RBQ-2A is used for research into RRBs in adulthood, which is often limited to retrospective informant report (e.g. Chowdhury et al., 2010; Seltzer et al., 2003). The RBQ-2A also represents an opportunity for autistic individuals to express themselves, albeit to a limited extent, in research.

Regarding the imagination findings, these have a less concrete advantage for autistic individuals given the caution necessary when interpreting underpowered studies. The strongest finding related to imagination was that a retrospectively reported lack of pretend play is associated with self-reported IS in autistic individuals. This finding may be important to families and professionals as it suggests that supporting a child with ASD with their pretend play may reduce IS later in life; however this particular hypothesis has not been tested and further research is needed before this advice can be given to the autism community. Studies Four and Five supported previous research suggesting that many autistic individuals do not engage in spontaneous pretend play when young. Accordingly, the use of interventions and therapies to support pretend play in autistic children is already the subject of research (e.g. Kasari, Freeman, & Paparella, 2007), but arguably effort should also go toward fostering imagination and creativity in autistic children in areas other than pretend play.

Finally, the inclusion of imaginative strengths – i.e., originality – in research represents a more positive view of imagination in ASD. Although it is important not to minimise the difficulties facing autistic individuals, highlighting potential creative strengths might have a positive effect on the self-esteem and self-image of autistic individuals. In addition, parents may react negatively to news of their child's diagnosis (e.g. Wachtel & Carter, 2008), and it is possible that some positivity may help alleviate these negative feelings. However, it is imperative to not introduce another myth related to autism by claiming that all autistic individuals are inherently creative. Rather one should acknowledge that while an ASD diagnosis may be associated with some imaginative difficulties – perhaps related to EF difficulties such as generativity, or specific to pretend play – this does not mean that there is no room for creativity in the life of an autistic adult.

Future research should continue to focus on positive aspects of imagination, as this would support the work some services already engage in by in providing support and resources, such as creative writing and art groups for autistic individuals. A stereotypical view that autistic people are not creative or have no interest in creative pursuits has emerged from the early work describing a difficulty with imagination. If individuals, parents and organisations subscribe to this view, then the amount of creative opportunities open to autistic individuals will be reduced. The work presented in this thesis does not constitute any specific strategies or therapies for engaging with autistic individuals, however the demonstration of a varied profile of imaginative strengths and weaknesses should encourage future academics and practitioners to research and design such programmes.

6.3.3 Limitations

This body of work is limited by several factors that are common to many studies in the field of ASD research. In the case of Study Two and Study Five, the research is limited in terms of small sample size, as autistic adults are a relatively difficult group of participants to recruit. This makes it difficult to interpret some findings from Study Five; the lack of relationships may simply reflect low power due to the small sample size and larger number of variables. More generally, the studies in this thesis are also limited in terms of the characteristics of participants. Both the

Study Four and Study Five samples include a relatively high proportion of women, and those who were diagnosed as adults, which is unusual in studies of ASD populations. Finally, the sample is also limited by the fact that only cognitively able participants were recruited. This is a common problem in ASD research, as many of the methods used to assess psychological constructs rely heavily on cognitive and verbal ability and therefore participant samples tend to not reflect a wide range of developmental levels or cognitive abilities. It is not clear how non-speaking or developmentally delayed (DD) autistic individuals would perform on these tasks and whether or not this would affect the relationship between imagination and RRBs.

More specific to the research carried out here is the issue of self-report. Although I have tried to address this by assessing the relationship between the RBQ-2A and the DISCO, a large amount of the measurements here rely on self-reported information. Aside from specific issues with autistic individuals and self-report as I described earlier (Chapter Two, page 73), self-reports are not the most desirable measurement of any psychological construct, due to the effect of a person's own interpretation and understanding of their behaviour, and social desirability. Another notable limitation of the present research that could be addressed in the future is the fact that most participants were diagnosed as adults and some very recently indeed. As such participants may be very aware of their symptoms having recently gone through the diagnostic process, or may be accessing material in order to gain information. Therefore they may have set ideas about what their symptoms 'should' be as an autistic individual, which may further affect their reliability in terms of self-report.

6.4 Future research

6.4.1 Future research with the RBQ-2A

Assessing a measure's reliability and validity is an ongoing and iterative process and never definitely established (Kline, 2000). Although the findings presented here represent good reliability and validity of the RBQ-2A, future work should continue to assess this measure in different samples. The most useful assessment currently would be whether or not scores on the self-reported RBQ-2A were correlated with scores on the parent-report RBQ-2 in autistic adults; this would address criticisms related to the

use of self-report measures in ASD. This would, however, require some adaptation of the parent version of the RBQ-2, given that it was originally designed for use with young children. Similarly, it would be useful to assess whether the RBQ-2A correlates with other measures such as the ADI-R, to build on the strong association with the DISCO, which may be partially explained by the fact the RBQ-2A has its origins in this measure.

Given that the internal consistency and factor structure of the RBQ-2A has not been entirely stable over studies[35], further investigation of these is also warranted. In particular, internal consistency was poorer for NT individuals compared to individuals with ASD. Where NT and ASD groups are being compared, it is important to ensure that the measure works well across both groups. The unusual factor structure should also be investigated further in larger samples; although 275 is fairly good for PCA, larger samples are desirable for accurate results. Another issue is that of construct validity, and the fact that the RBQ-2A did not correlate strongly with anxiety as measured by the HADS. This could represent a problem for the validity of the RBQ2-A; however, I have already suggested this may be due to the unsuitability of the HADS and therefore should be assessed using different measures of anxiety (page 159).

I have previously mentioned that a large proportion of the autistic participants in these studies have been diagnosed as adults (e.g. page 132). Therefore it would be interesting to test whether or not there is an effect of having a diagnosis confirmed or ruled out. Longitudinal assessment of the RBQ-2A could be conducted as adolescents become young adults, as younger people may not be aware that they have ASD. Alternatively, individuals could be assessed before and after diagnosis, to see whether the confirmation or ruling out of an ASD diagnosis affects how participants rate their RRBs.

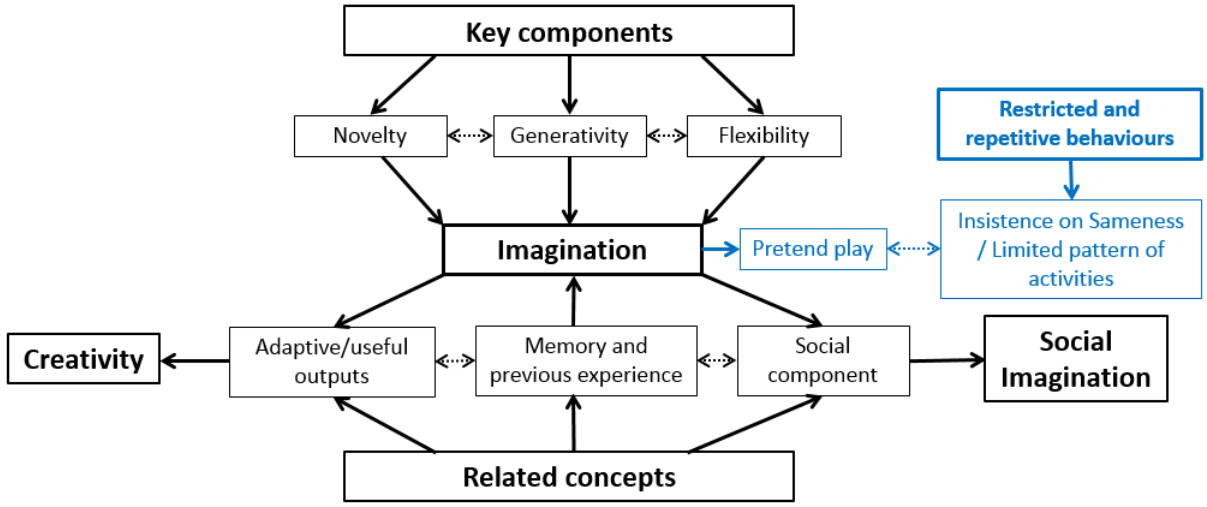
6.4.2 Future research in terms of imagination and its relationship with RRBs

The most obvious direction for future research with regards to imagination and RRBs is to further assess the relationship between pretend play and IS, on the basis of

[35] However, factor structure is certainly not stable across RRB measures (see Chapter One, pages 42-45), so this is not a limitation exclusive to the RBQ-2A.

the research presented in this thesis and previously (Harrop et al., 2014; Honey et al., 2007). Figure 2 below is an updated version of Figure 1 (Chapter One, page 12), a visual diagram based on my conceptual analysis of imagination, in order to conceptualise how RRBs may be related to imagination via pretend play.

Figure 6-1 Conceptualisation of imagination edited to incorporate RRBs via insistence on sameness and pretend play.



Further research should attempt to replicate Study Four's findings in larger samples of autistic individuals (including children) and using different measures, to rule out the effect of this relationship being an artefact of the DISCO, bearing in mind that both the RBQ-2A and the pretend play questions from Study Five were based on the DISCO. I noted earlier that it is not possible on the basis of the pretend play measure used in this thesis to determine which components of imagination (generativity, novelty, and/or flexibility) are responsible for this relationship. These three separate components were assessed in Study Five; however, I was not able to discern any significant, specific relationships between RRBs and any of these components. This may be a result of low power, or it may be that measuring these components in the context of pretend play would have revealed specific relationships. As mentioned, I did not explore pretend play in great detail in this thesis as I was primarily interested in autistic adults. However, future research could assess these components using existing pretend play measures and scales. The frequency of pretend play acts provides a measure of generativity and the ability of a child to substitute one object for another could provide a measure of flexibility; for example, a child who is willing to

pretend a Lego brick is a car is more flexible than a child who will only pretend a toy car is a real car. Finally, novelty could be assessed in relation to the rest of the sample in terms of the type of pretend games the child invents. In this way, the relationship between RRBs and these different dimensions of imagination could be assessed. Future research should also consider how age may affect the relationship between the two. I noted previously that there is some evidence of a relationship between pretend play and RSMBs in younger children (aged five years and younger; Harrop et al., 2014). I suggested that imagination may be associated with RSMBs when younger, and IS when older (page 57), and this hypothesis should be tested in future research. On a related note, it would be interesting to examine whether the relationship between RRBs and imagination is entirely restricted to childhood imagination, which may be the case as the only evidence in this thesis came from a measure of childhood imagination.

Outside of imagination's relationship with RRBs, another potential avenue of research that arises from this thesis is the consideration of the different types of imagination, and what these might be; for example, how different are the cognitive skills needed for imagining the future to those needed to create drawings? Further to this, each subtype of imagination should also be assessed in detail to ensure that it is a reliable and valid method, as assessing such a wide variety of imagination measures is inherently problematic given issues of statistical power.

Another important distinction to make is that between social and non-social imagination. Social imagination refers to the ability to foresee the consequences of their own and others' actions and to act in an appropriate fashion, as well as learning from past experience and mistakes (Wing et al., 2011). Few studies have examined the difference between social and non-social imagination in autistic individuals. There have been studies that examine how participants draw people and social scenes (e.g. Lewis & Boucher, 1991; Jolley et al., 2013), and one study showed that whereas NT adults preferred to read about people rather than objects, autistic adults did not show a preference between the two (Barnes, 2012).

To my knowledge, three studies have specifically examined social and non-social imagination in ASD. In their study, Ten Eycke & Müller (2015) administered the

adapted form of the impossible person task (Karmiloff-Smith, 1990; Low et al., 2009), and compared the drawing of a person versus a house. There was no difference between groups in terms of the house, but children with ASD found it significantly more difficult to produce imaginative drawings of people. These results were replicated in a later study using the same task (Ten Eycke & Müller, 2016). Although these findings lend some support to the distinction between social and non-social imagination, this particular measure is not relevant to the concept of social imagination as described above in a practical sense. A more relevant measure would be to assess this distinction in terms of thinking about the future, as this is one of the ways that social imagination has been conceptualised (e.g. Wing et al., 2011). The second study (Angus et al., 2015) compared the performance of autistic and TD children on formal imagination tasks (ideational fluency and storytelling) and a realistic anticipation task, in which a child was told that an interviewer was coming to see them, and after an interval were asked some questions about the anticipated interaction. Angus et al. found that whereas the groups did not differ in the formal imagination tasks, there was a difference between groups on just one of the four questions they asked about the anticipated interview ("*Have you thought about what you might say?*"). This task represents a more ecologically valid measure of social imagination; however, the study is limited in that more than half of all children were non-responsive, and that children were not asked whether or not they really believed an interviewer was coming to see them. A more natural measure of social imagination could be shared pretend play in children; that is whether or not individuals are willing to share their ideas and collaborate with others when carrying out pretend games.

However, when studying social imagination, care must be taken to distinguish it from ToM, which refers to the ability to ascribe mental states to ourselves and others in order to predict and explain behaviour (e.g. Baron-Cohen, Leslie & Frith, 1985; Premack & Woodruff, 1978). From this definition it can be seen how closely the two constructs are related. This is particularly pertinent when considering pretend play as a measure, given that the two have been theoretically linked (e.g. Leslie, 1987). Indeed there is some evidence of the association between imagination and ToM. For example, Hanson and Atance (2013) found that autistic children with low episodic

future thinking scores also scored lower on a battery of false belief tasks. Moreover, Angus et al. (2015) found that ToM was correlated with performance on their anticipation task but only in TD children. Similarly, Ten Eycke and Müller (2016) also found that social interaction predicted imaginative drawings of people in TD children but not children with ASD. It has also been argued that high levels of originality in autistic adults may result from a lack of ToM, as they are less bound by social conventions and social desirability (e.g. Kasirer & Mashal, 2014).

As mentioned in Chapter One (page 10), the ICD-10 and DSM-5 currently categorise imagination in the form of pretend play alongside social interaction and communication, and there is some evidence that imagination is associated with communication. Although Honey et al. (2007) identified a relationship between play behaviours and RRBs, they also identified a significant association between play and communication, the latter measured by an expressive language and a receptive language item from the DISCO. Honey et al. interpreted their results as evidence of a three-way relationship between imagination, RRBs and communication; although their measurement of communication is particularly limited by the use of just two items from the DISCO. It has also been found that generativity is related to communication (Bishop & Norbury, 2005; Dichter et al., 2009), as is playful pretence (Hobson et al., 2013). Taking these findings together, the relationship between imagination and communication warrants further research, although language level would need to be controlled.

Finally, the role of originality in ASD warrants further exploration, despite the lack of a significant relationship with RRBs in Study Five. As quoted at the beginning of this chapter, autistic individuals' "spontaneous and original mental activity, their narrowness and single-mindedness, as manifested in their special interests, can be immensely valuable and can lead to outstanding achievements in their chosen areas (Asperger, 1944, p. 88)". Indeed, Wing (1981) argued that a narrow focus of attention and disregard of culture result in unusual thought processes which may lead to novel insights. Previous research has demonstrated that autistic traits may be related to originality (e.g. Best et al., 2015; Liu et al., 2011) and some researchers have specifically suggested that RRBs (e.g. Lyons & Fitzgerald, 2013) and ToM (Kasirer &

Mashal, 2014) are associated with increased originality in ASD. The difficulty with past pretend play and limited patterns of activities seen here contrast with the variety of creative performance and the high proportion of original responses to the TTCT seen in Chapter Five (see Tables 5.5 and 5.7, for some examples). However, these findings may not be incompatible with each other from a theoretical point of view; Figures 1 and 2 show the three components of generativity, novelty and flexibility as being related to one another and to imagination, but some consider originality to be the most important aspect of creativity (Wallach and Kogan, 1965). I would argue that a lack of flexibility and fluency does not mean that one cannot be original (see Liu et al., 2011). Indeed, Fung (2009) noted that traditional imagination and creativity tasks focus on divergent thinking (represented by fluency tasks) as opposed to convergent thinking (Guilford, 1959), which requires a focused cognitive style that is important to originality. As convergent thinking is often associated with originality, and ASD is associated with a narrow focus of attention (e.g. Happé & Frith, 2006), this may explain why some autistic individuals show high levels of originality. Therefore, the creative strength of originality in ASD by virtue of autistic traits merits further research.

6.5 Conclusion

Throughout this thesis I have considered whether or not imagination and RRBs are related to one another in autistic individuals. They have been theoretically connected ever since ASD was originally conceptualised as a 'triad of impairments', and yet this relationship has received little empirical attention and has been overlooked in international diagnostic manuals. I have demonstrated that autistic individuals may have imaginative difficulties in some areas, but can still be highly creative in other areas. The key to the relationship between imagination and RRBs may be specific to pretend play, as demonstrated by the fact I found evidence of this relationship only when examining past pretend play. Pretend play was not the focus of the work presented here, as I was concerned with measuring imagination in autistic adults in as broad and wide-ranging a manner as possible; however, this presents a useful starting point for future research that may be considering this relationship. I have outlined several avenues for future research, but the priorities should be to examine the different aspects of imagination (generativity, novelty and flexibility) in

relation to pretend play and social imagination, and also to further our understanding of highly original thinking in ASD.

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8 Appendices

Appendix 1: Table of imagination studies comparing ASD to non-ASD groups

Table 8-1 Table of studies comparing imaginative abilities in ASD vs. non-ASD groups, organised by type of measure.

Pretend play and pretence					
Authors	**ASD Sample**	**Control Sample**	**Imagination Measures**	**ASD- specific Imagination Difficulty**	**Key Findings**
Baron-Cohen (1987)	10 ASD children 7 boys Age: 4,3-12,4 *M*=8,1, *SD*=2,6	10 children with Down's Syndrome (DS) 5 boys Age: 2,5-12,2 *M*=7,5, *SD*=2,9 Matched on mental age (MA) 10 TD children 7 boys Age: 3,0-5,1 *M*=4,1, *SD*=0,7 Matched on age	Free play (video coded) with three sets of toys, provided one at a time	Yes	Children with ASD produced fewer pretend play acts compared to TD and DS children, with no differences in terms of functional, sensorimotor and ordering Eight children with ASD produced no pretend play acts at all
Blanc et al. (2005)	21 ASD children Age: 44-140 months *M*=82, *SEM*=5.7	14 children with LD (learning disability) Age: 40-104 months *M*=70, *SEM*=5.3 Matched on age developmental age, functional	Free play and semi-structured play, video coded	Mixed	Children with ASD mostly engaged in repetitive, streotyped sensori-motor play, were able to initiate functional play, and had almost no symbolic play compared to TD and developmentally delayed (DD) children Guidance by an adult facilitated symbolic play regardless of child's diagnosis

		developmental age, and developmental IQ 15 TD children Age: 28-62 months *M*=40, *SEM*=2.6 Matched on developmental age			Correlation between disorders of regulation and cognitive impairment, indicating this dysregulation is a general disorder of cognitive functioning
Charman & Baron-Cohen (1997)	22 ASD children 18 male Age: 63-216 *M*=140.3, *SD*=48.0	19 LD children 7 male Age: 90-215 *M*=149.0, *SD*=41.3 Matched on age and verbal mental age (VMA)	2x Functional play trials and 2x Object substitution trials with open prompts, specific prompts, and modelling	Mixed	Majority of both groups produced functional play in response to open prompts Fewer participants produced pretend play acts in response to open prompts; children in both groups needed more specific prompts or modelling, or produced no pretence at all Significantly fewer children with ASD produced examples of *novel* pretend play compared to control participants; when children with ASD played pretend, this tended to be situationally appropriate object substitution
Hobson et al. (2013)	27 ASD children Age: 3,0-9,0 years *M*=5,10, *SD*=1,6 Diagnoses: Autism 14 ASD children Age: 2,11-7,11 years *M*=5,4, *SD*=1,5 Diagnoses: Atypical autism (AA), AS,	16 DD children Age: 3,9-9,8 years *M*=5,11, *SD*=1,6 Matched on age and VMA	Test of Pretend Play, video coded, Playfulness	Yes	Children with ASD scored lower on playfulness compared to DD children Degree of communication/social interaction impairment on Autism Diagnostic Observation Schedule (ADOS) associated with poorer scores for playful pretence; significant only for first ASD group

	Pervasive developmental disorder - not otherwise specified (PDD-NOS)				
Honey et al. (2007)	19 young ASD children 16 males Age=35-59m *M*=50.95, *SD*=7.65 60 older ASD children 41 males Age=72-106 m *M*=84.65, *SD*=11.23	61 young TD children 35 males Age=29-58 m *M*=46.36, *SD*=6.6 56 older TD children 26 males Age=72-104 m *M*=84.2, *SD*=7.94	Activities and Play Questionnaire – Revised	Yes	Children with ASD engaged in play less than TD children at all ages Significant correlation between RRBs and play in children with ASD but not TD children
Jarrold et al. (1994)	24 ASD children 20 male Age: 58-154 months *M*=107.1, *SD*=28.2	24 LD children Age: 75-149 months *M*=115.0, *SD*=23.5 Matched on Expressive VMA 24 LD children Age: 80-149 months *M*=114.0, *SD*=23.5 Matched on Receptive VMA 24 TD children Age:44-96 months *M*=59.3, *SD*=13.8 Matched on Receptive VMA	Play with props (Object substitution)	No	No significant main effect of group; children with ASD equally likely to select counter-functional props as substitutes in pretend play

Jarrold et al. (1996)	Experiment 1 14 ASD children 11 boys Age: 73-147 months *M*=100.0, *SD*=24.18	Experiment 1 14 LD children 9 boys Age: 72-121 months *M*=92.14, *SD*=12.80 Matched on age and VMA	Experiment 1 Elicited vs spontaneous pretend play and functional play with doll and doll-plus junk	Yes	Experiment 1 Children with ASD spent less time engaging in pretend play and produced fewer pretend play acts across both spontaneous and elicited conditions; same found for functional play
	Experiment 2 Same as above with additional pair of matched children	Experiment 2 Same as above with additional pair of matched children	Experiment 2 Instructed play	No	Experiment 2 No group differences in terms of producing play in response to instructions
	Experiment 3 15 ASD children 13 boys Age: 60-156 months *M*=109.6, *SD*=29.81	Experiment 3 15 LD children 8 boys Age: 82-144 months *M*=116.73, *SD*=21.61 Matched on VMA & age 15 TD children 8 boys Age: 47-99 months *M*=62.53, *SD*=16.43 Matched on VMA	Experiment 3 Free vs cued pretend play	Yes	Experiment 3 Children with ASD had difficulty generating pretend acts in relation to both groups across both cued and free conditions
Kavanaugh & Harris (1994) Experiment 3	12 Children with ASD 11 boys Age: 6;2-13;6 y *M*=9;11	12 LD children 9 boys Age: 5;5-13;6 y *M*=9;9 Matched on MA	Picture transformation task	No	Children with ASD scored better than chance at choosing correct outcome of transformation, unlike children with LDs

Lewis and Boucher (1988)	15 ASD children 11 male Age: 6,6-15,8 *M*=11,10	15 LD children 11 male Age: 5,10-10,8 *M*=8,2 Matched on VMA 15 TD children 12 male Age: 3,10-5,6 *M*=4,7 Matched on VMA	Free play with junk and conventional toys, elicited play	Mixed	Children with ASD spent less time spontaneously playing functionally; no group engaged in much spontaneous pretend play; play of children with ASD as varied and spontaneous as control participants Children with ASD not impaired in terms of elicited pretend play
Libby et al. (1997)	10 ASD children 9 male Age: 64-200 months *M*=126, *SD*=44.03	10 DS children 4 male Age: 39-80 months *M*=55, *SD*=13.59 Matched on VMA 10 TD children 7 male Age:26-31 months *M*=28, *SD*=2.08 Matched on VMA	Single- and multi-scheme pretend play acts, modelled by experimenter	Mixed	Children with ASD more likely to give correct response on single scheme acts Children with ASD performed less well on multi-scheme task when presented in correct order, although not significant, performed as well as other groups when presented in wrong order Children with ASD less likely to correct the multi-scheme acts when presented in the wrong order
Rutherford et al. (2007)	28 ASD Children Age (time 1): 26-41m *M*=33.65, *SD*=3.61 Age (time 2): 48-65m *M*=57.6, *SD*=3.89 Diagnosis: Autistic disorder (AD)	18 DD Children Age (time 1): 24-47m *M*=35, *SD*=7.21 Age (time 2): 47-71 *M*=59.0, *SD*=7.6 27 TD Children Age (time 1): 12-35m *M*=19.67, *SD*=4.77	Fewell Play Scale	Yes	Time 1 Children with ASD show less pretend and sensorimotor play than TD and DD children in both spontaneous and scaffolded conditions; no differences between TD and DD groups Time 2

		Age (time 2): 25-38m *M*=30.1, *SD*=4.1			Children with ASD show less pretend play than TD and DD children in both conditions; no group differences in terms of sensorimotor play Diagnosis and joint attention at Time 1 predict development of spontaneous pretend play; Diagnosis predicted development of scaffolded pretend play Overall, children with ASD show less spontaneous compared to scaffolded pretend play
Sigman & Ungerer (1984)	<u>16 children with ASD</u> 15 male Age: 39-74 months (*M*=51.7, *SD*=10.7)	<u>16 children with LD</u> 10 male Age: 32-80 months (*M*=50.7, *SD*=12.6) Matched on age, MA and intelligence quotient (IQ) <u>16 TD children</u> 15 male Age: 16-25 months (*M*=20.8, *SD*=3.0) Matched on MA	Unstructured and structured play	Yes	Children with ASD showed less pretend play both spontaneously and in response to cueing compared to both control groups; also performed more poorly in terms of imitation Children with ASD not impaired in terms of sensorimotor skills Functional and pretend play associated with receptive language in all three groups; sensorimotor play associated with receptive language only in the control groups
Wing et al. (1977)	<u>108 Children with DD/LD/ASD</u> 71 male Age: 5-12 years Diagnoses: DS (*N*=42); other including ASD (*N*=66)	-	Interview and observation	Yes	Children with ASD much more likely than children with LD/DS only to show no symbolic play or stereotyped play Only two children who showed symbolic play showed any features of ASD
Generativity and fluency tasks					

Authors	ASD Sample	Control Sample	Imagination Measures	ASD- specific Imagination Difficulty	Key Findings
Bishop & Norbury (2005)	Aged between 6 and 10 years 14 children w/ High Functioning Autism (HFA): 14 boys Age: 6.23-10.56 y *M*=8.30; *SD*=.99 Non-Verbal Ability (NVA)=84-130 *M*=107.21, *SD*=15.62	25 children with Pragmatic Language Impairment 21 boys Age: 7.08-10.9 y *M*=8.93, *SD*=1.43 NVA=80-130 M=105, SD=15.04 17 children with Specific Language Impairment 15 boys Age: 7.96-10.71 y *M*=9.33, *SD*=.92 NVA = 84-119 y *M*=98.94, *SD*=11.56 18 TD children 15 boys Age: 6.78-9.91 y *M*=8.56, *SD*=1 NVA=88-125 *M*=110.83, *SD*=10.38	Use of Objects Task (UOT) Pattern Meanings Task (PMT)	Mixed	UOT: No main effect of group or interaction between groups and object type Both the HFA group and the Pragmatic Language Impairment group scored significantly lower on percentage of correct responses than the control group No group differences in terms of repetitious and redundant responses PMT: No significant group differences in terms of total responses; HFA group gave significantly fewer correct responses compared to control groups
Craig & Baron-Cohen (1999)	15 Children with ASD: Age *M*=12;9, *SD*=3;1 y VMA *M*=6;9, *SD*=2;2 y 15 AS children: Age *M*=12;9, *SD*=2;6 y VMA *M*=9;10, *SD*=2;5 y	15 LD children: Age *M*=12;4, *SD*=2;4 y VMA *M*=6;9, *SD*=1;8 y TD children (*N* not reported): Age *M*=5;2, *SD*=2;7 y	Torrance Tests of Creative Thinking (TTCT) Figure Completion (two conditions) Toy Improvement	Yes	Children with ASD perform worse on both conditions of Figure Completion than control groups and children with AS. Children with AS perform worse than control groups on one condition of Figure Completion.

	AS matched with ASD on age but not VMA	ASD and LD matched on VMA	Other Imaginative Fluency		Children with ASD/AS generate fewer imaginative responses, and fewer rare, flexible responses on Toy Improvement compared to control groups
Dichter et al. (2009)	39 ASD children: 38 male Age *M*=9.72y, *SD*=2.66 NVI (Non-verbal intelligence) *M*=101.69, *SD*=17.5	29 TD children: 38 male Age *M*=10.57y, *SD*=3.35 NVI *M*=111.67, *SD*=16.11 Matched on NVI	Animal Fluency Task UOT	Yes	Children with ASD/AS made fewer animate responses in Imaginative Fluency, and fewer responses overall Children with ASD produced fewer correct responses on both Animal Fluency and UOT tasks No relationship between fluency scores and Restricted and Repetitive Behaviours (RRBs; measured by Repetitive Behaviour Scale-Revised [RBS-R])
Liu et al. (2011)	16 boys with AS Age: 10.5-11.7y *M*=10.6 NVI *M*=99.3, SD = 15.4 Vocabulary *M*=117.8, *SD*=14.2	42 TD boys Age: 10.2-11.9 y *M*=10.4 NVI *M*= 98.7, SD =13.1 Vocabulary *M*=118.4, *SD*=11.5	Divergent thinking & divergent feeling from the Creativity Assessment Packet (CAP)	Mixed	Children with AS scored significantly higher than TD children on originality and elaboration in divergent thinking task; TD children scored significantly higher than children with AS on openness and flexibility On divergent feeling task, TD children scored themselves higher on imagination than children with ASD
Pring et al. (2012)	9 savants w/ ASD: 7 males Age: 23-43y *M*=34.55, *SD*=5.13 Verbal IQ (VIQ)=56-111 *M*=83.66, *SD*=17.49 Performance IQ (PIQ)=55-114 *M*=84, *SD*=18.5	9 Non-savants with LD 7 males Age: 22-42 y *M*=33.56, *SD*=5.49 VIQ=63-117 *M*=95.11, *SD*=17.86 PIQ=53-115, *M*=83.55, *SD*=19.19	Incomplete and repeated figures task from TTCT Figural synthesis task	Mixed	Art students performed significantly better on TTCT No significant difference between other groups in terms of fluency, flexibility and originality; Savant artists scored higher in terms of elaboration Art students scored better than savant groups in terms of fluency on figural synthesis task; no difference between other groups; but both ASD groups scored

	Diagnoses : Autism (*N*=5), AS (*N*=3), AA (*N*=1) <u>9 non-savants w/ASD</u> 7 males Age: 22-43y *M*=32.22, *SD*=5.49 VIQ=53-109 *M*=78.78, *SD*=14.79 PIQ=54-112 *M*=82.33, *SD*=16.59 Diagnoses : Autism (*N*=5), AS (*N*=3), AA (*N*=1)	<u>9 neurotypical (NT) A-level art students</u> 7 males Age: 16-18 y *M*=33.56, *SD*=5.49 VIQ=95-125 *M*=114.67, *SD*=12.99 PIQ=94-120 *M*=114, *SD*=9			lower than other groups in terms of representational fluency Art students produced significantly more original responses than ASD groups; no difference between other three groups No evidence of generativity difficulty in savant artists
Turner (1997/1999b)	<u>22 ASD</u> 19 males Age - 6-32 years (*M*=12,0 ; *SD*=5,4) MA : *M*=11,6 (*SD*=3,8) VIQ: *M*=100 (*SD*=22.3) NVIQ: *M*=108 (*SD*=20.0) <u>22 ASD and LD</u> 19 males Age - 6-32 years (*M*=14,0 ; *SD*=7,2) MA : *M*=6,6 (*SD*=2,5) VIQ: *M*=60 (*SD*=9.6) NVIQ: *M*=88 (*SD*=22.4)	<u>21 Clinical (non-ASD)</u> 18 males Age - 6-32 years (*M*=11,11 ; *SD*=4,5) MA : *M*=12,4 (*SD*=4,7) VIQ: *M*=101 (*SD*=17.8) NVIQ: *M*=110 (*SD*=12.1) <u>22 LD</u> 16 males Age - 6-32 years (*M*=12,0 ; *SD*=6,5) MA : *M*=7,2 (*SD*=2,4) VIQ: *M*=59 (*SD*=5.6) NVIQ: *M*=79 (*SD*=12.7)	Letter fluency Category fluency Use of Objects Pattern Meanings Design fluency Repetitive Behaviour Interview (Turner [1997] only)	Mixed	Participants with ASD performed significantly worse than clinical control participants, regardless of LD status, in terms of verbal and ideational fluency Participants with ASD performed worse on design fluency also but only qualitatively rather than in terms of quantity Reported in Turner (1997) only: For autistic participants, but not control participants, number of novel responses on ideational fluency tasks was significantly negatively associated with sameness behaviour and circumscribed interests but not stereotyped movements or repetitive use of language; this finding replicated with design fluency and circumscribed interests

Drawing					
Authors	**ASD Sample**	**Control Sample**	**Imagination Measures**	**ASD- specific Imagination Difficulty**	**Key Findings**
Allen & Craig (2016)	16 ASD 12.5-15.7 years (*M*=13.6) 14 males	16 LD 11.6-15.7 years (*M*=13.0) 14 males Matched on age, MA and receptive vocabulary	Impossible Person/Dog drawings (spontaneous v. cued) Unreal category mixing	Mixed	Fewer children with ASD passed the spontaneous condition, and drew fewer impossible features, than children with LD No significant difference in cued condition in terms of pass rate or number of impossible features Fewer children with ASD passed the unreal category mixing tasks
Craig et al. (2001)	15 Children with ASD: Age *M*=12;9, *SD*=3;1 VMA *M*=6;9, *SD*=2;2 15 AS children: Age *M*=12;9, *SD*=2;6 VMA *M*=9;10, *SD*=2;5	15 children with LD: Age *M*=12;4, *SD*=2;4 VMA *M*=6;9, *SD*=1;8 15 TD children: Age *M*=5;2, *SD*=2;7	Impossible person Real v unreal category mixing Imagining combinations Transforming a picture	Mixed	Children with ASD worse at drawing an impossible person compared to TD but not MLD Children with ASD worse at mixing unreal categories only Fewer children with ASD passed unreal and spontaneous transformation, and made fewer transformations from inanimate to animate; more likely to make within-category transformations
Jolley et al. (2013)	15 ASD children 13 boys Age: 6,10-18,2	15 LD children Matched on age and VMA 15 TD children Matched on age 15 TD children	Happy vs sad drawing	Mixed	Main effect of group: TD group matched on age scored significantly higher than other three groups in terms of quality of expression; no differences among the other groups Children with ASD drew significantly more disembodied body parts than TD group matched on

		Matched on VMA			VMA; Children with ASD drew significantly fewer pictures of people than LD children Children with ASD drew fewer social scenes than TD children matched on age (approached significance for children matched on MA)
Leevers & Harris (1998)	<u>16 ASD children:</u> 13 male Age: 7;9 – 15;2y *M*=11;2, *SD*=24.8m VMA = 4;0 – 8;0 y *M*=5;0, *SD*=11.8 m	<u>16 LD children:</u> 10 male Age: 9;11 – 14;4 y *M*=11;7, *SD*=16.5m VMA = 4-6 y *M*=5;2, *SD*=6.2m <u>16 TD children:</u> 6 male Age: 4 – 4;11 y *M*=4;5, *SD*=4.2 m VMA = 4 – 6 y *M*=5;0, *SD*=7.8m All matched on VMA and sex; ASD and LD matched on age	Picture Completion Impossible Person and House Task	No	No differences between groups in terms of picture completion task No significant main effects or interactions in terms of group on the Impossible Person/House Task
Lewis & Boucher (1991)	<u>12 ASD children</u> 8 male Age: 10,11-15,0 *M*=13,1	<u>12 LD children</u> 8 male Age: 10,11-15,4 *M*=13,3 Matched on age and non-verbal IQ (NVIQ)	Free drawing task	Mixed	Drawing content: No differences between groups in terms of complexity of drawings, number of people included in drawings, range of objects Children with ASD included more symbols (e.g. letters) and schematics (e.g. maps) Generative strategies: No difference between groups in terms of copying/tracing or overall range of topics

					Children with ASD's drawings were more related to each other than control participants' (indicating difficulty with flexibility)
Low et al (2009)	27 ASD children: Age: 5.25-13.08y *M*=8.26, *SD*=2.17 VMA=4 – 10.83 y *M*=6.29, *SD*=2.23 Diagnoses: Autism (*N*=8), AS (*N*=9)	27 TD children: 23 males Age: 4.5-10.67y *M*=6.6, *SD*=1.31 VMA=1-10.83 y *M*=6.16, *SD*=2.09 Matched on VMA and gender	UOT PMT Impossible Person Task	Yes	Children with ASD produced drawings with significantly fewer imaginative features and showed lower generativity Generativity unique predictor of imaginative drawing content; but when visuospatial planning was entered the correlation between generativity and imaginative content became non-significant
Scott & Baron-Cohen (1996)	15 ASD children: Age: 8;9 –16;2 y *M*=13, *SD*=2;2 VMA=4-10 y *M*=4;11, *SD*= 1;6	14 LD: Age: 9;6-16;8 y *M*=12;8, *SD*= 2;6 VMA=4-5 y *M*=4;6, *SD*=0;5 Clinical groups matched on age and VMA 15 TD children: Age: 4;10-5 y *M*=4;10, *SD*=0;9	Impossible Person task Spontaneous and instructed drawings Functions of a Brick Verbal Fluency (F, A, S)	Mixed	Significantly fewer children with ASD produced drawings of impossible houses or men compared to control participants Children with ASD less likely to spontaneously generate imaginary responses and worse than control participants when drawing something imaginary under instruction Children with ASD produced fewer responses on Functions of a Brick compared to TD but not LD children; significantly fewer children with ASD produced abstract/pretend responses TD children performed better on the verbal fluency task, but no difference between clinical groups
Ten Eycke & Müller (2016)	22 children with ASD	29 TD children Age 61-167 months	Impossible person task	Mixed	No group differences on control tasks

	Age 60-176 months (*M*=111.6, *SD*=31.5) Diagnoses: AD (*N*=16); PDD-NOS (*N*=2); AS (*N*=4)	(*M*=103.3, *SD*=28,7) Matched on NVIQ, VMA, MA and age	UOT Design fluency Category fluency		No significant group differences on executive function (planning and working memory), generativity (UOT, design fluency and category fluency) or local processing bias No difference in terms of drawing houses, but children with ASD produced drawings of people with significantly fewer imaginative features Executive function (EF) was associated with imagination in children with ASD and young TD children; generativity and social interaction associated with imagination in person condition for TD children
Ten Eycke & Müller (2014)	25 children with ASD Age: 60-176 months *M*=115.3 (31.5)	29 NT children Age: 61-167 months *M*=103.3 (28.7) Matched on NVIQ, VMA, non-verbal mental age, MA and age	Impossible Person and House task	Mixed	Children with autism finding drawing imaginative people more difficult than houses No difference between groups in terms of houses but children with ASD drew fewer imaginative features on person than control participants

Thinking about the future

Authors	ASD Sample	Control Sample	Imagination Measures	ASD- specific Imagination Difficulty	Key Findings
Angus et al. (2015)	64 children with ASD 59 boys Age: 6.2-12.8 years (*M*=9.3, *SD*=1.8) Full Scale IQ (FSIQ): 75-145 (*M*=103.6, *SD*=14.9)	71 TD children 67 boys Age: 6.5-12.2 (*M*=9.3, *SD*=1.7) FSIQ: 70-139 (*M*=104.0, *SD*=14.7)	Social anticipation task Ideational fluency Storytelling	Mixed	No difference between groups in terms of ideational fluency or storytelling Ideational fluency and storytelling significantly positively correlated Children with ASD just as likely to guess age, gender and what the anticipated interviewer might ask them,

		Matched on age and FSIQ			but less likely to generate their own response; however, most children non-responsive in this task Theory of mind correlated with social anticipation performance in TD group only
Crane et al. (2013)	18 AS adults 13 males Age *M*=40.12, *SD*=13.94y	18 TD adults 13 males Age *M*=44.8, *SD*=11.59 y Matched on age, gender, VIQ, PIQ and FIQ	Sentence completion tasks for episodic future thinking (EFT) and episodic memory (EM)	No	No significant main effects on interactions in terms of group No correlation between EFT and EM in either group
Hanson & Atance (2013)	25 ASD children 22 male Age: 3;2 – 8;3 y *M*=5;10 Diagnoses: ASD (*N*=13), AS (*N=1)* PDD-NOS (*N*=7)	25 TD children 22 male *M*=4;10 y Matched on sex and MA	Battery of EFT, EF, and theory of mind (ToM) tasks	Mixed	Children with ASD perform significantly worse than TD children on two EFT tasks, two ToM tasks and one EF task; no differences on others In children with ASD, children with lower EFT scores had lower ToM and EF scores
Jackson & Atance (2008)	12 ASD children: 1 female Age: 4;8 - 13;1 y *M*=7;2, *SD*=2;4 VMA=4;1 – 8;4 y *M*=5;11. *SD*=1;4	12 TD children: 1 female Age: 3;6 – 5;10 y *M*=4;9, *SD*=0;9 VMA=4;3 – 8;5 y *M*=5;11, *SD*=1;4 Matched on VMA	Two self-based EFT tasks Two mechanical-based EFT tasks	Mixed	Children with ASD showed worse performance on self-based compared to mechanical-based EFT tasks TD children showed no differences
Lind & Bowler (2010)	14 ASD adults: 3 female Age: 21-57 y *M*=41.38, *SD*=12.71 VIQ=86-134 y *M*=107.86, *SD*=12.37	14 TD adults: 3 female Age: 23-57 y *M*=43.83, *SD*=10.39 VIQ=82=134 y *M*=110.71, *SD*=15.75	EM & EFT tasks Memory Characteristics Questionnaire	Mixed	Adults with ASD performed worse in EFT task than NT adults No group differences in terms of fluency

		Matched on gender, age, & VIQ	Letter, category and ideational fluency		EFT and EM significantly correlated in TD group but not ASD group EFT significantly correlated with imagination in the ADOS
Lind et al. (2014)	27 ASD adults 21 male Age *M*=35.46, *SD*=13.23y	29 NT adults 22 male Age *M*=33.25, *SD*=16.15y Matched for age, verbal ability and NVA	Scene construction task (including EFT and EM)	Yes	Adults with ASD performed worse than NT adults across all conditions of scene construction
Lind et al. (2014)	20 ASD children 16 male Age: *M*=8.67 (*SD*=1.37) Diagnoses: AD (*N*=15); AS (*N*=5)	20 TD children 16 male Age: *M*=8.32 (*SD*=.91) Matched on: VIQ, NVIQ, Structural language ability, sex, age	Event description (three conditions: EFT, EM and semantic event knowledge)	Mixed	No significant difference between groups in terms of specificity but children with ASD less accurate in terms of EFT, EM and semantic events – but not effect of condition or interactions No significant relationship between total RBS-R score and EFT in either group
Marini et al. (2016)	77 ASD children Age: 6-11.09 years *M*=8.11, *SD*=1.51	77 TD children Age: 6-11.11 years *M*=8.23, *SD*=1.51 Matched on age and IQ	Two self-based EFT tasks Two mechanical-based EFT tasks	Mixed	Children with ASD scored lower than participants with TD on both self- and mechanical-based tasks Both groups scored higher on mechanical- rather than self-based tasks
Terrett et al. (2013)	30 ASD children 77% male Age: 8-12 y *M*=9.5, *SD*=1.31 Diagnoses: AS (*N*=22), HFA (*N*=8)	30 TD children 70% male 8-12 y *M*=9.73, *SD*=1.02 Matched on age, FSIQ and VIQ	Autobiographical Interview (EFT and EM)	Mixed	Children with ASD produced fewer internal details overall compared to the TD group and produced more external details than the TD group for past events but no difference in terms of the future In both groups EFT and EM significantly correlated

Counterfactual thinking					
Authors	**ASD Sample**	**Control Sample**	**Imagination Measures**	**ASD- specific Imagination Difficulty**	**Key Findings**
Begeer et al. (2014)	71 Children with ASD 64 male Age: 6-12 years Diagnoses: PDD-NOS (*N*=45), AS (*N*=26)	71 TD children 67 male Age: 6-12 years Matched on gender, FSIQ, and age	Emotional counterfactual reasoning tasks (upwards and downwards)	Yes	Children with ASD performed worse on the counterfactual reasoning tasks across all emotion conditions This difference was particularly marked for downwards reasoning (e.g. feeling regret, disappointment) Unlike for TD children, performance on second-order false belief tasks was not significantly related to counterfactual reasoning in children with ASD
Begeer et al. (2009)	72 HFA children 65 male Age: 6-12 years	71 TD children 67 male Age: 6-12 years Matched on VIQ, FSIQ, gender and age	Counterfactual antecedent story RAKIT idea production task	Mixed	Counterfactual reasoning: No main effect of groups, however, for children with ASD as age increased so did subtractive counterfactual reasoning but not additive reasoning, which relies more on creativity. Opposite pattern for TD children Ideational fluency task: children with autism generated fewer ideas than TD children Ideational fluency was correlated with additive but not subtractive counterfactual reasoning
Leevers & Harris (2000)	16 ASD children 13 male Age: 7,9-15,2 years *M*=11,2y *SD*=25m	16 TD children 6 male Age: 4,0-4,11 years *M*=4,5y *SD*=4.2m Matched on VMA	Counterfactual reasoning task (Counterfactual only vs Counterfactual &	Yes	Effect of instruction strongest in TD group and weakest in ASD group Children with ASD displayed a *yes* response bias

		16 ASD children 10 male Age: 9,11-14,4 years *M*=11,7y *SD*=16m Matched on VMA and age	imagery instructions)		Children with ASD were not systematic in terms of their justifications to responses and performed around chance levels
Morsanyi & Handley (2012)	Experiment 1 26 ASD children 23 male Age: 11-16 years *M*=13y 3m	42 TD children 19 male Age: 11-16 years *M*=13y	Syllogistic reasoning tasks (both experiments)	Yes	Experiment 1 Children with ASD performed worse on the counterfactual reasoning task compared to TD children, not facilitated by use of fantasy context Not explained by ability to solve analogical reasoning problems
	Experiment 2 25 ASD children 22 male Age: 11-16 years *M*=14y 2m	49 TD children 26 male Age: 11-16 years *M*=13y 10m		Yes	Experiment 2 Again, children with ASD performed worse on counterfactual reasoning task; this was not explained by inhibition or flexibility
Peterson & Bowler (2000)	36 ASD children Age: 44-216 months *M*=130.3, *SD*=42.0	21 LD children Age: 125-220 months *M*=152, *SD*=26.4 54 TD children Age: 38-68 months *M*=48.4, *SD*=6.2 Both groups matched on MVA	Subtractive reasoning and false belief tasks	No	Children with ASD performed worse on FB task compared to TD children, no difference between two clinical groups or between TD and LD children No difference between groups in terms of subtractive reasoning task Children with ASD or LD found subtractive reasoning task easier than false belief task

Scott et al. (1999)	15 children with ASD Age: 7.9-18.0 y *M*=12.11, *SD*=35.7m VMA = 4-6 *M*=4.7, *SD*=7.57m	14 LD children: Age: 8.6-18.2y *M*=12.3, *SD*=36.28m VMA = 4-5 y *M*=4.6, *SD*=5.13m 15 TD children: Age: 4.9-4.11 y *M*=4.10, *SD*=.743 m	Counterfactual reasoning task (Counterfactual only vs Counterfactual & pretence)	Mixed	No main effect but significant interaction between group and condition: TD and LD children's task performance was helped by inclusion of pretence, but ASD group's was not Children with autism better than both control groups in terms of counterfactual reasoning only Children with autism performed poorly on the pretence questions
Writing					
Authors	**ASD Sample**	**Control Sample**	**Imagination Measures**	**ASD- specific Imagination Difficulty**	**Key Findings**
Dillon & Underwood (2012)	10 Children with ASD: 9 boys Age *M*=8.96y, *SD*=1.28 VMA *M*=8.4y, *SD*=3.56	10 TD children 6 boys Age *M*=8.6y, *SD*=.9 VMA *M*=9.07y, *SD*=1.86	Bubble Dialogue (Story-telling task)	No	No difference between groups in terms of narrative coherence or elaboration
Dowker, Hermelin & Pring, 1991	1 female poet with AS	1 NT female poet	Definition of Words and UOT Thematic analysis of poems Structural analysis of poetic devices	Mixed	Poet with AS produced same number of responses on Definition of Words (fluency task) and UOT but these were more likely to be incorrect or idiosyncratic for poet with AS There were few differences between the poets in terms of poetic content and use of structural devices
Kasirer & Mashal (2016)	34 children with ASD 29 boys, 5 girls Age 9-16 years	39 TD children 28 boys, 11 girls Age 10-15 years	Metaphor comprehension	Mixed	TD children performed better than ASD children on conventional metaphor comprehension, but no

	M=12.59, *SD*=1.92 NVI 33.35 (*SD*=6.85) Hebrew naming *M*=44.56 (*SD*=2.57) Vocabulary *M*=45.62 (*SD*= 7.05) Diagnoses: Autistic Disorder (AD; *N*=5); AS (*N*=7); PDD-NOS (*N*=22)	*M*=12.26, *SD*=1.58 NVI 31.85 (*SD*=6.57) Hebrew naming *M*=44.26 (*SD*=2.66) Vocabulary *M*=47.15 (*SD*= 5.84) Groups matched on sex, age, NVI, naming and vocabulary	Metaphor generation		difference found for comprehension of novel metaphors TD children performed better than ASD children on conventional metaphor generation, but ASD children performed better in terms of generating novel metaphors
Kasirer & Mashal (2014)	34 adults with High Functioning Autism (HFA) 14 men; 3 women Age 18-27 years *M*=21.06, *SD*=3.44 NVI *M*=38.8 (SD=4.13) Hebrew naming 46.47 (SD=1.73) Vocabulary *M*=48.18 (SD=6.46)	17 NT adults 8 men; 9 women Age 18-25 years *M*=22.71 (*SD*=2.02) NVI *M*=40.71 (*SD*=1.89) Hebrew naming *M*=46.71 (*SD*=1.82) Vocabulary *M*=55.82 (*SD*=3.34) Matched on age, NVI and naming	Metaphor comprehension Metaphor generation Creativity (using metaphor task)	No	Adults with ASD showed no difficulty in understanding metaphors Adults with ASD performed better in terms of generating metaphors and originality of metaphors

Appendix 2: Table of RRB factor analytic studies

Table 8-2 Factor analytic studies of RRBs in ASD populations organised by number of factors identified (2[N=13], 3[N=3], 4[N=1] or 5[N=4]), along with studies assessing RRBs in TD populations

Studies identifying two factors/components					
Authors	**Sample**	**Measure**	**EFA/CFA/PCA**	**Rotation**	**Factors/components**
Bishop et al. (2006)	*N*=830 Age=15m-11y (*M*=58m; *SD*=29m) 81% male Diagnoses=Autism, AS, PDD-NOS	ADI-R	PCA	Oblique (Promax)	Sensory motor behaviours Insistence on sameness and/or sensory aversions)
Bishop et al. (2013)	*N*=1825 Age=4-18 years (*M*=8.9; *SD*=3.5) 86% male Diagnoses=Autism, AS, PDD-NOS	ADI-R	PCA	Oblique (Promax)	RSM IS
Carcani-Rathwell et al. (2006)	*N*=621 Age=1-18 years 81% male Diagnoses=Pervasive developmental disorder (Childhood Autism, AA, AS, PDD-NOS) without LD, with LD, and LD only	Maudsley Item Sheet	CFA	-	Sensory/Motor Symptoms Cognitive Rigidity Symptoms
Cuccaro et al. (2003)	*N*=207 with autism Age= 29-254 months (*M*=108.7; *SD*=54.8)	ADI-R	PCA FA	Oblique (Promax)	RSM Actions Resistance to Change

	74% Male Diagnosis=Autism				
Georgiades et al. (2010)	*N*=205 Age=2-48 years (*M*=11.5; *SD*=8) 84% Males	RBS-R	EFA (principal axis)	Orthogonal (Quartimax)	Compulsive Ritualistic Sameness Restricted Behaviours Stereotyped Self-Injurious Behaviours
	Diagnosis=ASD				
Hanson et al. (2016)	*N*=704 Age=2-23 years 72% Males Diagnosis=ASD without LD, ASD and LD, LD, TD	BSIQ	CFA	-	RSM IS
Honey et al. (2012)	*N*=180 Age=37-192 months (*M*=45.53) 48% Males Diagnoses=ASD	RBQ	EFA	-	Insistence on sameness/circumscribed interests Sensory/motor
Hundley et al. (2016)	*N*=332 Age=2-17 years (*M*=6.15, *SD*=3.28) 85% Males Diagnoses=ASD	ADI-R	CFA	-	RSM IS
Lidstone, Uljarević et al. (2014)	*N*=120 Age=2-17 years 92% Males Diagnosis=Autism, AS	RBQ-2	PCA	Orthogonal (Varimax)	RSMB IS
Mooney et al. (2009)	*N*=137 Age=20-55 months (*M*=38.59; *SD*=7.21)	ADI-R	EFA (maximum likelihood)	Orthogonal (Varimax)	Lower-level factor 1 Higher-level factor 2

	83% males Diagnosis=AD, PDD-NOS, DD without PDD (*N*=61)				
Papageorgiou et al. (2008)	*N*=153 Age=19m-19y (*M*=71.56m; *SD*=39.65m) 84% Males Diagnosis=Autism, AS, PDD-NOS	ADI-R	PCA	Orthogonal (Varimax)	RSMB IS
Richler et al. (2007)	*N*=192 Age=2 years Diagnosis=ASD (*N*=165), Non-spectrum DD (*N*=49), TD (*N*=65)	ADI-R	CFA	-	RSM IS
Richler et al. (2010)	*N*=214 Age=2-9 years (4 cohorts) Diagnosis=ASD (*N*=165), Non-spectrum DD (*N*=49)	ADI-R	CFA	-	RSM IS
Shao et al. (2003)	*N*=221 Age=3-21 years Diagnosis=AD	ADI-R	PCA	Orthogonal (Varimax)	RSMB IS
Smith et al. (2009)*	*N*=245 Age=5-21 years (*M*=9, *SD*=3.36) 79% Male	ADI-R	PCA	Orthogonal (Varimax)	RSMB IS
	Diagnosis=ASD				
Szatmari et al. (2006)	*N*=339 Age *M*=110.79m (*SD*=66.13m)	ADI-R	PCA	Orthogonal (Varimax)	RSMB IS

	80% Male Diagnosis=Autism, AS, AA, PDD-NOS				
Tao et al. (2016)	<u>Discovery dataset:</u> *N*=1335 Age=1-44 years (*M*=8.0, *SD*=4.87) 79% Male Diagnosis=Autism, Not Quite Autism, Broad Spectrum <u>Replication dataset:</u> *N*=2588 Age=1-108 years (*M*=821.46, *SD*=13.96) 80% Male Diagnosis=Autism, ASD	ADI-R	PCA	Orthogonal (Varimax)	RSM IS

Studies identifying three factors/components

Authors	**Sample**	**Measure**	**EFA/CFA/PCA**	**Rotation**	**Factors/components**
Honey et al. (2008)	N=104 Age=24-48months (*M*=37.05; *SD*=6.08) 80% Males Diagnosis=Autism, ASD, Other (*N*=25)	ADI-R	PCA	Oblique (Direct oblimin)	Sensory Motor Resistance Interests
Lam et al. (2008)	*N*=316 Age=20m-29y (*M*=9.02y; *SD*=6.15) 83% Male Diagnosis=AD	ADI-R	PCA Comprehensive EFA	Orthogonal (Varimax) and Target	Repetitive Motor Behaviours IS Circumscribed Interests

Mirenda et al. (2010)*	*N*=287 Age=24-64 months (*M*=40.7; *SD*=9.3) 84% Males Diagnosis=ASD	RBS-R	CFA	-	Compulsive Ritualistic Sameness Behaviours Self-Injurious Behaviours Restricted Stereotyped Behaviours
Studies identifying four factors/components					
Authors	**Sample**	**Measure**	**EFA/CFA/PCA**	**Rotation**	**Factors/components**
Anagnostou et al. (2011)	*N*=181 Age=2-18 years (*M*=8; *SD*=5) 83% Male Diagnosis= Autism	Y-BOCS	EFA (principal axis) CFA	Orthogonal (Varimax) and oblique (Promax)	Obsessions Higher-Order Repetitive Behaviours Lower-Order Repetitive Behaviours Hoarding
Bourreau et al (2009)	*N*=145 Age=3-33 years (*M*=12.2, *SD*=7.3) 74% Males Diagnoses=AD, PDD-NOS, AS	RRB Scale	PCA	Orthogonal (Varimax)	Sensorimotor stereotypies Reaction to change Restricted behaviours Modulation insufficiency
Smith et al. (2009)*	*N*=245 Age=5-21 years (*M*=9, *SD*=3.36) 79% Male Diagnosis=ASD	ADI-R	PCA	Orthogonal (Varimax)	Simple RSMB Complex RSMB IS Intense preoccupations
Studies identifying five factors/components					
Authors	**Sample**	**Measure**	**EFA/CFA/PCA**	**Rotation**	**Factors/components**
Bishop et al. (2013)	*N*=1825 Age=4-18 years (*M*=8.9; *SD*=3.5)	RBS-R	EFA	Oblique (Promax)	Sensory-Motor Self-Injury Compulsive

	86% male Diagnoses=Autism, AS, PDD-NOS				Ritualistic/Sameness Restricted Interests
Lam & Aman (2007)	N=307 Age=3-48 years (*M*=15.34; *SD*=9.6) Diagnosis=Autistic Disorder, AS, PDD-NOS	RBS-R	EFA (ordinary least squares)	Orthogonal (Quartimax)	Rituals/Sameness Self-Injurious Behaviour Stereotypic Behaviour Compulsive Behaviour Restricted Interests
Mirenda et al. (2010)*	*N*=287 Age=24-64 months (*M*=40.7; *SD*=9.3) 84% Males Diagnosis=ASD	RBS-R	CFA	-	Stereotyped Behaviours Self-Injurious Behaviours Compulsive Behaviours Ritualistic Sameness Behaviours Restricted Behaviours
Scahill et al. (2014)	*N*=229 Age=4-17 years (*M*=7.8; *SD*=2.6) 84% Males Diagnosis=AD, AS, PDD-NOS	CY-BOCS adapted for ASD	PCA	Orthogonal (Varimax and Equimax) and Oblique (Promax)	Hoarding and Ritualistic Behaviour Sensory/Motor and Arranging Behaviours IS and Self-Injurious Behaviours Stereotypy Restricted Interests
Studies assessing TD children					
Authors	**Sample**	**Measure**	**EFA/CFA/PCA**	**Rotation**	**Factors/components**
Evans et al. (1999)	*N*=1488 Age=8-72 months 48% Males Diagnosis=None	CRI	PCA CFA	Orthogonal (Varimax)	Just Right Repetitive Behaviours
Leekam et al. (2007)	*N*=679 Age=24-33 months (*M*=29.02; *SD*=2.09) 51% Males Diagnosis=None	RBQ-2	PCA	Orthogonal (Varimax)	<u>Two factor model:</u> Motor/Sensory/Behaviours Rigidity/Routines/Preoccupation with Restricted Interests <u>Four factor model:</u>

					Repetitive motor movements Rigidity/adherence to routine Preoccupation with restricted patterns of interest Unusual sensory interest
Wolff et al. (2016)	*N*=914 Age=17-27 months (*M*=19.7; *SD*=2.4) 52% Males Diagnosis=None	RBS-EC	EFA CFA	Oblique (Promax)	<u>Three factor model:</u> Repetitive motor Ritual and routine Restricted behaviour <u>Four factor model:</u> Repetitive motor Ritual and routine Restricted behaviour Self-directed

*Mirenda et al. (2010) used CFA to test six possible models, and identified two models as being the best fit depending on for what purpose the measure is to be used; Smith et al. (2009) conducted two PCAs, the second of which included the item *verbal rituals* and resulted in a four-factor solution.

Appendix 3: The Adult Repetitive Behaviours Questionnaire-2

Do you like to arrange items in rows or patterns?

- ☐ Never or rarely
- ☐ One or more times daily
- ☐ 15 or more times daily
- ☐ 30 or more times daily

Do you repetitively fiddle with items? (e.g. spin, twiddle, bang, tap, twist, or flick anything repeatedly?

- ☐ Never or rarely
- ☐ One or more times daily
- ☐ 15 or more times daily
- ☐ 30 or more times daily

Do you spin yourself around and around?

- ☐ Never or rarely
- ☐ One or more times daily
- ☐ 15 or more times daily
- ☐ 30 or more times daily

Do you rock backwards and forwards, or side to side, either when sitting or when standing?

- ☐ Never or rarely
- ☐ One or more times daily
- ☐ 15 or more times daily
- ☐ 30 or more times daily

Do you pace or move around repetitively? (e.g. walk to and fro across a room, or around the same path in the garden?)

- ☐ Never or rarely
- ☐ One or more times daily
- ☐ 15 or more times daily
- ☐ 30 or more times daily

Do you make repetitive hand and/or finger movements? (e.g. flap, wave, or flick your hands or fingers repetitively?

- ☐ Never or rarely
- ☐ One or more times daily
- ☐ 15 or more times daily
- ☐ 30 or more times daily

Do you have a fascination with specific objects? (e.g. trains, road signs or other things?)

- ☐ Never or rarely
- ☐ Mild or occasional
- ☐ Marked or notable

Do you like to look at objects from particular or unusual angles?

- ☐ Never or rarely
- ☐ Mild or occasional
- ☐ Marked or notable

Do you have a special interest in the smell of people or objects?

- ☐ Never or rarely
- ☐ Mild or occasional
- ☐ Marked or notable

Do you have a special interest in the feel of different surfaces?

- ☐ Never or rarely
- ☐ Mild or occasional
- ☐ Marked or notable

Do you have any special objects you like to carry around?

- ☐ Never or rarely
- ☐ Mild or occasional
- ☐ Marked or notable

Do you collect or hoard items of any sort?

- ☐ Never or rarely
- ☐ Mild or occasional
- ☐ Marked or notable

Do you insist on things at home remaining the same? (e.g. furniture staying in the same place, things being kept in certain places, or arranged in certain ways?)

- ☐ Never or rarely
- ☐ Mild or occasional (does not affect others)
- ☐ Marked or notable (occasionally affects others)
- ☐ Serious or severe (affects others on a regular basis)

Do you get upset about minor changes to objects? (e.g. flecks of dirt on your clothes, minor scratches on objects?)

- ☐ Never or rarely
- ☐ Mild or occasional (does not affect others)
- ☐ Marked or notable (occasionally affects others)
- ☐ Serious or severe (affects others on a regular basis)

Do you insist that aspects of daily routine must remain the same?

- ☐ Never or rarely
- ☐ Mild or occasional (does not affect others)
- ☐ Marked or notable (occasionally affects others)
- ☐ Serious or severe (affects others on a regular basis)

Do you insist on doing things in a certain way or re-doing things until they are "just right"?

- ☐ Never or rarely
- ☐ Mild or occasional (does not affect others)
- ☐ Marked or notable (occasionally affects others)
- ☐ Serious or severe (affects others on a regular basis)

Do you play the same music, game or video, or read the same book repeatedly?

- ☐ Never or rarely
- ☐ Mild or occasional (not entirely resistant to change or new things)
- ☐ Marked or notable (will tolerate changes when necessary)

☐ Serious or severe (will not tolerate any changes)

Do you insist on wearing the same clothes or refuse to wear new clothes?

☐ Never or rarely
☐ Mild or occasional (not entirely resistant to change or new things)
☐ Marked or notable (will tolerate changes when necessary)
☐ Serious or severe (will not tolerate any changes)

Do you insist on eating the same foods, or a very small range of foods, at every meal?

☐ Never or rarely
☐ Mild or occasional (not entirely resistant to change or new things)
☐ Marked or notable (will tolerate changes when necessary)
☐ Serious or severe (will not tolerate any changes)

What sort of activity will you choose if you are left to occupy yourself?

☐ A range of different and flexible self-chosen activities
☐ Some varied and flexible interests but commonly choose the same activities
☐ Almost always choose from a restricted range of repetitive activities

Appendix 4: Breakdown of full sample from Chapter Three, Study Three

Initially, there were 2685 responses to the online survey as of the 8th October 2015. Of these, 92 were excluded for one of the following reasons: exact same response submitted twice, the participant was below the age of 18 years, or there was evidence of the participant not taking the survey seriously. Table 8.3 overleaf shows the descriptive statistics for the remainder of the sample (*N*=2593). For descriptive purposes, participants self-diagnosed as ASD are included with *ASD*. *Undergoing diagnosis or suspected ASD* includes those who indicated they thought they might have ASD or are actively seeking a diagnosis. *Missing/unknown* participants included those who did not report whether or not they had a diagnosis, as well as those who were not clear as to whether or not they had a diagnosis (e.g. some participants responded with *I don't know*). Participants had to clearly state they had no diagnosis to be coded under *No diagnosis*. When coding countries as *Other*, I first determined whether or not the national/official language of the country was English. If it was English, I then coded them under *Other (English-Speaking)*, along with participants who indicated they were ex-patriates of English-speaking countries. If the official/national language was anything other than English I coded them under *Other* separated into broad global regions.

Table 8-3 Descriptive statistics for full sample (N=2593) from Study Three, broken down by country/global region.

Country	*N*	Age (years)	Gender	Diagnosis	Ethnicity
United Kingdom	783	18-69 *M*=37.14 (*SD*=11.95)	38.7% Male 60.4% Female 0.6% Non-Binary 0.3% Missing	36.1% No diagnosis 45.2% ASD 6.1% Other diagnosis 3.2% Undergoing diagnosis or suspected ASD 9.3% Missing/Unknown	92.6% White 2.2% Mixed 2.9% Asian 0.8% Black 1.3% Other 0.3% Missing
United States of America	623	18-77 *M*=40.44 (*SD*=13.03)	40.9% Male 58.4% Female 0.5% Non-Binary 0.2% Missing	32.6% No diagnosis 46.5% ASD 8.8% Other diagnosis 3.0% Undergoing diagnosis or suspected ASD 9.0% Missing/Unknown	84.3% White 9.8% Mixed 1.6% Asian 2.6% Black 1.3% Other 0.5% Missing
Brazil	722	18-71 *M*=25.37 (*SD*=6.86)	75.5% Male 23.3% Female 0.1% Non-Binary 1.1% Missing	37.5% No diagnosis 26.3% ASD 9.0% Other diagnosis 3.2% Undergoing diagnosis or suspected ASD 24.0% Missing/Unknown	50.4% White 44.9% Mixed 1.0% Asian 2.5% Black 0.4% Other 0.8% Missing
Australia	50	19-75 *M*=40.30 (*SD*=13.97)	34.0% Male 66.0% Female	30.0% No diagnosis 56.0% ASD 4.0% Other diagnosis 8.0% Undergoing diagnosis or suspected ASD 2.0% Missing/Unknown	78.0% White 8.0% Mixed 8.0% Asian 2.0% Black 2.0% Other 2.0% Missing
Canada	48	19-64 *M*=37.67 (*SD*=11.83)	37.5% Male 60.4% Female 2.1% Missing	33.3% No diagnosis 56.3% ASD 6.3% Other diagnosis	85.4% White 4.2% Mixed 8.3% Asian

				4.2% Missing/Unknown	2.1% Missing
New Zealand	19	24-53 *M*=36.61 (*SD*=9.62)	68.4% Male 31.6% Female	26.3% No diagnosis 36.8% ASD 5.3% Other diagnosis 31.6% Missing/Unknown	89.5% White 10.5% Mixed
Republic of Ireland	10	19-51 *M*=35.70 (*SD*=10.79)	30.0% Male 70.0% Female	30.0% No diagnosis 50.0% ASD 10.0% Other diagnosis 10.0% Missing/Unknown	80.0% White 10.0% Mixed 10.0% Asian
South Africa	5	28-66 *M*=43.20 (*SD*=14.74)	20.0% Male 80.0% Female	60.0% No diagnosis 20.0% ASD 20.0% Undergoing diagnosis or suspected ASD	100.0% White
Other/Ex-patriate (English speaking)	15	19-62 *M*=40.93 (*SD*=12.30)	53.3% Male 46.7% Female	46.7% No diagnosis 40.0% ASD 13.3% Missing/Unknown	66.7% White 6.7% Mixed 26.7% Black
Other (Europe)	98	18-70 *M*=36.86 (*SD*=12.49)	51.0% Male 49.0% Female	33.7% No diagnosis 42.9% ASD 10.2% Other diagnosis 3.1% Undergoing diagnosis or suspected ASD 10.2% Missing/Unknown	89.8% White 5.1% Mixed 2.0% Asian 2.0% Black 1.0% Missing
Other (South/East Asia)	22	18-69 *M*=33.77 (*SD*=12.73)	63.6% Male 36.4% Female	22.7% No diagnosis 36.4% ASD 13.6% Other diagnosis 4.5% Undergoing diagnosis or suspected ASD 22.7% Missing/Unknown	27.3% White 13.6% Mixed 45.5% Asian 13.6% Other
Other (Middle East Asia)	6	21-46 *M*=32.17 (*SD*=9.41)	66.7% Male 33.3% Female	16.7 No diagnosis 50.0% ASD 16.7% Other diagnosis 16.7% Undergoing diagnosis or suspected ASD	33.3% White 16.7% Mixed 33.3% Asian 16.7% Black

Other (The Americas, The Caribbean)	5	24-29 *M*=27.20 (*SD*=1.92)	60.0% Male 40.0% Female	20.0% No diagnosis 80.0% ASD	20.0% White 80.0% Mixed
Missing/Unknown	187	18-62 *M*=30.46 (*SD*=9.29)	54.0% Male 42.2% Female 1.6% Non-Binary 2.1% Missing	45.5% No diagnosis 33.2% ASD 5.3% Other diagnosis 1.6% Undergoing diagnosis or suspected ASD 14.4% Missing/Unknown	51.3% White 18.7% Mixed 3.2% Asian 2.7% Black 24.1% Missing

Appendix 5: PCA solution for Chapter Three, Study Three following Varimax rotation

Table 8-4 Study Three: The rotated component matrix for the PCA of the ASD sample, after Varimax rotation.

	Component 1	Component 2	Component 3
Rotated item loadings:	IS	RMB	RSB
1. Arrange	.303	.282	.394
2. Fiddle	.121	**.665**	.117
3. Spin	-.036	**.604**	.076
4. Rock	.031	**.683**	.247
5. Pace	.161	**.643**	-.055
6. Hand/finger	.081	**.574**	.289
7. Fascination	**.474**	.247	.243
8. Angles	.207	.195	**.573**
9. Smell	.039	-.042	**.757**
10. Feel	.071	.193	**.761**
11. Carry	.311	.282	**.490**
12. Collect	**.569**	.164	.246
13. Home	**.745**	-.084	.103
14. Change	**.675**	-.103	.270
15. Routine	**.666**	.124	.015
16. Redoing	**.649**	-.044	.182
17. TV/Music	**.477**	.378	.103
18. Clothes	**.476**	.395	.110
19. Food	**.518**	.179	-.094
Percentage of variance explained:	18.07	14.24	12.15

Appendix 6: Selecting between the two PCA solutions

This section describes the differences between Study One and Study Three PCA solutions of the RBQ-2A, in order to conclude which solution is more suitable to use for the analyses in Chapter 5 of this thesis. The sample size of the Study Three PCA (*N*=275) gives it a clear methodological advantage over the smaller sample size of Study One (*N*=148). Furthermore, in this thesis I examine the construct of RRB and its relationship to imagination within an autistic population and as such the PCA solution arising from ASD data may be more valid; we have seen from the differing solutions across Study One and Study Three how diagnosis may influence the structure of RRBs. However, if the RBQ-2A is to be used in a research setting it is important to understand its reliability and validity in an NT population.

A less subjective criterion for deciding on a PCA solution is to examine the reliability of each component. Since the first PCA yielded two components, and the second PCA yielded three, there are five potential components of the RBQ-2A. Table 8.5 below shows the internal consistency (measured by Cronbach's alpha) and the mean inter-item correlation for each of the five possible components in the ASD sample (*N*=275).

*Table 8-5 The reliability (Cronbach's alpha and mean inter-item correlation) for the Study Three ASD sample (*N*=275) across both factor solutions for the RBQ-2A.*

	IS (Study One)	IS (Study Three)	RMB (Study One)	RMB (Study Three)	RSB (Study Three)
Cronbach's alpha	.76	.79	.71	.70	.67
Mean inter-item correlation	.30	.31	.29	.32	.34

In terms of internal consistency, there are only very small differences between the two IS components and the two RMB components; however, they are all acceptable. Similarly, they all show moderate mean inter-item correlations. Whereas the mean inter-item correlation for RSB is satisfactory, it is somewhat unacceptable in terms of internal consistency. When combining the two components to create an

RSMB component, the internal consistency is improved (α=.75) but the mean inter-item correlation is worsened (.25). Field (2013) argues that mean inter-item correlation is more important when assessing the reliability of components. On that basis, the second PCA shows a clear advantage in terms of component reliability. However, this is a somewhat circular examination of the components given that the second PCA was performed on these data. Therefore the five components were also examined in the sample of Australian adults from Study Two, and the reliability of these are shown in Table 8.6 below.

Table 8-6 The reliability (Cronbach's alpha and mean inter-item correlation) for the Study Three ASD sample (N=275) across both factor solutions for the RBQ-2A.

		IS (Study One)	IS (Study Three)	RMB (Study One)	RMB (Study Three)	RSB (Study Three)
ASD Group	Cronbach's alpha	.87	.89	.70	.71	.84
	Mean inter-item correlation	.47	.47	.32	.39	.56
		IS (Study One)	IS (Study Three)	RMB (Study One)	RMB (Study Three)	RSB (Study Three)
NT Group	Cronbach's alpha	.55	.62	.65	.60	.68
	Mean inter-item correlation	.11	.15	.26	.28	.36

For the ASD group, the second PCA solution is more reliable (though by a small margin). Notably for the ASD group the RSB component is actually the most reliable component in terms of mean inter-item correlation. Neither solution is ideal in the NT group; however, the second IS component is marginally better than the first IS component, and the RMB components are roughly equivalent with each having an advantage on one of the indicators. Again it is notable that RSB is the most internally consistent component for the NT group.

Table 8-7 Comparison of PCA solutions for the RBQ-2/RBQ-2A across four studies.

	Leekam et al. (2007)		Lidstone, Uljarević et al. (2014)		Study One (Barrett et al., 2015)		Study Three		
	RSMB	IS	RSMB	IS	RMB	IS	RMB	RSB	IS
Variance	27.8%	11.2%	11.1%	29.2%	25.67%	10.16%	10.44%	7.32%	26.72%
Cronbach's α	-	-	.79	.83	.78	.73	.70	.67	.79
Mean I-IC	-	-	.63	.67	.37	.25	.32	.34	.31
Items loading onto equivalent components across studies									
2. Fiddle	.77	-	.683	-	.611	-	.665	-	-
3. Spin	.66	-	.639	-	.713	-	.627	-	-
4. Rock	.61	-	.617	-	.871	-	.683	-	-
5. Pace	.75	-	.697	-	.718	-	.655	-	-
6. Hand/finger	.74	-	.660	-	.686	-	.559	-	-
13. Home	-	.72	-	.777	-	.702	-	-	.782
14. Change	-	.65	-	.716	-	.695	-	-	.689
15. Routine	-	.64	-	.741	-	.716	-	-	.687
16. Redoing	-	.73	-	.829	-	.505	-	-	.666
17. TV/Music	-	.56	-	.594	-	.507	-	-	.449
18. Clothes*	-	.53	-	.569	-	-	-	-	.445
Items which do not always load onto a component across studies, but load onto equivalent components									
7. Fascination	-	-	-	.390	-	-	-	-	.442
8. Angles**	.53	-	.571	-	-	-	-	.548	-
10. Feel**	.51	-	.565	-	-	-	-	.764	-
12. Collect	-	-	-	.579	-	.503	-	-	.551
Items which do not load onto equivalent components across studies									
1. Arrange	.55	-	-	-	.447	-	-	-	-
9. Smell	.44	-	-	.484	-	-	-	.791	-
11. Carry	-	.38	-	-	-	.424	-	.437	-
19. Food	-	.47	.447	-	-	.438	-	-	.539

*This item was not included in Study One due to poor endorsement by the participants (>80% responded *Never or rarely*).

**Both items loaded on to two components in Leekam et al.'s four-factor solution: *unusual sensory interest* and *preoccupation with restricted patterns of interests.* Since the latter falls under IS, these two items have been categorised as not always loading onto a component across studies, but loading onto equivalent components.

Table 8.7 on the previous page compares the solutions of Study One and Study Three with previous research (Leekam et al., 2007; Lidstone, Uljarević et al., 2014). It should be noted that, as discussed in the previous chapters and literature review, Leekam et al. (2007) actually found support for both a two-factor solution and a four-factor solution. For the ease of reading and comparison, the two-factor solution from Leekam et al. has been used in the table, although the following discussion will take into account findings from the four-factor solution.

There are eleven items that, when entered into a PCA, always load in the same way. Items 2-6 always load onto RSMB or RMB in across these studies; moreover in Leekam et al.'s (2007) four-factor solution, they formed their own component, *repetitive motor movements*. This mirrors the RMB component in Study Three and can be considered a part of RSMB. Items 13-18 always load on to the IS component and they loaded on to *rigidity/adherence to routine* in the four-factor solution, which can be considered a part of IS. Therefore we can be confident about the way in which these items are loading across different studies.

However, four items do not always load onto any component, but when they do they load onto equivalent components. For example, item 7 (*fascination with specific objects*) loaded on to IS in Lidstone, Uljarević et al.'s (2014) analysis and in Study Three, whereas it did not load at all in Leekam et al.'s (2007) analysis or Study One. In Leekam et al.'s four-factor solution, item 7 loaded on to *preoccupation with restricted patterns of interests*. There are also four items which do not always load onto equivalent components across studies. For example, item 1 (*arranging objects*) did not load in Lidstone, Uljarević et al.'s analysis or in Study Three, but it loaded onto RSMB in Leekam et al.'s two-factor solution and RMB in Study One. However, item 1 loaded on to *preoccupation with restricted patterns of interests*, in Leekam et al.'s four-factor solution.

It is notable that of the items that do not always load, or load in different ways, four of them are sensory items (items 7-10). Moreover, item 11 (carry) loaded on to RSB in Study Three. As discussed, it is not always clear whether a particular RRB is driven by insistence on sameness or the need for sensory feedback. For example,

refusal to eat certain foods (item 19) may reflect a desire to maintain routine or it may reflect a disliking of certain tastes and textures. The items which do not consistently load across studies may be too complex to definitively categorise as either RSMB or IS. Therefore, although most studies find support for a two-factor structure of RRB, a more complex structure may be closer to reality.

As summarised in Chapter 4 (page 130), the second PCA solution is more reliable in an independent sample and contains sensory items. The second solution is also more similar to previous research; in particular compared to Lidstone, Uljarević et al. (2014). Therefore I decided to analyse the sub-scales as identified by the second solution (Study Three, Chapter Three) in Chapter Five of this thesis.

Appendix 7: The effect of age at diagnosis for Chapter Three

Two hundred and sixty-three participants in Study Three and Study Four reported their age at diagnosis. Of these 63 (23.6%) were diagnosed as children (>18 years) and 204 (76.4%) were diagnosed as adults (≥18 years). There were no significant relationships between age at diagnosis and gender (χ^2[2]=.33, p=.85) or pretend play (χ^2[2]=.87, p=.65). Participants diagnosed as adults were significantly older (M=40.01, SD=11.09; Md=41.0, IQR=18) than participants diagnosed as children (M=26.44, SD=9.80;Md=22.0, IQR=9;Z=-7.98, p<.001). In addition, participants diagnosed as adults scored significantly higher on the AQ (M=39.65, SD=5.64; Md=40.0, IQR=9.0) than participants diagnosed as children (M=34.81, SD=5.14; Md=35.0, IQR=8.0; Z=-5.66, p<.001). Table 8.8 below shows the means, SDs, medians and IQRs for the RBQ-2A and its subscales across both groups. Those diagnosed as adults scored higher on the RBQ-2A (Z=-2.91, p=.004), IS (Z=-2.62, p=.009) and RSB (Z=-2.47, p=.014) but not RMB (Z=-.36, p=.722). There were two outliers across the sample; however, removing these did not affect the pattern of analyses.

Table 8-8 Means, SDs, medians and IQRs for the RBQ-2A total, IS, RMB and RSB scores by age of diagnosis

	RBQ-2A		IS		RMB		RSB	
	M (SD)	Md (IQR)	M (SD)	Md (IQR)	M (SD)	Md (IQR)	M (SD)	Md (IQR)
Child	2.10 (.35)	2.15 (.50)	2.32 (.47)	2.33 (.78)	1.94 (.48)	2.0 (.80)	1.80 (.52)	1.75 (.75)
Adult	2.25 (.35)	2.30 (.50)	2.50 (.40)	2.56 (.56)	1.96 (.51)	2.0 (.80)	1.99 (.56)	2.0 (1.0)

Appendix 8: The Adult Routines Inventory

Everyone has certain habits, routines or preferences as part of their personality and behaviour. We are interested in learning more about people's individual habits and traits.

Please read the items below and indicate the degree or frequency to which they apply to you or have applied to you <u>in your adult life</u>.

		Not at all/Never	A little/ Rarely	Somewhat/ Sometimes	Quite a lot/ Often	Very much/ Always
1	Do you prefer to do things in a particular order?					
2	Do you prefer to do things in a certain way?					
3	Are you attached to certain objects?					
4	Are you concerned with dirt, cleanliness, or neatness?					
5	Do you arrange objects or perform certain behaviours until they are "just right?"					
6	Do you like to eat your meals in a certain order or certain way?					
7	Do you have persistent habits?					
8	Do you prefer to have the items on the top of your desks, tables, or counters lined up in straight lines, or in patterns?					
9	Do you prefer to keep the same schedule or routine every day?					
10	Do you fiddle with objects (tap pens, rip labels on bottles, etc.)?					
11	Do you prefer to have certain belongings "in their place?"					
12	Are you a picky eater?					

13	Do you twirl or play with your hair?					
14	Do you enjoy collecting things?					
15	Do you focus on details when doing a task?					
16	Do you clench/grind your teeth during the day or when sleeping?					
17	Do you notice imperfections in objects, like scratches on furniture, spots/stains, or frays on clothing, etc.?					
18	Do you prefer to finish one task before moving on to the next?					
		Not at all/Never	**A little/ Rarely**	**Somewhat/ Sometimes**	**Quite a lot/ Often**	**Very much/ Always**
19	Do you prepare for bedtime by engaging in a routine?					
20	Do you avoid eating certain foods because of their "feel" or texture?					
21	Do you lick your lips until they are chapped?					
22	Do things have to be "in their place" before you can get anything else done?					
23	Do you chew non-edible objects (like pens or any other objects)?					
24	Are you sensitive to loud noises?					
25	Do you fidget or bounce your legs when you are bored or anxious?					

26	Are you sensitive to the ways that certain clothes feel?					
27	Do you notice when pictures on walls are not lined up, or are crooked?					
28	Do you feel you have to complete a task once you have started it?					
29	Does the sound of people eating bother you?					
30	Do you seem more aware of high-pitched noises than other people?					
31	Do you pick your skin?					
32	Are you aware of buzzing or other sounds that come from lights or electronics?					
33	Do you crack your joints (knuckles, neck, back, jaw, etc.)?					
34	Do you feel the urge to clear your throat even when you don't have a cold or allergies?					
35	Do you make odd sounds or noises?					
36	Are you bothered when objects seem not to be lined up evenly?					
37	Do you feel bothered if something disrupts your daily schedule or routine?					
38	Do you tend to tap your fingers when you feel stressed or bored or are trying to concentrate?					
		Not at all/Never	**A little/ Rarely**	**Somewhat/ Sometimes**	**Quite a lot/ Often**	**Very much/ Always**

39	Do you like to have a sense of evenness or balance, so if something touches one side of your body you have the urge to have it touch the other side of your body?					
40	Do you bite your nails or skin on the fingers (cuticle)?					
41	Do you rock your body when you feel stressed, bored, or ill?					
42	Do you order the same meals when you go to a particular restaurant?					
43	Do you bite your lips/cheeks?					
44	Do you tug on your hair, eyelashes, or eyebrows?					
45	Do you like to go to new places?					
46	Do you feel the urge to do or say things a certain number of times?					
47	Are you fascinated with one subject or activity?					
48	Do you recite lines from movies, videos, TV shows, or commercials that you have heard before?					
49	Are you good at imitating sounds or others' voices?					
50	Do you need to know when future events are happening so that you can plan for them?					
51	Once something is done a certain way do you feel like it has to be done that way every time?					

52	Do you insist that certain activities need to take place at a certain time?					
53	Do you like to try new things?					
54	Do you clean or straighten up your home or office even when there may be more important things to do at that time?					
55	Are there certain topics that, once you get started talking on them, it's difficult to stop?					

Appendix 9: Instructions for the Personal Future Task

"Now I'd like to ask you to think about things that might happen to you in the future. I will give you different time periods in the future, one at a time, and I'd like you to try to think of things that might happen to you in those time periods. This time, I will give you two minutes to try to think of as many things as you can. It doesn't matter whether the things are trivial or important, just say what comes to mind. But, they should be things that you think will definitely happen or are at least quite likely to happen. If you can't think of anything or if you can't think of many things, that's fine, but just keep trying until the time limit is up.

First I'm going to ask you to think of positive things in the future. So, I'd like you to try to think of things that you are looking forward to, in other words, things that you will enjoy. So, I want you to give me as many things as you can that you're looking forward to over the next week including today".

(R gives one minute and writes down as close to verbatim as time allows what subject says)

Now, I'd like you to do the same but this time I want you to give me things that you're looking forward to over the next week.

(R does same as for one week)

Now, I'd like you to do the same but this time I want you to give me things that you're looking forward to over the next five to ten years.

(R does same as for previous)

"Now, I'd like you to think of things that you're worried about or not looking forward to, in other words, things that you would rather not be the case or rather not happen. So, I want you to give me as many things as you can that you're worried about or not looking forward to over the next week including today".

(R does same as for previous)

"Now I want you to give me as many things as you can that you're worried about or not looking forward to over the next year"

(R does same as for previous)

Finally, I want you to give me as many things as you can that you're worried about or not looking forward to over the next five to ten years"

(R does same as for previous)

Appendix 10: RRB items from the DISCO

Table 8-9 DISCO items contributing to the DSM-5's RRB algorithm, listed according to DISCO section.

DISCO section	Item	DSM-5 algorithm
Stereotyped Activities	Unusual movements of hands or arms	Stereotyped and repetitive speech, motor movements or use of objects
	Complex movements	Stereotyped and repetitive speech, motor movements or use of objects
Responses to sensory stimuli	Smelling objects or people	Hypo or hyper reactivity to sensory input
	Touching objects	Hypo or hyper reactivity to sensory input
	Repetitive, aimless manipulation of objects (not near eyes)	Hypo or hyper reactivity to sensory input
	Indifference to pain, heat, cold	Hypo or hyper reactivity to sensory input
	Distress caused by sounds	Hypo or hyper reactivity to sensory input
	Twisting hands or objects near eyes	Hypo or hyper reactivity to sensory input
	Interest in studying objects from different angles	Hypo or hyper reactivity to sensory input
Routines, resistance to change	Collecting objects	Highly restricted, fixated interests
	Fascination with specific objects	Highly restricted, fixated interests
	Arranging objects	Obsessive adherence to routines
	Abstract property of objects	Stereotyped and repetitive speech, motor movements or use of objects
	Maintenance of sameness of environment	Obsessive adherence to routines
	Eats only a small range of foods	Obsessive adherence to routines
	Maintenance of sameness in routines	Obsessive adherence to routines
	Repetitive themes	Obsessive adherence to routines
	Activities related to special skills	Highly restricted, fixated interests
	Fascination with TV/DVDs	Highly restricted, fixated interests
Summary items	Limited pattern of self-chosen activities	Stereotyped and repetitive speech, motor movements or use of objects
Methods used to communicate	Delayed echolalia or repetitive use of words or phrases	Stereotyped and repetitive speech, motor movements or use of objects
	Tone of voice when using words, not babbling	Stereotyped and repetitive speech, motor movements or use of objects
Imaginative activities	Repetitive acting out roles	Obsessive adherence to routines

Appendix 11: Correlation analyses for Study Five

Table 8-10 Study Five: Correlation coefficients, significance values and power for the association between anxiety and RRBs.

	RBQ-2A Total	RMB	RSB	IS
HADS Anxiety (*N*=26)	*r*=.31, *p*=.123 Power=.36	r_s=.242, *p*=.233 Power=.23	*r*=.288, *p*=.154 Power=.31	r_s=.286, *p*=.156 Power=.31

Table 8-11 Study Five: Correlation coefficients, significance values and power for the association between verbal fluency and RRBs.

	IS	RMB	RSB
FAS (*N*=26)	r_s=.377, *p*=.057 Power=.26	r_s=.324, *p*=.106 Power=.17	*r*=.257, *p*=.205 Power=.09
CAT (*N*=26)	r_s=.137, *p*=.504 Power=.03	r_s=.139, *p*=.497 Power=.03	*r*=.226, *p*=.267 Power=.07

Table 8-12 Study Five: Correlation coefficients, significance values and power for the association between the TTCT measures and RRBs.

	IS	RMB	RSB
IFT Fluency (*N*=23)	r_s=.34, *p*=.112 Power=.14	r_s=-.099, *p*=.653 Power=.02	r_s=.206, *p*=.346 Power=.05
IFT Originality (*N*=23)	r_s=-.101, *p*=.645 Power=.02	r_s=.219, *p*=.315 Power=.06	*r*=.102, *p*=.642 Power=.02
RFT Fluency (*N*=23)	r_s=.158, *p*=.471 Power=.03	r_s=.007, *p*=.974 Power=.01	*r*=-.25, *p*=.25 Power=.08
RFT Originality (*N*=22)	r_s=.112, *p*=.62 Power=.02	r_s=.267, *p*=.229 Power=.08	*r*=-.034, *p*=.881 Power=.01
UUT Fluency (*N*=26)	r_s=.016, *p*=.937 Power=.01	r_s=.126, *p*=.538 Power=.03	*r*=-.096, *p*=.642 Power=.02
UUT Originality (*N*=26)	r_s=-.171, *p*=.405 Power=.04	r_s=.007, *p*=.972 Power=.01	*r*=-.429, *p*=.029 Power=.37
UUT Flexibility (*N*=26)	r_s=.014, *p*=.944 Power=.01	r_s=.028, *p*=.891 Power=.01	*r*=.159, *p*=.438 Power=.04
	RFT Fluency	UUT Fluency	
IFT Fluency	r_s=.275, *p*=.205 Power=0.1 (*N*=23)	r_s=-.086, *p*=.690 Power=.02 (*N*=24)	
RFT Fluency	-	*r*=.186, *p*=.384 Power=.04 (*N*=24)	
	RFT Originality	UUT Originality	
IFT Originality	*r*=.094, *p*=.669 Power=.02 (*N*=23)	*r*=.372, *p*=.073 Power=.22 (*N*=24)	
UUT Originality	*r*=.188, *p*=.391 Power=.04 (*N*=23)	-	

Table 8-13 Study Five: Correlation coefficients, significance values and power for the association between the PFT, RRBs, Anxiety and TTCT.

	IS	RMB	RSB
PFT Total	r_s=.284, *p*=.160	r_s=.093, *p*=.650	r_s=.065, *p*=.753
(*N*=26)	Power=.12	Power=.02	Power=.01
PFT Positive	r_s=.203, *p*=.321	r_s=.019, *p*=.926	r_s=.063, *p*=.760
(*N*=26)	Power=.06	Power=.01	Power=.01
PFT Negative	r_s=.339, *p*=.09	r_s=.198, *p*=.333	r_s=.046, *p*=.825
(*N*=26)	Power=.19	Power=.05	Power=.01
	Anxiety (HADS)		
PFT Total	r_s=.332, *p*=.097		
(*N*=26)	Power=.26		
PFT Positive	r_s=.256, *p*=.206		
(*N*=26)	Power=.15		
PFT Negative	r_s=.363, *p*=.068		
(*N*=26)	Power=.33		
	IFT Fluency	RFT Fluency	UUT Fluency
PFT Total	r_s=-.045, *p*=.836	r_s=.262, *p*=.216	r_s=641, *p*<.001
	Power=.01	Power=.09	Power=.93
	(*N*=24)	(*N*=24)	(*N*=27)
PFT Positive	r_s=-.078, *p*=.717	r_s=.17, *p*=.426	r_s=.497, *p*=.008
	Power=.01	Power=.04	Power=.58
	(*N*=24)	(*N*=24)	(*N*=27)
PFT Negative	r_s=.034, *p*=.873	r_s=.348, *p*=.096	r_s=.675, *p*=<.001
	Power=.01	Power=.19	Power=.97
	(*N*=24)	(*N*=24)	(*N*=27)

Appendix 12: Imagination tasks and DISCO items for Study Five

Table 8-14 Study Five: Correlations between DISCO imagination and other imagination tasks, and mean scores on imagination fluency measures in terms of scores on past pretend play measures

	IFT Fluency	RFT Fluency	UUT Valid	PFT Total	PFT Positive	PFT Negative
Imaginative activities	r_s= -.074, p=.715 Power=.02	r_s= .235, p=.239 Power=.11	r_s= .189, p=.345 Power=.08	r_s=.098, p=.627 Power=.03	r_s=-.027, p=.893 Power=.014	r_s=.218, p=.274 Power=.11
Pretend play						
No (*N*=11)	6.64 (3.8)	9.09 (7.48)	15.18 (10.22)	36.27 (25.68)	21.36 (16.13)	14.91 (13.04)
Yes (*N*=16)	6.94 (2.91)	11.88 (7.42)	17.0 (7.62)	37.88 (20.4)	18.56 (9.67)	19.31 (12.44)
Shared pretend play						
Marked problem (*N*=6)	6.83 (1.72)	10.33 (5.42)	18.5 (8.53)	49.83 (27.55)	24.0 (10.39)	25.83 (18.42)
Minor problem (*N*=7)	6.14 (3.84)	11.86 (8.99)	16.57 (7.81)	33.57 (9.81)	17.71 (7.85)	15.86 (4.53)
No problem (*N*=2)	10.0 (.00)	17.0 (11.31)	15.5 (10.61)	26.5 (16.26)	10.0 (8.49)	16.5 (7.78)
Repetitive pretend play						
Marked problem (*N*=9)	7.11 (3.59)	11.89 (8.68)	13.89 (4.83)	31.67 (11.2)	16.78 (8.9)	14.89 (4.2)
Minor problem (*N*=6)	6.67 (2.16)	12.0 (6.69)	22.17 (9.24)	50.33 (26.83)	22.83 (10.38)	27.5 (17.41)