

Cognitive underpinnings of symbolic pretend play and impossible entity drawings:

Imaginative ability in typical development and autism spectrum disorder

Steven Den-Kaat

300084352

Supervisor: Dr Jason Low

Thesis submitted in fulfilment of the requirements for

Degree of Master of Science in Psychology

Victoria University of Wellington

2008

VICTORIA UNIVERSITY OF WELLINGTON
Te Whare Wananga o te Upoko o te Ika a Maui



ABSTRACT

The individual differences in imagination ability in children with autism spectrum disorder (ASD) were tested in a sample of 14 children with ASD and 14 matched typically developing (TD) children. Analysis was conducted on the extent of imagination in symbolic pretend play and impossible entity drawings. Aside from difficulties with imagination, children with ASD showed significant group deficits in executive function (generativity, visuospatial planning and cognitive flexibility) and false belief theory of mind understanding. Amongst children with ASD, executive function abilities (generativity and visuospatial planning) related to imaginative play and drawings. In contrast, amongst participants in the TD group, a mixture of both executive function (cognitive flexibility) and false belief theory of mind understanding predicted imaginative ability. These results are discussed in terms of how executive control plays a broad and important role in imaginative ability across groups, but the contributions appear to be expressed and routed differently in ASD. The discussion also highlights the theoretical implications of not having theory of mind that underpin imagination in ASD.

Acknowledgments

Thank you to all of the participants, their families and schools who gave their time to this study. I am grateful to Autism New Zealand and Intellectual Disability Empowerment in Action Services for their interest in the project and continued support in participant recruitment. This research was supported by a Wellington Medical Foundation Grant to Dr Jason Low. I extend thanks to Dr Jason Low for his theoretical direction, enthusiasm, and editorial feedback. I would also like to thank Wendy Faust, Lucy Holland, Jo Melser and Jackki Yim at the Child-Clinical and Cognitive-Developmental Labs for their support. Finally, thanks Maddy, for your untiring interest, support and help throughout the year.

Table of Contents

Abstract	(i)
Acknowledgments	(ii)
Introduction	1
Method	19
Results	33
Discussion	44
References	56

There is one group of individuals for whom engagement in acts of spontaneity and fantasy in imagination appear to be formidably challenging: children with autism spectrum disorder (ASD). ASD is a life-long pervasive developmental disorder, and despite a continuum of differing degrees of severity and variety of manifestations, individuals with this condition exhibit a triad of core impairments in social interaction, communication and imagination (Rutter, 1978; Wing & Gould, 1979). While there has been extensive research geared towards investigating the social interaction and communication deficit components of the triad, research focusing on understanding impairments in imagination in ASD has been less prominent (Craig, Baron-Cohen, & Scott, 2001; Frith, 2003). It is the purpose of this study to further examine imaginative ability in children with ASD in comparison to typically developing controls. Before turning to extant research literature on imagination in ASD, it is important to get an understanding of imagination and what the term itself means. Leslie's (1987) conceptualization of imagination will be used to set the scene.

Imagination and meta-representation

Imagination is a different construct from imagery, although imagery may be necessary for imagination. Imagery is a visual mental representation of a situation or event in the outside physical world (Kosslyn, Reiser, Farah, & Fiegel, 1983). When we create a visual image in our mind, the image of the object has a direct and relatively truthful relationship to that object. According to the cognitive developmental psychologist Alan Leslie (1987), there are three steps relating an initial visual mental image to an imaginative thought. At the first step, the image itself is generated through our visual system and visual cortex. This image becomes our primary representation of the object (i.e., an image that has true relations to a

particular object; e.g., looking at a fish and creating a visual image of a fish). In the second step, a mental copy of this primary representation is made. This duplicate (or as Leslie terms it – second-order representation) provides a version of the original image which can be manipulated and modified without corruption to the original primary representation. Finally in the third step, this second-order representation may be altered, where upon we can deliberately manipulate its truth relationships with the outside world. For example, we can delete the top half of the fish and replace it with a human torso to create a mermaid or we can add robotic arms and legs to the fish's body to allow it to walk on land. These second-order representations of the "fish" do not have any true direct relations to real fish in the outside physical world. The primary representations are kept intact and separate from the second-order representations; in this way Leslie argues that we do not become confused about the true nature of objects. For Leslie, a key aspect of flexible imagination is the ability to modify second-order representations, providing the opportunity to uncover and consider infinite non-veridical possibilities.

Leslie (1987) maintains that imagination critically involves steps two and three and that meta-representational theory of mind capacity lies at the heart of these two steps. Just as our primary representation of a fish has true direct relations to real fish in the outside physical world, our beliefs or propositional sentences (e.g., "cats can fly") also have bearing on primary true relations of real world objects (cats cannot fly). When we deploy our theory of mind ability to put ourselves in someone's shoes or infer a variety of mental states that cause action, we take the primary representation (e.g., "cats cannot fly") (step 1), copy it as a second-order representation (step 2), and then insert a prefix (e.g., "*John believes* cats can fly") (step 3) so that the representation's true relations to the outside physical world changes. In this case, the

proposition (“cats can fly”) is true if John believes it, irrespective of us knowing that cats do not fly. According to Leslie, the meta-representational theory of mind capacity to consider decoupled second-order representations allows us to maintain our own knowledge base (cats do not fly) whilst representing someone else’s different false belief (John *believes* cats can fly) in the same way that, the theory of mind mechanism allows us to represent our own true perception of real world entities (this is a fish) whilst representing impossible imaginative ones (this is a mermaid). Development of an explicit meta-representational theory of mind has been shown to be stable at around 4- to 6- years of age (Wellman, Cross, & Watson, 2001). This is also around the same time that typically developing children demonstrate an explicit understanding of the intentional nature of pretend play (e.g., Lillard, 1998, 2002; Ma & Lillard, 2006) and also explicit representational flexibility in producing impossible entity drawings (e.g., Hollis & Low, 2005; Low, 2006; Low & Hollis, 2003). More direct evidence favouring a theory of mind explanation of imagination include children with higher false belief reasoning scores employing more fantasy in their day to day lives (e.g., Taylor & Carlson, 1997) and frequently engaging in joint symbolic play with peers (e.g., Astington & Jenkins, 1995). Overall, one influential view stemming from Leslie’s account is that meta-representational understanding of theory of mind underpins the development of children’s diverse imaginative activities such as symbolic pretend play and impossible entity drawings.

Imagination in ASD

Following Leslie’s (1987) account, Baron-Cohen and colleagues have adopted the view that in order to engage in symbolic activities such as pretend play or impossible entity drawings, children need to first produce a primary mental

representation of the items for play or to be drawn (e.g., Baron-Cohen, 1987; Baron-Cohen, Leslie & Firth, 1985; Charman, Sweetenham, Baron-Cohen, Cox, Baird & Drew, 1998; Scott & Baron-Cohen, 1996). A secondary copy representation of the primary representation can then be manipulated by the child and transformed into a novel object in the child's mind (e.g., pretending that a block is a car or drawing a man with two heads). In order to engage in imagination the child must be able to understand that pretend play actions or impossible depictions are separate from their true primary representations. Baron-Cohen and his colleagues also proposed that the meta-representational theory of mind mechanism (ToMM) underpinning imagination has a modular neuro-cognitive architecture that may be severely impaired in ASD.

In the influential study by Baron-Cohen (1987), levels of spontaneous pretend play in children with autism (CWA) were compared to children with Down's syndrome and typically developing (TD) controls. In this study, participants were presented with three different categories of toys and video-taped for 15 minutes (5 minutes with each toy group). The toy categories in this study were: (1) stuffed animals and wooden bricks; (2) a kitchen set and a green sponge; and (3) a set of commercially available play people. Scores on play practices were recorded into categories ranging from sensori-motor to symbolic. Symbolic play is seen as attributing properties to the object that it does not have (including referring to absent objects as if they were present), or using it as if it were something else (e.g., pretending a brick was a toy car). CWA produced significantly less symbolic play than both matched control groups. This result was presented as evidence that there is a deficit in the production of symbolic pretend play specific to autism. Scott and Baron-Cohen (1996) also assessed imagination deficits in autism through Karmiloff-Smith's (1990) seminal "Draw an Impossible Person" task. Findings from this study showed

that CWA (in comparison with TD children and children with moderate learning disability (MLD)), failed at drawing impossible pictures. Instead of impossible people, CWA drew real looking people. These results have also been replicated by Craig, Baron-Cohen and Scott (2001) with children in the subgroup towards the higher end of the autism spectrum of Asperger's Syndrome. Interpreting these results alongside a wealth of parallel research showing abnormalities in theory of mind understanding in ASD, Baron-Cohen and his colleagues (e.g., Baron-Cohen, 2000; Craig et al., 2001; Scott & Baron-Cohen, 1996) suggested that their observations of ASD impairments in imagination could be explained as deficits in understanding how beliefs are necessarily representational and can be decoupled from reality.

The view that imagination impairments are due to a limitation in theory of mind understanding has, however, been challenged by researchers who view difficulties with understanding mental states as themselves being attributable to a domain general deficit in executive functioning. For example, problems with inhibition, cognitive flexibility, and generativity have all been found to relate to difficulties with false belief reasoning amongst children with ASD (Hill, 2004; McEvoy, Rogers & Pennington, 1993; Russell Saltmarsh & Hill, 1999). In response to Baron-Cohen's (1987) study into imagination difficulties, Lewis and Boucher (1988) have criticized the findings to be the result of inadequate language ability matching between groups. According to Lewis and Boucher, lack of appropriate group matching led to floor effects in the symbolic play produced by CWA. Upon carefully matching groups on language ability, Lewis and Boucher found no difference between CWA and control participants when instructional prompts were provided (e.g., "What can these do? Show me what you can do with these"). However, the lack of group differences in Lewis and Boucher's study was primarily

attributable to the *absence* of symbolic play across *all* groups. Lewis and Boucher suggested that the props used in their study may not have been age appropriate to the participants and thus restricted the symbolic play of all the children. Upon refining Lewis and Boucher's task materials and also providing participants with instructional cues, Jarrold, Boucher and Smith (1996) found that CWA showed higher levels of symbolic play that were comparable to control counterparts. Jarrold et al. noted that CWA still produced symbolic play at a slower rate than controls. Executive function researchers have used these findings as a whole (that CWA can produce more symbolic play under cued conditions) to argue that CWA do understand pretend play but have problems in generating ideas for pretend play (Jarrold et al., 1996).

The process of simplifying the task by introducing instructional cues has also crossed over into imagination research focusing on impossible entity drawings. Leavers and Harris (1998) using a picture completion task reported that all groups (TD, CWA and moderate learning disability (MLD)) performed accurately in applying patterns that would classify a drawing as being impossible looking (e.g., colouring a snowman black; putting zebra stripes on a giraffe). In essence, their picture completion task made the Karmiloff-Smith (1990) drawing requirement simpler in that children only had to add elements to complete a picture rather than produce a whole picture from scratch. In the Leavers and Harris study, CWA also showed that they were able to identify and separate real looking pictures from impossible looking pictures. Consequently, Leavers and Harris proposed that an executive based difficulty, rather than in imagination or mental state understanding, underpins the deficit in completing impossible entity drawings. Specifically, Leavers and Harris believe that a separate limitation in the ability to carry out situational

visuospatial plans lies at the heart of CWA's difficulties in producing entire novel drawings.

In reply, Baron-Cohen and his colleagues (e.g., Baron-Cohen, 1989; Craig, Baron-Cohen & Scott, 2001) have commented that the instructed pretend play conditions used by Lewis and Boucher, 1988 / Jarrold et al. (1996) and the modified impossible entity drawing tasks used by Leavers and Harris (1998) may have been too easy and argued that if there is an imaginative impairment per se, the task focus should be on spontaneous pretend play or spontaneous drawings where children are required to explicitly manipulate knowledge structures in hypothetical ways. Unfortunately, much of the extant studies on imagination in ASD have concentrated only on demonstrating or challenging the magnitude of group differences in impossible entity drawings or symbolic play against a background of research into theory of mind versus executive dysfunction. If a particular cognitive deficit is principally responsible for imagination deficits in ASD, then variance in the display of that cognitive skill should be related to the extent and variability of imagination shown.

Attempts to specify the cognitive underpinnings of imagination

One study by Rutherford and Rogers (2003) has gone beyond documenting group success or deficits in imagination by studying whether theory of mind or executive function abilities are actually correlated with imagination performance. Given that the present project has a similar aim to Rutherford and Rogers' work, careful consideration of their findings is required. Replicating previous research, Rutherford and Rogers found that CWA produced significantly less symbolic pretend play than overall mental age matched control groups (TD and children with general

developmental disabilities (DD)). They did not find any significant difference in joint attention between the CWA and TD groups, although the autism group had lower joint attention scores than the DD group. They also did not find any group differences in generativity or cognitive flexibility between CWA and the control groups. In relation to generativity and cognitive flexibility, these findings directly contradict several studies that have found ASD impairments in generativity (e.g., Bishop, & Norbury, 2002; Turner, 1997, 1999) and cognitive flexibility (e.g., Colvert, Cusance, Swettenham, 2002; Zelazo, Jacques, Burack, & Frye, 2002).

One problem with Rutherford and Rogers' (2003) study is that they did not specifically match groups on verbal mental age (VMA). Given that language ability is actively recruited by TD children for flexibly integrating and shifting cognitive set (Jacques & Zelazo, 2005) and children with ASD routinely fail to rely on language for servicing executive control (Joseph, McGrath, & Tager-Flusberg, 2005), it is not clear whether failure to find group differences in generativity and set-shifting may be masked by the lack of group matching on general verbal ability. Due to developmental language delay present in ASD, any study looking into imagination would need to control for variance associated with individual differences in verbal ability (Jarrold, 2003).

Yet another significant problem is that Rutherford and Roger's (2003) generativity task measured play rather than generativity per se. Their generativity measure involved observing participants' spontaneous behavioural responses to different toys (e.g. when given a slinky, different responses such as sensorimotor squeezing, throwing and separating strands were scored as instances of novel behaviour). In contrast, studies that have found ASD deficits in generativity have used known tests of ideational fluency to tap the ability to generate new and imaginative

responses in addition to the ability to access and manipulate stored knowledge. For example, in Turner's (1999) Uses of Objects generativity task, children with ASD were asked to name as many possible uses of a given object (e.g., a newspaper) in a certain time period. Here it is possible to produce either common uses of the object (e.g., read it) or highly imaginative suggestions (e.g., for use as wallpaper, to keep warm). Although both types of response are correct, the latter class of response shows participants to be truly generative in the sense of looking at the situation from new perspectives and identifying new possibilities. Turner found that children with ASD had very low generativity scores as they could not combine and modify existing knowledge in their semantic network to generate uncommon imaginative ideas.

A final problem with Rutherford and Rogers' (2003) study is that even though they failed to find group differences in measures of executive function, data from all groups were still combined in conducting a regression analysis. Their combined regression analysis showed that even after the effects of overall mental age were factored out in the first block, only generativity (and not joint attention) in the second block accounted for unique variance in predicting spontaneous pretend play (they failed to factor out chronological age). As their result was yielded for the entire participant sample, the findings cannot be taken as specific to understanding the cognitive underpinnings of imagination in ASD. Further research is therefore required using separate pretend play and generativity measures in order to disambiguate Rutherford and Rogers' findings. If there is a link between generativity and symbolic pretend play, this association has not yet been directly shown, and is hence in need of further investigation.

Present study

Using correlational analyses, the main aim of the current project was to assess presumed links between individual differences in imagination ability with executive function versus theory of mind. In addition, while there is research exploring the ability of children with ASD at the group level to produce imaginative drawings as well as studies into symbolic play ability, no study has yet focused on investigating the cognitive underpinnings of both these constructs at the same time. By examining both pretend play and impossible entity drawing capabilities in children with ASD as compared to TD children, a clearer understanding of the cognitive processes involved in the development of imaginative flexibility may be revealed.

Based on Baron-Cohen and his colleagues' contention that imagination impairment may be a reflection of impairments in meta-representational mental state understanding (e.g., Baron-Cohen, 1987; Scott & Baron-Cohen, 1996), individual differences in symbolic pretend play and imaginative drawing in the ASD group should be straightforwardly related to variation in false belief attribution. However, several lines of evidence have converged to present a formidable challenge against such an expectation.

First, parallel to evidence of sophisticated prompted play in autism, the developmental literature on pictorial skills indicates that even young TD children can, through example priming, show above average performance in the range and complexity of imaginative ideas depicted (e.g., Berti & Freeman, 1997; Hollis & Low, 2005; Low, 2006; Zhi, Thomas, & Robinson, 1997). As reported earlier, group differences in the application of imaginative drawing ideas between ASD and TD children can even disappear under prompted conditions (e.g., Leavers & Harris,

1998). Second, various measures of language ability have been found to correlate with standard false belief theory of mind measures, in both ASD and in typical development (e.g., Fisher, Happé, & Dunn, 2005; Astington & Baird, 2005; Milligan, Astington, & Dack, 2007). Fisher et al. further reported that the correlation between receptive grammar ability and false belief comprehension is even stronger in ASD than in typical development. They suggested that CWA use and depend on language as a means for scaffolding mental state understanding. Such evidence implies that the strength of the contended ASD correlation linking false belief theory of mind understanding and imagination may become non-significant once variance due to receptive language (and chronological age) is removed. Furthermore, while there is a strong association between language and executive function in typical development (e.g., Hughes, 1996; Jacques & Zelazo, 2005), children with ASD do not appear to reliably use or depend on language for the service of executive control (e.g., Joseph, McGrath, & Tager-Flusberg, 2005; Russell, 1997). These findings, suggest that variations in executive function would *remain* uniquely related to the display of imagination in ASD even after variance due to receptive language (and chronological age) are partialled out. Consequently, in the current project it was hypothesised that variations in imagination ability would be uniquely linked to executive function performance for the ASD group relative to the matched TD control group. The study of executive function in relation to imagination in ASD must be constrained, however, as executive control as a construct on its own is too broad, and would tell us little about precise mechanisms underpinning achievements in imagination. Fortunately, extant evidence highlights at least two particular executive function skills that may be important for imagination in ASD: generativity and planning.

Generativity and planning underpinning imagination

With respect to pretend play in ASD, Turner (1997) has argued that generativity (the ability to generate novel ideas) is a key locus of difficulty where virtual symbolic production is concerned. Her theoretical position may be supported by several lines of evidence that was reviewed earlier indicating that: (1) CWA produce pretend play acts at a slower rate than control counterparts (e.g., Jarrold, Boucher & Smith, 1996) and (2) external prompts can help CWA engage in pretence and entertain counterfactual propositions (e.g., Lewis & Boucher, 1988). Beyond pretend play, the relevance of generativity for imagination via drawings comes from additional studies by Lewis and Boucher (1991) and Turner (1999). Lewis and Boucher found that the successive pictures of everyday objects produced by CWA showed a high degree of thematic relatedness, as compared to control participants. Turner (1999), upon asking CWA of different ability levels to generate as many interpretations as possible for meaningless two dimensional patterns, found that participants were less likely than control subjects to generate novel responses. The salience of generativity for flexible symbolic production has primarily been tested and supported with respect to pretend play in ASD by Rutherford and Rogers (2003), and their findings, as reviewed here, were ambiguous at best. In spite of this, given Turner's (1999) work showing ASD generativity deficits in novel interpretation of meaningless patterns, it was predicted that variations in generativity would also relate to individual differences in symbolic pretend play and drawing impossible entities in ASD.

It is also possible that the relationship between generativity and imagination in ASD is mediated by a third factor. Leavers and Harris (1998) have specifically

postulated that spontaneous imaginative drawings are difficult for CWA because such displays require the micro-deployment of new and potentially complex visuospatial plans. Due to distinct planning challenges faced by CWA, participants may instead choose to re-execute easy and already familiar graphic procedures. Leevers and Harris' reasoning fits with research on drawings by TD children showing that visuospatial planning (e.g., shape similarity and contrast, shape and line connection, axis orientation) is also an important control factor involved in novel picture production (e.g., Freeman, 1987; Low & Hollis, 2003; Thomas & Silk, 1990). The success of CWA on imaginative picture completion tasks that reduce planning demands is consistent with research showing that CWA have shown group deficits on measures of visuospatial planning (e.g., Prior & Hoffmann, 1990). This would mean that, even if individuals with ASD are able to generate novel imaginative drawing ideas, they may not be able to translate those ideas onto paper without a certain level of visuospatial planning ability. In the imaginative drawing task used by Scott and Baron-Cohen (1996), both generativity and planning may turn out to be important executive ingredients for successful problem solving. Weaving together Leevers and Harris' work on planning as a critical sub-component of the drawing process with Turner's (1999) findings on broader generativity deficits in ASD pattern categorization, it was specifically hypothesized that the relationship between generativity and impossible entity drawings in the ASD group would even be mediated through variations in visuospatial planning ability.

It is less evident that planning would necessarily mediate the relationship between generativity and symbolic pretend play amongst children with ASD. A fascinating study by Lillard (1996) indicated that TD kindergarten and young primary school children showed an appreciation and recognition of the physical action plans

involved in pretend play (e.g., pretending to be a puppy simply involves barking first and then sitting later), and that the mind is needed for translating plans into action (e.g., “I think what I want to play and then I start playing it”, p. 1720). However, whilst young children understood that action generation and planning were involved in preparing for pretence, they did not recognize that meta-representations were additionally involved in actualizing pretence. The young children in Lillard’s study reported that the actual execution of pretend play did not involve the mind, brain or combinations of mind and body. For example, one 8-year-old insisted that the actual play-pretending to be mothers required only a body and not mental engagement because to do so only required one to “cook, wash floors, go to work, [and then ...] send someone to their room” (p. 1725). Lillard’s findings guided and refined the current project’s predictions in two ways.

First, since executive capabilities in action generation and planning are implicated in pretend play, it was expected that variability in such skills would be related to individual differences in symbolic play in the ASD group. However, as compared the drawing modality where fine graphic visuospatial skills are necessary, planning may not need to specifically mediate ideational fluency to bring about gross symbolic pretend play with toys and objects. Hence, for the ASD group, separate to the process required for imaginative drawings, it was predicted that generativity and planning would not necessarily relate in a mediational fashion to link with symbolic pretend play. As to the manner by which imaginative drawings may unfold in ASD, contributing variance in generativity was predicted to be mediated through variance in visuospatial planning capability. Contrastingly, generativity and visuospatial planning capabilities were predicted to be independently linked to symbolic pretend play in ASD. Moreover, given that children with ASD tend to have enhanced perceptual

abilities for certain stimuli, tend to be visual problem solvers, and use non-mentalistic means of solving theory of mind tasks (e.g., Fisher et al., 2005; Kana, Keller, Cherkassky, Minshew, & Just, 2006; Mottron, Dawson, Soulières, Hubert, & Burack, 2006), it is not unreasonable to expect that variations in imagination (via play and drawings) may turn out to be especially related to variations in visuospatial planning ability in ASD compared to the TD control group.

A second key point arising from Lillard's (1996) findings is that even though young TD children easily generate and carry out plans involved in pretend play, there is a slowly emerging watershed in children's categorization of pretence that coalesces around an understanding of how minds are necessarily representational in nature. Consequently, for the TD group, it was hypothesized that false belief theory of mind understanding would also be centrally related to the extent of symbolic pretend play and imaginative drawing expression.

Cognitive flexibility additionally underpinning imagination

Impairments in generativity and planning do not succeed in accounting for all aspects of imagination ability in ASD. Imagination might also require other executive skills, for example, cognitive flexibility – the ability to coordinate multiple conflicting interpretations (of toys or drawings) at the same time (Jaques & Zelazo, 2005). Notably, children with ASD also show deficits in tasks measuring cognitive flexibility such as the Dimensional Change Card Sort task (DCCS; a variant of the Wisconsin Card Sort test) (e.g., Colvert et al., 2002; Zelazo, Jaques, Burack, & Frye, 2002; see also Ozonoff, Cook, Coon, Dawson, Joseph, Klin et al., 2004, for similar findings using a different measure). At a broader theoretical level, Zelazo (2004; Zelazo & Müller, 2002; Zelazo et al., 2002) theorized that cognitive flexibility in integrating

complex hierarchically embedded rules through self-directed speech may even assist children in tracking ideational fluency and hence be more generative (“If I have said that a newspaper can be used to make a fire then I should say that a newspaper can be used as wallpaper”) or assist children’s spatial plans (“If I put the largest disc on this peg, and if this smaller disc is on that peg, then I need to put the smallest disc on the other peg”).

Zelazo’s (2004) theoretical view that several unique phenomenological measures of executive function such as generativity and planning (and even going so far as to include measures of theory of mind) may be reducible to general cognitive flexibility is controversial. His perspective is facing strong theoretical challenges not only from theory of mind researchers (see Kloo & Perner, 2005) but also from executive function researchers (see Carlson, 2003). Given on-going debate surrounding whether cognitive flexibility could actually subsume domain specific and domain general measures of thought and reasoning, this project takes a neutral view by simply including cognitive flexibility as another separate measure of executive function which may be correlated to imagination in ASD (Rutherford & Rogers, 2003). A second broad prediction of this current project was that, following the executive function explanation of imagination in ASD, cognitive flexibility (alongside generativity and planning) would be predictive of individual differences in symbolic play and impossible entity drawing attempts.

Whilst Lillard’s (1996) study suggests that generativity and planning may not be critical watershed control factors involved in symbolic action implementation amongst TD children, there is other evidence indicating that cognitive flexibility could turn out to be relevant for imagination at other stages. Indeed, Carlson and Moses (2001) reported that children’s success in action pantomime (e.g., using finger

as toothbrush substitute when asked to pretend to brush one's teeth) was correlated with a combined battery measure of executive control that included the DCCS task. Separating out the DCCS as a distinct measure, Dick, Overton and Kovacs (2005) found positive but small correlations between action pantomime and the DCCS. The authors suggest that cognitive flexibility (as tapped by the DCCS) may help children coordinate, shift between, and integrate multiple representations during action pantomime specifically and symbolic activities generally. Dick et al. also found, dovetailing with Lillard's findings, that false belief theory of mind understanding was uniquely related to action pantomime. Unfortunately, all these correlations disappeared when chronological age was partialled out. The disappearance of the correlations upon partial analysis may be due to the incompatibility of the variance in the action pantomime task in relation to the variance in the other tasks. Consecutive coordination of representations are often needed in theory of mind and DCCS tasks (e.g., *from previous perspective and then to current perspective; from previous rule and then to current rule*) compared to the simultaneous coordination of representations need for pantomime tasks (e.g., using finger as toothbrush). Indeed, Dick et al. suggest that the supportive foundations provided by theory of mind and cognitive flexibility may yet be observed when using imagination type tasks that require consecutive coordination (e.g., extended free play using a variety of objects). Dick et al.'s findings are important in the sense that their data suggest that theory of mind and particular aspects of executive function such as cognitive flexibility may be relevant to how imagination typically unfolds in development. Consequently, it was predicted that aside from the executive skills of generativity and planning, variance in cognitive flexibility would so related to individual differences in imagination in the ASD and TD groups.

Summary

In this project, imagination in ASD was measured through pretend play and Karmiloff-Smith's (1990) impossible entity drawing task. A standard unprompted protocol was used for both domains as Baron-Cohen and colleagues have maintained that impairments in representing non-veridical content can only be detected and understood through such a procedure. However, this does not rule out the proposal that executive functioning may have considerable performance-competence implications for imagination, especially if this project uncovers, as was hypothesised here, that variations in imagination seen for children with ASD would be more strongly associated with generativity, planning and cognitive flexibility than compared to associations with false belief theory of mind reasoning. To summarize, the main hypotheses of this project were as follows:

For the ASD group -

H1. Compared to false belief theory of mind understanding, variation in executive function (generativity, visuospatial planning and cognitive flexibility) would be more strongly related to individual differences in imagination.

H1.1. For drawings specifically, visuospatial planning was predicted to mediate the relationship between generativity and extent of imaginative drawing content.

For the TD group -

H2. Executive function *and* theory of mind were predicted to be related to individual differences in imagination.

Method

Participants

The ASD participants with were recruited though Autism New Zealand and Intellectual Disability Empowerment in Action (IDEA) Wellington. The typically developing children were recruited through local mainstream schools. Each participant with ASD had been diagnosed under DSMIV-TR (American Psychiatric Association, 1994) criteria by at least two of a clinical psychologist, a paediatrician and a speech pathologist. As a check, the probability of autism and Asperger's syndrome and the degree of severity were confirmed using the caregiver questionnaire of the Gilliam Autism Rating Scale – Second Edition (GARS-2) (Gilliam, 2006) and the Gilliam Asperger's Disorder Scale (GADS) (Gilliam, 2001) respectively. GARS-2 and GADS were used as they reflect the most current definitions of ASD and have been revised to address criticisms of the original evaluative instruments (Hoffman, Sweeney, Gilliam, & Lopez-Wagner, 2006). For the autism group ($n = 9$) and the Asperger's group ($n = 5$), all participants' GARS-2 and GADS index scores were greater than cut-off points. Based on teacher reports, none of the control participants had a neurological or developmental disorder. The present study consisted of 28 participants. There were fourteen participants in the ASD group (1 female, 13 males; mean CA = 8 years 7 months; mean VMA = 9 years 10 months; mean non-verbal ability NVA = 27.71). There were fourteen typically developing controls (1 female, 13 males; mean CA = 7 years 3 months; mean VMA = 10 years 1 month; mean NVA = 23.71). Participants in the control group were selected to match participants in the ASD group on gender, VMA (via the Peabody Picture Vocabulary task), as well as NVA (via the Coloured Matrices) (Jarrold, Boucher & Smith, 1993).

Procedure

Children in the ASD group participated in a battery of measures over three sessions with the researcher, with each session spaced approximately one week apart. Sessions with the ASD group took place in the child's home in order to maintain a natural environment. Tasks were semi-randomly organized across sessions, but the order was the same across participants to ensure comparability of groups. The first session involved the administration of tasks relating to verbal and non-verbal skills along with imaginative drawing. The second sessions involved the child engaging in measures relating to theory of mind and executive function. In session three, participants took part in a test of symbolic pretend play. Sessions lasted no more than 45 minutes. The control group participated in sessions conducted in an allocated room at the participants' schools. Test sessions for the control group followed the order of the ASD group.

Verbal Ability

Verbal mental age (VMA) scores for all participants were obtained from administration of the Peabody Picture Vocabulary task: third edition (PPVT-III) (Dunn & Dunn, 1997).

Non-Verbal Ability

Non-verbal ability (NVA) scores for all participants were obtained from administration of the Ravens Progressive Matrices (children's colour version) (Raven, Raven, & Court, 1998). Participants were presented with 36 trials in which they had to choose the best alternative (from six alternatives) to complete the picture/pattern presented. Raw NVA scores were used to match groups.

Executive Function

Cognitive flexibility: The Dimensional Change Card Sort task (DCCS, Zelazo, 2006) is a task specifically designed to test the cognitive flexibility of children in the same way as the Wisconsin Card Sorting Test (WCST) is administered to adults. In this task participants were presented with two clear square trays placed side by side on the table in front of them. A target card stood at the back of each tray facing the participants. On one target card the child was presented with a picture of a blue rabbit while the other showed a picture of a red boat. These target cards were fixed and remained in position for the duration of the task.

Each participant was then administered three separate phases consecutively. In the first phase, the child was shown one of two test cards, one with the picture of a red rabbit and one with a blue boat. The instruction was then given for the child to sort the cards by colour. As an example the researcher then showed the participant a picture of the red rabbit and placed it face down in the tray with the target picture of a red boat. This was followed by showing the participant the same process with the blue boat. The trial continued with the child having to sort a further six test cards (three of each colour) into the correct trays. Participants need to score 6 out of 6 in order to move to the second phase. The second phase followed the same procedure as the first, but this time the task context was switched and participants were now given the instruction to sort the cards by shape (e.g., the red rabbit goes in the tray with the blue rabbit target card). A score of 5 out of 6 is required in order to progress to the third phase.

In the final third phase, each participant is shown a new set of test cards. Each card continues to have a picture of a red rabbit or a blue boat. In addition, 50% of the test cards in this phase have a thick black border around the edges of the card. The participant is then given the instruction that each card with a black border must be

sorted by colour and each card that does not have a black border must be sorted by shape. A demonstration of the correct placing of each of the four possible test cards was then completed showing the participants the new sorting rules. Each participant is then presented with 12 test cards and must correctly sort 9 of the 12 in order to pass the final phase. A score of 1, 2 or 3 was given in relation to how many phases each participant successfully completed.

At this point it is important to state that there were no group differences between the two groups on the DCCS when scores were calculated out of 3 over the three phases. One possible reason for the lack of group differences on the DCCS may be due to both groups successfully completing the pre- and post-switch phase of the DCCS (phases one and two). Indeed, there were no between group differences when looking at mean scores over the first two phases alone ($p > .05$): the pre- and post-switch phases may have been too easy for both groups. The first two phases of the DCCS is routinely used to assess cognitive flexibility in rule use amongst young children less than 5 years of age. Given that in the current study the mean chronological age of both groups was around 7 to 8 years, scores from phases 1 and 2 may artificially deflate potential group differences in cognitive flexibility. Fortunately, the DCCS comes with a third more challenging phase (the 12 border trials); this final phase of the task has previously been used successfully with older chronologically aged children and also with adults to measure continuous developmental changes in cognitive flexibility (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). This study therefore limited participants' scores on cognitive flexibility to cover only the border trials at the final phase of the DCCS (scores out of 12). The border trial scores were used in all subsequent analyses.

Visuospatial planning: The objective of the Tower Test (Delis, Kaplin, & Kramer, 2001) is to construct a designated tower by moving discs of varying sizes between a set of three pegs in as few moves as possible. In order to complete the task correctly each participant must follow two pre-directed rules: (1) only one disc can be moved at a time, and (2) a larger disc may not be placed on top of a smaller disc. During the test the participant proceeds through a maximum of nine trials; each trial becoming progressively more complex, with the test discontinued after 3 consecutive trial failures. Trials one to three involved two disks and a time limit of 30 seconds. Trials four and five used three disks with 60 and 120 seconds time limit respectively. Trials six and seven involved four disks with 120 and 180 seconds time limit. The final two trials used all five disks with a 240 seconds time limit. Failure on a trial was indicated by the participant either: (1) exceeding the time limit for the individual trial; or (2) non completion of the trial.

For each trial the participant was presented with the three pegs and the discs to be used pre-loaded in a predetermined position. The participant was then presented with a picture indicating the final position of the discs. The instruction was then given for the participant to “make your tower look like the one in the picture”. Each participant was timed from start to completion and the total number of moves was recorded. The combination of completion time and total number of moves was used to generate an achievement score for each trial. By adding these scores a total visuospatial planning score was obtained (range = 0 to 30).

Generativity: The ability to generate diverse novel ideas was measured by two ideational fluency tasks taken from Turner (1999) - Uses of Objects and Pattern meanings. Results from a combined score on these two measures have been shown to

be especially sensitive towards detecting limitations in generativity in autism (Bishop & Norbury, 2005). In the Uses of Objects task, participants were shown one object at a time and asked to generate uses for which it could be put: a brick, a cup, a pencil, a piece of doweling, a piece of fabric, and a piece of elastic. The first three objects had obvious conventional uses while the later three did not. Order of presentation of conventional and non-conventional objects was counterbalanced, but within each object group, the order of items remained the same. For each conventional item, a typical use (e.g., a cup could be used to drink from) and a novel use (e.g., a cup could be used as a dolls hat) were given. For each non-conventional item, a novel use was suggested (e.g., a piece of elastic could be used as a catapult). Following the example suggestions, participants were invited to: “tell me all the other ways you think a [object] could be useful”. Participants were given 2½ minutes for each object. Following Bishop and Norbury, each idea was coded as either a correct response (a plausible use, such as using a piece of cloth to make a doll’s shirt), incorrect responses (a vague or implausible use, such as eating a brick), a repetition (identical to a previous response for that specific item or any previous item), a redundant use (varying in some small way from a previous response, such as a brick could be used to make a shed after saying it could be used to make a house) or a not-useful response (such as carry the brick).

The second generativity task, Pattern Meanings, used five meaningless line drawings, each printed on separate pieces of paper. Each participant was presented with one practice item and five test items. For the practice item, the examiner asked, “What could this look like?” Responses were praised and other suggestion prompts were offered such as: “a hedgehog” and “a brush”. Participants were then shown the test stimuli one by one, and for each design were asked to think of as many things as

possible that it could be. Each participant was given 2½ minutes to respond to each item. Bishop and Norbury's (2005) scoring instructions were adopted and responses were coded as correct response (a plausible interpretation), an incorrect response (a vague or implausible interpretation), a repetition or a redundant response.

Agreement between two independent raters coding over 1165 responses across the Use of Objects and Pattern Meanings tasks was 94%. All differences were resolved upon discussion. In agreement with Bishop and Norbury (2005), there was a significant correlation between the Use of Objects and Pattern Meanings tasks for the proportion of correct responses ($r = 0.49$, $N = 28$, $p < .01$). Following Bishop and Norbury, then, the mean proportion of correct responses across both tasks were taken as a measure of generativity.

Theory of Mind

First-Order Unexpected Contents (adapted from Perner, Frith, Leslie, & Leekham 1989): A matchbox was shown to each participant and they were then asked, "What do you think is inside here?" When the child responded with "matches" or something similar (e.g. "fire sticks"), the container was opened and a coin removed ("Look, it's a coin inside"). The coin was placed back inside and the matchbox closed. The child was then asked the self false-belief question: "What did you think was inside when I first showed you the box and it was all closed up like this?" A puppet was then introduced to the child: "This is Sally. Sally hasn't seen inside this box. When Sally sees the box all closed up like this, what will Sally think is inside?" To pass the false-belief for other (i.e., Sally) question, participants were required to predict that Sally would expect the contents of the matchbox to be matches or something similar. All participants were then asked the reality control question: What

is inside the box right now? All participants passed the reality control question. Participants were awarded a maximum score of 2 for correct responses to both false-belief questions.

First-Order Unexpected Transfer (adapted from Baron-Cohen, Leslie & Frith 1985): The researcher introduced two different hand puppets by saying, “This is Emma and this is John.” The researcher then places Emma down and John down on the table. The researcher then took out a yellow container and placed it in front of Emma saying, “Here’s a yellow container”. The researcher then took out a blue container and placed it in front of John saying, “Here’s a blue container”. The researcher then picks up Emma and uses the hand puppet to place a toy car into the yellow container saying, “Emma puts her toy car into the yellow container. Then Emma goes away”. The researcher hides Emma away from view. The researcher then picks up John and uses the hand puppet to move the toy car from the yellow container into the blue container saying, “Now John takes the toy car and hides it in the blue container. Then John goes away”. The researcher then hides John from view. The Emma puppet is then brought back into view and placed sitting down between the yellow and blue containers, with the researcher saying, “Emma has come back now”. The following questions were then asked:

False-Belief question: “Where will Emma look first for the toy car?”

Reality control question: “Where is the toy car really?”

Memory control question: “Where was the toy car in the beginning?”

Participants received a score of 0 or 1 for the false-belief question. All participants passed the control questions.

Second-Order James & Lauren task (Baron-Cohen, 1989): For the second-order false belief task, the study employed the use of a model village and villagers. The story narrated was taken from Baron-Cohen's (1989) study and the procedure is set out below:

"This is James and this is Lauren. They live in this village".

Naming Question: "Which is James? Which is Lauren?"

"Here they are in the park. Along comes the snack-truck man. James wants to buy some chips but has left his money at home. He is very sad. "Don't worry", says the snack-truck man, "You can go home and get your money, and buy some chips later. I'll be waiting in the park all day". "Oh good", says James, "I'll be back in the afternoon to buy some chips"."

Prompt question 1: "Where did the snack-truck man say to James he would be all afternoon?"

"So James goes home (the researcher moves James to his model house). He lives in this house. Now the snack-truck man tells Lauren, "I am going to drive my van to the church to see if I can sell my snacks outside there"."

Prompt question 2: "Where did the snack-truck man say he was going?"

Prompt question 3: "Did James hear that?"

"The snack-truck man drives over to the church. On his way he passes James's house (researcher moves the snack-truck van and man to James's house). James sees him and says, "Where are you going?" The snack-truck man says, "I'm going to sell some snacks outside the church." So off he drives to the church (researcher moves the van and man to the church). So James goes to the church to buy some chips.

Prompt question 4: "Where did the snack-truck man tell James he was going?"

Prompt question 5: “Does Lauren know that the snack-truck man has talked to James?”

“Now Lauren goes home (researcher moves Lauren to her model house). She lives in this house. Then she goes to James’s house (researcher moves Lauren to James’s model house). She knocks on the door and says, “Is James in?” James’ mother says, “No he’s not in. James has gone out to buy some chips.”

Belief question: “Where does Lauren think James has gone to buy some chips?”

Justification question: “Why?”

Reality question: “Where did James really go to buy his chips?”

Memory question: “Where was the snack-truck man in the beginning?”

All participants passed the prompt and control questions. If participants answered the belief question correctly, they received a score of 1. Responses to the justification question were scored according to criteria set out by Baron-Cohen (1989). Participants received a justification score of 2 if they mentioned both James and Lauren’s perspectives. Participants received a justification score of 1 if they only mentioned either James or Lauren’s perspectives. If participants did not mention either character’s perspectives, then a justification score of 0 was given. Summing across the belief and justification questions, participants could receive a total maximum score of 3.

Theory of mind composite score: Recent research has shown that a single coherent construct underpins various false-belief tasks (Wellman et al., 2001). This leads to the reliability of false belief scores becoming improved by the use of a composite score rather than individual tests (Hughes et al., 2000). Within the present study, there was also a positive correlation between first and second-order theory of

mind was significant ($r = 0.56, p < .01$). There was also adequate internal consistency between the two levels of false belief theory of mind understanding ($C\alpha = 0.71$). Consequently scores were summed to give a composite theory of mind score (0 to 6). The composite theory of mind score was used in all of the analyses conducted here.

Imaginative Drawing

The Karmiloff-Smith (1990) drawing task, or adaptations of it, has been fruitfully used to study imagination in typically developing children (e.g., Hollis & Low, 2005; Zhi et al., 1997), children with ASD (e.g., Scott & Baron-Cohen, 1996), and even typically developing adults (e.g., Marsh, Landau, & Hicks, 1996). Following Hollis and Low, a slight modification to the presentation context of the Karmiloff-Smith task was applied to make clear the task's goal. Participants were first shown a picture of people walking towards a sparkling door that opened into a path leading to a different faraway planet in space. Participants were then told a story that when people walk through the magic door which transports them to go and live on a different planet, they get changed into funny, strange, pretend looking people that no one has ever seen before. Participants were then asked to draw three pictures of changed people, making each changed person as funny and strange looking as possible. Hollis and Low have argued that such minor modifications to the presentation of the drawing task helps children understand the task without sacrificing the essential structural requirement of explicitly manipulating knowledge to entertain and produce non-veridical content. It was further reasoned that the use of scores based on the proportion of imaginative ideas averaged over three drawings would increase the reliability of this behavioural measure relative to prior studies that operationalised their dependant measure of the ability to represent imaginative content based on a

single drawing (e.g., Scott & Baron-Cohen, 1996). Participants were instructed to depict each of their drawings on separate pieces of paper. Each drawing was taken away immediately after it was finished. No time limit was imposed.

After the drawings were completed, the experimenter invited participants to describe the content of each drawing that had been produced. All responses were praised and recorded.

Each figure drawn was coded according to whether or not it was imaginative. Scoring criteria and techniques used by Marsh et al. (1996) were followed; dividing the number of features that were imaginative by the total number of features drawn constituted the proportion of imaginative content for each picture. For example, one ASD participant drew a man with insect antennae as his pretend looking person. In this case there were a total of six main features: the head, face, body, arms/hands, legs/feet, and antennae. There was only one imaginative feature, the antennae. Hence, the proportion of imaginative content for that drawing was 0.17 (1/6). As a further example, one ASD participant drew and described his picture of a pretend looking person as having a thorny (having spikes) head, arms and legs. Correspondingly, there were three imaginative features (targeted to the head, arms/hands, and legs/feet) and two standard features (the face and body), and the proportion of imaginative content was calculated as 0.6 (3/5). When participants instead drew real looking people for their imaginative drawings, with standard looking heads, faces, arms/hands, bodies, and legs/feet, then the proportion of imaginative content was 0 (0/5). In this manner, the proportion of imaginative content was calculated for each drawing produced by participants in the ASD and TD groups. The overall mean proportion of imaginative content drawn was then calculated by averaging the proportion of scores across all

drawings produced. Overall agreement between two independent raters coding across all drawings (a combined total of 442 drawing features) was 95%.

Coding issues that arose between raters related to superficial changes that were possible in reality (e.g., hairstyle, multi-colour clothing); these were agreed to not constitute as imaginative features. Another coding issue related to whether a drawing constituted an instance of a pretend looking person when a completely different but unreal object or event was drawn. For example, one ASD participant drew various animals at the zoo. In such cases, the entities drawn actually exist in reality, and more importantly, do not measure up to another parameter set out by Karmiloff-Smith (1990) where successful instances of drawing pretend people “must introduce appropriate changes while simultaneously retaining core concepts of personhood” (p.62). As such, upon mutual discussion between the raters, agreement was reached whereby the drawings of real objects and entities were not considered as successful non-veridical instantiations. In these cases, participants received a zero score for the proportion of imaginative content found in those respective drawings. After the imaginative drawing task, it was also checked that participants were able to draw a normal looking human figure to begin with. All participants were able to do so. Such checks also helped in confirming that the content coded in the pretend people drawings did indeed constitute novel and imaginative drawings. Note also that participants were invited to draw a real looking person only after completing the imaginative drawing task, so that proponent activations arising from drawing a typical object did not spill into and inhibit impossible entity draw performance.

Symbolic Pretend Play

Following procedures used in previous research (e.g., Baron-Cohen, 1987; Charman et al., 1998; Lewis & Boucher, 1988), the researcher emptied all of the toys from a box and spread them randomly over the floor. The toys included: (1) a toy tea-set; (2) commercially available play people; (3) junk accessories – brick, straw, raw plug, cotton wool, cube and a box wrapped in metal foil; and (4) conventional toy accessories such as animals, cars and building blocks. Each child sat on a designated spot on the floor in front of all the toys. The video camera was then turned on. The researcher then led the child into the room to conduct the spontaneous play task. The child was directed to the toys with the instruction “You can play with anything on the floor in front of you”. The researcher sat away from the child and the toys. The child was filmed for five minutes. On completion of the five minutes the researcher joined the child placing the toys back in the toy box.

Participants’ play was coded into one of five mutually exclusive categories: *no play* – the child did not engage in any play at this time; *sensorimotor* – play in this category was limited to sucking, throwing, banging, waving, rolling, twiddling or sniffing; *ordering* – lining up items, putting items inside one another, piling items up, or arranging by shape or colour; *functional* – play in which objects were used in ways appropriate to their conventional function; and *symbolic* – using an object as if it were another object, attributing properties to the object that it does not have, referring to absent objects as if they were there, making a collection of objects into a new object and animating dolls and animals (Baron-Cohen, 1987; Charman et al., 1998).

These categories were chosen as they have been shown to represent a temporal developmental sequence; moving from complete disengagement through to simple play and then onto more complex play. The play session was coded using time

interval analysis (Libby, Powel, Messer and Jordan, 1998). Play behaviour was scored at 5-second intervals over the entire 5-minute session providing a coded set of scores for each participant covering 60 data points. Two independent raters first received intensive training on how to code play behaviour according to the above categories using data from a 5-minute play session from a typically developing child (whose data were reserved for training in coding purposes). After the training, the raters independently scored all of the pretend-play video sessions for all of the actual 28 participants. They achieved a reliability of 0.92 across 1680 pretend-play data points. All disagreements were resolved after discussion.

Raw frequencies of symbolic play were treated as the key measure of interest because this is the locus of pretend play difficulty that is often debated amongst autism researchers (e.g., Baron-Cohen, 1987 versus Lewis & Boucher, 1988). In this study there were no significant group differences with respect to the other play categories, all $ps > .05$.

Results

Overall Group Differences

The results of the MANOVA that included all key measures (chronological age, non-verbal ability, verbal mental age, imaginative drawing, symbolic play, generativity, visuospatial planning, cognitive flexibility and theory of mind) revealed a significant overall group difference: $F(9, 18) = 5.31, p < .001; \eta_p^2 = 0.73$; *observed power* = 0.99). MANOVA assumptions were satisfied.

Separate one-way analyses of variance (ANOVAs) were conducted to test for significant differences between the groups on individual variables (see Table 1).

There was a significant difference found between the groups in chronological age,

with the ASD group being significantly older than controls ($F(1, 26) = 4.71, p < .05$).

No significant difference was found between the groups in their verbal ($F(1, 26) = 0.03, p > .05$) and non-verbal ($F(1, 26) = 2.36, p > .05$) ability – these results were expected as the groups were matched specifically on these scores.

The ASD group scored significantly lower in imaginative drawing and also scored significantly lower on symbolic play. These results show a deficit in the spontaneous imaginative ability of children with ASD. Means and standard deviations of the imagination variables by group are reported in Table 1.

Table 1

Group means, standard deviations and group differences on measures of interest

Measure	Group	Range				<i>F</i>
		<i>Mean</i>	<i>Min---Max</i>		<i>SD</i>	
Imaginative Drawing	TD	0.65	0.13	0.93	0.22	8.08**
	ASD	0.41	0.00	0.70	0.23	
Symbolic Play	TD	13.43	2.00	26.00	7.50	5.99*
	ASD	6.79	1.00	25.00	6.84	
Generativity	TD	0.66	0.22	0.93	0.18	7.48*
	ASD	0.47	0.15	0.74	0.18	
Visuospatial Planning	TD	10.93	5.00	16.00	3.20	4.83*
	ASD	8.14	2.00	15.00	3.51	
Cognitive Flexibility	TD	8.21	5.00	12.00	2.58	4.88*
	ASD	5.14	0.00	12.00	4.52	
Theory of Mind	TD	3.86	1.00	6.00	1.61	11.16**
	ASD	1.93	0.00	5.00	1.44	

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

In relation to the underlying cognitive processes believed to underpin imagination, the results showed significant group differences in generativity, visuospatial planning and cognitive flexibility as well as in false belief theory of mind understanding (see Table 1). For each of these cognitive abilities, the TD group scored significantly higher than the ASD group. In one sense, particular group differences found on false belief reasoning are consistent with extant cognitive theorizing that highlights a theory of mind deficit in children with ASD. However, much of the results also support growing research highlighting a limitation in the executive function of children with ASD, especially in the areas of cognitive flexibility, generativity and visuospatial planning.

Within-Group Correlations

Associations amongst chronological age, verbal mental age, non-verbal ability, cognitive flexibility, visuospatial planning, generativity, theory of mind, symbolic play and imaginative drawing were calculated for the ASD group and the TD group separately. This was followed by full partial correlations that controlled for general developmental factors (chronological age, VMA, and NVA).

For the ASD group, bivariate correlations indicated that imaginative drawing and symbolic play were both positively related to generativity and visuospatial planning (Table 2). Imaginative drawing and symbolic pretend play were also related to each other. These overall results did not change upon partial correlation (Table 3).

Table 2

Significant bivariate correlations among measures of interest for the ASD group

<i>ASD</i>	1	2	3	4	5	6	7	8
1. Imaginative Drawing	-----							
2. Symbolic Play	.58*	-----						
3. Chronological Age	.66*	ns	-----					
4. Non-verbal Ability	.58*	ns	ns	-----				
5. Verbal Mental Age	.62*	ns	.69**	.70**	-----			
6. Generativity	.77**	.61*	ns	.72**	.67**	-----		
7. Visuospatial Planning	.84**	.66*	ns	.73**	.66**	.83**	-----	
8. Cognitive Flexibility	ns	ns	.69**	ns	.75**	ns	ns	-----
9. Theory of Mind	ns	ns	ns	.56*	.84**	.54*	ns	.65*

* $p < .05$, ** $p < .01$, ns = non-significant

Table 3

Significant full partial correlations among measures of interest for the ASD group

<i>ASD</i>	1	2	3	4	5
1. Imaginative Drawing	-----				
2. Symbolic Play	.61*	-----			
3. Generativity	.61*	.65*	-----		
4. Visuospatial Planning	.87**	.74**	.63*	-----	
5. Cognitive Flexibility	ns	ns	ns	ns	-----
6. Theory of Mind	ns	ns	ns	ns	ns

* $p < .05$, ** $p < .01$, ns = non-significant

In the ASD group theory of mind was also correlated with generativity and cognitive flexibility (Table 2); however the relationship became non-significant once general developmental factors were controlled (Table 3). However, the positive bivariate association between generativity and visuospatial planning continued to be significant even after full partial correlation analysis.

For the TD group, bivariate correlations indicated positive associations amongst imaginative drawing and symbolic play with generativity and theory of mind (Table 4). With the exception of the bivariate link between symbolic play and generativity, the other associations remained upon full partial correlation analysis (Table 5).

Table 4

Significant bivariate correlations among measures of interest for the TD group

<i>TD</i>	1	2	3	4	5	6	7	8
1. Imaginative Drawing	-----							
2. Symbolic Play	.65*	-----						
3. Chronological Age	ns	ns	-----					
4. Non-verbal Mental Age	ns	ns	ns	-----				
5. Verbal Mental Age	ns	ns	.78**	.60*	-----			
6. Generativity	.69**	.61*	ns	.61*	.57*	-----		
7. Visuospatial Planning	ns	ns	ns	ns	.72**	ns	-----	
8. Cognitive Flexibility	ns	.81**	.54*	.57*	.58*	.62*	ns	-----
9. Theory of Mind	.84**	.74**	ns	.61*	ns	.77**	ns	.64*

* $p < .05$, ** $p < .01$, ns = non-significant

Table 5

Significant full partial correlations among measures of interest for the TD group

<i>TD</i>	1	2	3	4	5
1. Imaginative Drawing	-----				
2. Symbolic Play	.63*	-----			
3. Generativity	.71*	ns	-----		
4. Visuospatial Planning	ns	ns	ns	-----	
5. Cognitive Flexibility	ns	.75**	ns	ns	-----
6. Theory of Mind	.81**	.70*	.73*	ns	ns

* $p < .05$, ** $p < .01$, ns = non-significant

In the TD group there was also a positive correlation between symbolic play and cognitive flexibility. A positive bivariate relationship was also present between generativity and cognitive flexibility, between cognitive flexibility and theory of mind, as well as between generativity and theory of mind (Table 4). However, the bivariate relationships between generativity and cognitive flexibility, and between cognitive flexibility and theory of mind, all ceased to be significant, once variance associated with non-verbal ability, chronological age and verbal mental age were removed (Table 5). Only the association between generativity and theory of mind remained significant upon full partial correlation analysis.

Regression and Mediation Analyses

ASD Group

Bivariate and full partial correlation analyses indicated that generativity and visuospatial planning performance were both associated with the proportion of imaginative content drawn. These results were further refined by a regression analysis conducted to examine whether generativity and visuospatial planning each contributed unique variance to imaginative drawing content in the ASD group. In a stepwise linear regression analysis, the effects of chronological age ($\beta = 0.52$) ($p > .05$), verbal mental age ($\beta = -0.07$) ($p > .05$) and non-verbal ability ($\beta = 0.35$) ($p > .05$) were jointly removed at the first step ($R^2 = 0.51$, $F(3, 10) = 3.43$, $p > .05$). Generativity and visuospatial planning scores were entered in the second and third steps respectively, in line with the theoretically guided hypothesis that successful solutions to the imaginative drawing task require participants to initially generate a novel idea before needing to spatially plan it (Turner, 1997, 1999; Leavers & Harris, 1998). Variation in generativity was found to be a unique predictor of differences in

imaginative drawing content, independent of chronological age, VMA and NVA, $\beta = 0.65$, $\Delta R^2 = 0.19$, $\Delta F(1, 9) = 5.87$, $p < .05$. Visuospatial planning also accounted for further unique variance, $\beta = 0.82$, $\Delta R^2 = 0.18$, $\Delta F(1, 8) = 11.66$, $p < .01$. The resolution in such results are still not sufficiently clear, because the theoretically guided prediction was that, for the ASD group, visuospatial planning would bridge the relationship between generativity and imaginative drawing content. The mediation prediction was tested using the computer programme 'MedGraph' (Jose, 2003). First, sample size and correlation coefficients between the variables of interest were entered. Second, the potential mediator (visuospatial planning) was regressed on generativity. Third, imaginative drawing content scores were regressed on both visuospatial planning and generativity. The relevant regression data were entered into the 'MedGraph' programme which analysed for mediation. These regression results are reported in Table 6.

Table 6

Summary of regressions testing visuospatial planning mediating the relationship of generativity to imaginative drawing in ASD group

		<i>B</i>	<i>SE</i>	β	<i>R</i>	R^2
Regression 1:						
Generativity on Planning	Generativity	16.61	3.17	0.83**	0.83	0.70**
Regression 2:						
Generativity and Planning on Imaginative Drawing	Generativity	0.29	0.38	0.22		
	Planning	0.04	0.02	0.66*	0.85	0.72**

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

The significance of Sobel's z -value = 2.12, $p < .05$, revealed full mediation; when visuospatial planning as the mediator was considered, the correlation between generativity and imaginative drawing content reduced to a non-significant level and the β weight of the direct effect of generativity to imagination dropped to non-significance.

Bivariate and partial correlation analyses also indicated significant tripartite relationships involving generativity, visuospatial planning and symbolic pretend play in the ASD group. Whilst tripartite correlations can signify the potential for mediation relationships (Baron & Kenny, 1986), this study specifically expected there to be no mediation relationship for symbolic pretend play in the ASD group. As explained in the Introduction, visuospatial planning was not predicted to bridge the link between generativity and symbolic play because play actions, unlike drawing procedures, does not appear to weigh heavily upon fine mechanical skills or fine visual and spatial analysis (cf. Lillard, 1996; Low, 2006). As expected, the MedGraph programme indicated that visuospatial planning did not mediate the relationship from generativity to symbolic pretend play ($p > .05$). However, because generativity and visuospatial planning were correlated to symbolic play, a regression analysis was performed to at least disambiguate the unique contributions of generativity and planning. In a stepwise linear regression analysis, the effects of chronological age, verbal mental age and non-verbal ability were jointly removed at the first step ($R^2 = 0.13$, $F(3, 10) = 0.48$, $p > .05$). Planning and generativity scores were entered in the second and third steps respectively, in order of bivariate correlation strength. Variation in planning was found to be a unique predictor of differences in symbolic play, independent of chronological age, VMA and NVA ($\Delta R^2 = 0.47$, $\Delta F(1, 9) = 10.48$, $p = .01$). Generativity did not account for further unique variance once contributions associated

with planning were considered ($\Delta R^2 = 0.05$, $\Delta F(1, 8) = 1.03$, $p > .05$). However, we need to remember that generativity and planning were also inter-correlated, and consequently, generativity could make independent contributions if it were entered into the second and not last step of the regression analysis. When the regression was re-run as such, generativity accounted for unique variance ($\Delta R^2 = 0.38$, $\Delta F(1, 9) = 6.79$, $p < .05$) but planning did not ($\Delta R^2 = 0.14$, $\Delta F(1, 9) = 3.13$, $p > .05$). Overall, the regression analyses suggest that both generativity and visuospatial action planning capabilities may run parallel and feed into each other when it comes to the nature by which children with ASD execute pretend play.

TD Group

The correlation analyses for the TD group showed significant tripartite associations connecting generativity, theory of mind and imaginative drawing content. The existence of tripartite correlations suggests that mediational processes could be operating (Baron & Kenny, 1986). Compared to the theoretically predicted mediation analysis for the ASD group, testing for mediation in the TD group was data-guided. However, there is extant concurrent and longitudinal research with TD groups suggesting: (1) generativity can support the display and emergence of false belief reasoning (e.g., Peterson & Riggs, 1999) and (2) false belief reasoning supports creative thinking (e.g., Suddendorf & Fletcher-Flinn, 1999). Consequently, we may be reasonably confident in speculating that in typical development, generativity may be related to imagination but the bridging might be an indirect one that is linked via false belief reasoning. This mediation route was tested using the ‘MedGraph’ computer programme. First, sample size and correlation coefficients between the variables of interest were entered. Second, the potential mediator (theory of mind)

was regressed on the generativity. Third, imaginative drawing content scores were regressed on both generativity and theory of mind (see Table 7 for regression information).

Table 7

Summary of the regressions testing theory of mind mediating the relationship of generativity to imaginative in TD group

		<i>B</i>	<i>SE</i>	β	<i>R</i>	<i>R</i> ²
<hr/>						
Regression 1: Generativity on Theory of Mind	Generativity	6.99	1.69	0.77**	0.77	0.59**
 Regression 2: Generativity and Theory of Mind on Imaginative Drawing						
	Generativity	0.14	0.31	0.12		
	Theory of Mind	0.10	0.03	0.75*	0.84	0.71**
<hr/>						

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

The relevant data were entered into the ‘MedGraph’ programme and the significance of Sobel’s z -value = 2.40, $p < .05$, revealed full mediation; when theory of mind as the mediator was considered, the correlation between generativity and imaginative drawing became non-significant and the β weight of the direct effect of generativity for imaginative drawings dropped to non-significance.

Despite the routes in the mediation analysis for the TD group being consistent with some literature indicating that generativity is important for false belief reasoning (Peterson & Riggs, 1999), and that false belief understanding can support creative problem solving (Suddendorf & Fletcher-Flinn, 1999), the analysis was still ad hoc. Given the concurrent nature of the data, it is prudent to be cautious in the interpretation by at least checking the potential for an initial route that begins with

variation in children's theory of mind supporting generativity (see Perner, 1998). The possibility that generativity mediated the relationship from theory of mind to imagination in drawings was not significant ($p > .05$).

Finally, the correlational analyses also showed significant tripartite associations between symbolic play, theory of mind and cognitive flexibility. MedGraph did not reveal any significant mediation ($p > .05$). To simply disambiguate the unique contributions of theory of mind and cognitive flexibility for symbolic play, a stepwise linear regression analysis was performed. The effects of chronological age, verbal mental age and non-verbal ability were jointly removed at the first step ($R^2 = 0.26$, $F(3, 10) = 1.63$, $p > .05$). Compared to the full partial correlation link between symbolic play and theory of mind ($r = .70$, $p < .05$), the correlation between cognitive flexibility and symbolic play was only slightly higher ($r = .75$, $p < .01$). Entering cognitive flexibility and theory of mind into the second and third steps of the regression analysis respectively, in order of bivariate correlation strength, would in some ways be parsimonious with Zelazo's (2004) radical theoretical view that the development of cognitive flexibility can account for and subsume widespread changes in domain specific and domain general reasoning. However, in doing so, we would fail to take into account early precursors to theory of mind development that appear long before embedded rule reasoning capabilities (e.g., anticipatory gaze, joint attention, imitation). Indeed, this study included both first-order and second-order false belief reasoning to take into account, at least in some small way, the continuous nature of theory of mind development. Consequently, it was deemed safer on theoretical grounds for theory of mind scores and cognitive flexibility scores to be entered at the second and third steps of the regression analysis respectively. In doing so, the steps of the regression would also align with more moderate theoretical views

that both theory of mind and a variety of executive function skills play unique roles in children's reasoning and problem solving (e.g., Carlson, 2003; Kloo & Perner, 2005). Variation in theory of mind was found to be a unique predictor of differences in symbolic play, independent of chronological age, VMA and NVA ($\Delta R^2 = 0.32$, $\Delta F(1, 9) = 6.78$, $p = .05$). Cognitive flexibility accounted for further unique variance once contributions associated with theory of mind were considered ($\Delta R^2 = 0.19$, $\Delta F(1, 8) = 6.68$, $p > .05$).

Discussion

The current project was designed to assess underlying cognitive processes involved in imaginative ability. In order to achieve this goal, concurrent data on false belief theory of mind reasoning and executive function were collected from 14 children with ASD and 14 TD controls. By measuring spontaneous symbolic pretend play and impossible entity drawing in every single participant, this project attempted to form empirical links between these two methods of demonstrating imaginative capability. The focus of this project was on the extent to which particular cognitive skills (theory of mind and executive function) might underpin imaginative ability. Before turning to discuss the findings, several of the key findings are briefly highlighted.

In relation to the findings of Baron-Cohen (1987; Scott and Baron-Cohen, 1996), the present study also uncovered a significant difference in symbolic play production and imaginative drawing between the ASD and TD groups. Given an observed concurrent difference in false belief reasoning between the two groups as well, autism imagination deficits could be interpreted in terms of impairments in theory of mind. Such an interpretation would only be at the group level, and would

not speak about the involvement of theory of mind at the individual level. Indeed, in support of executive function researchers (e.g., Jarrold et al., 1996; Leavers & Harris, 1998; Turner, 1999; Zelazo, 2004), the ASD group also showed significantly lower scores in generativity, visuospatial planning and cognitive flexibility compared to the TD group. Underlying the current study was the principle that if a particular cognitive deficit is principally responsible for imagination deficits in ASD, then variance in that cognitive skill should be related to the extent and variability of imagination shown. The general and overarching prediction of this project was that variations in imagination seen in children with ASD would be more strongly associated with executive function compared with theory of mind false belief reasoning. This prediction was partially supported; with generativity and planning but not cognitive flexibility, showing significant associations with symbolic pretend play and impossible entity drawing in the ASD group; false-belief understanding was not correlated to imaginative ability. Fitting with the hypotheses, the relationship between generativity and imaginative drawings turned out to be mediated by visuospatial planning. The current results support generativity and planning as integral parts of the broader imaginative process, especially for children with ASD.

In the TD group, theory of mind was related to both measures of imagination, even when the influence of general development (i.e., chronological age, non-verbal ability and verbal mental age) was controlled. Cognitive flexibility was related to symbolic play but not imaginative drawing (both with and without the effect of general development). Similar to the ASD group, generativity was associated with imaginative drawing in the TD group. Dissimilar to the ASD group, however, the association between generativity and imaginative drawings was mediated through theory of mind.

Understanding the Findings

In considering possible explanations for the results there is a need to explain why particular cognitive processes may individually, and in combination, be influencing imaginative ability. With respect to imagination ability in ASD, Turner (1997) and Jarrold et al. (1996) have argued generativity to be a key locus of difficulty where virtual symbolic production is concerned. Indeed, one logical first step to creative problem solving is to generate a hypothetical idea or scheme. Fitting with Turner, Jarrold and colleagues' view, individual differences in generativity were related to variance in pretend play and drawings in the ASD group. However, generativity aside, and especially in the drawing modality, further sub-processes may be involved in spontaneous imagination. In this case, planning may specifically be implicated at several finer levels of problem solving. First, children need to construct a visuospatial representation of the generated drawing idea in working memory (Leevers & Harris, 1998). Following that, children need to execute the particular plan whilst maintaining it in working memory and matching the drawing that is unfolding in relation to the satisfaction of that plan. Without some degree of concurrent ability to graphically plan and translate the generated novel ideas for imagination, individuals with ASD may instead execute more familiar schemes. This may explain why the impact of generativity for imaginative drawings in ASD was mediated through variance in visuospatial planning.

However, why did visuospatial planning not mediate the effects of generativity for pretend play in the ASD group? It is possible that differences in how the two executive skills were recruited were a manifestation of or adaptation to task difficulty. While both the drawing and play tasks are measures of imagination, they have different processing complexities (and even developmental timetables). In the

play task, props are provided and physically present at all times, and children are free to incorporate as few or as many of the different sets of toys into their symbolic play. Participants could, for example, generate and plan out a play idea with some of the toys (e.g., rolling a toy car over a sequentially arranged set of blocks to represent a bridge). Participants, however, do not necessarily need to playfully integrate every single toy into highly complex play. Participants, after playing with some toys, could even abandon them to generate and plan new play ideas with other objects. Each toy could even become a fresh starting point from which another imaginative idea may be generated. In this sense, generativity and planning may be independently used to support symbolic pretend play on a relatively rapid moment-by-moment basis. Of course, the lack of a tight sequential coupling between generativity and visuospatial planning in the play task could instead reflect that there might have been a lack of complexity or organization in ASD children's play, even amongst individuals who did show some signs of symbolic behaviour. Without an assessment of what toys were used or the extent to which different groups of objects were used in an inter-connected fashion, it is difficult to theoretically pin down why executive skills worked in parallel and contributed independently to pretend play. However, a different set of skills (theory of mind and cognitive flexibility) contributed to the TD group's pretend play, but these two skills also contributed independently to pretend play. In the TD group, cognitive skill contributions for imaginative drawings were also revealed in a mediational fashion. This suggests that both groups of children may have found the drawing task more complex than the play task, and responded to them accordingly, albeit recruiting different types of cognitive processes.

It is then possible to appreciate why cognitive skills might need to work in connection with each other (e.g., mediation) in the drawing context. In the drawing

task, there is no physically present cue to guide children's graphic production. Children have to rely on and maintain the generated idea in working memory, and attempt to (re)produce the idea on paper. Given that generated ideas held in the sketch-pad component of working memory are potentially fast-fading, it is important for children to recruit visuospatial planning abilities to pull off their drawing production (van Sommers, 1995). Drawings, may also call upon fine motor or graphic coordination (e.g., for joining lines and connecting shapes) that necessitates some level of visuospatial proficiency. Furthermore, unlike the play task, participants in the drawing task cannot so readily move to the next graphic production until the first idea is seen through to the end and completed on paper. In order to begin producing the next drawing, participants need to work towards ensuring that the first drawing idea materializes on paper. Consequently, the processing complexities of drawing may specifically require executive skills such as generativity and visuospatial planning to work in sequence with each other.

In a different but related sense, the mediation underpinning ASD participants' impossible entity drawing but not for symbolic pretend play may even reflect different working memory resources required by both tasks. Unfortunately, there was no measure of working memory ability in the present study. It is important for future research to include such measures (e.g., digit span) to find out whether generativity and visuospatial planning complexities uniquely underpin imaginative ability, or whether individual differences in the effects of generativity and planning reflect the operation of broader third party variables such as working memory.

The findings that visuospatial planning ability was related to both measures of imagination in the ASD group but not in the TD control group tantalisingly suggest that imagination in ASD might be visualisation based. Visuospatial planning bridging

generativity with imaginative drawings in the ASD group may be interpreted as some children with ASD indirectly adopting a strategy of abstracting schematic impressions of their generated ideas, and then perceptually manipulating them to allow creative solutions to be realised (Barsalou, 1999). Interpreted as such, visuospatial planning contributing to imagination in ASD is broadly convergent with accumulating accounts of some individuals with ASD preferring to use a visual thinking style (e.g., Kana et al., 2006). On a cautionary note, the visuospatial channelling of generated ideas for imagination in ASD may not be always sufficient or successful where problem solving is concerned. While the generation of relatively straightforward ideas for imagination may be grounded in some form of perceptual analysis, the translation and on-line monitoring of highly complex drawing solutions would severely tax the capacity limit of imagery resources in working memory (van Sommers, 1995) – this may explain why there is still an overall ASD group deficit in imaginative drawing content. Moreover, if individuals with ASD generate novel ideas at a very slow rate, there would only be a limited set of schemes to creatively draw and plan from, and individuals may in longitudinal assessments start to show repetition in their imaginative drawing ideas. Indeed, the correlation between generativity and imagination (in the drawing context) for the ASD group, although significant, was smaller than the same relationship found for the TD group.

Another interesting point for discussion revolves around how ideational generativity was mediated through visuospatial planning for imaginative drawings in the ASD group but mediated through false belief theory of mind reasoning in the TD group. False belief reasoning ability was also independently related to symbolic pretend play in the TD group. In one sense, it could be argued that theory of mind *is* naturally and normally implicated in how ideas are imaginatively manifested.

Understanding of mental states may not turn out to be associated with imagination in ASD because modular abnormalities in theory of mind could lead individuals to develop specialisation in engaging generativity alongside, or in relation to, planning for imagination. This possibility is a compelling one but faces some interpretive challenges. First, the mediational analysis for the TD group suggested that the means to imagination, at least for drawings, potentially begins *from* relating generativity *to* false belief reasoning. Confidence in such data is also bolstered by other concurrent and longitudinal research showing that there is a stronger direction of effect from executive functioning to false belief understanding than the reverse (e.g., Carlson, 2003; Hughes, 1998). Moreover, several individuals with ASD did exhibit some level of false belief understanding, albeit achieved through a linguistically based route (suggested via a slightly higher correlation with receptive language ability, as seen in the bivariate correlation analyses). In this case, the fact that false belief knowledge still did not correlate with imagination in ASD, suggests that individuals may have failed to apply that understanding to process imaginative thinking tasks due to parallel limitations in executive functioning skills (Zelazo & Müller, 2002). The application of generativity and planning in the ASD group may reflect an uneven profile in executive function: selection of these processes in the ASD group may be due to greater limitations in false belief understanding and cognitive flexibility than in generativity and planning. It is also possible that failure to apply false belief understanding to imagination tasks might stem from impaired cross talk between brain systems governing domain specific and general reasoning. Consequently, it is possible to extrapolate that, for individuals with ASD, spontaneous imagination may be based more upon executive routes and their organizational irregularities, irrespective of gained false belief understanding. Relatedly, false belief reasoning

may have been used to handle imagination in typical development because individuals in the control group possessed effective executive control and can use language to service executive control. Finally, meta-representational focused accounts do not readily explain why children with ASD also show generativity impairments in *reality* based tasks that require action flexibility (e.g., word generation and free recall; see Boucher & Lewis, 1989). The above interpretive challenges aside, false belief reasoning still served as a process for bringing out imaginative ability, at least in typical development. The critical even-handed point may simply be that, given that executive function skills such as generativity and cognitive flexibility were *also* related to impossible entity drawings and symbolic play respectively in the TD group, strengths in mentalistic understanding may not singularly contribute at a super-ordinate level to relative successes in imagination. Both theory of mind and executive function may simply work together to bring out imagination in typical development. It is still important to be mindful of the possibility that theory of mind may yet turn out to have developmental primacy for how we interpret the underpinnings of imagination in TD and ASD groups, as its foundational skills (not measured here) (e.g., anticipatory eye gaze, joint attention, imitation) may be significantly related to individual and group differences in imaginative ability.

The current findings show generativity to be a common executive skill that is recruited by both the TD and ASD groups. Speaking towards the importance of executive function, the present data across the ASD and TD groups suggest that generativity is necessary for imagination but its effects may be differentially processed or routed in ASD and in typical development. The findings that generativity is linked with planning for imaginative drawings in the ASD group but instead expressed through false belief reasoning in the TD group could more

generally suggest “cool” detached cognitive control over imagination in ASD, but “cool” *and* “hot” control over non-veridical drawing representations in typical development (cf. Zelazo & Mueller, 2000). “Cool” cognitive measures include those that operate on abstract reasoning and decontextualized problem solving such as the Mazes task, the Tower of Hanoi task, the DCCS, and design fluency tasks. In contrast, “hot” cognitive control is invoked when participants care about or have an emotional connection to the tasks they are trying to solve (Zelazo, Qu, & Müller, 2005). Zelazo et al. view “hot” measures to include mentalistic tasks such as false belief scenarios where interpretations of meaningful concrete socially relevant information (people’s knowledge, beliefs and desires) are required. Similarly, then, the fact that false belief understanding and cognitive flexibility (on the DCCS) are both related to pretend play in the TD group could suggest the operation of both hot *and* cool cognitive control over typical problem solving in the play modality. Here it is worth noting that ‘cool’ cognitive flexibility did not relate to imaginative drawings but only to pretend play in the TD group. It is unlikely that cognitive flexibility is not necessary for imaginative drawings per se, but rather the relationship may be stronger in the play modality because the TD participants may have been proactive in switching between and consecutively incorporating all the toy items (cf. Dick et al., 2005). This relates back to an earlier point made in the discussion that it would be worthwhile for future research to look at variability with the nature and style of play between ASD and TD groups.

Suggestively, theory of mind by being related to imagination in the TD group could mean that neuro-typical children may also feel emotionally connected to their drawings, play and problem solving in general (e.g., find pride, sense of accomplishment, and invest intentional communicative value in the solutions and

actions). Indeed, the revelation of theory of mind being also related to imagination could also suggest that typically developing children are able to meta-reflect on their creative actions and on the domain general skills by which they use to produce those actions (Lillard, 1996; Perner, 1998). In contrast, the absence of theory of mind being involved with imagination in the ASD group could potentially mean that these individuals perceived (unreflectively) the drawing and play tasks as simple exercises of logic. The children in the ASD group, even those who were successful in producing imaginative drawings and play, may be emotionally disconnected to the final products of their effort. Overall, even though executive function may be important to imaginative ability for both children with ASD and typically developing children at the level of product, only TD children, perhaps with recourse to implicit mentalising skills, may find imagination challenging and affectively rewarding.

Limitations

In light of the concurrent nature of the present data (and a moderate number of comparisons to yield the correlations), it is not possible to make strong causal claims about how generativity and planning may have come to be developmentally associated for imagination in ASD (or whether generativity and planning would also be important for even younger typically developing children). Steps toward clarifying such issues could include future research examining whether training in generativity and planning are jointly necessary for prompting imagination in ASD or whether support training in either executive component could sufficiently cue imagination. Although the hypotheses in the current project were theoretically informed and guided, it must be acknowledged that the study included a relatively small participant sample. The sample size makes generalizability to the autism *spectrum* of cognitive

abilities difficult. It would therefore be advantageous to include a larger participant group, composing of distinct subgroups differentiated by ability; further research would benefit from separating the autism and Asperger's subgroups and examining individual differences between as well as within them. It would also be prudent to include an even more diverse set of executive function measures (e.g., working memory, inhibitory control) and core theory of mind measures (e.g., imitation, joint-attention, eye gaze) to thoroughly assess domain general and domain specific underpinnings of imagination.

Implications

The present project has highlighted separate cognitive processes contributing to the imaginative capabilities of TD children and children with ASD. By focusing efforts on the *relative* strengths of children with ASD (generativity and planning) as well as the more impaired areas (theory of mind and cognitive flexibility), interventions may be more successful. Strategies to further develop imaginative ability should include skills training in generating alternative novel ideas by varying degrees of support (e.g., completing task with physical cues and/or social prompts and gradually expanding to completing tasks in a self-directed unprompted manner). Likewise, strategies to elicit more organizational and visuospatial planning skills in children with ASD would improve their imaginative ability. A graded approach to advancing spontaneous planning strategies (e.g., beginning with diagrammatic techniques such as mind mapping) would place children with ASD in a better position to produce more symbolic pretend play and imaginative drawings.

Conclusion

The current study investigated the cognitive underpinnings of imagination in children with ASD through imaginative drawing and symbolic pretend play production. Links between the variation in imaginative flexibility with theory of mind and executive function were explored. The executive abilities to generate ideas and visuospatially plan actions were found to be especially important for imagination in children with ASD. Typically developing children's performances were underpinned by executive skills in generativity and cognitive flexibility, and also theory of mind. On balance, the extent to which executive function skills are relied upon (whether in relation to each other or in relation to domain specific theory of mind skill) can contribute to explaining the extent and nature of imagination in ASD and in typical development.

References

- American Psychiatric Association. (1994). *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed. Washington, DC: American Psychiatric Association.
- Astington, J., & Baird, J. (2005). *Why language matters for theory of mind*. Oxford, UK: Oxford University Press.
- Astington, J. W., & Jenkins, J. M. (1995). Theory of mind development and social understanding. *Cognition and Emotion*, 9, 151-165.
- Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51, 1173-1182.
- Baron-Cohen, S. (1987). Autism and symbolic play. *British Journal of Developmental Psychology*, 5, 139-148.
- Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry* 30, 285-297.
- Baron-Cohen, S. (2000). Autism and 'theory of mind'. In Hartley, J & Braithwaite, A. (Eds), *The Applied Psychologist*. London: Oxford University Press.
- Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition*, 21, 37-46.
- Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioural and Brain Sciences*, 22, 577-660.
- Berti, A. E., & Freeman, N. H. (1997). Representational change in resources for pictorial innovation: A three-component analysis. *Cognitive Development*, 12, 405-426.

- Bishop, D. & Norbury, C. (2002). Exploring the borderlands of autistic disorder and specific language impairment: A study using standardised diagnostic instruments. *Journal of child Psychology and Psychiatry*, 43, 917-929.
- Bishop, D. & Norbury, C. (2005). Executive functions in children with communication impairments, in relation to autistic symptomatology I: Generativity. *Autism*, 9, 7-27.
- Carlson, S. M. (2003). Executive function in context: Development, measurement, theory, and practice. In The development of executive function in early childhood Zelazo, P. D., Müller, U., Frye, D., & Marcovitch, S (Eds): *Monographs of the Society for Research in Child Development*, 68 (3, serial number 274).
- Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, 72, 1032-1053.
- Charman, T., Sweetenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1998). An experimental investigation of social-cognitive abilities in infants with autism: Clinical implications. *Infant Mental Health Journal. Special Issue: 6th World Congress, World Association of Infant Mental Health*, 19, 260-275.
- Colvert, E., Cusance, D., & Sweetenham, J. (2002). Rule-based reasoning and theory of mind in autism: A commentary on the work of Zelazo, Jacques, Burack and Frye. *Infant and Child Development. Special Issue: Executive functions and development: Studies of typical and atypical children*, 11, 197-200.
- Craig, J., Baron-Cohen, S., & Scott, F. (2001). Drawing ability in autism: A window into the imagination. *Israel Journal of Psychiatry*, 3-4, 242-253.

- Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *The Delis-Kaplan Executive Function System*. San Antonio: The Psychological Corporation.
- Dick, A. S., Overton, W. F., & Kovacs, S. L. (2005). The development of symbolic coordination: Representation of imagined objects, executive function and theory of mind. *Journal of cognition and development*, 6, 133-161.
- Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test: 3rd edition*. Circle Pines, Minnesota: American Guidance Service.
- Fisher, N., Happé, F., & Dunn, J. (2005). The relationship between vocabulary, grammar, and false belief task performance in children with autistic spectrum disorders and children with moderate learning difficulties. *Journal of Child Psychology and Psychiatry*, 46, 409-419.
- Freeman, N. H. (1987). Current problems in the development of representational picture-production. *Archives de Psychologie*, 55, 127-152.
- Frith, U. (2003). *Autism: Explaining the enigma*. Malden, MA: Blackwell Publishers Ltd.
- Gilliam, J. E. (2001). *Gilliam Asperger's Disorder Scale*. Austin, Texas: PRO-ED Incorporated.
- Gilliam, J. E. (2006). *Gilliam Autism Rating Scale - 2: 2nd Edition*. Austin, Texas: PRO-ED Incorporated.
- Hill, E. (2004). Evaluating the theory of executive dysfunction in autism. *Developmental Review*, 24, 189-233.
- Hoffman, C. D., Sweeney, D. P., Gilliam, J. E., & Lopez-Wagner, M. C. (2006). Sleep problems in children with autism and typically developing children. *Focus on Autism and Other Developmental Disabilities*, 21, 146-152.

- Hollis, S. & Low, J. (2005). Karmiloff-Smith's RRM distinction between adjunctions and redescriptions: It's about time (and children's drawings). *British Journal of Developmental Psychology*, 23, 623-644.
- Hongwanishkul, D., Happaney, K. R., Lee, W., & Zelazo, P. D. (2005). Hot and cold executive function: Age-related changes and individual differences. *Developmental Neuropsychology*, 28, 617-644.
- Hughes, C. (1996). Control of action and thought: Normal development and dysfunction in autism: A research note. *Journal of Child Psychology and Psychiatry*, 37, 229-236.
- Hughes, C. (1998). Finding your marbles: Does preschoolers' strategic behavior predict later understanding of mind? *Developmental Psychology*, 34, 1326-1339.
- Hughes, C., Adlam, A., Happe, F., Jackson, J., Taylor, A., & Caspi, A. (2000). Good Test-retest reliability for standard and advanced false-belief tasks across a wide range of abilities. *Journal of Child Psychology and Psychiatry*, 41, 483-490.
- Jacques, S., & Zelazo, P. D. (2005). Language and the Development of Cognitive Flexibility: Implications for theory of mind. In Astington, J. W., & Baird, J. A. (Eds), *Why Language Matters for Theory of Mind*. New York, NY: Oxford University Press.
- Jarrold, C. (2003). A review of research into pretend play in autism. *Autism*, 7, 379-390.
- Jarrold, C., Boucher, J. & Smith, P. (1993). Symbolic play in autism: A review. *Journal of Autism and Developmental Disorders*, 23, 281-307.
- Jarrold, C., Boucher, J. & Smith, P. (1996). Generativity deficits in pretend play in autism. *Journal of Autism and Developmental Disorders*, 14, 275-300.

- Jose, P. (2003). *MedGraph-I: A programme to graphically depict mediation among three variables: The internet version*. Retrieved February 15, 2008, from Victoria University, Department of Psychology Web site: <http://www.vuw.ac.nz/psyc/staff/paul-jose/files/medgraph/medgraph.php>
- Joseph, R. M., McGrath, L. M., & Tager-Flusberg, H. (2005). Executive Dysfunction and its Relation to Language Ability in Verbal School-Age Children with Autism. *Developmental Neuropsychology*, 27, 361-378.
- Kana, R. K., Keller, T. A., Cherkassky, V. L., Minshew, N. J., & Just, M. A. (2006). Sentence comprehension in autism: Thinking in pictures with decreased functional connectivity. *Brain: A Journal of Neurology*, 129, 2484-2493.
- Karmiloff-Smith, A. (1990). Constraints on representational change: Evidence from children's drawing. *Cognition*, 34, 57-83.
- Kloo, D., & Perner, J. (2005). Disentangling dimensions in the dimensional change card-sorting task. *Developmental Science*, 8, 44-56.
- Kosslyn, S. M., Reiser, B. J., Farah, M. J., & Fliegel, S. L. (1983). Generating visual images: Units and relations. *Journal of Experimental Psychology: General*, 112, 278-303.
- Leevers, H. J., & Harris, P., L. (1998). Drawing impossible entities: A measure of the imagination in children with autism, children with learning disabilities, and normal 4-year olds. *Journal of Child Psychology and Psychiatry*, 39, 399-410.
- Leslie, A. M. (1987). Pretence and representation: The origins of "theory of mind". *Psychological Review*, 94, 412-426.
- Lewis, V., & Boucher, J. (1988). Spontaneous, instructed and elicited play in relatively able autistic children. *British Journal of Developmental Psychology*, 6, 325-339.

- Lewis, V., & Boucher, J. (1991). Skill, content and generative strategies in autistic children's drawings. *British Journal of Developmental Psychology*, 9, 393-416.
- Libby, S., Powell, S., Messer, D., & Jordan, R. (1998). "Spontaneous play in children with autism: A reappraisal", *Journal of Autism and Developmental Disorders*, 28, 487-497.
- Lillard, A. (1996). Body or mind: Children's categorizing of pretence. *Child Development*, 67, 1717-1734.
- Lillard, A. (1998). Wanting to be it: Children's understanding of intentions underlying pretence. *Child Development*, 69, 981-993.
- Lillard, A. (2002). Pretend play and cognitive development. In Goswami, U. (Ed), *Blackwell handbook of childhood cognitive development. Blackwell handbooks of developmental psychology*. Malden, MA: Blackwell Publishing.
- Low, J. (2006). Internal constraints on representational flexibility: Reformulating the research evidence from children's drawings. In Flinn-Fletcher, C. M., & Haberman, G. M. (Eds), *Cognition and Language: Perspectives from New Zealand*. Bowen Hills, QLD: Australian Academic Press.
- Low, J., & Hollis, S. (2003). The eyes have it: Development of children's generative thinking. *International Journal of Behavioural Development*, 27, 97-108.
- Ma, L., & Lillard, A. S. (2006). Where is the Real Cheese? Young children's ability to discriminate between real and pretend acts. *Child Development*, 77, 1762-1777.
- Marsh, R. L., Landau, J. D., & Hicks, J. L. (1996). How examples may (and may not) constrain creativity. *Memory and Cognition*, 24, 669-680.

- McEvoy, R. E., Rogers, S. J., & Pennington, B. F. (1993). Executive function and social communication deficits in young autistic children. *Journal of Child Psychology and Psychiatry*, 34, 563-578.
- Milligan, K., Astington, J. W., & Dack, L. A. (2007). Language and theory of mind: Meta-analysis of the relation between language ability and false-belief understanding. *Child Development*, 78, 622-646.
- Mottron, L., Dawson, M., Soulières, I., Hubert, B., & Burack, J. (2006). Enhanced Perceptual Functioning in Autism: An update, and eight principles of autistic perception. *Journal of Autism and Developmental Disorders*, 36, 27-43.
- Ozonoff, S., Cook, I., Coon, H., Dawson, G., Joseph, R. M., Klin, A., et al. (2004). Performance on Cambridge Neuropsychological Test Automated Battery Subtests Sensitive to Frontal Lobe Function in People with Autistic Disorder: Evidence from the collaborative programs of excellence in autism network. *Journal of Autism and Developmental Disorders*, 34, 139-150.
- Perner, J. (1998). The meta-intentional nature of executive functions and theory of mind. In P. Carruthers & J. Boucher (Eds.), *Language and thought: Interdisciplinary themes* (pp. 270-283). Cambridge: Cambridge University Press.
- Perner, J., Frith, U., Leslie, A. & Leekam, S. (1989). Exploration of the autistic child's theory of mind: Knowledge, belief, and communication. *Child Development*, 60, 689-700.
- Peterson, D. M., & Riggs, K. J. (1999). Adaptive modelling and mindreading. *Mind & Language*, 14, 80-112.
- Prior, M., & Hoffmann, W. (1990). Brief report: Neuropsychological testing of autistic children through an exploration with frontal lobe tests. *Journal of Autism and Developmental Disorders*, 20, 581-590.

- Raven, J., Raven, J. C., & Court, J. H. (1998). *Manual for Raven's Progressive Matrices and Vocabulary Scales*. Section 2: The Coloured Progressive Matrices. San Antonio, TX: Harcourt Assessment.
- Russell, J. (1997). How executive disorders can bring about an inadequate 'theory of mind'. In Russell, J (ED), *Autism as an executive disorder*. New York, NY: Oxford University Press.
- Russell, J., Saltmarsh, R., & Hill, E. (1999). What do executive factors contribute to the failure on false belief tasks by children with autism? *Journal of Child Psychology and Psychiatry*, 40, 859-868.
- Rutherford, M. D., & Rogers, S. J. (2003). Cognitive underpinnings of pretend play in autism. *Journal of Autism and Developmental Disorders*, 33, 289-302.
- Rutter, M. (1978). Diagnosis and definitions of childhood autism. *Journal of Autism & Childhood Schizophrenia*, 8, 139-161.
- Scott, F. J., & Baron-Cohen, S. (1996). Imagining real and unreal things: Evidence of a dissociation in autism. *Journal of Cognitive Neuroscience*, 8, 371-382.
- Suddendorf, T., & Fletcher-Flinn, C. M. (1999). Children's divergent thinking improves when they understand false beliefs. *Creativity Research Journal*. *Special Issue: Longitudinal studies of creativity*, 12, 115-128.
- Taylor, M., & Carlson, S. M. (1997). The relation between individual differences in fantasy and theory of mind. *Child Development*, 68, 436-455.
- Thomas, G. V., & Silk, A. M. J. (1990). *An introduction to the psychology of children's drawings*. New York, NY: New York University Press.
- Turner, M. (1997). Towards an executive dysfunction account of repetitive behaviour in autism. In Russell, J. (Ed), *Autism as an executive disorder*. New York, NY: Oxford University Press.

- Turner, M. A. (1999). Generating novel ideas: Fluency performance in high-functioning learning disabled individuals with autism. *Journal of Child Psychology and Psychiatry*, 40, 189-201.
- van Sommers, P. (1995). Observational, experimental and neuropsychological studies of drawing. In C. Lange-Küttner & G.V. Thomas (Eds.), *Drawing and looking* (pp. 44-61). Great Britain: Harvester Wheatsheaf.
- Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development*, 72, 655-684.
- Wing, L. & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. *Journal of Autism and Developmental Disorders*, 9, 11-29.
- Zelazo, P. D. (2004). The development of conscious control in childhood. *Trends in Cognitive Sciences*, 8, 12-17.
- Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): a method of assessing executive function in children. *Nature Protocols*, 1, 297-301.
- Zelazo, P. D., Jacques, S., Burack, J. A., & Frye, D. (2002). The relation between theory of mind and rule use: Evidence from persons with autism-spectrum disorders. *Infant and Child Development. Special Issue: Executive functions and development: Studies of typical and atypical children*. 11 (2), 171-195.
- Zelazo, P. D., & Müller, U. (2002). The balance beam in the balance: Reflections on rules, relational complexity and development processes. *Journal of Experimental Child Psychology*, 81, 458-465.
- Zelazo, P. D., Qu, L., & Müller, U. (2005). Hot and cool aspects of executive function: Relations in early development. In Schneider, W., Schumann-Hengsteler, R., & Sodian, B. (Eds). *Young children's cognitive development:*

Interrelationships among executive functioning, working memory, verbal ability, and theory of mind, Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Zhi, Z., Thomas, G. V., & Robinson, E. J. (1997). Constraints on representational change: Drawing a man with two heads. *British Journal of Developmental Psychology*. 15, 275-290.