SYMBOLIC UNDERSTANDING OF PICTURES IN LOW-FUNCTIONING CHILDREN WITH AUTISM AND TYPICALLY DEVELOPING CHILDREN

by

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Declaration

I declare that the thesis is my own work, and has not been submitted in substantially the same form for the award of a higher degree elsewhere.

First Middle Last name

Date

Abstract

This thesis investigates how low-functioning children with autism and language-matched typically developing children comprehend symbolic relations between pictures, words and the objects they represent. Using a series of cognitive-behavioural paradigms, this research documents how these developmental populations use pictures as a source for deducing information about the world and whether they differ in their understanding of what fundamentally relates pictures and referents. Study one tests whether children's mapping of referential picture-object relations is facilitated by iconicity (the extent that a picture resembles its referent) and/or verbal labelling, and study two examines the perceptual cues that direct the generalisation of labels from colour photographs. The third study addresses the factors that influence children's ability to contextualise pictorial symbols and use them to adaptively guide their behaviour in real time and space. Study four investigates the relative importance of artists' communicative intentions and perceptual resemblance to children's mapping of word-picture and picture-object relations, and study five examines whether representational status (as determined by artists' intentions) influences children's naming and reproduction of ambiguous shapes. The findings of this thesis indicate that children with autism can recognise perceptual similarities between pictures and objects, but they do not understand the rules that constrain symbolic word-picture-object mapping. Across studies, iconicity emerges as an important factor that mediates symbolic picture comprehension in autism. Furthermore, unlike their typically developing peers, children with autism do not reflect on the social-communicative intentions underlying pictures when naming, drawing or identifying referent objects. Instead, they derive meaning based exclusively on resemblance, making them naïve realists. Theoretically, this thesis contributes to the field by

informing our understanding of how low-functioning children with autism, an extremely under-researched population, comprehend symbols. At an applied level, these results have important implications for the design and delivery of picture-based communication interventions.

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Dedication

This thesis is dedicated to my parents, Pat and Keith Hartley.

Publications

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List of Symbols, Abbreviations and Nomenclature

Symbol	Definition
ASD	Autism spectrum disorder
TD	Typically developing
CARS	Childhood autism rating scale
BPVS	British picture vocabulary scale

Epigraph

"No facet of human development is more crucial than becoming symbol minded"

(Judy DeLoache, 2006, p.66).

Chapter One: **General Introduction**

Over thousands of years, human culture has evolved through the increasingly sophisticated use of symbols (Corballis, 1999; Deacon, 1997). The ability to create and comprehend symbols is arguably uniquely human, and the natural selection of these skills is largely responsible for the evolutionary gulf that has emerged between our species and other primates (Deacon, 1997). Over time and across disciplines, the meaning of the term "symbol" has varied dramatically (see DeLoache, 2002 for overview), thus, it is important to clarify my use of the term. In contemporary psychology, a symbol is defined as an "entity that someone intends to stand for something other than itself" (DeLoache, 1995, p. 67). While some symbols, such as colour photographs and scale models, have a close perceptual correspondence with the things they represent (*referents*), others, such as abstract art and company logos, relate to the world in an almost arbitrary fashion. Unlike most 3-dimensional entities which can be unequivocally identified through the analysis of their defining features (e.g. size, shape, physiology, DNA), there is nothing intrinsic to symbols that 'links' them to their referents (Browne & Wooley, 2001). The one condition that is both necessary and sufficient for something to symbolise something else is the human intention to communicate. Each and every symbol is created with the intention of transmitting meaning to other members of one's culture, and recipients derive meaning by inferring the communicative intentions of the symbol's creator or user (Callaghan, 2008).

Throughout our daily lives we are exposed to an enormous variety of symbols, a point which is beautifully illustrated by Ittelson: "As I sit at my breakfast table, my morning newspaper has printing on it; it has a graph telling me how the national budget will be spent, a map trying to tell me something about the weather, a table of baseball statistics, an engineering drawing with which I can build a garden chair, photographs of distant places and people, a caricature expressing what the editor thinks of a political figure, and an artist's rendition of what the city will look like 20 years from now... On the wall in front of me hangs an abstract painting. Next to that, there is a calendar. Above the calendar is a clock. All this and more, and I haven't even turned on the TV or the computer" (Ittelson, 1996, p.171). Via these symbols, it is possible to learn about specific things, categories of things, distant places, past and future events, abstract theoretical concepts, the emotions and attitudes of others, things that existed long ago and things that may never exist. Indeed, the ability to infer meaning from the myriad symbols that surround us bestows an almost limitless capacity for intellectual development (DeLoache, 2004).

If children are to become effective communicators and navigators of the modern social world, it is crucial that they learn to master the many symbol systems that pervade our environment (Happé, 1995; Klin, Jones, Schultz, Volkmar & Cohen, 2002; Wetherby, Prizant & Schuler, 2000). Alongside words, pictures are a class of symbols that play an extremely important role in children's early learning. Pictures visually represent objects, or states of affairs, that exist independently in time and space. By viewing pictures, we can learn about reality without directly experiencing it (e.g. most people know what a unicorn looks like, but nobody has seen a real one; DeLoache, 1995) and through the creation of pictures we can transmit our knowledge to future generations (e.g. through cave paintings and books; Langer, 1942; Vygotsky, 1962). In modern cultures, pictures play a vital role in children's education and, for some children with linguistic impairments, they also provide an alternative means of communication. For these reasons, it is important to study how typically and atypically developing infants and children comprehend pictorial symbols.

As picture experts, adults spontaneously generalise labels and information between pictures and their real world counterparts. For example, if you were to encounter a picture resembling a tiger, you would effortlessly interpret the picture as a representation of 'a tiger', and thus refer to the picture with the verbal label "tiger". You would also extend any information that you learn about the picture to its real life referent (e.g. if someone points to the tiger picture and says "this has sharp teeth", you would automatically apply that fact to any real tigers that you encounter). Although we are immersed in visual representations from early infancy, children's exposure to pictures increases dramatically at around 1-year of age when they begin to spend considerable time engaged in joint picture-book reading interactions with adults (e.g. DeBaryshe, 1993). In this context, adults name and provide facts about pictures with the good-faith expectations that children a) understand that pictures represent real things, and b) that they will generalise information to depicted objects in a manner consistent with mature symbolic understanding. These expectations are based on adults' implicit knowledge that pictures are *referential*; that they are intended to stand for things in the world. But, are we correct to assume that symbolically inexperienced children understand the referential relations that exist between words, pictures and the objects they represent?

Important research has shown that picture comprehension is surprisingly challenging for infants and young children. Studies have documented a complex developmental trajectory that gradually unravels through early childhood (DeLoache & Burns, 1994; DeLoache, Pierroutsakos, Uttal, Rosengren & Gottlieb, 1998; Pierroutsakos & DeLoache, 2003; Preissler & Carey, 2004; Salsa & de Mendoza, 2007) and culminates at around 5-years when children's symbolic understanding of pictures has more-or-less fully matured (Jolley, 2008; Rochat & Callaghan, 2005).

Interestingly, it has been revealed that the emergence of children's ability to understand and utilise pictures as symbols is intimately related to social cognition (Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Rochat & Callaghan, 2005) and language (Callaghan, 2000; Callaghan & Rankin, 2002; Kirkham, Stewart & Kidd, 2012). These meta-findings have important implications for the symbolic development of populations who are impaired in these two domains, most notably, children with Autism Spectrum Disorder (ASD; Lord & Paul, 1997; Tager-Flusberg, 1992; Volkmar, Klin & Cohen, 2000).

To date, relatively few researchers have investigated how children with ASD comprehend pictorial symbols. Consequently, we have little knowledge about how the profound linguistic and social-pragmatic impairments (Anderson et al., 2007; Baron-Cohen, 1995; DSM-IV: American Psychiatric Association, 1994; Gliga et al., 2012; Griffin, 2002; Hobson, 2002; Lord, Risi & Pickles, 2004; Volkmar, Lord, Bailey, Schultz & Klin, 2004) that characterise autism might impact on this crucial ability. The existence of this gap in knowledge is surprising given that pictures provide a solitary means of functional communication for many low-functioning children with ASD (e.g. Frost & Bondy, 2002), and are ubiquitously used as communicative supports in classroom settings. When we consider the factors that are thought to underpin pictorial development – namely social-cognition and language – we may expect low-functioning children with ASD to be impaired in this domain. More positively, however, empirical studies – such as those reported in this thesis – can shed light on what properties of pictures, or aspects of interactions involving pictures, mediate whether or not children with ASD successfully comprehend pictorial symbols. By identifying the factors that facilitate symbolic understanding of pictures in children with ASD, we can optimise the way in which pictures are used with this population in clinical and educational settings, and provide data-grounded guidance regarding what types of pictures are most (and least) likely to be understood.

Before discussing symbolic understanding in children with ASD in greater detail, the following sections review the developmental trajectory of pictorial understanding in typically developing (TD) children, and the factors that influence their picture comprehension.

1.1 Picture comprehension in typically developing children

1.1.1 Early understanding of pictures in typically developing children

Historically, the question of whether picture comprehension is an innate ability has been hotly contested. Gibson (1971, 1979) argued that pictorial representations present more-or-less the same higher-order invariant information as their 3-dimensional referents, meaning they can be analysed in the same way as equivalent scenes in the viewer's environment. Accordingly, he proposed that the processes underpinning picture interpretation are the same as those used to derive meaning from the "real world", thus negating the need to develop a specialised picture processing skill-set. However, on the other side of the fence, Gombrich (1974) and Goodman (1976) argued that pictures are a *cultural convention*, and that the rules governing their comprehension and usage must be learned through experience. Ultimately, contemporary picture research has shown that there is no simple answer to the 'innate vs. learned' debate, as both perspectives are correct in part. The issue is complicated by the fact that picture comprehension is not a single all-encompassing ability, but rather the outcome of multiple processes that emerge and consolidate at different stages of development (Jolley, 2008).

In order to fully understand the symbolic meaning of a picture, a viewer must meet several cognitive requirements. First, they must recognise *what* a picture represents. This simply requires sensitivity to perceptual similarities between visual representations and objects in one's environment. Next, they must appreciate that pictures are fundamentally *different* from their referents, and that these differences mediate how we interact with pictures and the information that we can glean from them (e.g. a real watch can be picked up, worn on one's wrist and used to tell the time, whereas a picture of a watch has none of these properties). Viewers must also understand that pictures can serve both *general* and *specific* referencing functions. That is, the purpose of one picture may be to communicate general information about an object category (e.g. a prototypical line drawing of a car in a child's picture book), whereas another may be intended to inform the viewer about a specific exemplar or current reality (e.g. a colour photograph of a Porsche 911 in a car enthusiast's magazine). In addition, viewers must be aware that pictures are not intrinsically linked to their referents – they are independent objects in their own right. Thus, if a picture (or referent) undergoes some kind of transformation, the referent (or picture) is not automatically subjected to the same change. Finally, and most importantly, a mature symbolic understanding of pictures demands that all of these components are considered simultaneously; a viewer is not restricted to thinking about a picture as *either* a representation of a symbolised referent *or* as an object in its own right – they can reflect on both identities flexibly and concurrently.

Studies investigating pictorial understanding in TD infants and young children have found that the above components emerge at different stages along a developmental trajectory. In line with Gibson's theory that picture recognition is effectively the same as object recognition, research has shown that the ability to identify depicted referents is unlearned. For example, Hochberg and Brooks (1962) famously reported that their own child was perfectly able to name photographs and line drawings of familiar objects and people despite having negligible experience of pictures prior to testing at 19-months. Other studies have shown that 5-month-olds look longer at photos of novel dolls (DeLoache, Strauss & Maynard, 1979) and novel faces (Dirks & Gibson, 1977) than familiar exemplars. For example, DeLoache and colleagues (1979) showed 5-month-old infants a toy doll until they displayed signs of habituation. At test, they were presented with a picture of the doll they had become familiar with, and a picture of a novel doll. An analysis of looking preferences revealed that the infants spent longer gazing at the picture of the new doll, suggesting that they recognised the familiar doll and continued to habituate to its 2-D representation. Even more impressive are the findings that 3-month-olds can recognise their mother's face in a colour photograph (Barrera & Maurer, 1981) and neonates can recognise a 2-D version of a simple 3-D pattern (Slater, Rose & Morison, 1984). Although these studies tell us nothing about infants' symbolic understanding, they do suggest that the ability to recognise the referents of pictures is present extremely early in life.

However, in spite of their precocious recognition abilities, it appears that infants do not initially understand the meaning of 2-dimensionality. More specifically, their sometimes unusual behaviour towards pictures suggests that they fail to recognise that pictures are merely *representations* of their referents, and therefore should be treated as "objects of contemplation" rather than objects of action (Werner & Kaplan, 1963, p.18). Throughout the literature, there are numerous anecdotal reports of young children attempting to interact with pictures as if they *were* the symbolised referents (Church, 1961; Murphy, 1978; Ninio & Bruner, 1978; Perner, 1991). For example, Church (1961) recounts watching a child try to stroke a picture of an animal, and Perner (1991) describes his child's efforts to step into a picture of a shoe. In an attempt to make sense of these accounts, DeLoache and colleagues systematically investigated and formally documented this curious phenomenon (DeLoache, Pierroutsakos, Uttal, Rosengren & Gottlieb, 1998). In Experiment 1 of their classic study, 9-month-olds were presented with picture books containing colour photographs of novel objects and the infants' behaviour towards the pictures was video recorded. The authors found that every single participant manually explored at least one picture, often attempting to grasp at the depicted image as if it were a real 3-D object. In a subsequent experiment, they observed that young children living in rural West Africa behave in an identical manner when presented with colour photographs. In stark contrast to the middle-class American children in Experiment 1, these African children lived in a severely impoverished and largely nonliterate society where pictorial representations were extremely rare. Thus, the manual exploration of pictures by young children is a robust cross-cultural phenomenon. In another experiment, DeLoache et al discovered that the frequency of manual explorations decreases significantly between 9 and 15-months, and has virtually disappeared by 19-months of age. Conversely, the 19-month-olds responded to pictures in a culturally-normative manner – by pointing, vocalising and looking up at the experimenter as if trying to initiate an interaction.

Behavioural errors, such as those reported by DeLoache and colleagues (1998), suggest that young infants do not fully understand the differences between pictures and objects before 19-months. One interpretation of these findings is that young children mistake highly-iconic pictorial representations for their 3-D referents, and make genuine attempts to interact with depicted objects based on the incorrect belief that they are "real". However, this is an unlikely explanation, as the same study showed that 9-month-olds will reach towards a novel object 86% of the time when it is presented alongside a colour photograph of the same object (DeLoache et al, 1998). This reliable preference for 3-D, rather than 2-D, stimuli demonstrates that those children who engage in the tactile exploration of pictures are also sensitive to dimensionality, and are aware that pictures are somehow different from objects. Perhaps, then, what young children do not understand from birth, and must learn through experience, is precisely *how* pictures differ from the objects they represent.

As a category of objects, pictures "are unique... for they are seen both as themselves and as some other thing, entirely different from the paper or canvas of the picture" (Gregory, 1970, p. 32). Typically, viewers spend most of their time reflecting on the symbolised referent of a picture (this is the intended purpose after all) without paying much attention to the picture as an object in its own right. This point was famously made by René Magritte in his painting "The Treachery of Images". The painting consists of a realistic representation of a smoking pipe above the paradoxical scripture *"Ceci n'est pas une pipe"* (translation: This is not a pipe). Upon reading this statement, it is natural for the viewer to enter a state of mild confusion, perhaps thinking to themselves "Of course it's a pipe, it looks just like a pipe. How can it *not* be a pipe?" The answer to this question is startlingly obvious, although our overwhelming tendency to view pictures from a symbolic, rather than concrete, perspective may prevent us from realising it initially. Magritte's painting "is not a pipe" because it is a representation – it possesses none of the physical qualities associated with a real pipe. Like all pictures, The Treachery of Images possesses a "dual nature" (Sigel, 1978), and conveys two different streams of information – the first stream corresponding to the symbolic content of the picture (the symbolised referent), and another stream corresponding to the "real-world surface on which the picture appears" (Ittelson, 1996, p. 175). If a viewer is to appreciate the representational function of a picture, they must acknowledge and simultaneously represent both the picture's symbolic relation to its referent *and* its status as a concrete surface (DeLoache, 2002; DeLoache, Pierroutsakos & Uttal, 2003).

To summarise, although young infants are able to process information relating to a picture's symbolic identity (as evidenced by their impressive recognition abilities; e.g. Barrera & Maurer, 1981; DeLoache, Strauss & Maynard, 1979; Dirks & Gibson, 1977) and information relating to its surface (as evidenced by their ability to discriminate pictures from objects; e.g. DeLoache et al, 1998), they are initially unable to represent both streams of information simultaneously. It has been suggested that this failure to dual-represent prevents young children from "decoupling" referential information from a picture's surface (Ittelson, 1996), causing them to be "captured" by the symbolic content of the picture. In other words, they "see through" the picture to its referent, without seeing that the picture *is* a picture. Hence, the transition from grasping to pointing at pictures between 9 and 19 months (DeLoache et al., 1998) may reflect infants' growing awareness that pictures are merely representations.

1.1.2 Contextualisation of pictures in typically developing children

Once children develop an understanding of what pictures are, their next step is to begin using pictures as a source of information about the world. This ability requires the awareness that pictures correspond to real-life referents, even if those referents are not present at the time of viewing. Given that children rarely view pictures in conjunction with their referents (e.g. in picture book reading interactions), the question of whether young children can contextualise the symbolic information communicated by pictures is an intriguing one. This aspect of pictorial understanding was investigated by DeLoache and Burns (1994) using the former's famous "search task" paradigm. In this task, an experimenter concealed a toy in one of several hiding places in a room, and then communicated the location of the toy by showing children a picture of the toy in its hiding place. Children were then allowed to enter the room and search for the toy. Crucially, children never saw the depicted room and the real room concurrently. In order to solve this task, participants needed to a) recognise the depicted objects (toy and hiding location), b) perceive the relation between the depicted objects (e.g. recognise that the toy is behind the chair), c) construct a meaningful "mental model" of the depicted scenario (Perner, 1991), d) discriminate between their mental model of the picture and their mental model of reality, and e) realise that the picture represents a current situation, and use the symbolised information to guide their actions in reality.

In their first experiment, DeLoache and Burns (1994) found a significant difference between the abilities of 24- and 30-month-olds to succeed at the search task; the older children searched the correct location first-time in 72% of trials, while the younger children's mean errorless retrieval rate was just 13%. These contrasting success rates suggest that children aged 24-months failed to represent any relation between the depicted room and the real room, whereas children just 6 months older were competent at using the picture to guide their actions in reality. The inability of 24-month-olds to use pictures as a source of information about a current situation was affirmed by several subsequent experiments that included various manipulations intended to facilitate their mapping of picture-referent relations. For example, in one experiment, children received an extensive preliminary orientation, during which they were introduced to each hiding location, observed the toy being hidden at every location, were shown all of the test photographs and had the experimenter explicitly point out the relation between each photograph and its corresponding referent. In another, the experimenter highlighted picture-referent relations by taking photographs of hiding locations using a Polaroid camera. Surprisingly, neither of these procedural adjustments significantly improved 24-month-olds' errorless retrieval rates. However, in their final experiment, 24-month-olds were highly successful (83% correct) when asked to place (rather than retrieve) a toy at a specific location depicted in a photograph, demonstrating that there is at least one situation in which 2-year-olds can make use of symbolic information communicated by pictures.

Overall, DeLoache and Burns (1994) showed that children aged 24-months can make use of pictures when they symbolise the recipient of a future action (i.e. in placement trials), but struggle enormously when required to comprehend pictures that symbolise a current reality (i.e. in retrieval trials). This discrepancy was explained in terms of their contrasting abilities to mentally represent current and future states of affairs (with the latter being significantly easier than the former). But the really interesting question is *why* young children are unable to use pictures as a source of knowledge about a current situation. The authors claim that 24-month-olds fail the search task because they have yet to learn that pictures can be *contextualised* (i.e. that they can refer to specific elements of current reality). Despite explicit instructions and demonstrations suggesting that the pictures of hiding locations should be contextualised, their corresponding mental representations maintained a rigid decontextualized status. Consequently, the young children viewed the pictures as if they were non-informative depictions of a random or generic room, rather than highly-informative representations of the specific room they were required to search. Thus, between 24- and 30-months of age, children's ability to flexibly use pictures as symbols improves as a consequence of learning that pictures can be contextualised; that they can refer to current real-life referents, even when those referents are not immediately present at the time of viewing.

However, an alternative explanation for 24-month-olds' poor performance in the search task was explored by Suddendorf (2003). He points out that 24-month-olds' inability to suppress a mental representation of a picture that was formed on a previous trial may prevent them from flexibly modifying their behaviour on the basis of a new symbol-referent relation. In line with this hypothesis, the most frequent mistake made by 24-month-olds is exploring the hiding place that was correct on the immediately preceding trial (known as a 'perseveration error'; DeLoache & Burns, 1994). If 24-month-olds' apparent failure to use pictures as a source of symbolic information is a direct consequence of their reduced ability to inhibit prior representations, they should display above-chance success rates in completely novel situations that are untainted by the effects of reinforcement.

In one experiment, Suddendorf (2003) found that nearly 60% of 24-month-olds searched the correct location in the first trial of DeLoache's picture search task, however, their mean errorless retrieval rate dropped below-chance across 4 trials, with two thirds of all errors due to perseveration. Therefore, in first-trial conditions that are unbiased by reinforcement learning, 24-month-olds are capable of using pictures as a symbolic source of information about current reality. This conclusion was corroborated by another experiment that cleverly mimicked first-trial conditions in each of the 4 trials: each retrieval trial involved a different toy and took place in a different room, with each room containing a unique set of hiding locations arranged in a unique spatial configuration. Under these conditions, 24-month-olds' errorless retrieval rate across four trials significantly exceeded chance. As the setting was completely different in each trial, perseveration errors caused by proactive-interference from prior representations were ruled out, and children presumably approached each trial as if it was a novel problem that required the computation of a novel solution (Aguiar & Baillargeon, 2000). Thus, TD children aged just 24-months can contextualise symbolic information communicated by photographs, however, this ability is fragile and error-prone.

1.1.3 Word-referent mapping in typically developing children

The finding that children are relatively inconsistent in their ability to contextualise pictures before 30-months has important implications for their ability to generalise information from pictures to depicted referents. During picture-book reading interactions, children are taught the names of 3-D objects via the labelling of their 2-D counterparts. However, in order for this learning to be successful, children must understand that pictures are intended to stand for real things *and* that verbal labels refer to symbolised objects rather than pictures themselves. Depending on how young children form relations between words, pictures and objects, learning from pictures may be surprisingly difficult.

According to proponents of associative learning theory, young children initially form one-to-one mappings between symbols and referents based on statistical regularities in the environment (Plunkett, 1997; Rescorla & Wagner, 1972). If this account is correct, children must encounter a symbol in the same context as the real-world object it represents in order for a correct symbol-referent relation to be established (e.g. hearing the word "monkey" whilst looking at a real monkey). A consequence of this learning style might be that children form associative mappings between pictures and verbal labels. Obviously, this would negatively impact on children's ability to learn from pictures, as they may not spontaneously generalise labels from depictions to real objects, or vice versa.

However, in opposition to associative learning theory, many empirical studies have yielded robust evidence that TD children understand the referential function of words by 18-months. In Baldwin's (1991) classic study, 16- to 19-month-old infants were given an unfamiliar object to explore. In the 'discrepant condition', the experimenter uttered a novel label ("look, it's a modi") whilst staring at an occluded object in a bucket whilst the child's focus was on the object they were holding. Rather than mapping the novel word to the object that was the focus of their attention at the moment of hearing (the response predicted by associative learning theory), children spontaneously consulted the speaker's face for cues to their referential intentions and assigned the label to the object in the bucket. In a later study by Baldwin and colleagues (Baldwin, Markman, Bill, Desjardins, Irwin & Tidball, 1996), 15- to 20-month-old infants heard a novel label whilst they were exploring an unfamiliar object. In the 'coupled condition' the participants could see the orator, whose attention was concurrently focussed on the unfamiliar object, while in the 'decoupled condition' the speaker was stationed outside the child's view. Subsequent comprehension questions revealed that infants aged 18- to 20-months only formed a word-object mapping in the coupled condition when the orator's referential intentions could be unequivocally evaluated. Together, these important studies show that young children understand that words represent objects and recognise that speakers' intentions determine referential relations.

Moreover, research explicitly investigating how young children relate words, pictures and objects confirms that children can form referential symbol-object mappings by 18-months. Preissler and Carey (2004) taught 18- and 24-month-olds the name of an unfamiliar object (a whisk) depicted in a black-and-white line drawing. At test, children were asked to select the referent of the newly-learned word from an array consisting of the relatively familiar whisk-picture and a previously unseen, perceptually similar, real whisk. Given this choice, an associative word learning strategy would direct children to select the whisk-picture, as this was the primary stimulus mapped to the word. However, the children in this study never selected the picture to be the sole referent of the label. Instead, both age groups consistently selected either the real whisk alone, or both the whisk-picture and the real whisk together. As explanations based on object-preference and within-category novelty biases were ruled out by systematic controls, this pattern of responding provides compelling evidence that, by approximately 18-months, children form referential relations between words, pictures and objects. More specifically, it is clear that young children spontaneously map labels onto symbolised referents, demonstrating their understanding that pictures are intentional representations, and facilitating the generalisation of information to real objects (also see Ganea, Allen, Butler, Carey & DeLoache, 2009; Ganea, Pickard & DeLoache, 2008). Overall, this study shows that children younger than 24-months are successful at mapping symbolic relations between pictures and real-life referents when circumstances are favourable (e.g. when picture and referent are viewed simultaneously).

Collectively, the studies reviewed in the preceding sections have shown that humans develop the numerous cognitive components of symbolic picture comprehension over the first few years of life. Within months after birth, infants are able to recognise familiar referents (e.g. DeLoache, Strauss & Maynard, 1979) and can also discriminate between real and depicted objects (DeLoache et al., 1998), indicating their awareness that pictures are somehow different from the things they represent. However, infants' unusual behaviour towards pictures suggests that they are not fully aware of the nature of this difference. Between 9- and 24-months, infants transition from manually exploring pictures (treating them as objects of action) to pointing at them in a culturally normative fashion (treating them as objects of contemplation; DeLoache et al., 1998; Werner & Kaplan, 1963). By 24- to 30-months, children understand that pictures are not always decontextualized generic representations, but can symbolise real objects that exist in the world and can provide useful information about current realities (DeLoache & Burns, 1994; Suddendorf, 2003). Furthermore, this knowledge enables them to generalise information (e.g. verbal labels) from pictures to their previously unseen real-life referents (Preissler & Carey, 2004; Ganea, et al., 2009).

1.2 The development of pictorial understanding in typically developing children

The research reviewed so far has documented the developmental trajectory over which TD children learn what pictures are and how they relate to referents in the world. These studies, however, do not tell us what *causes* children to become aware of the symbolic relationships that exist between pictures and objects, nor do they identify any of the forces that drive the development of pictorial understanding. Studies investigating the abilities and mechanisms – social-cognitive skills and language – that mediate development in the pictorial domain are discussed in the following sections.

1.2.1 The relation between pictorial development and social-cognition

In agreement with Gombrich (1974) and Goodman (1976), Callaghan emphasises that pictorial communication is a cultural convention that must be learned from more experienced social partners (e.g. Callaghan & Rankin, 2002; Callaghan, Rochat, MacGillivray & MacLellan, 2004). She draws a parallel between the learning of pictorial and linguistic symbols, stating that children must receive certain exposure to adults using each type of symbol in order to acquire them. Because cultures around the world employ different symbolic conventions, all human infants are born with the capacity to rapidly develop social-cognitive skills that will allow them to adopt the specific symbol systems of the culture they are born into (Callaghan et al., 2011). One of the most important of these skills, and particularly pertinent to this thesis, is the ability to read intentions. At the heart of any symbol system is the intention to represent reality, hence the ability to infer this intention from others' actions involving symbols is vital. Various studies have shown that infants develop a rudimentary ability to read intentions within the first year of life. Experiments have demonstrated that infants as young as 9-months understand the intentions underlying goal-directed actions (Woodward, 2009) and react differently to intentional versus non-intentional actions (Behne, Carpenter, Call & Tomasello, 2005). Another crucial skill is instrumental imitation – the reproduction of others' intentional goal-directed actions towards objects (Bruner, 1971; Callaghan & Rochat, 2008; Rochat & Callaghan, 2005; Tomasello, Kruger & Ratner, 1993). Through instrumental imitation, infants acquire symbolic behaviours that communicate meaning to others (Tomasello, 1999). Although the ability to imitate is almost certainly innate (see Meltzoff & Moore, 1989), infants can infer the intentions underlying goal-directed behaviours between 12- and 18-months, as shown by their preference for reproducing intended (rather than accidental) actions on objects (Bellagamba & Tomasello, 1999; Callaghan et al., 2011; Carpenter, Nagell & Tomasello, 1998; Johnson, Booth & O'Hearn, 2001; Meltzoff, 1995).

Infants entering the world of symbols must also understand that other people perceive things, and that their attention can be directed to external entities. By 12-months, infants who see an adult gazing at something behind a barrier will crawl to get a better view of the hidden location, thus indicating their awareness of the adult's perception (Moll & Tomasello, 2004). Also at 12-months, infants begin to direct the attention of others by pointing to features of their environment using their index finger

(Bates, Benigni, Bretherton, Camaioni & Volterra 1979; Butterworth, 2003; Carpenter, Akhtar & Tomasello, 1998; Leung & Rheingold, 1981; Murphy & Messer, 1977). According to Tomasello and colleagues, infant pointing is driven by the intention to influence the mental states of others, making it the earliest mode of referential communication (Tomasello, Carpenter & Lizskowski, 2007). Collectively, the studies cited above confirm that the major social-cognitive skills required to become symbol-minded are in place by 1 to 1.5 years of age.

According to Rochat and Callaghan (2005; Callaghan & Rochat, 2008), pictorial development is initiated by a "basic affiliative need" – an instinct that drives human beings to communicate and maintain social proximity with one another. In the absence of language, the primary means through which young infants relate to others is imitation. Infants living in modern societies are immersed in a world of pictures, and it is not long before they spontaneously reproduce the referential actions that they observe adults directing towards pictures. In a study by Callaghan and colleagues (2004), infants aged 6- to 18-months were presented with toys and colour photographs depicting those toys, and an experimenter demonstrated one of two behavioural stances towards each item. One behavioural stance conveyed a contemplative attitude (e.g. the experimenter looked and pointed at the item while shifting gaze between the participant and the item), while the other behavioural stance highlighted the physical interactive properties of the item (e.g. the experimenter explored the item with their hands). After these demonstrations, the infants performed their own actions on the test objects, which were coded as referential (e.g. looking at the item) or manipulative (e.g. handing the item). The results showed that, by 12-months, infants were more likely to adopt a contemplative stance and spend longer looking at the picture after a referential demonstration, and they were more likely to manually explore the picture following a manipulative demonstration. By contrast, infants always manually explored the 3-D toys irrespective of which behaviour the experimenter demonstrated towards them. Callaghan et al's (2004) finding that young infants reliably model adult behaviour towards pictures, regardless of its appropriateness, suggests that the "referential stance" evidenced by 19-month-olds (see DeLoache et al., 1998) is socially constructed.

In developing a mature understanding of pictures, children must recognise the communicative intentions that underlie their creation and comprehension (Callaghan, 2004; Callaghan & Rochat, 2008; Rochat & Callaghan, 2005). Pictorial symbols are inherently collaborative – they demand the bidirectional coordination of two implicit roles, artist and viewer, and the success of a given picture is contingent on how accurately and comprehensively the artist's communicative intentions can be inferred by the viewer. When an artist creates a picture, their goal is not simply to represent an object (e.g. a cat), but also to ensure that viewers who are disparate in time and space derive their intended meaning from that representation (e.g. they interpret it as a cat, rather than a dog). Thus, the artist holds the recipient in mind while creating the picture, and strategically positions markings on the paper or canvas in a configuration that they feel is most likely to elicit their intended mental representation in a viewer. Likewise, it is not merely the viewer's goal to derive referential meaning from a picture, but to interpret that picture in a way that reflects the artist's intended meaning. Because, "the correct interpretation of any communication is what the communicator intends to communicate" (Ittelson, 1996, p. 183), the viewer holds the artist in mind when comprehending a picture, and endeavours to extract the meaning that was intended for them. Therefore, in order to become a proficient picture-user, children must infer and simulate the communicative intentions that underlie the roles of both artist and viewer.

There are two branches of evidence that suggest TD children learn how to comprehend pictures by inferring representational intent from more experienced symbol-users (Callaghan et al., 2011; Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Callaghan, Rochat & Corbit, 2012). The first branch demonstrates that young children's symbolic understanding of pictures can be improved by increasing their exposure to referential actions involving pictures. At the onset of Callaghan and Rankin's (2002) longitudinal study, none of the 28-month-old participants could complete a search task using realistic pictures, nor had they shown any evidence of representational drawing. Half of the children were assigned to a treatment group that received weekly training sessions that were intended to facilitate picture comprehension and production over a 4-month period, while the remaining children received "placebo" training sessions over the same time frame. Training sessions for the treatment group involved the experimenter drawing objects selected by the participant, and highlighting the picture-referent correspondences. By contrast, children in the control group selected objects and watched the experimenter position them in a line (i.e. they did not observe drawing). Children's picture comprehension and production abilities were assessed at monthly intervals. The authors reported that the treatment group experienced a substantial improvement in their picture comprehension and production after 2 and 3 months' training respectively, while the skills of the control group did not develop. Overall, these findings indicate that infants spontaneously deduce the knowledge and rules that underlie pictorial representation from the behaviour of others, and that development in this domain can be accelerated by providing infants with regular opportunities to infer the referential intentions of symbolically-experienced adults (Callaghan & Rankin, 2002).

The second branch of evidence consists of cross-cultural studies reporting that rate of pictorial development is mediated by frequency of exposure and social scaffolding opportunities (Callaghan et al., 2011; Callaghan et al., 2012). In one study, Callaghan and colleagues (2011) assessed symbolic understanding of pictures in 2- to 4-year-olds living in Canada, India and Peru. Mothers reported that their infants began to show an interest in pictures at the same time across cultures (approximately 10-months), however, their exposure to pictures varied significantly. While 100% of Canadian children were provided with rich pictorial environments filled with picture books, child-directed symbols and family photographs, most Peruvian and Indian children only had access to one picture (usually a wall poster or a calendar) which they rarely viewed. Children's pictorial understanding was assessed via a picture-object matching task that tested comprehension and a production task that involved drawing unfamiliar objects using lines and circles. The results of the comprehension task revealed that the Canadian children had superior picture-referent mapping ability and achieved an above-chance performance rate much earlier (at approx. 2.5-years) than the Peruvian and Indian children who scored above-chance at 4-years or later. Furthermore, the results of the production task showed that Canadian children made representational drawings at a younger age and with greater frequency than children from the other cultures; at least 2 thirds of the drawings produced by Canadian 4-year-olds were coded as representational, while Indian and Peruvian children achieved this performance level at 5- and 5.5-years respectively.

In addition to investigating the effect of culture on children's pictorial development, Callaghan et al (2011) also examined the cross-cultural emergence of various social-cognitive abilities that precede symbolic understanding. Across a series of experiments, the prevailing finding was that children in Canada, Peru and India all acquire skills relating to intention reading, imitation, gaze following, communicative pointing and joint attention at approximately the same ages. Thus, the differences in pictorial understanding displayed by these three cultural groups cannot be attributed to differences in their social-cognitive skills. Instead, these findings suggest that pictorial development is dependent on a child's engagement in the picture symbol system. That is, children who frequently engage in picture-based interactions with symbolically-experienced adults acquire competence with pictures significantly earlier than children who have little exposure to pictures. The conclusions drawn by Callaghan and colleagues (2011) have since been corroborated by another recent study in which children from Canada, India and Peru were assessed on two standard false-belief tasks and an experimental false-belief task that assessed children's symbolic understanding of pictures (Callaghan et al., 2012). While children from all cultural settings passed the standard false-belief tasks at similar ages (between 4.1- and 4.9-years), the Canadian children passed the pictorial false-belief task at least a year earlier (at 4.1-years) than children in India (5.2-years) or Peru (5.7-years).

Overall, the studies reviewed in this section suggest that children develop an understanding of pictures through social exchanges with symbol-minded others. An infant who continually observes adults performing referential actions towards pictures will spontaneously reproduce those actions in future social exchanges, and will naturally infer the shared communicative intentions that underlie those actions. Over time, as an infant's experience with pictures grows, they come to develop an increasingly sophisticated theory of what pictures are, what they are used for, and eventually achieve the ability to communicate via their own pictorial symbols.

However, children born into cultures that do not promote early pictorial understanding are delayed in their comprehension and production of pictures despite the fact that the foundational social-cognitive skills emerge at virtually the same ages across cultures.

1.2.2 The relation between pictorial development and language

In most cultures, words are the primary symbols used to communicate in routine social interactions. Infants are immersed in spoken language from the moment they are born, and caregivers prioritise facilitating infants' understanding and acquisition of linguistic representations over all other symbol systems (Adamson, 1995). As infants' understanding of language is scaffolded earlier and more extensively than their understanding of pictures, it follows that development should be more rapid in the former domain. However, Callaghan argues that these domains are fundamentally related, and that symbolic understanding of language is an important precursor to understanding picture-referent relations (Callaghan, 1999, 2000, 2008; Callaghan & Rankin, 2002).

To date, two studies have directly investigated how linguistic and pictorial development inter-relate. The first, Callaghan and Rankin (2002; see page 21 for further details), tested children's comprehension and production abilities in three different symbolic domains – language, play and pictures – at monthly intervals between 28–36 months, and once more at 42 months. To identify whether language provides a scaffolding base for other symbol systems, the authors employed variants of each measure that either enabled or prevented linguistic support. The results revealed significant positive correlations between comprehension and production measures across all three domains. However, language comprehension and production emerged *before* unsupported symbolic play, unscaffolded picture comprehension and first representational drawings. Based on these results, Callaghan and Rankin concluded that children's performance in symbolic play and picture tasks is supported by their already-established linguistic symbol system, and that positive correlations between these symbolic domains are caused by children's employment of language across tasks.

The second study, Kirkham, Stewart and Kidd (2012), measured TD children's abilities in the domains of symbolic play, language, picture production and nonverbal intelligence at 36–48 months, and then again 12 months later. At time 1, picture production was positively correlated with symbolic play and overall language ability, and predictive relationships were found between most domains. However, the results from the second test session revealed that only language ability at time 1 significantly predicted children's ability to produce representational pictures and sophistication of symbolic play at time 2. Thus, the significant relationships between symbolic domains at time 1 suggest that these systems develop concurrently and equivalently during the 4th year of life. However, the results from time 2 suggest that symbolic domains do not develop in parallel beyond the 4th year. The finding that language *predicted*, but was not *predicted by*, picture production and symbolic play suggests that linguistic symbols are mastered earlier in development and henceforth serve as a scaffolding base for other symbolic domains. Overall, these findings indicate that language is a privileged symbol system that, once mastered, mediates children's understanding and development in the pictorial domain (Callaghan, 2000, 2008; Carpenter, Nagell & Tomasello, 1998; Tomasello, 1999, 2003).

So, how might a child's understanding of linguistic symbols bolster their picture comprehension? One possibility is that adult-directed picture book reading interactions effectively teach young children to decode pictures using language (Callaghan & Rankin, 2002). The majority of pictures in books targeted at young infants are decontextualized and do not relate to specific elements of reality (e.g. they represent generic category prototypes or depict pure fantasy; DeLoache & Burns, 1994). Thus, when viewing picture books with infants, adults very rarely highlight the symbolic function of visual representations by pointing out how they relate to 3-D referents in the world. Rather, adults tend to focus on labelling each picture, and often encourage infants to label them as well. Through labelling, the adult conveys the meaning of the novel symbol (the picture) using a symbol that the infant is already familiar with (the linguistic representation). As an infant's experience with picture books grows, they become increasingly adept at naming pictorial symbols without actually developing a conceptual understanding of how they relate to objects in the world (Callaghan & Rankin, 2002). However, by labelling a picture, the child essentially replaces the graphic symbol with a linguistic symbol that is much easier to derive referential meaning from.

Callaghan argues that children's early understanding of pictures is facilitated by the ability to mentally substitute them for linguistic representations (Callaghan, 1999, 2000; Callaghan & Rankin, 2002). Furthermore, she believes that linguistic scaffolding of this nature can bolster children's performance in experimental picture tasks. In many investigations of pictorial understanding, infants are either presented with pictures that depict familiar entities that they already have labels for (e.g. DeLoache & Burns, 1994), or they are provided with verbal labels for unfamiliar pictures (e.g. Preissler & Carey, 2004). Consequently, it is possible for children in these paradigms to utilise their more advanced language skills to decode the meaning of the relatively enigmatic pictorial symbols. For example, if a child in DeLoache's search task is shown a photograph of a chair, the child's recognition of the referent object may trigger the retrieval of the associated linguistic representation, 'chair', which can be held in mind while searching the room. The child might then recognise the referent of the memorised word (i.e. the real chair) and make an errorless retrieval, without being explicitly aware that the picture was intended to represent that location in the room. Thus, it may be that children's symbolic responses to pictures are scaffolded by their linguistic system until they develop a genuine understanding of picture-referent representational relations (Callaghan, 1999, 2000, 2008; Callaghan & Rankin, 2002).

In order to identify when children can decode symbolic picture-referent relations without the support of language, Callaghan (2000) assessed 2.5- and 3-year-olds in conditions that inhibited linguistic scaffolding. The general paradigm involved children viewing a realistic black-and-white line drawing and then selecting the depicted referent from a pair of choice objects. In control trials, the choice objects were members of the same basic level category and shared the same verbal label (e.g. two different breeds of dog), while in standard trials, the choice objects belonged to different categories and had distinct verbal labels (e.g. a cat and a dog). Furthermore, half the choice objects in each type of trial were familiar (children had access to the verbal labels) and half were unfamiliar (children did not know the associated verbal labels). Thus, linguistic scaffolding was only possible in trials involving familiar objects with different verbal labels (standard-familiar), and impossible in trials involving unfamiliar objects (standard-unfamiliar, control-unfamiliar) or familiar objects that had the same verbal label (control-familiar). The results showed that 2.5-year-olds performed at chance in the control trials, and were most successful and significantly above-chance in the standard trials involving familiar objects. By comparison, the 3-year-olds performed above chance in both trial types, but were relatively more successful in standard trials and trials involving familiar objects.

These findings suggest that 2.5-year-olds' symbolic understanding of pictures is mediated by language, and demonstrate that their ability to decode picture-referent relations deteriorates when linguistic scaffolding is unavailable. Contrastingly, the finding that 3-year-olds are successful even when verbal labels are unknown or identical suggests that they possess a deeper understanding of how pictures relate to objects.

It is also possible that TD children's understanding that pictures represent *categories* is related to their early word learning. TD children begin learning word-referent relations at approximately 12-months (Bloom, 2002), and the majority of the earliest-acquired words refer to object categories that are well-organised by shape (Samuelson & Smith, 1999). Smith and colleagues state that the process of learning object names selectively tunes children's attention to shape, which in turn accelerates their acquisition of novel object names (Smith, Jones, Landau, Gershkooff-Stowe & Samuelson, 2002). Attentional tuning to shape starts with the learning of individual noun-referent relations (e.g. mapping "car" to a specific car) and, as children map a particular noun to additional category members, they quickly realise that "cars" share the same global shape (Samuelson & Smith, 1999). This realisation evokes first-order generalisations about the structures of known object categories (e.g. that "cars" are car-shaped), enabling the child to recognise and label new members of familiar object categories. Subsequently, children infer the general rule that object categories are all organised by shape (e.g. "X's are X-shaped"), eliciting the second-order generalisation that shape is the criterial perceptual determinant when mapping and extending novel word-referent relations (commonly known as a "shape bias").

The emergence of the shape bias is underpinned by categorisation – the cognitive process that organises known information into conceptual groups and enables the evaluation of new information based on existing concepts (Klinger & Dawson, 2001). At the core of categorisation is the ability to focus on objects' category-defining characteristics (i.e. shape), while ignoring details that are not intrinsic to an object's identity (e.g. colour or size). Typically developing infants organise object categories through the abstraction of prototypes (e.g. Younger, 1990). A prototype is a minimalist psychological representation of an object's defining shape, which can be considered the "central tendency" of a particular category (Posner & Keele, 1970). It is believed that abstract mental representations of category-defining shapes direct children's generalisation of object names (Son, Smith & Goldstone, 2006). That is, if the global shape of a newly encountered object (e.g. a Persian cat) is sufficiently similar to a stored prototype (e.g. the cat basic level category), the child may generalise the label for that prototype (e.g. "cat") to the novel object. By 24-months, TD children can correctly generalise a newly-learned label to similarly-shaped category members after hearing a single word-referent pairing (Markman, 1989). Therefore, early in development, young TD children spontaneously recognise that shape is the correct basis for generalising noun-referent relations; they do not need to experience a myriad of Xs in order to establish the sorts of things that *are* Xs. Importantly, categorisation plays a vital role in picture comprehension. When a child views a picture, they must compare the depicted referent against their existing prototypes in order to decide what object is represented. Alternatively, if a picture is of an unfamiliar object, viewers can generate a prototype directly from the depicted image, enabling generalisation to other pictures and real world referents. Importantly, by 18-24 months, TD children almost always extend newly-learned words from pictures to depicted objects, thus demonstrating their knowledge of symbolic word-picture-object relations (Preissler & Carey, 2004).

1.3 Pictures and autism

The preceding sections have discussed evidence that typical pictorial development is mediated by children's social-cognitive engagement with others and their symbolic understanding of language. In this section, I speculate how specific deficits in social-cognition, language and visual processing may impact on pictorial development in autism.

Autism is a pervasive neurodevelopmental disorder characterised by profound social-cognitive and linguistic impairments, in addition to significant atypical behaviours (Baron-Cohen, 1995; DSM-IV: American Psychiatric Association, 1994; Frith, 2003; Kanner, 1943; Volkmar et al., 2000). A striking and defining feature of autism is that sufferers display an alarming lack of motivation to engage in dyadic or triadic social interactions with family members or peers. This primary deficit in social motivation is thought to originate from neurobiological abnormalities in the orbitofrontal-striatum-amygdala circuit (Bachevalier & Loveland, 2006), and can be observed virtually from birth. In the first year of life, infants subsequently diagnosed with ASD show infrequent orienting to their own name and other social stimuli, diminished eye contact, and social aloofness (Klin, 199; Nadig, Ozonoff, Young, Rozga, Sigman & Rogers, 2007; Osterling., Dawson & Munson, 2002; Ozonoff et al., 2010; Presmanes, Walden, Stone & Yoder, 2007; Riby & Hancock, 2008; Zwaigenbaum, Bryson, Rogers, Roberts, Brian & Szatmari, 2005). They are significantly less likely to follow gaze (Dawson, Meltzoff, Osterling, Rinaldi & Brown, 1998), suggesting a failure to recognise that others' selectively attend. Unlike TD children, those with ASD rarely attempt to communicate or establish joint attention with others through declarative pointing (Mitchell, Brian, Zwaigenbaum, Roberts, Szatmari, Smith & Bryson, 2006; Swinkels, Dietz, van Daalen, Kerkhof, van

Engeland & Buitelaar, 2006). The absence of early referential gestures indicates impaired awareness that others' attention can be directed to aspects of one's environment – arguably the core principle underlying pictorial representation. Also, perhaps most consequential to pictorial development, children with ASD show impaired imitation (D'Entremont & Yazbek, 2007; Gopnik, Capps & Meltzoff, 2001; Rogers, Hepburn, Stackhouse & Wehner, 2003) and intention reading (Baron-Cohen, 1989, 1995; Charman, Swettenham, Baron-Cohen, Cox, Baird & Drew, 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996). Hence, children with ASD may not develop a referential stance towards pictures by replicating the intentional actions of other picture-users, nor develop the ability to infer the symbolic-representational function of pictures from others' social-communicative behaviours.

Another hallmark of autistic development is severely impaired language acquisition and usage (Lord, Risi & Pickles, 2004). Around 80% of children with ASD aged 5-years and younger who enter special education are unable to functionally communicate (Bondy & Frost, 1994), and approximately 30% are nonverbal at 9-years (Anderson et al., 2007). Impaired language generally inhibits the ability of children with ASD to socially interact, and specifically limits their acquisition of conversational experience – both of which facilitate, and are probably intrinsic to, the development of a functional Theory of Mind (i.e. the ability to recognise and understand that other people have their desires, intentions and beliefs; Baron-Cohen, 1995; Perner, Baker & Hutton,1994). Without language, many children with ASD are unable to express their needs and desires, unable to reject, and are unable to engage in routine social interactions. Understandably, these impairments elicit intolerable frustration, which can cause children to display self-injurious behaviours or strike out aggressively at others. Furthermore, their inability to understand the communications of others makes life bewildering and chaotic, inducing the development of complex and lengthy rituals as a means of establishing a structured routine (Bondy & Frost, 2002). In recognition of these grave difficulties, clinicians and special educators have developed numerous augmentative and alternative communication systems (AACs) that enable low-functioning children with ASD to communicate without expressive verbal language. There is a huge market of ACCs available today, including high-tech strategies (e.g. Voice Output Communication Aids) and low-tech strategies (e.g. sign-language and picture-exchange systems), however, the success of a particular ACC is largely dependent on the characteristics of the recipient and can vary dramatically between children.

In addition to their expressive language difficulties, previous research suggests that receptive word learning is atypical in ASD. Contemporary theories of word learning emphasise the importance of social cues (e.g. gaze, gesture, posture, facial expression) in the process of mapping novel word-referent relations (Baldwin & Moses, 2001; Bloom; 2000; Tomasello, 2003), and are supported by evidence that social-cognitive skills, such as joint attention, are strong predictors of typical language development (Morales, Mundy, Delgado, Yale, Neal & Schwartz, 2000; Watt, Wetherby & Shumway, 2006). However, it is well-documented that children with ASD (particularly low-functioning individuals) fail to use social information to guide their interpretation of language (Baron-Cohen, Baldwin & Crowson, 1997; Carpenter, Pennington & Rogers, 2002; Golinkoff & Hirsh-Pasek, 2006; McDuffie, Yoder & Stone, 2006; Preissler & Carey, 2005). For example, using Baldwin's (1991) paradigm (see page 15), Baron-Cohen, Baldwin and Crowson (1997) discovered that children with ASD mapped novel labels onto objects that were the focus of *their* attention, rather than the speaker's intended referents. By contrast, ability-matched TD and intellectually disabled children utilised the experimenter's direction of gaze as a cue to mapping. In a more recent study, Gliga et al (2012) found that linguistically impaired children with ASD could follow gaze to the correct referents of words, but then failed to map word-referent relations. Together, these studies suggest that word learning in children with ASD is not directed by cues to a speaker's referential intent. Rather, children with ASD tend to learn the meaning of words via an associative mechanism (Baron-Cohen et al., 1997; Carpenter et al., 2002; Frith & Happé, 1994; Kanner, 1946; McDuffie et al., 2006; Preissler, 2008; Preissler & Carey, 2005).

As briefly discussed on page 14, an associative mapping is a relation that can be formed between any two arbitrary stimuli, and is governed by nothing more than statistical regularities in the environment (e.g. frequency and temporal contiguity; Rescorla & Wagner, 1972). When acquiring language, an associative learning style is highly maladaptive as every word (or picture) would have to be initially encountered in the same context as its referent (Plunkett, 1997). In reality, words are generally spoken without their referents in line-of-sight, and associative learning in ASD can lead to incorrect mappings between words and objects in the listener's immediate environment (Baron-Cohen et al., 1997; Kanner, 1946). By contrast, typically developing children rarely make such errors, indicating a more adaptive learning style based on thei understanding of representation (Baldwin, 1991; Bloom; 2000; Harris, Jones & Grant, 1983). Furthermore, the one-to-one nature of associative mappings will often prevent the generalisation of labels – a problem frequently observed in ASD (e.g. Preissler, 2008). In relation to pictorial development, impairments in expressive communication coupled with associative word learning would likely prevent children with ASD from utilising linguistic symbols as a scaffolding platform. Moreover, the failure to understand the symbolic nature of word-referent relations may prevent children with ASD from using language to distance themselves from the concrete properties of pictures, a process that facilitates dual representation in TD children (Homer & Nelson, 2005).

Comprehension of word-picture-object relations in children with ASD may also be influenced by their atypical visual processing. When viewing objects, children with ASD demonstrate a preference for processing localised perceptual details at the expense of deriving global meaning (Frith, 2003; Happé, 1999; Happé & Frith, 2006; Mottron, Burack, Iarocci, Belleville & Ennis, 2003; Mottron, Dawson, Soulières, Hubert & Burack, 2006), and there is substantial evidence that individuals with autism are unable to generate prototypes of object categories (e.g. Klinger & Dawson, 2001; Plaisted, 2000). For example, Klinger and Dawson (2001) examined the ability of high-functioning children with ASD to abstract prototypes of unfamiliar animal-like categories. In some trials, category membership was defined by a rule (e.g. "all mips have long feet"), and in other trials children had to abstract a prototype representation in order to successfully learn the concept. Children with ASD were just as able to perform rule-based categorisations as controls, but they failed to learn categories via prototype formation. The failure of children with ASD to selectively attend to global shape when learning object names may subsequently impact on their ability to categorise pictures via the abstraction of shape-based prototypes. When processing pictures, it may be that category defining details (e.g. global shape) and category irrelevant details (e.g. size, colour, texture) are not psychologically separable. Consequently, some children with ASD may be unable to weight these perceptual details when deciding *what* a picture represents or whether to extend a known label on the basis of category membership.

At present, very few studies have specifically investigated symbolic understanding of pictures in children with ASD (see Allen, 2009; Preissler, 2008; Preissler & Carey 2005). This gap in the autism literature is rather surprising when we consider the importance and prevalence of picture-based communication interventions. Since its conception in 1985, Bondy and Frost's Picture Exchange Communication System (PECS) has emerged as the most popular and widespread AAC for nonverbal children with ASD in educational and clinical settings. PECS is a manualised intervention protocol that is designed to develop children's expressive communication abilities through the use of reinforcement, delay and generalisation across trainers and settings. PECS-users are taught to make requests by giving a picture to a communicative partner in exchange for the depicted item and are encouraged to initiate interactions with others using their personal picture library. In addition, trainees learn to associate pictures with various daily activities, allowing them to better understand the structure of their day and facilitating the establishment of adaptive behavioural routines.

PECS training is delivered through six formulaic phases (Bondy & Frost, 1994, 2002). In Phase One: Initiating Communication, children are taught to initiate a request for one highly desired item. The child learns how to pick up a picture of the desired reinforcer and release the picture into the hand of a communicative partner, who then provides and names the item. A second trainer, sitting behind the child, provides physical assistance which is gradually faded out. In Phase Two: Expanding the Use of Pictures, a communication book (a ring binder with Velcro strips where pictures are stored and easily removed) is introduced and the distance between the child and the communicative partner is increased. The child is taught to locate their communication book, open it, retrieve a picture of a desired object and travel to the communicative partner to request the object. Spontaneity and persistence are developed by placing pictures in different places within the book, and generalisation is encouraged by conducting the picture exchange in different settings and with different communicative partners. In Phase Three: Picture Discrimination, the child is taught to discriminate between two pictures. Initially, the pictures will be of one highly desired item and one less desired or neutral item, but eventually comparisons are made between pictures of two equally reinforcing items. Correspondence checks are introduced to ensure that the child is requesting the preferred item. In Phase Four: Sentence Structure, the child learns to construct a simple sentence and make a request using a 'sentence strip'. An "I want" picture is placed on the sentence strip next to a picture of a desired item, and the entire strip is exchanged for that item. After the child has requested the item, the communicative partner provides the verbal model "I want..." and pauses before labelling the desired item. The sentence strip and the requested item are then handed to the child. A recent meta-analysis of the PECS empirical literature concluded that there was some evidence that the verbal modelling and delay components of Phase Four could be linked with the acquisition of spoken language for those children who develop speech through PECS (Flippin, Reszka & Watson, 2010). In Phase Five: Answering Simple Questions, the communicative partner asks the child "What do you want?" Initially, this verbal prompt is immediately followed by a gestural prompt towards the "I want" picture, however, a gradually increasing time delay is inserted between the two prompts. Eventually, the child begins to form the "I want" picture sentence before their communicative partner makes a gestural prompt. In Phase Six: Teaching Commenting, children learn to comment in response to questions such as "What do you see?" and "What do you have?" by constructing sentences with new starter pictures (e.g. "I see a..." and "I have a...").

One of the main advantages of PECS is that it appeals to the relatively stronger visual-spatial processing abilities of children with autism (Mottron, Belleville & Ménard, 1999; O'Riordan, Plaisted, Driver & Baron-Cohen, 2001; Plaisted, O'Riordan & Baron-Cohen, 1998); unlike word-referent relations which are arbitrary, picture-referent relations can be mapped based on perceptual resemblance. In addition, trainees do not need to master prerequisite skills, such as eye contact, progress is not dependent on fine motor skills, and children are highly motivated by their desired reinforcers. From an interventionist's perspective, the training required to implement PECS is not financially expensive or overly time consuming, enabling clinicians, teachers and parents to apply the strategy with relative ease.

Over the last decade, studies examining the efficacy of PECS have demonstrated that the strategy can successfully facilitate communication in low-functioning children with ASD (for review, see Flippin et al., 2010). However, there is no evidence that PECS-users can comprehend symbolic relations between words, pictures and objects. To date, a single study by Preissler (2008) has addressed this important issue. In that study, a sample of low-functioning children with ASD, half of whom were PECS-users, were taught an unfamiliar word (e.g. "Whisk") repeatedly paired with a simple black-and-white line drawing of an unfamiliar object (e.g. a whisk). At test, the children were asked to identify the referent of the newly-learned word when presented with the drawing and the previously unseen depicted object. The results showed that children with ASD (especially PECS-users) displayed a strong tendency to select the picture alone, whereas TD children almost always included the depicted object in their response (Preissler & Carey, 2004). These findings suggest that low-functioning children with ASD do not understand symbolic word-picture-object relations, and instead map words to pictures via an associative mechanism that may inhibit the generalisation of labels to depicted objects. At an applied level, it may be that PECS capitalises on a general tendency in ASD to learn in a context-based manner; by repeatedly pairing a picture with an object, the child may realise that the two entities are connected without understanding that the picture *represents* the object.

From a theoretical perspective, it is possible that the deficits that characterise autism may cause children with ASD to derive meaning from pictorial representations in a manner that is qualitatively atypical. Although children with ASD may receive as much exposure to pictures as their TD peers, their inability to infer representational intentions from others' communicative actions involving pictures may prevent them from inferring the symbolic nature of picture-referent relations. Moreover, because picture comprehension is initially scaffolded by symbolic understanding of words (Callaghan, 2000; Kirkham, Stewart & Kidd, 2012), severe linguistic impairments (Anderson et al., 2007; Lord, Risi & Pickles, 2004) may further inhibit the ability of children with ASD to map picture-referent relations early in development. Therefore, in the absence of these foundational processes, it may be that some low-functioning children with ASD can only relate pictures to objects in their environment by virtue of resemblance. In the following section, I discuss how TD children decode what pictures represent, and introduce the possibility that children with ASD differ in their understanding of what fundamentally relates a picture to its referent.

1.4 Decoding of picture-referent relation in typical development and autism: Intentions vs. resemblance

Once children understand that pictures are vehicles for symbolic communication, how do they decipher *what* exactly is represented in a specific picture? This important question directly relates to a centuries-old philosophical debate over what makes a picture represent its referent in the mind of a viewer. One school of thought captures the "common-sense" notion that picture-referent relations are determined entirely by *resemblance* – the extent to which perceptual properties of an image and an object overlap (e.g. Hopkins, 1995, 1998; Hyman, 2006; Peacocke, 1987). Thus, a picture represents a cat only if it provides viewers with the same category-defining perceptual information that they would derive from observing a real cat (Neander, 1987). This principle underlies the theory of naïve realism, which posits that young children process pictures exclusively in terms of their resemblances to objects in the world, ignoring factors external to the image such as the artist's intentions (Freeman, 1991; Freeman & Sanger, 1995). Hence, to a naïve realist, a picture that looks like a cat *is* "a cat", even if the artist intended to represent a dog.

However, there are several criticisms of the pure resemblance account of pictorial representation. Firstly, Goodman (1976) argues that resemblance alone cannot explain the representational qualities of pictures. He points out that while resemblance is *symmetrical* (a picture of a red car resembles a real red car, and vice versa) symbolic representation is *asymmetrical* (a picture of a red car represents a real red car, whereas a real red car does not represent a picture of a red car). This criticism implicitly highlights the fact that pictures, unlike their referents (in the majority of cases), are *intended* to be representational. Secondly, Browne and Woolley's (2001) observation that "a portrait intended to portray person X equally resembles X's identical twin, Y, yet we would not say that the picture actually represents the two twins equally" (p. 390) illustrates that even the interpretation of highly iconic pictures requires the observer to consider more than just resemblance. Thirdly, the pure resemblance-based account cannot adequately explain how humans are able to attribute and extract meaning from non-iconic pictures that do not resemble anything. Representational ambiguity can be the calculated result of an artist's desire to depart from reality and portray a referent without the use of naturalistic visual references. Although uniformed viewers may find it extremely difficult to decode the abstract paintings of Wassily Kandinsky or Joan Miró, few would question their statuses as symbolic representations.

Building on the notion that a picture's referential meaning transcends its perceptual features, contemporary theorists purport that the inference of communicative intentions underlies picture comprehension (e.g. Bloom, 1996; Bloom & Markson, 1998; Preissler & Bloom, 2008; Rochat & Callaghan, 2005; Taylor, 1998). According to their intentional account, a picture's referent is whatever object the artist *intended* to depict, and resemblance merely serves as a window to those intentions. For example, if we see a picture that possesses the perceptual characteristics of a cat, the meaning we derive from that picture is based on an inference about the artist's referential intentions. This inference is guided by resemblance – if a drawing looks like a cat, it is highly probable that the artist intended to represent a cat (Bloom & Markson, 1998). However, a high level of iconicity (the degree to which a picture resembles its intended referent) is not necessary for a referential relation to exist. Thus, according to intentional theorists, it is perfectly acceptable to call a roughly-drawn rectangle "a cat" if we have reason to believe that its creator intended the image to represent a cat.

In the context of developmental psychology, one might predict that children start life as naïve realists, interpreting pictures exclusively in terms of their perceptual features, and gradually learn the intentional basis of pictorial representation as they acquire experience of creating and interpreting pictures, whilst developing an increasingly sophisticated theory of mind. However, empirical evidence suggests that children derive referential meaning from artists' intentions by 2- to 3-years of age. In their classic study, Bloom and Markson (1998) asked 3- and 4-year-olds to draw pairs of objects that closely resembled each other, such as a balloon and a lollipop. Following a distraction task, the experimenter asked participants to name their own drawings. Predictably, the pairs of pictures produced by the young children were virtually indistinguishable, and thus could not be accurately matched to their original referents based on resemblance alone. Nevertheless, the authors reported that 3- and 4-year-olds correctly named 76% and 87% of their drawings respectively. These findings show that toddlers consider their original representational intentions *in addition* to appearance when assigning meaning to their own pictures. In fact, a child's protestations resulting from the experimenter calling their balloon picture "a lollipop" would suggest that representational intentions are a more decisive influence on toddlers' picture comprehension than similarity of shape. Moreover, the referential identities that young toddlers assign to their graphic productions are highly consistent, even after delays as long as 3 months (Gross & Hayne, 1999).

Yet more remarkable is the finding that young toddlers perform mentalistic reasoning when interpreting ambiguous pictures created by others (Gelman & Ebeling, 1998; Priessler & Bloom, 2008). Gelman and Ebeling (1998) showed 2- and 3-year-olds a series of line drawings roughly shaped like familiar nameable objects (e.g. a kite). Half of the children were informed that the pictures had been created intentionally (e.g. someone painted a picture), while the other half were told that the pictures had been created by accident (e.g. someone spilled some paint). At test, children were more likely to name the ambiguous pictures according to shape (thus regarding them as symbolic representations) when they believed the pictures to be intentional, rather than accidental, creations. In another study, 2-year-olds watched an experimenter produce an ambiguous line drawing that looked equally like two visible unfamiliar objects (Priessler & Bloom, 2008). When asked to extend a novel label from the picture, the majority of children generalised the word to the object that the artist had been gazing at whilst drawing, indicating that they perceived this object to be the picture's intended referent. Together, these studies suggest that, between 2- and 3-years of age, children consider intentional information when comprehending pictures created by themselves and others.

While these studies indicate that young toddlers are sensitive to artists' intentions when comprehending pictures, they do not directly assess the relative importance of intentions and resemblance. Other studies have examined this issue by pitting these cues in direct conflict. Browne and Woolley (2001) showed 4-year-olds, 7-year-olds and adults a puppet show in which the protagonist announced his intention to draw a bear, but actually produced a picture that resembled a rabbit. Subsequently, 84 to 100 percent of each age group named the picture according to its appearance (e.g. a rabbit) rather than the artist's stated intentions (e.g. a bear). In a similar study by Richert and Lillard (2002), children aged 4 to 8 years comprehended drawings after being provided with explicit information about the knowledge of the artist. At the start of the procedure, children were introduced to a troll who was said to be from a distant land where no animals existed. The children then watched the troll create a picture that looked exactly like a fish, but were informed that the artist had neither seen nor heard of fish before. When asked whether the troll was in fact drawing "a fish", all but the eldest children responded in the affirmative, thus failing to consider the mental state of the artist (i.e. one cannot draw a fish if one does not know what a fish is).

The results of Browne and Woolley (2001) and Richert and Lillard (2002) suggest that if a picture is sufficiently recognisable, resemblance rather than intent determines what it represents for both children and adults. However, it may be that the findings of these studies were biased by the conflict between children's existing knowledge of pictures and the extremely unusual task demands. Through countless hours of joint picture-book reading interactions with adults, children in modern cultures learn that the appearance of a picture tends to be highly congruent with its intended referential meaning. That is, if a drawing looks like X, it is highly likely that its creator intended it to represent X. By contrast, it is extremely irregular to encounter a drawing that is intended to represent X, but looks uniquely like another category member, Y (Bloom & Markson, 1998). As pictures are deliberately created to communicate a specific message to viewers, it is illogical that an artist would create a picture of Y when they intend to direct viewers' thoughts towards X. Yet this is the scenario that was presented to children in these two studies.

While it may be inconceivable that an artist would draw one thing whilst intending to represent something entirely different, it is culturally acceptable to assign meaning to pictures that do not appear to resemble anything (e.g. abstract art). Therefore, studying how children interpret abstract pictures may provide a more ecologically valid method of assessing the relative importance of resemblance and representational intent. To date, very few studies have examined children's comprehension of abstract pictures, with Bloom and Markson (1998) being a notable exception. In their "Size Task", 3- and 4-year-olds were shown pairs of differently-sized scribbles that had supposedly been drawn by a child with a broken arm. For each pair of scribbles, the experimenter explained that the artist had attempted to draw two objects – one large (e.g. an elephant) and one small (e.g. a mouse). Crucially, the pictures looked nothing like the named objects, and could only be matched to their intended referents based on relative size. When asked to describe each pair of pictures, the children reported that the large shape represented the large named object (e.g. an elephant) and the small picture represented the small named object (e.g. a mouse). The authors claimed that participants had reflected on the intentions of the artist, perhaps reasoning that it would be logical for an individual with a broken arm to represent an elephant and a mouse as differently-sized scribbles.

However, it is possible that children used *non-intentional* reasoning to complete the Size Task. Rather than considering how the artist may have distinguished their intended referents following the loss of fine motor control, participants may have simply noted the parallel between the relative sizes of the scribbles and the named objects, and assigned names to the drawings without considering the role of the artist or perceiving the drawings as referential symbols. If the intentional information provided by the experimenter did not factor in the children's reasoning, they may not have believed that the scribbles were created with the intention of representing the named objects. If this was the case, Bloom and Makson (1998) may have overestimated young children's referential understanding of abstract pictures and underestimated the importance of perceptual similarity to their comprehension of pictures drawn by others.

In summary, there is evidence that young TD children derive meaning from the communicative intentions underlying pictures (Bloom & Markson, 1998; Gelman & Ebeling, 1998; Preissler & Bloom, 2008), however, there is counter evidence that resemblance is the relatively more important cue (Browne & Woolley, 2001; Richert & Lillard, 2002), but these findings are potentially flawed. Thus, the question of how TD children map pictures to objects remains open. Furthermore, there is reason to believe that children with ASD might weight communicative intentions and resemblance differently when mapping picture-referent relations. In Allen (2009), children with ASD watched an adult turn towards one of two named objects on a table, and produce a drawing that resembled both objects equally. When asked to label the picture, children with ASD named the object that was in the experimenter's line of sight on just 25% of trials, whereas TD children made the same response on 75% of trials. These findings suggest that, unlike their typically developing peers, children with ASD do not use intentional information to decode the referents of ambiguous pictures drawn by others.

One possibility that is investigated in later chapters is that picture comprehension in children with ASD conforms to the theory of naïve realism. That is, due to their great difficulty understanding the intentions of others in social-communicative situations (Baron-Cohen, 1989, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996), picture comprehension in autism may privilege resemblance and neglect external sources of meaning that are not immediately perceptible (e.g. the artist's intentions, whether the picture was created accidentally, expectations of the viewer). If so, to a child with autism, a picture that resembles a cat is "a cat", even if the artist intended to represent a dog.

1.5 Objectives of this thesis

This thesis will explore symbolic understanding of pictures in low-functioning children with ASD (primarily PECS-users) and young ability-matched TD children. Chapters 2, 3 and 4 have an applied focus, and examine the factors that mediate the ability of TD children and children with ASD to use pictures as a source of information about the world. More specifically, Chapter 2 investigates whether referential word-picture-object mapping in children with ASD is facilitated by iconicity or verbal labelling. Chapter 3 builds on Chapter 2 by elucidating the cues that direct the generalisation of labels from colour pictures in children with ASD. Chapter 4 addresses whether iconicity and familiarity influence the ability of children with ASD to contextualise pictures in a search task. Chapters 5 and 6 address the theoretical question of whether children with and without ASD differ in their understanding of what fundamentally relates a picture to its referent. In particular, Chapter 5 investigates whether artists' communicative intentions or resemblance guide children's mapping of word-picture and picture-object relations, and Chapter 6 assesses whether artists' intentions influence children's own naming and reproduction of pictures.

Chapter Two: **Symbolic understanding of pictures in low-functioning children with autism: The effects of iconicity and naming.**[1]

In typical development, spoken words are the primary symbols used to communicate in social interactions. However, the early development of children with ASD is characterised by severely impaired language acquisition and usage (Lord, Risi & Pickles, 2004), with approximately 25% of individuals remaining functionally non-verbal (Volkmar, Lord, Bailey, Schultz & Klin, 2004). These children cannot express their needs effectively and are often unable to comprehend the language of others. In recognition of these grave difficulties, Bondy and Frost (1994) developed the Picture Exchange Communication System (PECS) – a manualised intervention protocol that enables non-verbal children with ASD to communicate using pictures instead of words.

Despite the popularity of PECS in educational and clinical settings, and the ubiquitous use of pictures as communicative supports in classroom settings, relatively little research has investigated how children with ASD fundamentally comprehend pictures. In one study, Preissler (2008) tested whether children with ASD form symbolic or associative relations (i.e. one-to-one mappings based on statistical regularities; Rescorla & Wagner, 1972) between pictures, words and the objects they represent. Low-functioning children with ASD, half of whom were PECS-users, were taught a novel word (e.g. "Whisk") repeatedly paired with a simple black-and-white line drawing of an unfamiliar object (e.g. a whisk). At test, the children were asked to identify the referent of the newly-learned word when presented with the drawing and

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[1] Based on Hartley, C., & Allen, M. (in press). Symbolic understanding of pictures in children with autism: The effects of iconicity and naming. *Journal of Autism and Developmental Disorders*. doi:10.1007/s10803-013-2007-4.

the previously unseen depicted object. In this paradigm, TD children aged 18-24 months almost always extended the label to the depicted object (Preissler & Carey, 2004), demonstrating their knowledge that pictures and words are symbolic. By contrast, children with ASD (especially PECS-users) displayed a strong tendency to select the picture alone, suggesting that they learn word-picture relations instead via an associative mechanism that may prevent the extension of labels to depicted objects.

Children with ASD may fail to treat pictures as symbols for several reasons. In TD children, this achievement has been linked to language development (Callaghan, 2000) and the ability to understand referential intentions (Callaghan & Rankin, 2002; DeLoache, 2002; DeLoache & Burns, 1994; Salsa & de Mendoza, 2007). Thus, it could be that impairments in both of these areas (Baron-Cohen, 1995; Bloom, 2000; DSM-IV: American Psychiatric Association, 1994; Griffin, 2002) prevent children with ASD from understanding that pictures are symbolic. However, it is also possible that the associative responding of children with ASD in Preissler (2008) was exacerbated by the iconicity of the pictorial stimuli. While the black-and-white line drawings broadly resembled their referents, the strength of the perceptual relationship could be increased markedly. The present study will therefore investigate whether iconicity mediates symbolic understanding of pictures in children with ASD.

Iconicity is defined as the perceptual resemblance between a symbol and its referent, with symbols that are highly iconic (e.g. colour photographs) labelled as transparent, symbols that are moderately iconic (e.g. black and white line drawings) labelled as translucent and symbols with little or no resemblance to their referent (e.g. written words) labelled as opaque (Fuller, 1997). According to DeLoache (1995), "iconicity generally facilitates symbol use" (p. 111): higher levels of perceptual similarity between picture and referent make the symbolic relationship more salient, increasing the likelihood that the viewer will map the correspondence between the two and draw an inference from one to the other. This notion is supported by evidence from TD children (Callaghan, 2000; Ganea et al., 2008; Simcock & DeLoache, 2006) and individuals with intellectual disabilities (Brady & McLean, 1998; Mirenda & Locke, 1989; Sevcik & Romski, 1986). For example, the degree that young TD children successfully imitate a sequence of actions following a picture-book reading interaction varies as a function of iconicity (Simcock & DeLoache, 2006) and TD 15-18-month-olds are more likely to generalise a label to an object depicted in a highly iconic photograph rather than a moderately iconic cartoon (Ganea et al., 2008).

Given that relationships between highly iconic pictures and their referents are easier to recognise, low-functioning children with ASD may be more likely to view such pictures as symbols. This would have important implications for PECS and other picture-based educational supports. There are many symbol sets designed for use with PECS that provide graphic representations of vocabulary (e.g. Blissymbols, Picsyms, Picture Communication Symbols), but the pictures within and between these sets vary considerably along the continuum of iconicity (Bloomberg, Karlan & Lloyd, 1990; Mirenda & Locke, 1989). If the ability of children with ASD to perceive pictures as symbols benefits from greater iconicity, educators and therapists would have a data-grounded rationale for selecting highly iconic symbols for picture-based treatments.

Although greater iconicity may increase the likelihood that children with ASD recognise a picture-referent relation, we cannot assume that they will interpret that relation in the same manner as TD children. An important aspect of pictures is that the same depiction can be taken to represent a unique exemplar (e.g. my red chair) or an object category (e.g. chairs in general). Accordingly, verbal labels (e.g. "chair") can be extended to objects that share the same category-defining shape (e.g. blue chairs) as a picture's specific referent. This comes naturally to TD children, who spontaneously generalise labels to novel objects based on resemblances to familiar things (e.g. generalising the word "ball" to other new round objects; Smith et al., 2002), and similarity of shape is the most important aesthetic feature when forming novel noun-referent relations (Smith, 2000). This 'shape bias' facilitates rapid word learning and underlies a link between semantic and conceptual development by indicating category membership (Gelman, 2003; Rosch, 1973; Samuelson & Smith, 1999). By contrast, impairments in category and prototype formation prevent children with ASD from utilising sameness of shape as a basis for extending nouns to novel objects (Tek, Jaffery, Fein & Naigles, 2008). Thus, even if a child with ASD was to recognise that a colour photograph (e.g. of a yellow ball) was symbolic, he may not generalise the referent's label to other objects that belong to the same category (e.g. a green ball). Indeed, the fact that a colour photograph shares so many perceptual features with its referent may elicit the belief that it only represents the specific depicted exemplar.

The present study examined whether picture comprehension in low-functioning children with ASD is influenced by iconicity and naming. Experiment 1 investigated whether iconicity mediates how children with ASD form relations between words, pictures and objects. Following the paradigm of Preissler (2008), children were taught a novel word (e.g. "zepper") repeatedly paired with a target picture of an unfamiliar object. They were then asked to identify the referent of the newly-learned word when presented with the target picture paired with the depicted object and then a novel category member (a differently-coloured version of the target object). Unlike Preissler (2008), who exclusively used black-and-white line drawings, I manipulated the strength of the resemblance between picture and referent by varying the iconicity of target pictures. Based on her study, it was predicted that children with ASD would not view less-iconic pictures (i.e. black-and-white line drawings) as symbols, and therefore would not extend labels to their depicted referents. As greater iconicity facilitates recognition of picture-referent relations in TD children (DeLoache, 1995), I predicted that children with ASD may extend labels to objects depicted in highly iconic colour photographs. It was also expected that, unlike TD children who privilege sameness of shape when extending labels to novel objects, children with ASD would not generalise labels to differently coloured versions of objects depicted in colour photographs due to impairments in category formation (Tek et al., 2008). Experiment 2 tests whether verbal labels influence how children with ASD view pictures. When young TD children know the name of a picture, they usually view it from a symbolic perspective and categorise it with its referent rather than with another picture (Callaghan, 2000; Preissler & Bloom, 2007). However, when the name of a picture is unknown or not provided, they are more likely to view it from a non-symbolic perspective and categorise it with another picture rather than its referent. Thus, I examined whether knowledge of word-picture relations similarly guides how children with ASD perceive pictures. Overall, the findings of these studies will shed light on how children with ASD understand pictures by identifying whether increased iconicity facilitates the extension of labels from pictures to their referents and whether labelling elicits picture-referent mapping as in TD children.

2.1 Experiment 1

2.1.1 Method

Participants

Participants were 20 low-functioning children with ASD (all male; *M* age = 9.7 years, range = 5.3–14 years) and 20 TD children (14 males, 6 females; *M* age =

3.3 years, range: 2.5–5.3 years). Children with ASD were recruited from specialist schools in Kendal and Preston, United Kingdom. TD children were recruited from primary schools, nurseries and preschools in Kendal. All children with ASD received a clinical diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord, Rutter, DiLavore & Risi, 2002; Lord, Rutter & Le Couteur, 1994) and expert clinical judgment. Clinical diagnosis was confirmed for children with ASD using the Childhood Autism Rating Scale (CARS; Schopler, Reichler, DeVellis & Daly, 1980), which was completed by a class teacher (*M* score = 43, range = 31–55.5). Groups were matched on receptive vocabulary as measured by the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton & Burley, 1997).[2] The mean receptive vocabulary of children with ASD was 3.7 years (range: 2.4–5.7) and the mean receptive vocabulary of TD children was 3.5 years (range: 2.6–5.7).

All children with ASD were current PECS-users with impaired expressive language skills. The language abilities of children within the sample varied somewhat, as is expected in a low-functioning population. Nine children with ASD were functionally non-verbal (no spoken words), 9 had some words and produced utterances of 1-2 words in length (however, echolalia accounted for many utterances in this group) and 2 could speak some short phrases over 3 words in length. Therefore,

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[2] Ten children with ASD achieved scores that had standardised age equivalents (*M* ability: 3.8 years, *SD*: 1.1) which were individually matched to those of TD children (*M* ability: 3.7-years, *SD*: 1). The BPVS scores of 3 children with ASD who completed the measure did not have age equivalents (they were too low), and so they were matched to 3 TD children based on their raw scores. Another seven children with ASD were unable to complete the BPVS due to behavioural issues, thus these participants were matched to 7 TD children who each had a receptive language age of approximately three-years. Although it would have been desirable to acquire a measure of receptive language from every child with ASD, it is important to note that this research is particularly relevant to nonverbal individuals who have difficulty with standardised assessments, display challenging behaviours and receive picture-based communication training.

this sample was linguistically representative of children who receive and typically benefit from picture-based communication interventions. Participants had 1-6 years' experience of using PECS. Their progress through the programme ranged from Stage 1 to fully-trained user (see Frost & Bondy, 2002). The pictures used by participants to communicate varied on an individual basis, with coloured drawings/symbols and black-and-white drawings/symbols being the most common. Several children used a mixture of picture types that varied in iconicity and only one child in the sample used "some" colour photographs. Three children acquired spoken words through the use of PECS. PECS heavily scaffolded the spoken language of the 2 subjects who produced longer utterances (3+ words), particularly when learning new concepts. One child used PECS in conjunction with manual signs.

The study was approved by the Lancaster University Ethics Committee and informed consent was obtained from parents before children were tested. Please refer to Appendix A for additional information concerning the inclusion and exclusion of children with ASD across experiments in this thesis.

Materials

The stimuli were 'unfamiliar' objects and small laminated pictures of those objects. There were 8 types of objects, with two differently coloured versions of each object type. One exemplar in each pair was the 'target object' and the other alternately coloured version was the 'novel object'. All pictorial stimuli were 2 x 2 inches, thus conforming to the recommendations outlined in the PECS training literature (Frost & Bondy, 2002). There were 4 pictures of each target object (a black-and-white line drawing, a colour line drawing, a greyscale photograph and a colour photograph; see Fig. 1).

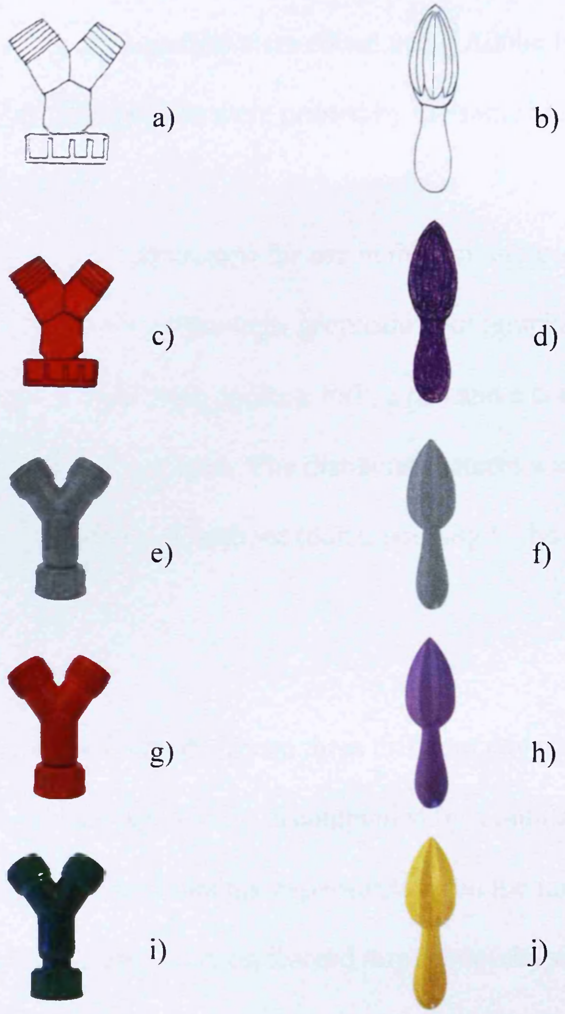

Figure 1. Examples of stimuli; black-and-white line drawings (a, b), coloured line drawings (c,d), greyscale photographs (e, f), coloured photographs/target objects (g, h) and novel objects (i, j).

The black-and-white line drawings were created using a black 'finewriter' pen and white paper. Digital copies of each drawing were created and their sizes were standardised. The colour line drawings were created by colouring print-outs of the edited black-and-white line drawings with crayons. Colour photographs were taken of each target object using a 9.2 megapixel camera, and a greyscale version of each photograph was created. The photographs were edited using Adobe Photoshop and their size was standardised. All pictures were printed by the same high-quality laser printer, cut out, and laminated.

Several sets of pictures were created for use in the training procedure. Black-and-white line drawings, colour line drawings, greyscale photographs and colour photographs of four familiar objects (an apple, a fork, a pen and a comb) and twenty unfamiliar distracter objects were created. The distracter pictures were divided into sets of 5, and there were 4 versions of each set (corresponding to the 4 levels of Iconicity).

Procedure

Participants were tested individually on three different days (approx. 1 week apart) in their own schools and were always accompanied by a familiar adult. They were seated at a table next to or opposite the experimenter and the materials were placed within their reach. Children were reinforced throughout the session for attention and good behaviour. Correct performance was only reinforced during the Training Stage.

Participants received two levels of Iconicity (picture types) in the first test session and two levels in the second test session, counterbalanced for order. Each child received one trial per level of Iconicity (i.e. one trial with each type of picture), and the procedure was identical for all picture types. Trials always consisted of a Training Stage, a Mapping Stage and a Generalisation Stage (experienced in a fixed order). If a child included the target object in their response at the Mapping Stage, they also received a Novelty Test Trial immediately after the Generalisation Stage. In the third test session, participants completed a brief Preference Task to rule out general picture/object selection biases.

Training Stage

Children were taught a novel word repeatedly paired with a target picture of an unfamiliar object. There were 4 novel words (zepper, miggy, drogart, slipsal) and 8 unfamiliar objects represented in pictures of varying iconicity (see Fig. 1). Pictures depicting four of these objects were used as target pictures. Children were initially shown the target picture in isolation and told, “This is a zepper. Touch the zepper.” The target picture was then presented with an iconicity-matched picture of a familiar object (e.g. an apple) and participants were asked to show the experimenter “a zepper”. This was repeated until a criterion of three consecutive correct responses was reached. If participants made an error, the training procedure was re-implemented from the initial step (presenting the target picture in isolation) until criterion was reached. To ensure that participants had learned the new word and could distinguish the target picture from pictures of other unusual objects, they were asked to identify “a zepper” from an array of 5 iconicity-matched pictures of random unfamiliar objects. There were four sets of these distracter pictures and four versions of each set (one version represented at each level of Iconicity). Children viewed a different set each trial. The frequency that each set appeared at a particular level of Iconicity was counterbalanced between participants.

Mapping Stage

Children were presented with the target picture and the previously unseen 3-dimensional depicted object (target object) and were asked to show the experimenter the referent of the newly-learned word (e.g. “show me a zepper”). If the participant had learned the word through a paired association – without understanding the referential function of words and pictures – we would expect them to select the target picture alone. If, however, they understand that both words and pictures are symbolic, they should always include the target object in their response (see Preissler & Carey, 2004). After making their selection, the experimenter removed the stimuli from the child's line of sight and recorded the selection. The Generalisation Stage followed immediately.

Generalisation Stage

The experimenter presented the target picture and a differently coloured version of the depicted object (novel object), and asked participants to identify the referent of the newly-learned word (e.g. "show me a zepper"). If the child had formed an associative relation between the novel word and the target picture, we would once again expect them to select the target picture alone. However, in trials involving coloured pictures, I anticipated that some children with ASD would select the target picture having previously selected the target object at the Mapping Stage. This pattern of responding may indicate that the child perceived the picture to be a representation of a specific exemplar (i.e. the target object), thus preventing generalisation of the label to differently-coloured category members. After making their response, the experimenter removed the stimuli from the child's line of sight and recorded the selection.

Novelty Test Trial

The Novelty Test Trial was included to rule out the possibility that children who selected the 3-D objects did so because they were novel and more salient than the target pictures. If the participant selected the target object alone or with the target picture at the Mapping Stage, they were presented with an additional array consisting of the target picture and a different unfamiliar object ('distracter object'), and were asked to identify the referent of the newly-learned word (e.g. "show me a zepper"). In order to demonstrate symbolic understanding, children must suppress novelty and object preferences and re-select the relatively familiar target picture alone. If, however, a child included the object in their responses to the previous test stages and then selected the distracter object here, this would suggest that their responding was driven by a novelty preference rather than genuine symbolic understanding. The frequency that each object appeared as a target and a distracter at each level of Iconicity was counterbalanced.

Preference Task

In the third test session, children were presented with 4 arrays, each consisting of one real familiar object (cat, car, ball or cup) and one picture of a familiar object (key, spoon, banana, toothbrush), and were asked to identify one of the two items (e.g. "Show me a ball"). Each participant received one black-and-white line drawing, one colour line drawing, one greyscale photograph and one colour photograph (order of appearance and requested referent were counterbalanced between participants). This was a control to ensure that participants could choose an item named by the experimenter, and would not always be drawn to either the picture or object irrespective of its identity. It is possible that PECS-users may be biased to select pictures, since they frequently handle pictures as part of their daily routine. Thus, this control serves to rule out simple object or picture preferences.

Coding

Responses were coded as the item(s) that participants pointed to or gave to the experimenter in each trial. Possible codable responses were 'target picture only', 'target/novel object only' or 'both picture and object'. Following Preissler's (2008) coding criteria, only responses judged to be deliberate were coded (e.g. giving or sliding an item to the experimenter, pointing to or picking up and showing the experimenter an item). If the child played with or manipulated an item without clearly indicating a response, this was noted but excluded from the final coding. For example, if a child clearly indicated that the target picture was correct by pointing to it before manually exploring the target object, this would be coded as a 'target picture only' response.

2.1.2 Results and Discussion

Training Stage

All children met the word-learning criterion (5 consecutive correct pairings) on completed trials. Due to challenging behaviour, one child with ASD failed to complete a 'colour photograph' trial and another child with ASD did not complete a 'greyscale photograph' trial. The TD children completed every trial. For the TD children, there were no significant effects of gender on training or responding in Experiment 1 or 2. See Table 1 for mean pairings between verbal label and the target picture for children with ASD and TD children at each level of Iconicity. Within-group analyses confirmed that there were no differences between the numbers of pairings across levels of Iconicity for children with ASD or TD children. Between-group analyses revealed that children with ASD required significantly more pairings to reach criterion than TD children, $F(1, 38) = 10.06$, $MSE = 4.58$, $p = .003$, $\eta p^2 = .21$.[3] At each level of Iconicity, more TD children learned to pair the verbal label with the target picture without error, while more children with ASD required at least one re-implementation of the procedure from the initial step (see Table 1).

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[3] Group means replaced the missing values of the 2 children with autism who did not complete colour photograph and greyscale photograph trials respectively.

Table 1

Mean number of pairings at training between verbal label and target picture for children with autism (ASD) and typically developing children (TD) at each level of Iconicity in Experiment 1. Ranges in parentheses

	Iconicity of target picture			
	Black-and-white line drawing	Colour line drawing	Greyscale photograph	Colour photograph
ASD	5.9 (5–9)	6.6 (5–14)	6.7 (5–12)	6.1 (5–10)
Number that learned word-picture pairing without error.	13/20	9/20	10/19	12/19
TD	5.1 (5–7)	5 (5)	5.5 (5–9)	5.4 (5–12)
Number that learned word-picture pairing without error.	19/20	20/20	16/20	18/20

Test Stages

For ease of interpretation, the results are presented in subsections according to Iconicity. These are further divided into sections corresponding to the stages within each condition (Mapping Stage, Generalisation Stage, Novelty Bias Trial). See Figure 2 for rates of responding for typically developing children and children with autism as a function of Iconicity.

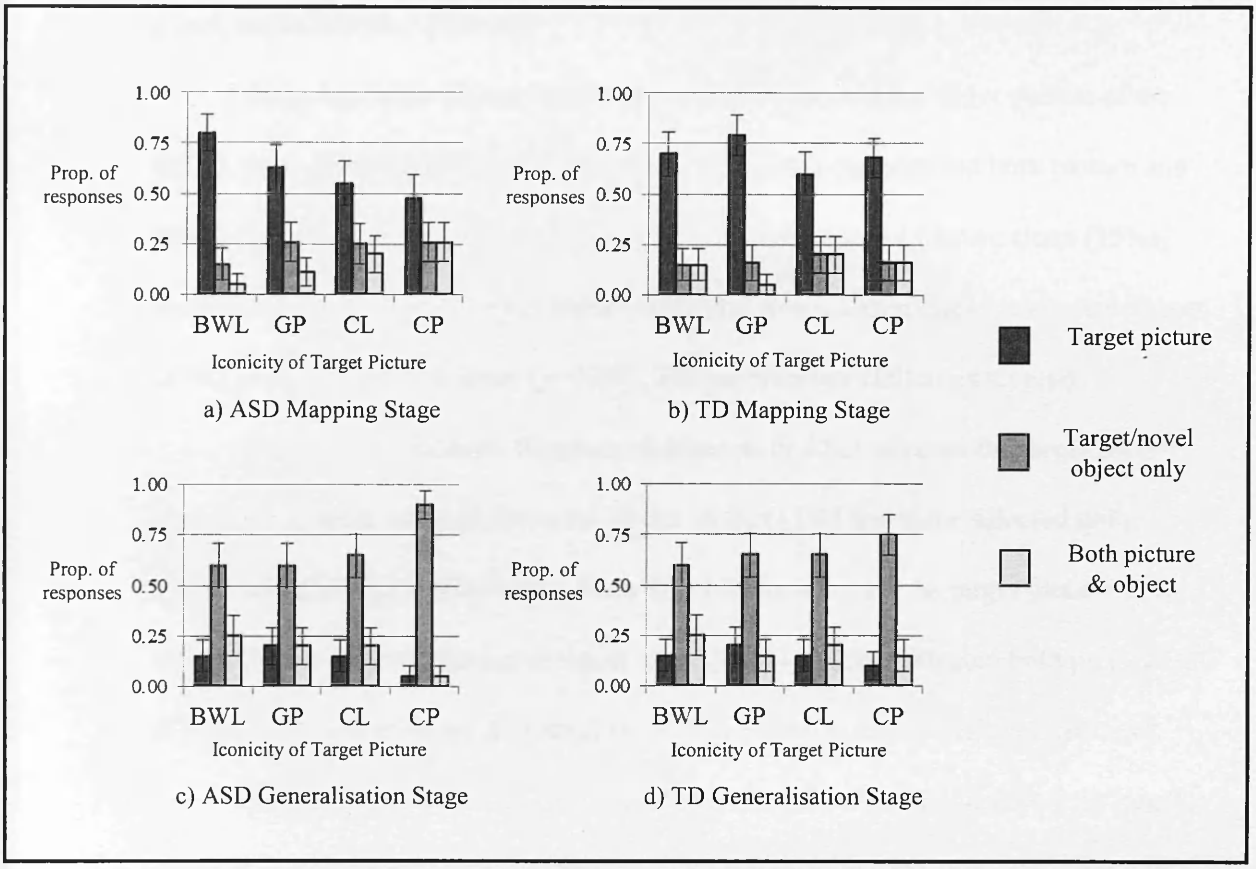

Figure 2. Responses of children with autism (ASD) and typically developing children (TD) at the Mapping (a, b) and Generalisation stages (c, d) of Experiment 1. Bars represent standard error of the mean. *Note*. BWL = black-and-white line drawing; GP = greyscale photograph; CL = colour line drawing; CP = colour photograph.

Due to small expected frequencies, the statistical significance of group differences was assessed using the Fisher-Freeman-Halton exact test rather than chi-squared test (see Ruxton & Neuhäuser, 2010). The Fisher-Freeman-Halton test is an extension of the Fisher's exact test that can be applied to 2 x 3 contingency tables, and gives the probability of observing a table that provides at least as much evidence of association between variables as the one observed, assuming that the null hypothesis is true.

Black-and-white line drawings

Mapping Stage. Sixteen children with ASD selected the target picture alone (80%), three selected the target object alone (15%) and one selected both picture and object (5%). By contrast, three TD children selected the target picture alone (15%), twelve selected the target object alone (60%) and five selected both picture and object (25%), a significant difference ($p < .001$, Fisher-Freeman-Halton exact test).

Generalisation Stage. Fourteen children with ASD selected the target picture alone (70%), three selected the novel object alone (15%) and three selected both picture and object (15%), whereas three TD children selected the target picture alone (15%), twelve selected the novel object alone (60%) and five selected both picture and object (25%), a significant difference ($p = .001$, Fisher-Freeman-Halton exact test).

Novelty Test Trial. All four of the children with ASD who included the target object in their response at the Mapping Stage responded in a manner consistent with symbolic understanding by selecting the target picture rather than the distracter object. Of the 17 TD children who included the target object in their response at the Mapping Stage, 16 correctly selected the target picture and 1 selected the distracter object.

Colour line drawings

Mapping Stage. Eleven children with ASD selected the target picture alone (55%), five selected the target object alone (25%) and four selected both picture and object (20%). Conversely, three TD children selected the target picture alone (15%), thirteen selected the target object alone (65%) and four selected both picture and object (20%), a significant difference ($p = .016$, Fisher-Freeman-Halton exact test).

Generalisation Stage. Twelve children with ASD selected the target picture alone (60%), four selected the novel object alone (20%) and four selected both picture and object (20%), while three TD children selected the target picture alone (15%), thirteen selected the novel object alone (65%) and four selected both picture and object (20%), a significant difference ($p = .007$, Fisher-Freeman-Halton exact test).

Novelty Test Trial. All nine of the children with ASD who included the target object in their response at the Mapping Stage correctly selected the target picture rather than the distracter object. Of the 17 TD children who included the target object in their response at the Mapping Stage, 13 correctly selected the target picture and 4 selected the distracter object.

Greyscale photographs

Mapping Stage. Twelve children with ASD selected the target picture alone (63.2%), five selected the depicted object alone (26.3%) and two selected both picture and object (10.5%), whereas four TD children selected the target picture alone (20%), twelve selected the depicted object alone (60%) and four selected both picture and object (20%), a significant difference ($p = .029$, Fisher-Freeman-Halton exact test).

Generalisation Stage. Fifteen children with ASD selected the target picture alone (78.9%), three selected the novel object alone (15.8%) and one selected both picture and object (5.3%). By contrast, four TD children selected the target picture alone (20%), thirteen selected the novel object alone (65%) and three selected both picture and object (15%), a significant difference ($p < .001$, Fisher-Freeman-Halton exact test).

Novelty Test Trial. Of the seven children with ASD who included the target object in their response at the Mapping Stage, 5 correctly selected the target picture and 2 selected the distracter object. Of the 16 TD children who included the target object in their response at the Mapping Stage, 10 correctly selected the target picture and 6 selected the distracter object.

Colour photographs

Mapping Stage. Nine children with ASD selected the target picture alone (47.4%), five selected the depicted object alone (26.3%) and five selected both picture and object (26.3%). By contrast, only one TD child selected the target picture alone (5%), eighteen selected the depicted object alone (90%) and just one selected both picture and object (5%), a significant difference ($p < .001$, Fisher-Freeman-Halton exact test).

Generalisation Stage. Thirteen children with ASD selected the target picture alone (68.4%), three selected the novel object alone (15.8%) and three selected both picture and object (15.8%). Conversely, two TD children selected the target picture alone (10%), fifteen selected the novel object alone (75%) and three selected both picture and object (15%), a significant difference ($p < .001$, Fisher-Freeman-Halton exact test).

Novelty Test Trial. Of the ten children with ASD who included the target object in their response at the Mapping Stage, 9 correctly selected the target picture and 1 selected the distracter object. Of the 19 TD children who included the target object in their response at the Mapping Stage, 17 correctly selected the target picture and 2 selected the distracter object.

Preference Task

Both children with ASD and TD children responded correctly on 98% of trials. There was no difference between trial types (picture or object requested) for either group and there were no item effects. These ceiling rates of performance indicate that neither group had a general preference for selecting pictures or objects irrespective of their identity.

Categorising participants' response patterns

To gain a more comprehensive understanding of how TD children and children with ASD were responding in each condition, participants' were categorised based on their pattern of performance across the 2 or 3 test stages they experienced (see Table 2). Following Ganea and colleagues (2009), I was primarily interested in the relative rates of associative vs. symbolic responding. Since people use the same label to describe both real and depicted versions of the same object, 'target/novel object only' and 'both picture and object' responses were collapsed. For each level of Iconicity, children were allocated to one of the following categories:

a) Symbolic (robust): Selected the target object alone or with the target picture at the Mapping Stage, then selected the novel object alone or with the target picture at the Generalisation Stage, and finally selected the target picture at the Novelty Test Trial. Extension of the verbal label to the target object and the novel object indicates the child's understanding that pictures represent categories of objects. This is consistent with a mature understanding of pictures.

b) Symbolic (fragile): Selected the target object alone or with the target picture at the Mapping Stage, then selected the target picture alone at the Generalisation Stage, and finally selected the target picture at the Novelty Test Trial. Extension of the verbal label to the target object but *not* the novel object suggests that sameness of shape *and* colour (rather than just sameness of shape) cue the child's mapping of picture-referent relations. This could be regarded as a lower level of pictorial understanding.

c) Associative: Selected the target picture alone at the Mapping Stage and then selected the target picture alone at the Generalisation Stage. The child's failure to extend the verbal label to the target object or novel object suggests that they believe that the target picture is its true referent. As the target picture is the entity that was directly paired with the verbal label throughout training, this is consistent with associative learning.

d) Novelty bias: Selected the target object alone or with the target picture at the Mapping Stage, then selected the novel object alone or with the target picture at the Generalisation Stage, and finally selected the distracter object at the Novelty Test Trial. Selection of the distracter object following the selection of the target object and novel object suggests that the child's responding was motivated by a simple preference for the more novel and interesting 3-D stimuli.

e) *Other*: Pattern of performance that did not fit into any of the above categories. Child makes a series of responses that cannot be explained by associative word learning, symbolic understanding or a novelty bias.

Table 2

Patterns of performance associated with response categories in Experiment 1

		Response	
	Mapping Stage	Generalisation Stage	Novelty Test Trial
Symbolic (robust)	TO or Both	NO or Both	TP
Symbolic (fragile)	TO or Both	TP	TP
Associative	TP	TP	/
Novelty Bias	TO or Both	NO or Both	DO
Other		Any other combination of responses.	

Note. TO = target object alone; TP = target picture alone; NO = novel object alone; Both = both target/novel object and target picture; DO = distracter object

The numbers of children with ASD and TD children in each of the above categories at each level of Iconicity are displayed in Table 3. Children with ASD tended to map verbal labels onto target pictures in each condition, while TD children recognised that they were symbolic representations of target and novel objects. It is notable, however, that children with ASD more frequently responded in a manner consistent with symbolic understanding in the colour line and photograph conditions (18 symbolic responses) than in the non-colour line and photograph conditions (9 symbolic responses). Furthermore, as a group, children with ASD responded similarly overall in the two colour conditions and in the two non-colour conditions. Thus, these categorical data appear to indicate an effect of picture colour. To examine this further, the black-and-white line drawing condition was collapsed with the greyscale photograph condition, and the colour line drawing condition was collapsed with the colour photograph condition. Additionally, the two symbolic response types (robust and fragile) were collapsed, and the frequencies associated with the "novelty bias" and "other" categories were omitted from the data below due to their low frequency.

Table 3

Number of children with autism (ASD) and typically developing children (TD) in each response category at each level of Iconicity in Experiment 1. Children were assigned to a category according to their pattern of responding across the Mapping Stage, Generalisation Stage and possibly Novelty Test Trial

		Iconicity of target picture			
		Black-and-white line	Greyscale photograph	Colour line	Colour photograph
ASD	Symbolic (robust)	4	3	7	5
	Symbolic (fragile)	0	2	2	4
	Associative	14	12	10	9
	Novelty Bias	0	1	0	1
	Other	2	1	1	0
TD	Symbolic (robust)	16	10	12	16
	Symbolic (fragile)	0	0	1	1
	Associative	3	4	1	1
	Novelty Bias	1	6	3	2
	Other	0	0	3	0

Non-colour conditions. The children with ASD made 9 "symbolic" responses (25.7%) and 26 "associative" responses (74.3%) across the two non-colour conditions. By contrast, the TD children made 26 "symbolic" responses (78.8%) and 7 "associative" responses (21.2%).

Colour conditions. The children with ASD made 18 "symbolic" responses (48.6%) and 19 "associative" responses (51.4%) across the two colour conditions. Conversely, the TD children made 30 "symbolic" responses (93.8%) and 2 "associative" responses (6.2%).

Overall, these values confirm that low-functioning children with ASD tend to form *associative* word-picture mappings, and do not extend labels learned for pictures to real depicted objects. However, they generalised verbal labels to target objects, and sometimes novel objects, in nearly 50% of trials in colour picture conditions. By comparison, they only extended labels to depicted objects in 25% of trials involving non-colour pictures. It may be that viewing a colour picture alongside its colour-matched referent helps children with ASD recognise that the picture is a symbol, and in some individuals, this might evoke the idea that it could represent other objects as well (e.g. differently-coloured versions of the depicted object). By contrast, TD children almost always extended novel labels from pictures to their referents and also generalised those labels to objects that matched depicted referents on shape but not colour. The between-condition difference was in the same direction as for children with ASD (i.e. more symbolic responses in the colour picture conditions), although the relative difference was much smaller.

Over and above the observed effect of Iconicity, it is clear that verbal labels impact differently on how children with ASD and TD children view pictures. Previous research has shown that the symbolic use of pictures by TD children is facilitated by knowledge of verbal labels corresponding to their referents (Callaghan, 2000). Thus, the process of learning a unique verbal label for each target picture may have guided TD children to view them as symbols when presented alongside their perceptually similar referents. However, it appears that word-picture relations do not similarly scaffold the symbolic understanding of children with ASD. This differential effect of picture naming was explored in Experiment 2.

The following experiment employed the paradigm reported in study 1 of Preissler and Bloom (2007). Children were presented with arrays consisting of two unfamiliar objects and two black-and-white line drawings of those objects. The experimenter drew attention to one of the drawings in the array, with or without assigning it a novel label, and asked the participant to show her "another one". Preissler and Bloom (2007) found that TD 2-year-olds in the "Labelled" condition tended to select the depicted object, whereas those in the "Unlabelled" condition typically selected the other picture. This pattern of responding suggests that naming prompts TD children to view pictures from a symbolic perspective. An important difference from Experiment 1 of this thesis is that children in the Labelled condition heard word-picture pairs only once per trial. A single pairing of stimuli is much less likely to elicit a narrow one-to one mapping than repeatedly presenting and reinforcing a word-picture relationship. Thus, the responses of children with ASD in Experiment 2 will also help us identify whether the Training Stage of Experiment 1 suppressed a potentially beneficial effect of naming by promoting associative learning. Overall, the results of Experiment 2 will shed light on whether or not language influences how children with ASD view pictures.

2.2 Experiment 2

2.2.1 Method

Participants

Participants were the same individuals from Experiment 1. Half of the children in each group (children with ASD and TD children) were randomly assigned to the Labelled condition and half to the Unlabelled condition. Children with ASD in the two conditions did not vary significantly on chronological age (Labelled: $M = 9$ years, $SD = 2.5$ years; Unlabelled: $M = 10.3$ years, $SD = 2.9$ years), CARS score (Labelled: $M = 40.25$, $SD = 6.87$; Unlabelled: $M = 45.65$, $SD = 8.55$) or receptive vocabulary

(Labelled: *M* = 3.3 years, *SD* = 1 year; Unlabelled: *M* = 2.9 years, *SD* = 1 year).[4] Similarly, TD children in the two conditions were not significantly different on chronological age (Labelled: *M* = 3.4 years, *SD* = 0.8 years; Unlabelled: *M* = 3.5 years, *SD* = 0.9 years) or receptive vocabulary (Labelled: *M* = 3.4 years, *SD* = 0.5 years; Unlabelled: *M* = 3.8 years, *SD* = 1 year). Children with ASD and TD children in the Labelled condition did not differ significantly on receptive vocabulary, nor did children with ASD and TD children in the Unlabelled condition.

Materials

Stimuli were 8 small unfamiliar objects (different from those in Experiment 1) and 8 2 x 2 inch laminated black-and-white line drawings of those objects (see Fig. 3). Only black-and-white line drawings were used in this experiment because a) I wanted the results to be directly comparable to Preissler and Bloom (2007), and more importantly, b) I sought to rule out the possibility that children with ASD were impaired in their ability to match pictures to objects based on resemblance. In Experiment 1, children with ASD may have selected the target picture alone because they failed to perceive picture-object relations in the least iconic conditions. The black-and-white line drawings were created in the same way as those in Experiment 1.

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[4] As stated previously, some children with autism did not have BPVS scores. In order to assess the relative language abilities of children with autism in the Labelled and Unlabelled conditions, we conservatively assigned participants without a BPVS score a receptive vocabulary age of 2.5 years as this is the youngest age at which typically developing children can complete the task (which all children with autism managed).

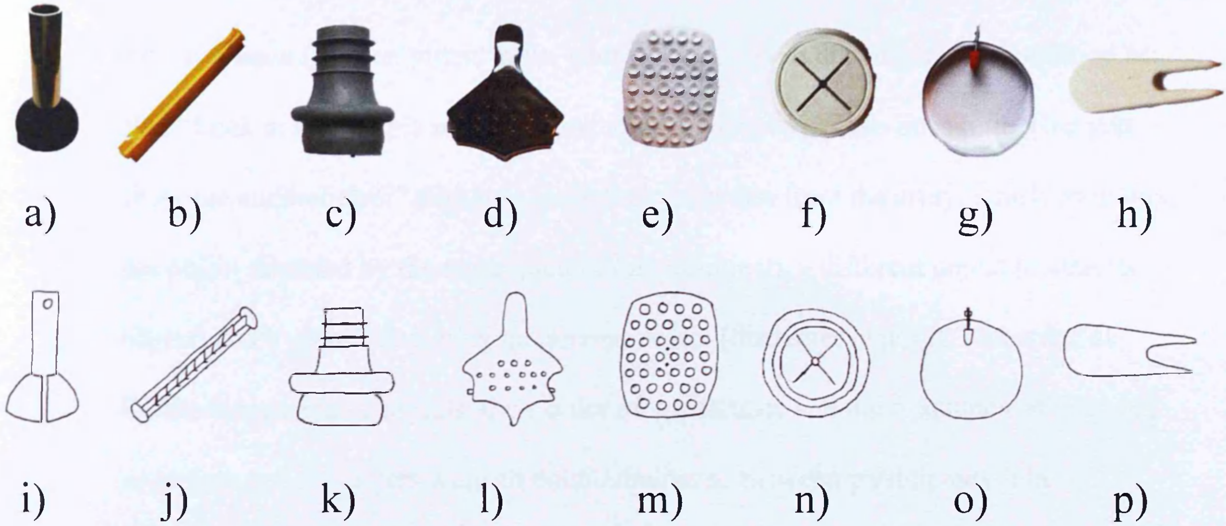

Figure 3. Stimuli used in Experiment 2; objects (a-h) and black-and-white line drawings (i-p).

Procedure

Participants were tested individually in their own schools, approximately 2 weeks after completing Experiment 1. Testing was completed in one session. All participants were accompanied by a familiar adult throughout the testing procedure. Children were seated at a table opposite the experimenter, and the materials were placed within their reach. Participants were reinforced throughout the session for attention and good behaviour, but the experimenter never indicated whether their responses were correct or incorrect.

Both conditions – Labelled and Unlabelled – consisted of 4 trials. Each trial involved four items – 2 different unfamiliar objects and 2 black-and-white line drawings depicting those objects. In both conditions, the two objects and one of the pictures were placed in a line in front of the participant. The experimenter then held up the remaining picture (target picture) and made a condition-specific utterance whilst pointing to the picture. In the Labelled condition the experimenter said "Look!

This is a *noun* (ploffer, yitter, trella, gedro)", whereas in the Unlabelled condition he said "Look at this!" This utterance was always followed by the question: "Can you show me another one?" Children made their selection from the array, which contained the object depicted by the target picture (target object), a different object (distracter object) and a picture depicting the second object (distracter picture). The order of labels, the pairing of objects, their order of appearance and the frequency of their use as targets and distracters were all counterbalanced between participants. The positioning of items in the array was counterbalanced between trials.

Coding

Responses were coded as the item(s) that participants pointed to or gave to the experimenter in each trial. Only responses judged to be deliberate were coded (e.g. giving or sliding an item to the experimenter, pointing to or picking up and showing the experimenter an item). If the child interacted with an item without clearly indicating a response, this was noted but excluded from the final coding.

2.2.2 Results and Discussion

The number of trials in which participants selected the target object, the distracter picture and distracter object were calculated (each out of 4). Of the 80 trials received by each group, 2 children with ASD failed to respond in 1 trial each (once in both Labelled and Unlabelled conditions) and another in the Unlabelled condition selected the distracter object in 1 trial. Two TD children in the Labelled condition each selected the distracter object in a single trial. Because the distracter object was selected so rarely, these data were excluded from the subsequent analyses.

In the Labelled condition, children with ASD selected the target object on 82.5% of trials ($M = 3.3$, $SD = 1.25$; see Fig. 4) and the distracter picture on 15% of trials ($M = 0.6$, $SD = 1.26$), while TD children selected the target object and distracter picture on 92.5% ($M = 3.7$, $SD = 0.48$) and 2.5% of trials ($M = 0.1$, $SD = 0.32$) respectively. In the Unlabelled condition, children with ASD selected the target object on 57.5% of trials ($M = 2.3$, $SD = 1.7$) and the distracter picture on 37.5% of trials ($M = 1.5$, $SD = 1.43$), whereas the TD children chose the target object on 22.5% of trials ($M = 0.9$, $SD = 1.66$) and the distracter picture on 77.5% of trials ($M = 3.1$, $SD = 1.66$). It is noteworthy that the TD children responded in a very similar fashion to the 2-year-olds in Preissler and Bloom (2007) who selected the target object in 90% and 30% of trials in the Labelled and Unlabelled conditions respectively.

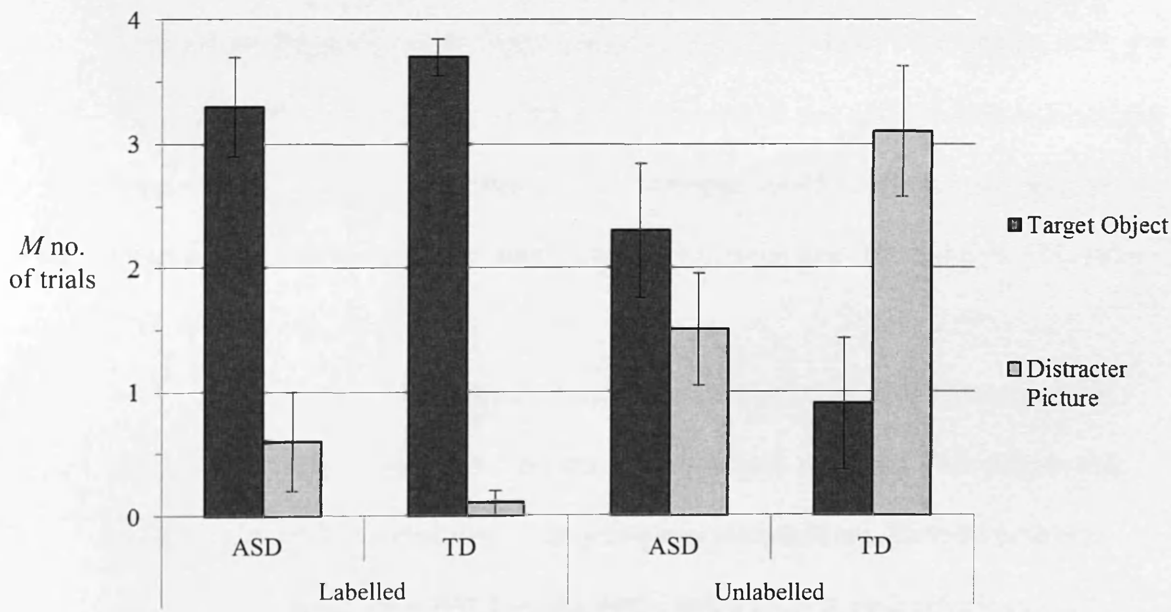

Figure 4. Mean numbers of target object and distracter picture responses by children with autism (ASD) and typically developing children (TD) in the Labelled and Unlabelled conditions of Experiment 2. Bars represent standard error of the mean.

The proportion of trials in which children selected the target object was calculated by dividing their number of target object responses by their total number of valid responses. These proportion data were entered into a 2(Group, typically developing children, children with autism) x 2(Condition: Labelled, Unlabelled) univariate ANOVA. The analyses yielded a significant main effect of Condition, $F(1, 36) = 22.82$, $MSE = 0.12$, $p < .001$, $\eta p^2 = .39$, indicating that the target object was selected more frequently in the Labelled condition than the Unlabelled condition across groups. More interestingly, there was a significant Group x Condition interaction, $F(1, 36) = 4.9$, $MSE = 0.12$, $p = .033$, $\eta p^2 = .12$. Pairwise comparisons subjected to the Bonferroni correction revealed no effect of Condition on target object selection in children with ASD, whereas TD children were significantly more likely to select the target object in the Labelled condition (and therefore selected the distracter picture more frequently in the Unlabelled condition), $F(1, 18) = 31.4$, $MSE = 0.09$, $p < .001$, $\eta p^2 = .64$. In the Labelled condition, children with and without ASD selected the target object at similar rates, while in the Unlabelled condition, there was trend for children with ASD to select the target object more often than TD children, $F(1, 18) = 3.52$, $MSE = 0.18$, $p = .065$, $\eta p^2 = .16$.

These results show that low-functioning children with ASD can categorise pictures with their referents, and that this is their default response. This affirms that children with ASD are sensitive to the perceptual relationships that exist between pictures (even black-and-white line drawings) and objects in their environment. Crucially, their preference for selecting the target object regardless of whether the target picture was named, suggests that verbal labels do not scaffold the symbolic use of pictures by children with ASD.

Unlike the children with ASD, and in line with previous research (Preissler & Bloom, 2007), the TD children tended to select the target object in the Labelled Condition and the distracter picture in the Unlabelled Condition. This further demonstrates that labelling underpins whether young TD children view pictures from a symbolic or non-symbolic perspective.

2.3 General Discussion

This study explored how low-functioning children with ASD comprehend pictures as symbols. In Experiment 1, participants were taught a series of novel words paired with different target pictures that varied in iconicity. When a target picture was presented alongside its previously unseen referent, children with ASD most frequently indicated that the picture alone was the referent of the word in 3 out of 4 Iconicity conditions. However, when the target picture was a colour photograph (the most iconic condition), children with autism extended the label to the depicted referent in 52% of trials. Overall, children with ASD extended verbal labels to target objects (and sometimes novel objects) approximately twice as often in colour picture trials relative to non-colour picture trials (48.6% vs. 25.7%). Irrespective of Iconicity, TD children almost always extended labels from target pictures to their referents and also generalised those labels to objects that matched depicted referents on shape but not colour. However, like children with ASD, they appeared more likely to view colour pictures as symbols.

The results of Experiment 1 implicate colour as an important influence on whether children with ASD extend labels from pictures to depicted objects. One possibility is that children with ASD are more likely to view colour pictures as symbols because sameness of colour cues their recognition of picture-referent relations. Thus, because iconic colour pictures are more transparent than iconic non-colour pictures, children with ASD may be increasingly likely to generalise information from the former in a manner consistent with symbolic understanding (DeLoache, 1995; Fuller, 1997; Fuller & Lloyd, 1991). Furthermore, and contrary to my predictions, most children with ASD who extended the label to the target object at the Mapping Stage then generalised the same label to the novel object at the Generalisation Stage (12 of 18 responses in colour conditions), despite the difference in colour. Perhaps the viewing of a colour picture alongside its colour-matched referent at the Mapping Stage encouraged these children to view it from a symbolic perspective, and this opened the possibility that it could stand for other objects (e.g. those that match shape, but not necessarily colour). By comparison, those children who extended the label to the target object at the Mapping Stage but *not* the novel object at the Generalisation Stage may not have understood that pictures are generally intended to represent categories of objects rather than specific exemplars. Hence, I would argue that the symbolic understanding of these individuals is fragile. They may perceive picture-referent relations as one-to-one pairs (i.e. one picture represents one object), with colour being critical to the definition of these relationships. By contrast, TD children clearly understand that pictures can represent categories of objects and recognise that sameness of shape, rather than sameness of colour, is the best indicator of category membership (Smith et al., 2002). Hence, they were adept in their use of shape as a basis for generalising labels to objects, even when colour was incongruent.

Experiment 2 explored whether children with ASD view pictures differently depending on whether or not they are named and, in conjunction with Experiment 1, sheds light on how they form relations between words and pictures. Children with ASD categorised black-and-white line drawings with their 3-D referents more often than with another drawing, regardless of whether they were assigned a verbal label. This confirms that children with ASD have no difficulty matching pictures (even black-and-white line drawings) with perceptually similar objects and, crucially, suggests that verbal labelling does not significantly influence how children with ASD view pictures. Moreover, when word-picture relations are not reinforced through repeated simultaneous exposures, children with ASD spontaneously match them with their referents. This suggests that the high rate of picture alone responses in Experiment 1 may have been fostered by the Training Stage. It is well documented that children with ASD form associations between words and stimuli that co-occur, indicating that they do not realise that word learning is driven by referential intent, and that appropriate referents of spoken words are often outside one's current focus of attention (e.g. Baron-Cohen et al., 1997; Frith & Happé, 1994; Kanner, 1946; Preissler, 2008; Preissler & Carey, 2005). Therefore, the repeated and reinforced pairing of the novel label with the target picture in Experiment 1 may have caused them to map the label onto the picture itself (the entity that they experienced co-occurring with the word), rather than the symbolised object. By contrast, the single word-referent pairing experienced in the Labelled Condition of Experiment 2 did not generate a strong associative bond, enabling them to match the picture to its referent (a behaviour that they perform frequently in their daily lives) when asked to show the experimenter "another one".

As children with ASD require a high number of mappings in order to learn word-picture relations (see Experiment 1 Training Stage data), the single word-picture pairings in Experiment 2 may not have been meaningful. That is, the children with ASD may not have registered the symbolic link between the spoken word and the target picture. Furthermore, because their comprehension of pictures is not guided by language, the lack of naming in the Unlabelled condition did not have the same impact on the children with ASD as it did on the TD children. Together, these experiments show that children with ASD and TD children are not relating pictures, words and objects in the same way. While children with ASD are able to match pictures with their referents, the repeated pairings required to learn the names of pictures often narrows the word-referent relation to the extent that the picture itself (rather than the depicted object) is considered the referent of the word. However, children with ASD were nearly twice as likely to extend verbal labels to objects depicted in colour pictures, suggesting that these are more often viewed as symbols. Conversely, TD children understand that words refer to depicted referents and can be generalised to real objects accordingly.

Are there other explanations for the associative responding of children with ASD in Experiment 1? While designing the study, it was recognised that children who have experienced picture-based communication training may be biased to select pictures irrespective of their identity, since handling pictures is a common feature of their daily routine. However, the Preference Task coupled with the results of Experiment 2 confirmed that they did not have a general preference for selecting pictures over objects. Perhaps children with ASD are just more likely to associate words with pictures when given the choice of a picture and its referent. Preissler (2008) addressed this possibility and found that when a word is initially paired with an object, rather than a picture, children with ASD do not show a significant preference for the picture when asked to select the word's referent. Given that the participants in Preissler (2008) were very similar to those in the present study, there is no reason to believe that my sample of children with ASD would respond differently. Also, based on another control by Preissler (2008), we can rule out perseveration (a characteristic of autism resulting from impairments in frontal lobe function; e.g. Shu, Lung, Tien & Chen, 2001) as an explanation for the associative responding of children with ASD.

It might be that low-functioning children with ASD map verbal labels onto individual pictures because they have difficulty forming dual representations. In word learning contexts, children with ASD may represent pictures as objects and neglect to represent their relations to symbolised referents. A bias towards viewing pictures as objects contrasts markedly with the stance of TD children (and adults) who reflect primarily on the referents of pictures. Such atypical processing in children with ASD could be attributable to impaired social-cognitive skills, which enable TD children to "acquire" the pictorial symbol system from social partners (e.g. Callaghan & Rochat, 2008), and impaired language, which usually provides a scaffolding base for the pictorial domain (Callaghan, 2000). Perhaps these deficits inhibit low-functioning children with ASD from fully appreciating the intended symbolic-communicative function of pictures, which in turn, causes them to focus on their object (rather than symbolic) identity when mapping word-picture relations. However, this explanation is speculative at present and requires investigation in future research.

Of course, I must caution against generalising the results of these experiments across the autism spectrum. Higher-functioning individuals who are more linguistically developed may have an understanding of word-picture-object relations that is similar to typical development. However, the children with ASD that participated in these experiments were representative of the population that this research is most relevant to: low-functioning individuals with impaired language development who receive and benefit from picture-based communication training.

Overall, the results of these experiments have important implications for picture-based communication interventions. At present, there are no data-grounded guidelines regarding what types of pictures are best suited for such interventions and it is not uncommon for children with ASD to be taught using relatively abstract black-and-white line drawings and symbols (see participant information in Experiment 1). While it is clear that children with ASD have a general difficulty using pictures as symbols, this study has shown that they are twice as likely to generalise information to objects depicted in colour pictures than non-colour pictures. This may be because they are more likely to perceive colour pictures as symbols in contexts that foster associative learning, such as the Training Stage of Experiment 1 and the early stages of the PECS programme (although this requires confirmation in future research). Thus, these findings support the use of iconic colour pictures, which promote the extension of information from pictures to objects, when implementing picture-based communication training. Furthermore, because “experience responding to a given entity as a representation of something other than itself increases an individual’s readiness to respond to other entities in an abstract rather than concrete mode” (DeLoache, 1995, p.112), perceiving iconic colour pictures as representations may elicit general gains in symbolic development.

Chapter Three: **Generalisation of word-picture relations in low-functioning children with autism and typically developing children.**[5]

TD children begin learning word-referent relations at approximately 12-months (Bloom, 2002), and the majority of the earliest-acquired words refer to object categories that are well-organised by shape (Samuelson & Smith, 1999). The process of learning object names selectively tunes children's attention to global structure (Smith et al., 2002) and, by approximately 24-months, TD children infer the general rule that shape is the criterial perceptual determinant when mapping and extending novel word-referent relations (commonly known as a "shape bias"; Landau, Smith & Jones, 1988; Smith, 2003).

The shape bias is underpinned by categorisation (the process that organises known information into conceptual groups), and TD infants categorise objects through the abstraction of prototypes (e.g. Klinger & Dawson, 2001; Younger, 1990). It is believed that prototypical representations of objects' category-defining shapes direct children's shape-based generalisation of labels (Son, Smith & Goldstone, 2006). Categorisation is also involved in children's picture comprehension. When a child views a picture, they must compare the depicted referent against their existing prototypes in order to decide what object is represented. Alternatively, if a picture is of an unfamiliar object, viewers can generate a prototype directly from the depicted image, enabling generalisation to other pictures and real world referents. From 2-years of age, TD children extend newly-learned labels from pictures to similarly shaped objects, irrespective of colour, thus evidencing their understanding that shape defines

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[5] Based on Hartley, C., & Allen, M. (in press). Generalisation of word-picture relations in children with autism and typically developing children. *Journal of Autism and Developmental Disorders*.

referential word-picture-object relations (Hartley & Allen, in press (a); Preissler & Carey, 2004).

In contrast to TD children, children with ASD tend to learn object names via an associative mechanism (e.g. Baron-Cohen et al., 1997; Preissler & Carey, 2005), and do not privilege sameness of shape as a basis for extending labels to novel objects (Tek et al., 2008). Using a preferential looking paradigm, Tek and colleagues investigated whether children with ASD aged 2- to 3-years (at the start of the study) evidenced an attentional bias to shape in word learning across a 12-month period. Over the year, the children with ASD developed sizeable vocabularies (exceeding 100 count nouns), but at no stage evidenced the shape bias heuristic, suggesting a dissociation between vocabulary size and the maxims governing word learning in autism.

It could be that differences in word-object mapping and generalisation evidenced by children with ASD are related to inherent deficits in visual processing and categorisation. There is evidence that high-functioning children and adults with autism are unable to generate prototypes of object categories (e.g. Klinger & Dawson, 2001; Plaisted, 2000), thus explaining their inability to organise unfamiliar stimuli and atypical examples of familiar categories (e.g. Gastgeb, Strauss & Minishew, 2006; Tek et al., 2008). One possibility is that children with ASD are unable to form minimalist representations because they do not selectively attend to shape when processing visual stimuli. Prototype formation demands the ability to selectively abstract global shape information, but children with ASD evidence a preference for processing local details at the expense of holistic meaning (Mottron et al., 2006; Frith & Happé, 1994). It may be that children with ASD process novel objects in a predominantly feature-based fashion (similar to how they process faces; e.g. Joseph &

Tanaka, 2003), and fail to develop a shape bias because they do not identify shape as the most pertinent determinant of category membership. Unlike TD children, who can abstract a shape-based category representation after a single exposure (Markman, 1989), it might be that children with ASD require multiple experiences with multiple category members in order to formulate a set of rules that define category membership. However, before these rules are established, it may be that their representations of categories are characterised by several separable, and equally weighted, perceptual details.

Difficulties in word learning and category formation in children with ASD also manifest in the pictorial domain. Priessler (2008) reported that low-functioning children with ASD map associative relations between words and black-and-white line drawings, indicating their failure to understand that labels refer to the symbolised categories. One explanation of these findings is that picture comprehension in low-functioning children with ASD is contingent on a high degree of iconicity (the extent that a symbol resembles its referent). In their recent study, Hartley and Allen (in press (a); see Chapter 2) found that children with ASD extended verbal labels to referent objects approximately twice as often in colour picture trials relative to non-colour picture trials (48.6% vs. 25.7%). Furthermore, most children with ASD who extended labels to depicted objects also generalised the same labels to differently-coloured category members. These findings implicate colour as an important influence on whether children with ASD comprehend symbolic picture-referent relations and extend labels to depicted objects.

However, given their impairments in prototype and category formation, it cannot be assumed that children with ASD map relations between words, colour pictures and objects in the same manner as TD children. While it is clear that children with ASD benefit from greater iconicity when generalising words from pictures, they may not abstract minimalist shape-based representations of symbolised referents. Due to their localised processing bias and weak central coherence (Frith & Happé, 1994), category defining details (e.g. global shape) and category irrelevant details (e.g. size, colour, texture) may not be psychologically separable for children with ASD. As a result, some children with ASD may be unable to weight these perceptual details when deciding whether to extend a known label to a novel item (picture or object) on the basis of category membership. Thus, it is possible that children with ASD may generalise newly-learned word-picture relations based on multiple and independent perceptual details (e.g. shape and/or colour).

The present study investigates whether low-functioning children with ASD generalise labels from colour pictures to objects based on similarity of shape, colour, or both shape and colour. Samples of children with ASD and ability-matched TD children were taught novel words paired with colour photographs of unfamiliar target objects, and were required to sort items into two buckets according to whether or not they were also referents of the newly-learned labels. Sorted items included real target objects, differently-coloured variants of target objects, other unfamiliar objects that were colour-matched to target objects, familiar objects, and pictures of each object. Based on Hartley and Allen (in press (a)), it was anticipated that some children with ASD would map associative word-picture relations and fail to generalise, while others would generalise labels to target objects and differently-coloured variants of target objects. I also predicted that the absence of a shape bias (Tek et al., 2008) may cause some children with ASD to over-extend labels to unfamiliar objects that match pictures on colour, but not shape. By contrast, it was expected that TD children would only generalise labels to items that matched pictures on shape.

3.1 Experiment 3

3.1.1 Method

Participants

Participants were 17 low-functioning children with ASD (all male; *M* age = 9.7 years, range = 4.1–16.1 years) and 17 TD children (6 males, 11 females; *M* age = 3.5 years, range: 2.2–6.4 years). Children were recruited from local specialist schools, mainstream schools, nurseries and preschools. All children with ASD received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. ADOS and ADI - Revised; Lord et al., 2002; Lord et al., 1994) and expert judgment. Diagnosis was confirmed using the Childhood Autism Rating Scale (CARS; Schopler et al., 1980), as completed by a class teacher (*M* score: 41, range: 31.5–51.5). Groups were matched on receptive vocabulary (ASD: 3.5 years, range: 2–6.2 years; TD: 3.5 years, range: 2–5.4 years) as measured by the British Picture Vocabulary Scale (BPVS; Dunn et al., 1997).[6] In addition, the nonverbal intellectual abilities of each group, as measured by the Leiter-R (Roid & Miller, 1997), were not significantly different, $t(32) = -.81, p = .43$.

All children with ASD were current PECS-users, and the sample was linguistically representative of children who receive and benefit from picture-based communication interventions. Seven children with ASD were functionally non-verbal (no spoken words), 7 had some words and produced utterances of 1-3 words in length (including echolalic utterances) and 3 could speak some short phrases over 4 words long. Participants' experience using PECS varied between 5 months and 10 years, and

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[6] The BPVS scores of 4 children with ASD and 1 typically developing child were marginally below the lowest raw score with a standardised age equivalent (of 2.3 years). Consequently, we conservatively assigned these children a receptive language ability of exactly 2 years. This research is particularly relevant to individuals with language impairments who have difficulty with standardised assessments, display challenging behaviours and receive picture-based communication training.

their progress ranged from Stage 1 to fully-trained user (see Frost & Bondy, 2002). The pictures used by participants to communicate varied individually, with coloured drawings/symbols and black-and-white drawings/symbols the most common. Several children used a mixture of picture types that varied in iconicity and only four children in the sample used "some" colour photographs.

The study was approved by the Lancaster University Ethics Committee and informed consent was obtained from parents.

Materials

Stimuli included familiar objects, unfamiliar objects, laminated colour photographs of those objects, and two opaque white 6-litre Tupperware boxes. Photographs were taken with a 9.2 megapixel camera and edited using Adobe Photoshop. All photographs were standardised to 2 x 2 inches, conforming to the PECS training literature guidelines (Frost & Bondy, 2002).

Sixteen familiar objects were used in two Training Trials. Each of the 4 Test Trials involved a unique set of 4 objects and colour photographs of those objects (see Fig. 5).

a) Target Object b) Novel Object c) Distracter Object d) Familiar Object

e) Target Object f) Novel Object g) Distracter Object h) Familiar Object

i) Target Object j) Novel Object k) Distracter Object l) Familiar Object

m) Target Object n) Novel Object o) Distracter Object p) Familiar Object

Figure 5. Object stimuli used in Experiment 3; Set 1 (a-d), Set 2 (e-h), Set 3 (i-l) and Set 4 (m-p).

Procedure

Participants were tested individually in their own schools and accompanied by a familiar adult. Children were reinforced throughout the session for attention and good behaviour. Correct performance was only reinforced during Training Trials.

Children sat at a table opposite the experimenter, with two Tupperware boxes positioned between them (one left and one right of centre). The experimenter told the child that they would be playing a game that involved sorting things. Two Training Trials were then administered, counterbalanced for order. First, the experimenter showed the child a familiar practice object (car/dog) and named the object several times (e.g. "This is a car (dog). See, it's a car (dog). Have a look at the car (dog)"). He then pointed to one of the containers and demonstrated that the named object should be placed inside, before allowing the child to copy this action (e.g. "Cars go in here. See, the car goes in here [experimenter places object in appropriate container]. Can you put the car in here?"). The experimenter then informed the child that they should place further examples of the named object in the same container (e.g. "I want you to put cars in here"), and then pointed to the other container and stated that non-named items should be placed in there (e.g. "Other things go in here."). A series of items were presented one-by-one and in a random order for the child to sort (e.g. "So where does this go? And where does this go?"). To reinforce task understanding, the first item presented was always identical to the practice object. The remaining items were either cars/dogs or other familiar objects from different categories. If a child made an error, the experimenter demonstrated the correct response and re-started the trial from the initial step. Training Trials were repeated until the child correctly sorted all items without help. The distribution of sorted items was 5 cars (vs. 3 non-cars) and 4 dogs (vs. 4 non-dogs). This discrepancy was intended to prevent children from inferring that a certain number of items should be sorted into each container in the Test Trials.

Four Test Trials followed (see Fig. 6). For each trial, the experimenter showed the child a colour photograph of an unfamiliar object (target picture) and assigned it a novel label (e.g. "This is a blicket. See it's a blicket. Have a look at the blicket"). Four novel labels (blicket, parloo, gariff, nellby) were counterbalanced for order. The experimenter then pointed to one of the containers and demonstrated that the named item should be placed inside, before allowing the child to copy this action (e.g. "Blickets go in here. See, the blicket goes in here [experimenter places target picture in the appropriate container]. Can you put the blicket in here?). The experimenter then informed the child that they should place further examples of the named object in the same container (e.g. "I want you to put blickets in here"), and then pointed to the other container and stated that non-named items should be placed in there (e.g. "Other things go in here."). Additionally, the experimenter retrieved the target picture and placed it in front of its container to prevent children from forgetting where named items should go. The experimenter then presented a series of 8 items, one-by-one and in a random order, for the child to sort into the two containers (e.g. "So where does this go? And where does this go?"). Those items consisted of the target object (the unfamiliar object depicted in the target picture), a novel object (a differently coloured version of the target object), a distracter object (a different unfamiliar object that was exactly the same colour as the target object), a familiar object, a copy of the target picture, a novel picture (a photograph of the novel object), a distracter picture (a photograph of the distracter object) and a familiar picture (a photograph of the familiar object). After sorting 4 items, the experimenter reminded the child which container the named items were meant to be placed inside (e.g. "Remember, blickets go in here. Other things go in here"). A different set of stimuli was used on each Test Trial, and order of sets was counterbalanced.

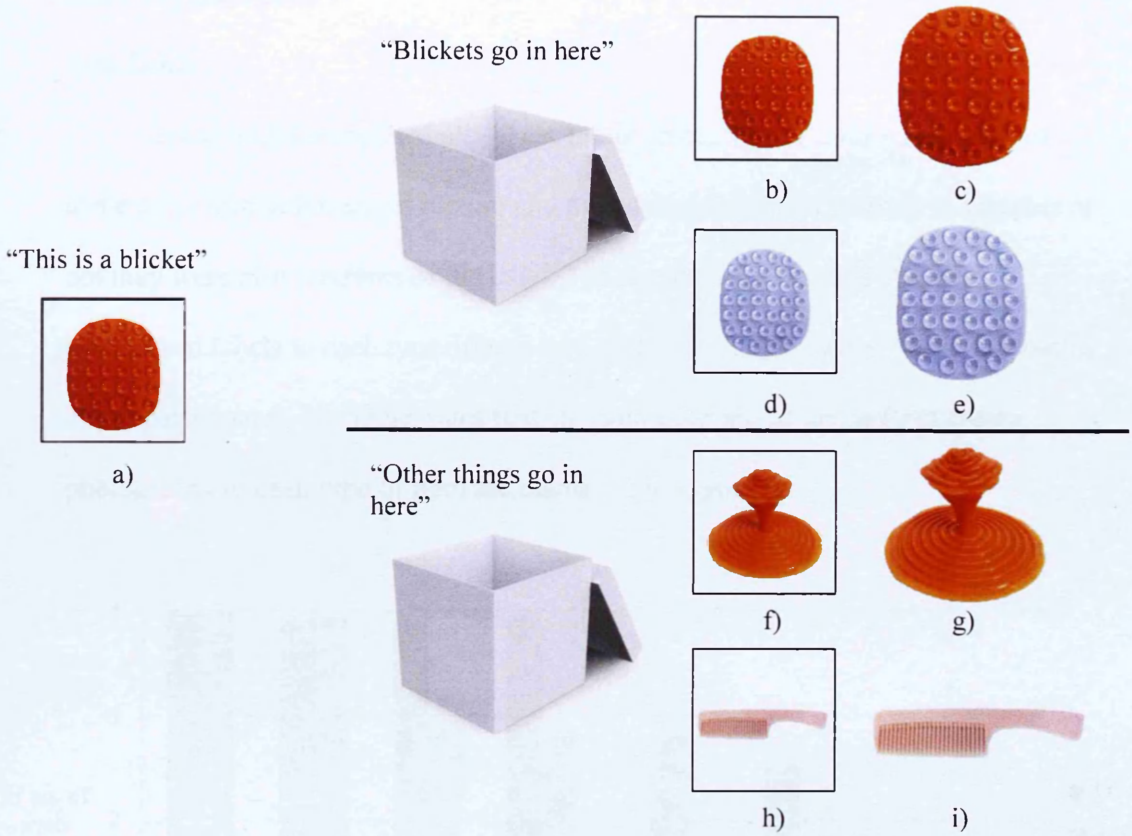

Figure 6. Illustration of Test Trial procedure and stimuli: target picture (a), copy of target picture (b), target object (c), novel picture (d), novel object (e), distracter picture (f), distracter object (g), familiar picture (h) and familiar object (i).

3.1.2 Results

Training Trials

All children passed both Training Trials by placing all of the named items in one box and all of the non-named items in the other box. All TD children passed both Training Trials at their first attempt. Thirteen children with ASD passed both Training Trials at their first attempt, two required two attempts to pass Training Trial 1, one required two attempts to pass Training Trial 2, and one required two attempts to pass both Training Trials.

Test Trials

Every child completed all 4 Test Trials. In each trial, children learned the name of an unfamiliar target picture and then sorted 8 items according to whether or not they were also referents of the label. The number of times that children generalised labels to each type of item was calculated, yielding 8 scores (each out of 4) per participant. The mean rates that children generalised labels from colour photographs to each type of item are displayed in Figure 7.

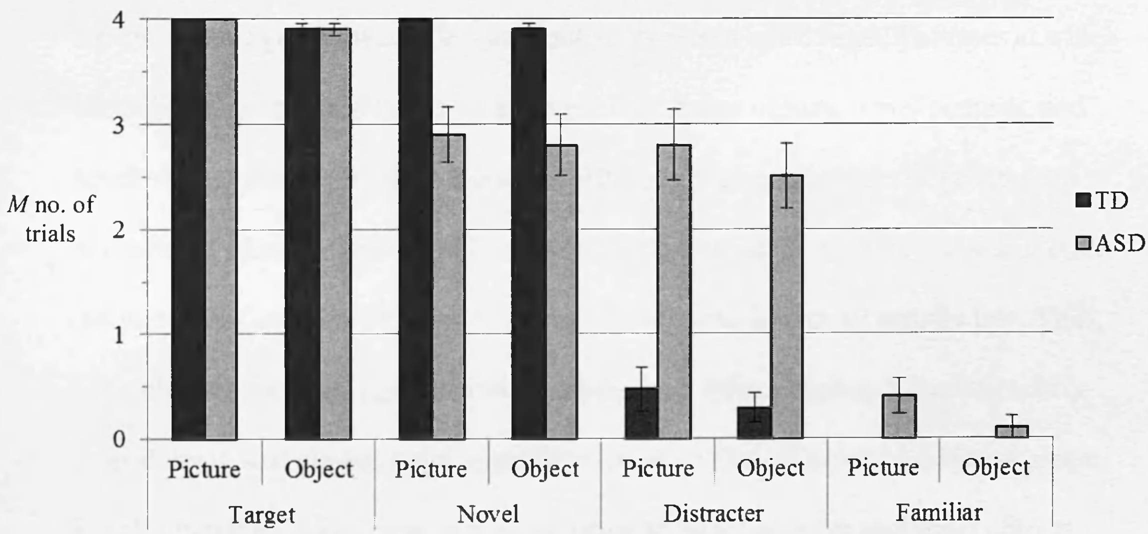

Figure 7. Mean number of trials (out of 4) that children with autism (ASD) and typically developing children (TD) generalised labels from target pictures to each item type in Experiment 3. Bars represent standard error of the mean.

These data were entered into a 2(Group) x 8(Item) repeated measures ANOVA. Main effects of Group, $F(1, 32) = 13.86$, $MSE = .59$, $p = .001$, $\eta p^2 = .3$, and Item, $F(1.89, 60.31) = 180.62$, $MSE = 1.87$, $p < .001$, $\eta p^2 = .85$,were qualified by a significant Group x Item interaction, $F(1.89, 60.31) = 28.24$, $MSE = 1.87$, $p < .001$, $\eta p^2 = .47$ (please note that all of the following pairwise comparisons were subjected to the Bonferroni correction). Between-group comparisons for each item showed that TD children and children with ASD generalised labels to target pictures and target objects at equal rates, TD children generalised labels to novel pictures, $F(1, 32) = 16.1$, $p < .001$, and novel objects, $F(1, 32) = 15.69$, $p < .001$, significantly more frequently than children with ASD, children with ASD generalised labels to distracter pictures, $F(1, 32) = 33.07$, $p < .001$, and distracter objects, $F(1, 32) = 40.56$, $p < .001$, significantly more frequently than TD children, children with ASD generalised labels to familiar pictures significantly more frequently than TD children, $F(1, 32) = 5.68$, $p = .023$, and the two groups generalised labels to familiar objects at equal rates. The rates at which TD children generalised labels to target pictures, target objects, novel pictures, and novel objects were equivalent and all significantly higher than rates of generalisation to distracter pictures (all *p*s < .001), distracter objects (all *p*s < .001), familiar pictures (all *p*s < .001) and familiar objects (all *p*s < .001), which were all equally low. Thus, TD children almost always generalised labels from colour photographs to similarly-shaped items, and almost never generalised to items that possessed a different shape. For children with ASD, rates of generalisation to target pictures and target objects were equivalent and significantly higher than rates for almost every other item (*p*s = .001–.08; the difference between rates for target objects and novel pictures bordered on significance). Children with ASD generalised labels to novel pictures, novel objects, distracter pictures and distracter objects at statistically equivalent rates, that were all significantly above-chance (*t*s = 2.06–3.57, *p*s = .003-.056; rate of generalisation to the distracter object was borderline), and significantly greater than rates of generalisation to familiar pictures and familiar objects (all *p*s < .001), which were both equally low. Overall, children with ASD almost always generalised labels from pictures to items that matched depicted objects on shape *and* colour, but they also extend labels at above-chance rates to shape-matched items (novel pictures/object) *and* colour-matched items (distracter pictures/objects), suggesting that both perceptual cues directed their extension of words from photographs. As the ASD sample only consisted of males, two follow-up analyses were conducted to rule out a possible effect of Gender. Firstly, the data from the TD children were entered into a 2(Gender) x 8(Item) mixed ANOVA, which showed that Gender had no influence on their generalisation of word-picture relations. Secondly, I reran the between-groups analyses including only the male TD children ($n = 6$). Exclusion of the female TD children yielded exactly the same Group x Item interaction and simple main effects as the primary analyses.

For TD children, generalisation rates did not correlate with chronological age, receptive language ability or nonverbal intellectual ability. This is unsurprising given that the whole group demonstrated the same general response pattern. For children with ASD, generalisation rates did not correlate with chronological age, nonverbal intellectual ability or years of PECS training. Generalisation to novel objects positively correlated with receptive language ($r = .57, p = .02$), and generalisation to distracter pictures negatively correlated with receptive language ($r = -.53, p = .03$). Also, there were significant correlations between CARS score and generalisation to novel pictures ($r = -.62, p = .008$) and novel objects ($r = -.77, p < .001$). These correlations suggest that children with more severe autism were less likely to generalise labels from photographs based on sameness of shape, without sameness of colour.

3.1.3 Discussion

This study investigated the cues that direct the generalisation of words from colour photographs by low-functioning children with ASD and language-matched TD children. Participants were taught novel words paired with photographs of unfamiliar target objects, and were required to sort a series of items according to whether or not they were also referents of the newly-learned labels. Children with ASD almost always extended labels to items that matched depicted objects on shape and colour, but also frequently generalised to items that matched on only shape *or* colour. By contrast, TD children only generalised labels to pictures and objects that matched the depicted referent's shape. These findings suggest that low-functioning children with ASD understand that words paired with colour photographs relate to independently existing referents, however, they often generalise based on incorrect dimensions (i.e. colour). This atypical pattern of responding indicates a fundamental misunderstanding of the rules that govern symbolic word-picture-object relations.

The finding that children with ASD frequently generalised labels from colour photographs was somewhat surprising, given that Preissler (2008) and Hartley and Allen (Experiment 1; in press (a)) reported that children with ASD often form associative word-picture relations. It is likely that the higher rate of generalisation in this study was elicited by differences in the present word learning procedure. In both previous studies, children were required to actively pair words and target pictures over a minimum of 5 consecutive training trials, and were directly reinforced for doing so. This repeated and reinforced pairing may have narrowed the referential relation to the extent that the picture itself (rather than the depicted object) was considered the referent of the word. Indeed, in a second experiment, Hartley and Allen showed that children with ASD tend to categorise pictures with their referents when word-referent relations are not reinforced (however, unlike TD children, children with ASD do require multiple pairings in order to map word-picture relations). I contend that the procedure in the present study was sufficient to foster learning of non-associative word-picture relations; children heard labels paired with target pictures multiple times, however, the relation was not narrowed through repeated reinforcement, enabling children with ASD to generalise.

Although children with ASD in this study extended labels from photographs to objects, they generalised based on both shape and colour at above-chance rates. Therefore, this low-functioning population did not display a shape bias; they utilised colour, a category-irrelevant cue, as a basis for naming just as frequently as shape, a category-defining cue. This atypical response pattern clearly indicates that children with ASD have significant difficulty organising new word-referent concepts around shape. Visual processing in children with ASD tends to be localised and feature-based (e.g. Mottron et al., 2006), and I argue that their failure to selectively attend to global shape when learning object names may subsequently impact on their ability to categorise via the abstraction of shape-based prototypes. Weak central coherence may prevent children with ASD from identifying similarity of global shape as the perceptual constraint that organises word-referent categories, thus inhibiting the development of a shape bias word learning heuristic. Consequently, in my sorting task, low-functioning children with ASD may have categorised pictures based on two separate parts – shape and colour – without deriving meaning from the sum of the information or global whole. This informs our understanding of *how* new concept formation in autism and typical development might differ. When TD children learn a novel word-picture relation, they generate a minimalist representation of the depicted referent's shape, which provides a basis for comparison when deciding if additional objects belong to the same category and thus receive the same label. By contrast, children with ASD do not selectively abstract global shape and may instead generate mental representations that are characterised by multiple, equally-weighted, perceptual details (e.g. shape and colour) that serve as independent bases for label extension.

Generalisation to novel category members (shape-matched items) was negatively correlated with CARS score, suggesting that children with more severe autism were less likely to generalise labels from photographs based on similarity of shape. As nonverbal intellectual ability did not correlate with generalisation rates for any items, we can conclude that this effect was not an artefact of higher cognitive ability in children with lower CARS scores. It is possible that those children with the most severe autism experience the greatest difficulty recognising sameness of shape when categorising novel objects that differ in colour and, for these children, colour may be the most pertinent cue when establishing new word-referent concepts (see Hartley & Allen, in press (a)). Receptive language also positively correlated with generalisation to novel objects, and negatively correlated with generalisation to distracter pictures. Although previous research suggests that the shape bias is directly related to language development in young TD children (e.g. Tek et al., 2008), it is difficult to draw a similar conclusion here given that receptive language did not correlate with generalisation to novel pictures or distracter objects.

At an applied level, this study provides further evidence that iconic colour pictures facilitate the generalisation of words to objects in children with ASD (also see Hartley & Allen, in press (a)). As such, it could be beneficial to deliver picture-based interventions, such as PECS, using iconic colour pictures in order to maximise the probability that recipients map referential word-picture-object relations. However, given that low-functioning children with ASD have difficulty abstracting shape as the key constraint underlying word-referent relations, it is possible that their categorisation is rule-based. Due to impairments in prototype formation (Klinger & Dawson, 2001), it may be that children with ASD require multiple experiences with a variety of category members in order to generate hypotheses that correctly define category membership. As such, it may be beneficial to deliver picture-based interventions using differently-coloured depictions of objects in order to increase the likelihood that children with ASD recognise that shape, rather than colour, defines category membership. The benefits of such training would be an interesting topic for future research.

The failure of children with ASD to demonstrate a shape bias when generalising labels from photographs cannot be attributed to insufficient language development, as all children had a receptive language age of at least 2-years – the age at which the shape bias typically emerges. Furthermore, Tek and colleagues (2008) showed that the absence of a shape bias in autism is not related to general word learning deficits, inadequate vocabulary size, or the inability to notice similarity of shape among visual stimuli. Indeed, Hartley and Allen (in press (a)) showed that low-functioning children with ASD are good at matching even black-and-white line drawings with similarly-shaped objects regardless of labelling. Thus, it appears that low-functioning children with ASD have specific difficulty identifying shape as the primary cue that directs the mapping of categorical word-picture-object relations. Naturally, I must caution against generalising these results to high-functioning children or adults with autism. However, it is important to state that the children who participated in this study were representative of the population that this research is most relevant to: low-functioning individuals with impaired language development who receive and benefit from picture-based communication interventions.

In summary, this study has shown that low-functioning children with ASD form referential relations between words and colour photographs, however, they do not evidence a shape bias when generalising labels to real objects. I propose that deficits in categorisation and prototype formation (e.g. Klinger & Dawson, 2001) may prevent children with ASD from privileging shape as a basis for generalising word-picture relations. Consequently, they are just as likely to incorrectly extend labels to objects that match depicted referents on colour (but not shape). Conversely, language-matched TD children only generalise labels to objects that belong to the same category as depicted objects, as indicated by sameness of shape, rather than sameness of colour. Thus, this study is the first to demonstrate that different cues constrain the mapping of novel word-picture-object relations for TD children and children with ASD.

Chapter Four: **The effect of iconicity on the performance of low-functioning children with autism in a pictorial search task.**[7]

Some pictures are intended to inform viewers about specific objects, people and events in the world (they are *contextualised*). The ability to utilise these pictures requires the understanding that visual representations correspond to specific elements of reality, even if they are absent at the time of viewing. Through infancy and early childhood, typically developing (TD) children learn what pictures are and how they relate to real world referents (Callaghan, 2000, 2008; Callaghan et al., 2011; DeLoache & Burns, 1994; Ganea et al., 2008, Preissler & Carey, 2004; Suddendorf, 2003). During this developmental period, children's success at using pictures as a source of information is contingent on several mediating factors, including iconicity (Ganea et al., 2008; Simcock & DeLoache, 2006), linguistic scaffolding (Callaghan, 2000) and the ability to infer referential intentions (Callaghan & Rankin, 2002; Preissler & Bloom, 2008; Salsa & Peralta de Mendoza, 2007). For many low-functioning children with Autism Spectrum Disorder (ASD), pictures provide an alternative form of functional communication in the absence of verbal language (Anderson et al., 2007; Lord, Risi & Pickles, 2004; Volkmar, Lord, Bailey, Schultz & Klin, 2004). However, despite the popularity of picture-based communication interventions, such as the Picture Exchange Communication System (PECS; Frost & Bondy, 2002), little research has investigated the ability of children with ASD to contextualise symbolic information communicated by pictures.

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[7] Based on Hartley, C., & Allen, M. (revisions under review). Iconicity influences how effectively children with autism use pictures as symbols in a search task. *Journal of Experimental Child Psychology*.

Pictures are unique in that they are both symbolic representations of independently-existing referents and 3-D objects in their own right (Sigel, 1978). With experience, children develop an increasingly nuanced concept of how pictures are both similar and different from their referents, and how these qualities should guide their behaviour towards pictures (DeLoache & Burns, 1994; DeLoache et al., 1998). Once acquired, it is thought that the 'Picture' concept activates automatically whenever a picture is encountered, triggering the formation of a 'dual representation' (a mental representation of both the symbolised referent and the picture's status as an independent concrete object). For example, if we see a picture of a flower, the corresponding dual-representation would consist of 'Picture' and 'Flower'. Recognition of the flower's perceptual properties activates the mental representation corresponding to 'Flower' (including the associated semantic information and verbal label), but the 'Picture' tag inhibits the activation of information relating to the physical interactive properties of 'Flower'. Thus, the 'Picture' concept serves to prevent direct physical action by *decontextualising* the mental representation elicited by the referential content of the picture (DeLoache & Burns, 1994).

The decontextualizing component of the 'Picture' concept serves to prevent one's mental representation of a picture from merging with their representation of reality (Leslie, 1987). However, some pictures are intended to communicate information that directly relates to specific realities. In their classic study, DeLoache and Burns (1994) investigated the ability of 24- and 30-month-old TD children to contextualise pictorial symbols. In their task, an experimenter concealed a toy in one of several hiding places in a room, and then communicated the location of the toy by showing children a picture of the toy in its hiding place. Children were then allowed to enter the room and search for the toy. Crucially, children never saw the depicted room and the real room concurrently – they had to rely on their internal representation of the picture to guide their searching, and update their internal representation to accommodate changes in hiding location.

In their first experiment, DeLoache and Burns (1994) found that the performance of 24- and 30-month-old TD children differed; the older children searched the correct location first-time in 72% of trials, while the younger children's rate of errorless retrieval was just 13%. These contrasting success rates suggest that TD children aged 24-months failed to represent any relation between the depicted room and the real room, whereas children just 6 months older were competent at using the picture to guide their actions in reality. Moreover, the errorless retrieval rate of 24-month-olds could not be significantly improved through facilitatory procedural adjustments (e.g. observing the experimenter create photographs of hiding locations using a Polaroid camera prior to searching). DeLoache and Burns (1994) claim that 24-month-old TD children fail in the search task because they have yet to learn that pictures can be contextualised. Despite explicit instructions and demonstrations suggesting that the pictures of hiding locations should be contextualised, their mental representations maintained their rigid decontextualized status. Consequently, these young children viewed the pictures as if they were non-informative depictions of a random or generic room, rather than highly-informative representations of the specific room they were required to search.

However, Suddendorf (2003) proposed that poor performance on the search task could be explained by children's inability to suppress a mental representation of a picture that was formed on a previous trial. Indeed, the most frequent mistake made by 24-month-olds was exploring the hiding place that was correct on the immediately preceding trial (a 'perseveration error'; DeLoache & Burns, 1994). In one experiment, Suddendorf (2003) found that nearly 60% of 24-month-old TD children searched the correct location on the first trial of the search task, but their mean errorless retrieval rate dropped below-chance across 4 trials, with 2 thirds of all errors due to perseveration. In another experiment that cleverly mimicked first-trial conditions in all 4 trials (each trial involved a different toy, a different room, and a different set of hiding locations), 24-month-olds' overall errorless retrieval rate significantly exceeded chance. Thus, in conditions that preclude proactive interference from prior representations, even 24-month-olds can contextualise symbolic information communicated by photographs. Furthermore, it is important that contemporary studies employing search task paradigms are designed to minimise perseverative responding, which may be particularly prevalent in children with ASD (e.g. Shu et al., 2001).

Before approximately 3-years of age, children's ability to contextualise pictures is heavily influenced by several independent factors. One factor is iconicity, the perceptual resemblance between a symbol and its referent. According to DeLoache (1995), "iconicity generally facilitates symbol use" (p. 111): higher levels of perceptual similarity between picture and referent make the symbolic relationship more salient, increasing the likelihood that the viewer will map the correspondence between the two and draw an inference from one to the other. Several studies have shown that symbolically-inexperienced children are increasingly likely to contextualise highly-iconic pictures (e.g. photographs) than less-iconic pictures (e.g. line drawings). For example, the degree that young TD children successfully imitate a sequence of actions following a picture-book reading interaction varies as a function of iconicity (Simcock & DeLoache, 2006) and typically developing 15-18-month-olds are more likely to generalise a label to an object depicted in a highly iconic photograph rather than a moderately iconic cartoon (Ganea et al., 2008).

Another influence on children's picture comprehension is language. Kirkham and colleagues' finding that language *predicted*, but was not *predicted by*, picture production and symbolic play suggests that linguistic symbols are mastered earlier in development and henceforth serve as a scaffolding base for other symbolic domains (Kirkham et al., 2012). Callaghan proposes that, through picture-book reading interactions, young TD children become increasingly adept at naming pictures without necessarily developing a conceptual understanding of how they relate to objects (Callaghan & Rankin, 2002). By labelling a picture, the child essentially substitutes the relatively unfamiliar graphic symbol with a familiar linguistic symbol that is easier to comprehend. Linguistic scaffolding of this nature can also bolster children's performance in experimental paradigms. For example, if a child in DeLoache's search task is shown a photograph of a chair, the child's recognition of the referent object may trigger the retrieval of the associated linguistic representation, 'chair', which can be held in mind while searching the room. The child might then recognise the referent of the memorised word and make an errorless retrieval, without being explicitly aware that the picture was intended to represent that location in the room. Thus, it may be that children's ability to contextualise pictorial information is initially supported by their linguistic system (Callaghan, 1999, 2000, 2008; Callaghan & Rankin, 2002).

Children's contextualisation of pictures is also mediated by their ability to infer their intended symbolic-communicative function from other picture-users (Salsa & Peralta de Mendoza, 2007). In a series of studies (see Peralta, Salsa, Maita & Mareovich, 2012), TD children aged 2.5-years completed an object retrieval task using a small furnished space and colour photographs depicting individual hiding places. Some children received complete instructions from the experimenter that highlighted both the individual picture-object correspondences *and* the intended symbolic function of the pictures, some received no instructions, and some received instructions that highlighted *either* the one-to-one picture-object correspondences *or* the pictures' intended function as a source of information about the hidden toy. It was shown that children achieved above-chance retrieval rates when the instructions highlighted the intended function of the pictures, and performed below-chance when this information was omitted. Therefore, young children's ability to contextualise symbolic information communicated by pictures is dependent on their ability to infer from others their intended function in a given situation.

Despite the prevalence of PECS in educational and clinical settings, and the ubiquitous use of pictures as communicative supports in classroom environments, no research to date has investigated the ability of low-functioning children with ASD to contextualise pictorial symbols using a search task paradigm. However, those studies that have investigated picture comprehension in children with ASD suggest that this population may have a fundamental difficulty understanding the symbolic nature of pictures (Allen, 2009; Hartley & Allen, in press (a); Preissler, 2008). For example, in Preissler (2008), low-functioning children with ASD were taught a novel word (e.g. "Whisk") repeatedly paired with a black-and-white line drawing of an unfamiliar object (e.g. a whisk). At test, children were asked to identify the referent of the newly-learned word when presented with the drawing and the previously unseen depicted object. In this paradigm, TD children aged 18-24 months almost always extend the label to the depicted object (Hartley & Allen, in press (a); Preissler & Carey, 2004), demonstrating their knowledge that pictures and words are symbolic. By contrast, children with ASD (especially PECS-users) displayed a strong tendency to select the picture alone, suggesting that they failed to understand that pictures represent specific 3-D referents.

At a theoretical level, there are several reasons why symbolic understanding of pictures may be impaired in low-functioning children with ASD. Research investigating the acquisition of pictorial understanding has shown that social-cognitive skills (e.g. intention reading and imitation) enable TD children to learn about pictures through interactions with symbolically-experienced adults (Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Callaghan et al., 2004; Rochat & Callaghan, 2005). However, many children with ASD show deficits in the social-cognitive skills that underlie pictorial development (Baron-Cohen, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996). Thus, if a low-functioning child with autism is unable to infer representational intentions from a social partner's communicative actions involving pictures, they may fail to learn that pictures are symbols for specific real-world objects. Additionally, because early picture comprehension is scaffolded by symbolic understanding of words (Callaghan, 2000; Kirkham et al., 2012), severe linguistic impairments (Anderson et al., 2007; Lord, Risi & Pickles, 2004) may also inhibit children with ASD from recognising referential relations between pictures and objects. Therefore, in the absence of intention-reading abilities and linguistic scaffolding, it may be that some low-functioning children with ASD can only relate pictures to objects in their environment by virtue of resemblance.

It is possible that picture-object mapping in some children with ASD is contingent on a high degree of iconicity. In line with this theory, Hartley and Allen (in press (a); see Chapter 2) recently found that low-functioning children with ASD were much more likely to generalise labels to objects depicted in highly-iconic colour pictures than less-iconic non-colour pictures. These findings implicate colour as an important influence on whether children with ASD comprehend symbolic picture-referent relations and extend labels to depicted objects. However, it is important to note that children in this study viewed pictures alongside the depicted objects, and perhaps this simultaneous viewing encouraged children to map referential picture-object relations. It is currently unknown whether iconicity facilitates picture comprehension in children with ASD when picture and referent are not viewed concurrently, and mapping is based on a mental representation of the picture. One might predict that children with ASD would be more successful at contextualising colour pictures in real life environments because the corresponding mental representations can be matched to potential referents based on two dimensions – shape and/or colour. By contrast, children with ASD might have difficulty contextualising non-colour pictures because the corresponding mental representations are defined only by shape, which may not be sufficient for children with ASD to map referential picture-object relations (Preissler, 2008). Evidence of this dichotomy would have important implications for PECS and other picture-based educational supports. There are many symbol sets designed for use with PECS that provide graphic representations of vocabulary (e.g. Blissymbols, Picsyms, Picture Communication Symbols), but the pictures within and between these sets vary considerably along the continuum of iconicity (Bloomberg et al., 1990; Mirenda & Locke, 1989). If the ability of children with ASD to contextualise mental representations of pictures is contingent on a high degree of iconicity, educators and therapists would have a data-grounded rationale for selecting highly iconic symbols for picture-based treatments.

The present study investigates the ability of low-functioning children with ASD to solve a search task by contextualising symbolic information communicated by pictures. Previous studies of picture comprehension in autism have examined how children learn word-picture relations and then generalise labels to objects that are viewed concurrently. Here, I employ a task that does not involve word learning, and children could not simultaneously view depicted and real hiding locations while searching – they had to generate a mental representation of the depicted hiding location and then identify the corresponding 3-D referent. In each trial, children were introduced to a small toy character who was said to enjoy hiding underneath things. A unique set of 4 occluders (various upturned buckets) were presented and the experimenter demonstrated the toy hiding under each one. Children were then shown 4 pictures, one representing each occluder, and the experimenter pointed out the one-to-one picture-referent correspondences *and* stated their intended function (information that is critical to children's understanding of the task; e.g. Salsa & Peralta de Mendoza, 2007). Participants then left the room and the toy was hidden underneath one of the occluders. Outside the room, the experimenter showed the child a picture of that occluder and the child was then allowed to search for the hidden toy. Stimuli were designed to minimise perseverative responding.

There were two independent variables: pictorial iconicity and familiarity of depicted referents. Children played the "hide and seek" game on 3 different days using colour photographs (matched referents on shape and colour), line drawings (matched referents only on shape) and 'abstract pictures' (matched referents only on colour). It was predicted that children with ASD would be most successful in colour photograph trials and perform poorly in line drawing trials. I also expected children with ASD to perform poorly in abstract picture trials as, in the absence of conventional shape-based resemblance, children needed to infer intended picture-referent relations from the communicative behaviour of the experimenter. Referent familiarity was manipulated in colour photograph and line drawing trials; in some trials the occluders were individuated by familiar nameable objects that were clearly visible in their pictures, and in other trials the occluders were individuated by unfamiliar unnameable objects.

If children with ASD explicitly employ language when decoding pictures, they would be expected to perform better on familiar than unfamiliar trials. Importantly, this study will shed light on the cues that mediate the ability of children with ASD to use pictures as a source of symbolic information about real-world referents and situations.

4.1 Experiment 4

4.1.1 Method

Participants

Participants were 16 low-functioning children with ASD (all male; *M* age = 9.9 years, range = 4.1–16.1 years) and 16 TD children (6 males, 11 females; *M* age = 3.6 years, range: 2.2–6.4 years). Children with ASD were recruited from a specialist school in Preston, United Kingdom. TD children were recruited from primary schools, nurseries and preschools in Kendal, United Kingdom. All children with ASD received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord et al., 2002; Lord et al., 1994) and expert judgment. Diagnosis was confirmed using the CARS (Schopler et al., 1980), which was completed by a class teacher (*M* score: 40.66, range: 31.5–51.5). Groups were matched on receptive vocabulary as measured by the British Picture Vocabulary Scale (BPVS; Dunn et al., 1997).[8] Mean receptive vocabulary of children with ASD was 3.6-years (range: 2–6.2 years) and mean receptive vocabulary of TD children was 3.6-years (range: 2–5.4 years). In addition, the nonverbal intellectual abilities of each

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[8] The BPVS scores of 3 children with ASD and 2 TD children were marginally below the lowest raw score with a standardised age equivalent (of 2.3 years). Consequently, we conservatively assigned these 5 children a receptive language ability of exactly 2 years. Although it would have been desirable to ascertain a standardised language score for every child with autism, it is important to note that this research is particularly relevant to individuals with language impairments who have difficulty with standardised assessments, display challenging behaviours and use pictures to facilitate communication.

group were measured using the Leiter-R (Roid & Miller, 1997), a nonverbal measure of IQ that is specifically designed and normed for use with linguistically impaired individuals. The mean IQ of children with ASD was 57.5 (range: 36–95), indicating impairments in nonverbal intellectual development and confirming the low-functioning status of the sample. However, the nonverbal performance of TD children and children with ASD at the time of testing, as indicated by participants' raw scores, was not significantly different, $t(30) = -.79, p = .44$.

All children with ASD were current PECS-users with impaired expressive language skills. The language abilities of children within the sample varied somewhat, as is expected in a low-functioning population. Seven children with autism were functionally non-verbal (no spoken words), 6 had some words and produced utterances of 1-3 words in length (however, echolalia accounted for many utterances in this group) and 3 could speak some short phrases over 4 words in length. Thus, the sample was linguistically representative of children with autism who receive and benefit from picture-based communication interventions. Participants' experience using PECS varied between 5 months and 10 years. Their progress through the programme ranged from Stage 1 to fully-trained user (see Frost & Bondy, 2002). The pictures used by participants to communicate varied on an individual basis, with coloured drawings/symbols and black-and-white drawings/symbols being the most common. Several children used a mixture of picture types that varied in iconicity and only four children in the sample used "some" colour photographs. A number of children acquired spoken words through the use of PECS. Pictures scaffolded the spoken language of the 3 children who produced longer utterances (4+ words), particularly when learning new concepts and during communication therapy sessions.

Materials

The stimuli were small toy figures, sets of plastic occluders and pictorial representations of those occluders varying in iconicity. There were 4 toy figures that resembled familiar characters from children's media (Buzz Lightyear, Scooby Doo, Thomas the Tank Engine, Mickey Mouse). Each toy figure was approximately 6cm tall and could be hidden easily under each type of occluder.

The construction of the occluders was informed by evidence that children's tendency to perseverate can disguise their true ability to comprehend symbolic picture-referent relations (Suddendorf, 2003) and that children's early understanding of pictures is scaffolded by their use of linguistic representations (Callaghan, 2000). The 16 occluders were made from different types of upturned containers (see Fig. 8). Four occluders were made from cube-shaped boxes (12cm tall, 12cm wide), four were made from sandcastle buckets (14cm tall, 15cm wide), four were made from jelly moulds (9.5cm tall, 15.5cm wide) and four were made from large plastic drinking goblets (18cm tall, 9cm wide). The four occluders made from the same type of container were grouped together in a set. Thus, there were 4 sets of occluders; the occluders within each set were all made from the same type of container (e.g. four jelly moulds), but the sets of occluders were markedly different from each other, reducing the likelihood of perseveration across trials. Furthermore, each of the 16 occluders was painted a unique colour using Plasti-kote spray paint. This modification meant that occluders within each set could be discriminated on colour, enabling the inclusion of an 'Abstract Picture' condition in which colour was the only cue to intended picture-referent mappings.

In order to assess the impact of iconicity via a black-and-white 'Line Drawing' condition, the shape of occluders had to be modified so that hiding locations in the same trial could be discriminated in the absence of colour. This was achieved by attaching a unique individuating object to the top of each occluder (see Fig. 8). Eight of the individuating objects were highly familiar (plastic apple, toy baby bottle, toy plane, soft toy dog, baby book, toy car, rubber duck, miniature chair), and were selected on the basis that the majority of children understand their linguistic labels by 15-months (Fensen, Dale, Reznick, Bates, Thal & Pethick, 1994). These 8 familiar individuating objects were divided into two groups of 4, and each group was attached to a set of occluders (sandcastle buckets and boxes). The other eight individuating objects were very unfamiliar, and were selected on the basis that no children in the samples tested would know their linguistic labels. These 8 unfamiliar individuating objects were also divided into two groups of 4, and each group was attached to a set of occluders (jelly moulds and goblets). By comparing performance on trials involving occluders topped with familiar nameable objects versus unfamiliar unnameable objects, it could be determined whether access to a linguistic representation is necessary for picture comprehension in low-functioning children with ASD. Individuating objects were a different colour from the occluder they were attached to, and objects in the same set were all different colours. Individuating objects were glued to small metal disks and attached to occluders using self-adhesive Velcro, allowing them to be removed for Abstract Picture trials. The mean height of each occluder set, including their individuating objects, was as follows: 19cm for the food boxes, 22cm for the sandcastle buckets, 17cm for the jelly moulds and 16cm for the goblets.

Figure 8. Occluders used in Experiment 4; a-d) Set 1 (familiar individuating objects), e-h) Set 2 (familiar individuating objects), i-l) Set 3 (unfamiliar individuating objects), m-p) Set 4 (unfamiliar individuating objects).

By attaching different individuating objects, hiding locations made from the same type of container could be discriminated on the basis of shape in black-and-white line drawings. Also, their addition meant that each possible hiding location was unique, and that the appearances of hiding locations in different trials varied on 3 dimensions (shape of occluder, colour of occluder, and individuating object). By removing similarities between occluders in different trials, the likelihood of children perseverating was reduced and the probability that they would successfully map new picture-referent relations was increased (Suddendorf, 2003). When not in use, the sets of occluders were kept out of view in opaque storage boxes.

Three pictures of each occluder were created. One picture was a colour photograph, one picture was a black-and-white line drawing and one picture was an abstract representation that only resembled its referent on the basis of colour (see Fig. 9). Colour photographs were taken of each occluder with a 9.2 megapixel camera and edited using Adobe Photoshop. The black-and-white line drawings were created using a black 'finewriter' pen and white paper. Digital copies of each drawing were created and their sizes were adjusted to match their photograph counterparts. The dimensions of the photographs and line drawings varied slightly according to the different dimensions of the occluders with their unique individuating objects attached (heights ranged from 8 to 10.5cm and widths ranged from 5.5cm to 6.5cm). Crucially, pictures of occluders in the same set were exactly the same scale (they only varied on height: taller occluders had taller pictures than shorter occluders) and all pictures were large enough to clearly perceive the details of individuating objects. The abstract pictures were created in Microsoft PowerPoint by generating 16 'cloud shapes' and colouring them to match the 16 occluders. Thus, for every occluder, there was an abstract cloud picture that was exactly the same colour. The abstract pictures were 6cm tall and 6.5cm wide. To avoid confusion, the individuating objects (which contrasted in colour with their respective occluders) were removed in the abstract condition. All pictures were printed by the same high-quality laser printer, cut out, and laminated.

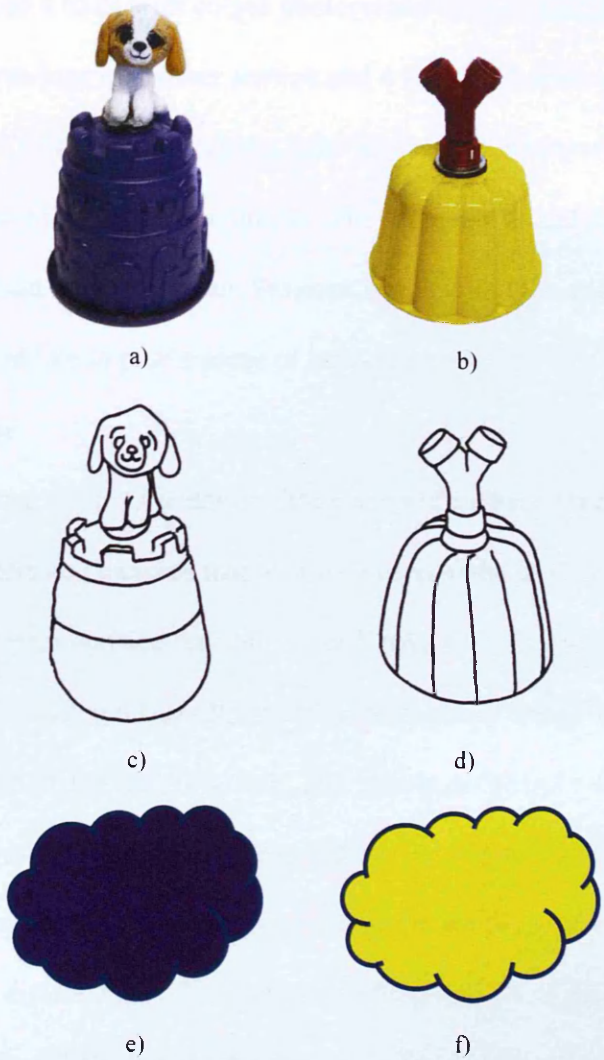

Figure 9. Example pictorial stimuli used in Experiment 4; a and b) colour photographs, c and d) black-and-white line drawings, e and f) abstract colour pictures.

Procedure

Participants were tested individually on three different days (approximately 1 week apart) in their own schools and were always accompanied by a familiar adult. Children were reinforced throughout each session for attention and good behaviour. Sessions comprised of 4 trials and each trial consisted of an Orientation Stage and a Test Stage. Participants received one level of Iconicity in each session. In other words, children completed 4 trials with colour photographs in one session, 4 trials with black-and-white line drawings in another session and 4 trials with abstract colour pictures in another session. The order in which the three levels of Iconicity were administered was counterbalanced between participants. The same 4 toys and the same 4 sets of occluders were used in each session. Sessions began with the experimenter asking the child if they would like to play a game of hide-and-seek.

Orientation Stage

The purpose of the Orientation Stage was to familiarise the child with the toy character, occluders and pictures that would be used in the trial. At the start of the trial, the experimenter showed the child a small toy character and began to explain the task (e.g. "This is Buzz and Buzz likes to hide underneath things"). A different toy character was used in each of the 4 trials, and their order of use was randomly determined. The experimenter then presented one set of 4 occluders in a line in front of the child and explained their role (e.g. "These are the things that Buzz likes to hide underneath."). A different set of occluders was used in each of the 4 trials. In the colour photograph and black-and-white line drawing conditions, two sets of occluders were topped with familiar nameable objects and two sets were topped with unfamiliar unnameable objects. In the abstract picture condition, the individuating objects were removed from the tops of the occluders. The occluder sets were presented in a different order in each session, and the relative position of the occluders within each set was randomly determined. The experimenter then demonstrated the toy hiding under each occluder from left-to-right or right-to-left (counterbalanced across trials) (e.g. "See, Buzz might hide under here. Or he might hide under here. Or, he might hide under here. Or, he might hide under here"). Next, the experimenter presented the pictures of the occluders. Each picture was positioned in front of its respective occluder and the child's attention was drawn to each picture-referent relation from left-to-right or right-to-left (opposite direction to the hiding demonstration). The experimenter explicitly stated that the pictures were intended to help the child solve the task (e.g. "Now look at these pictures! These are pictures of where Buzz likes to hide. See, this one looks like this. And this one looks like this. This one looks like this. And this one looks like this. The pictures will show you where to look for Buzz when he hides!"). The Orientation Stage ended at this point and transitioned to the Test Stage.

Test Stage

The Test Stage began with the experimenter leading the participant and their familiar adult a short distance away from the testing location so that the occluders were not visible to them (e.g. "Ok, let's play hide-and-seek with Buzz! First we need to let Buzz hide…"). The experimenter then explained that they would leave momentarily to hide the toy, and that the child could search for the toy once they got back (e.g. "I'm going to help Buzz hide underneath something, and when I come back, you can go find him!"). The experimenter returned to the test array and positioned the toy underneath one of the occluders in the array. As the occluders were positioned in a line, the toy could be hidden in one of the following locations: far left, middle left, middle right, far right. The toy was hidden at a different location on each of the 4 trials in a session. The order of hiding locations was randomised before each session. The experimenter then returned to the child with the picture that represented the hiding location, showed the child the picture and informed them that the toy was hiding there (e.g. "This is where Buzz is hiding [pointing to picture]. Can you find Buzz here?"). The pictures depicting the three other occluders were hidden before the child began their search. If the participant failed to find the toy on their first search, the experimenter provided a prompt (e.g. "Remember, Buzz is hiding in the same place as I pointed in the picture."). If they searched unsuccessfully again, the experimenter offered more explicit cues until the toy was discovered. Upon finding the toy, the experimenter offered positive verbal reinforcement. The occluders and toy character were removed from view and the four pictures of the occluders in that trial were presented in a line in front of the child. As a memory control, the child was asked to identify the picture they had been shown in isolation (e.g. "Which picture did I show you?"). If a child failed to find the toy on their first search and also failed to identify the correct picture, this would suggest their error was caused by poor memory rather than a lack of symbolic understanding. This memory control question was asked at the end of every trial, regardless of whether the child found the toy on their first search.

Following the memory control, the experimenter administered the next trial. The Orientation Stage and Test Stage, as described above, were repeated for each trial until all 4 trials in the session were completed.

4.1.2 Results

The number of errorless retrievals (out of 4) made by children in each Iconicity condition was calculated. A response was coded as an errorless retrieval if the child's first search was in the correct location and was unprompted. Incorrect responses were coded as either a perseveration error (searching the location that had served as the hiding place on the immediately preceding trial) or a non-perseveration error (searching an incorrect location that was not the hiding place on the immediately preceding trial). For ease of interpretation, the descriptive statistics are presented in subsections corresponding to the three levels of Iconicity.

Colour Photographs

Children with ASD made errorless retrievals on 72% of Familiar trials (M = 1.44, SD = 0.81), and 75% of Unfamiliar trials (M = 1.5, SD = 0.63). Examination of error data showed that 23.5% and 76.5% of errors made by children with ASD were perseverative and non-perseverative respectively. TD children made errorless retrievals on 84.5% of Familiar trials (M = 1.69, SD = 0.6) and 78% of Unfamiliar trials (M = 1.56, SD = 0.81). Of all errors made by TD children, 33.3% were perseverative and 66.7% were non-perseverative.

Line Drawings

Children with ASD made errorless retrievals on 65% of Familiar trials (M = 1.31, SD = 0.79) and 50% of Unfamiliar trials (M = 1, SD = 0.89). In this condition, 27.6% of errors made by children with ASD were perseverative and 72.4% were non-perseverative. TD children made errorless retrievals on 62.5% of Familiar trials (M = 1.25, SD = 0.93) and 59.5% of Unfamiliar trials (M = 1.19, SD = 0.98). Error data showed that 24% of errors made by TD children were perseverative, and 76% were non-perseverative.

Abstract Pictures

Children with ASD made errorless retrievals on 62.5% of trials (M = 2.5, SD = 1.4) – trials did not vary on Familiarity as the individuating items were removed from the tops of occluders. Only 16.7% of errors made by children with ASD were perseverative, and 83.3% were non-perseverative. TD children made errorless retrievals on 67.3% of trials (M = 2.69, SD = 1.25). Just 23.8% of errors made by TD children were perseverative and 76.2% were non-perseverative.

The first analyses examine the effect of Iconicity in isolation. The Familiar and Unfamiliar trials in the Colour Photograph and Line Drawing conditions were collapsed, and entered into the analysis with the Abstract Picture data (see Fig. 10 for mean rates of errorless retrievals). A 2(Group: ASD, TD) x 3(Iconicity: Colour Photograph, Line Drawing, Abstract Picture) mixed ANOVA was conducted, which revealed a significant main effect of Iconicity, $F(2, 60) = 12.93$, $MSE = 0.39$, $p < .001$, $\eta p^2 = .3$. Pairwise comparisons subjected to the Bonferroni correction showed that both groups made significantly more errorless retrievals in Colour Photograph trials than in Line Drawing Trials ($p < .001$) and Abstract Picture trials ($p = .003$), which were not statistically different from each other. There was no effect of Group and no interaction. Additionally, both groups performed significantly above-chance (1 errorless retrieval; alpha value corrected to .0083 to compensate for multiple comparisons) in Colour Photograph trials (ASD: $t(15) = 5.78$, $p < .001$, $d = 2.98$; TD: $t(15) = 6.71$, $p < .001$, $d = 3.47$), Line Drawing trials (ASD: $t(15) = 3.05$, $p = .008$, $d = 1.58$; TD: $t(15) = 3.36$, $p = .004$, $d = 1.74$) and Abstract Picture trials (ASD: $t(15) = 4.11$, $p = .001$, $d = 2.12$; TD: $t(15) = 5.4$, $p < .001$, $d = 2.79$). Thus, low-functioning children with ASD and TD children were able to contextualise all picture types, however, performance in both groups was facilitated by a high degree of Iconicity (i.e. they were most successful in Colour Photograph trials).

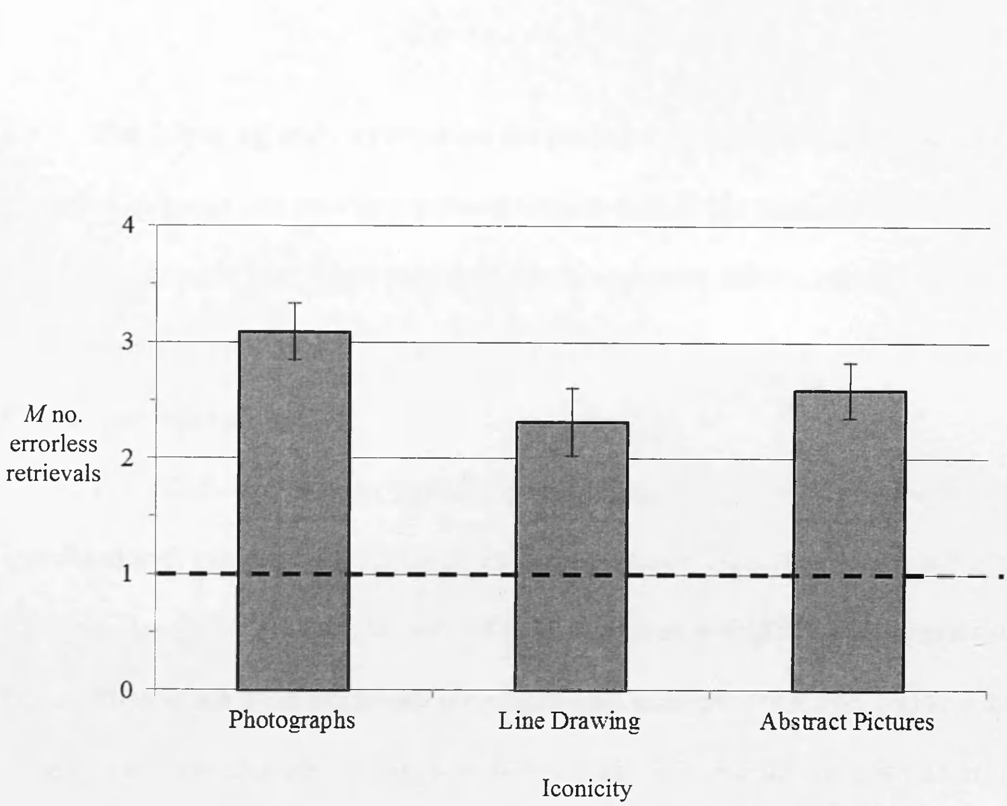

Figure 10. Mean errorless retrieval rates for each picture type in Experiment 4 (participant groups collapsed). Chance-level responding indicated by the dashed line and bars represent standard error of the mean.

The second analyses investigated whether Familiarity of depicted referents influenced children's ability to contextualise pictorial symbols. The data from Familiar and Unfamiliar trials in the Colour Photograph and Line Drawing trials were entered into a 2(Group: ASD, TD) x 2(Iconicity: Colour Photograph, Line Drawing) x 2(Familiarity: Familiar, Unfamiliar) mixed ANOVA. As above, there was a significant main effect of Iconicity, $F(1, 30) = 14.51$, $MSE = 0.29$, $p = .001$, $\eta p^2 = .33$, indicating that both groups made significantly more errorless retrievals in the Colour Photograph trials than Line Drawing trials. There was no effect of Familiarity and no interactions. Therefore, access to linguistic representations relating to the shapes of depicted referents had no influence on children's ability to contextualise pictorial symbols in the hide-and-seek task.

The following analyses examine the relationships between chronological age, receptive language and errorless retrieval rates in each of the Iconicity conditions. As the preceding ANOVAs failed to identify any populations differences, TD children and children with ASD were collapsed for the regressions to provide sufficient power.

Colour photographs

For TD children, chronological age and receptive language both positively correlated with performance in Colour Photograph trials (Age: $r(14) = .47, p = .066$; Receptive language: $r(14) = .51, p = .042$). For children with ASD, performance in Colour Photograph trials positively correlated with receptive language, ($r(14) = .69, p = .003$), and nonverbal ability, ($r(14) = .69, p = .003$). To establish which factor(s) significantly predicted errorless retrieval rates, chronological age, receptive language, nonverbal ability and group (TD, ASD) were entered as predictor variables into a stepwise regression. The analysis yielded a significant model containing only receptive language ability, $F(1, 30) = 17$, $MSE = 1.16$, $p < .001$, which accounted for 36% of variation in performance ($R^2 = .36$, Adjusted $R^2 = .34$).

Line Drawings

For TD children, chronological age, receptive language and nonverbal ability all positively correlated with performance in Line Drawing trials (Age: $r(14) = .68, p = .004$; Receptive language: $r(14) = .75, p = .001$; Nonverbal ability: $r(14) = .6, p = .013$). For children with ASD, receptive language and nonverbal ability both positively correlated with performance in Line Drawing trials (Receptive language: $r(14) = .69, p = .003$; Nonverbal ability: $r(14) = .64, p = .008$). As above, chronological age, receptive language, nonverbal ability and group (TD, ASD) were entered as predictor variables into a stepwise regression. The analysis produced a significant model containing only receptive language, $F(1, 30) = 30.93$, $MSE = 1.33$, p

< .001, which accounted for 51% of variation in performance (R^2 = .51 , Adjusted R^2 = .49).

Abstract Pictures

For TD children, chronological age, receptive language and nonverbal ability positively correlated with performance in Abstract Picture trials (Age: $r(14) = .8, p < .001$; Receptive language: $r(14) = .82, p < .001$; Nonverbal ability: $r(14) = .62, p = .01$). For children with ASD, receptive language, $r(14) = .74, p = .001$, and nonverbal ability, $r(14) = .58, p = .019$, both positively correlated with performance in Abstract Picture trials. Chronological age, receptive language, nonverbal ability and group (TD, ASD) were entered into a stepwise regression, which calculated a significant model containing only receptive language, $F(1, 30) = 44.4$, $MSE = 0.75$, $p < .001$, and accounted for 60% of variation in performance (R^2 = .6 , Adjusted R^2 = .58).

To summarise, the results of the preceding analyses clearly implicate both iconicity and receptive language as important mediators of children's ability to contextualise pictures. TD children and children with ASD with higher receptive language produced more errorless retrievals than their peers with low receptive language, and both groups also showed increased performance in the most iconic Colour Photograph trials.

The final analyses assess the relationship between task performance (success or failure on first search attempt) and memory check performance (remembered or forgotten target picture) across conditions. Children's responses to each trial were coded as belonging to one of the following 4 mutually exclusive categories. As the parametric analyses revealed no effect of Familiarity, trial types were collapsed for Colour Photograph and Line Drawing trials.

a) 'Trial correct, memory correct'– the child made an errorless retrieval (i.e. their first search was in the correct location and was unprompted) and selected the correct picture at the memory check. This response indicated that the child intentionally used the picture as a symbol to solve the task.

b) 'Trial incorrect, memory correct'– the child did not make an errorless retrieval, but selected the correct picture at the memory check. This response indicated that the child failed to use the picture as a symbol to solve the task, but could remember the picture they were shown.

c) 'Trial correct, memory incorrect'– the child made an errorless retrieval, but they did not select the correct picture at the memory check. This response suggests that the child made a correct search by chance as they could not remember the picture.

d) 'Trial incorrect, memory incorrect'– the child did not make an errorless retrieval and did not select the correct picture at the memory check. This response suggests that the child failed to form a mental representation of the picture which could be used as a symbolic source of information to solve the task.

Colour Photographs

Out of 64 trials (4 per participant), children with ASD made 43 'Trial correct, memory correct' responses (67.19%), 11 'Trial incorrect, memory correct' responses (17.19%), 4 'Trial correct, memory incorrect' responses (6.25%) and 6 'Trial incorrect, memory incorrect' responses (9.37%). By comparison, TD children made 52 'Trial correct, memory correct' responses (81.25%), 4 'Trial incorrect, memory correct' responses (6.25%), 0 'Trial correct, memory incorrect' responses and 8 'Trial incorrect, memory incorrect' responses (12.5%). A chi square test of independence showed that there was no relation between Group (ASD, TD) and frequency of 'Trial correct, memory correct' and 'Trial incorrect, memory incorrect' responses, providing further confirmation that both groups responded similarly in Colour Photograph trials.

Line Drawings

Out of 64 trials, children with ASD made 31 'Trial correct, memory correct' responses (48.44%), 10 'Trial incorrect, memory correct' responses (15.63%), 4 'Trial correct, memory incorrect' responses (6.25%) and 19 'Trial incorrect, memory incorrect' responses (29.68%). TD children made 39 'Trial correct, memory correct' responses (60.94%), 8 'Trial incorrect, memory correct' responses (12.5%), 0 'Trial correct, memory incorrect' responses and 17 'Trial incorrect, memory incorrect' responses (26.56%). A chi square test of independence showed that there was no relation between Group and frequency of 'Trial correct, memory correct' and 'Trial incorrect, memory incorrect' responses.

Abstract Pictures

Out of 64 trials, children with ASD made 36 'Trial correct, memory correct' responses (56.25%), 12 'Trial incorrect, memory correct' responses (18.75%), 3 'Trial correct, memory incorrect' responses (4.69%) and 13 'Trial incorrect, memory correct' responses (20.31%). TD children made 41 'Trial correct, memory correct' responses (64.06%), 8 'Trial incorrect, memory correct' responses (12.5%), 2 'Trial correct, memory incorrect' responses (3.13%) and 13 'Trial incorrect, memory incorrect' responses (20.31%). A chi square test of independence showed that there was no relation between Group and frequency of 'Trial correct, memory correct' and 'Trial incorrect, memory incorrect' responses.

4.1.3 Discussion

The present study investigated the ability of low-functioning children with ASD and language-matched TD children to contextualise pictorial symbols in a search task. A small toy character was concealed underneath one of four unique occluders that were individuated by familiar nameable objects or unfamiliar unnameable objects, and the hiding location was communicated to children via pictures that varied in iconicity. In order to solve this task, children needed to construct a meaningful "mental model" of the picture (Perner, 1991), recognise that the picture related to a current situation, and use the symbolic information to guide their actions in reality (DeLoache & Burns, 1994). The results revealed zero between-group differences; neither children with ASD nor TD children were influenced by referent Familiarity, and both groups' errorless retrieval rates were above-chance in all three Iconicity conditions. Performance was universally predicted by receptive language ability, and both groups displayed significantly greater success rates in the most-iconic Colour Photograph trials. Therefore, both low-functioning children with ASD and young TD children can contextualise mental representations of pictures and use them to adaptively guide their behaviour in real time and space. However, this ability is significantly influenced by receptive language development and the degree of perceptual similarity between picture and symbolised referent.

Importantly, this study has documented the first evidence that low-functioning children with ASD, who receive and benefit from PECS, can contextualise symbolic information communicated by pictures. These findings contrast somewhat with Preissler (2008) and Hartley and Allen (Experiment 1; in press (a)), who showed that children with ASD may have difficulty understanding the referential nature of pictures. However, these previous studies both employed tasks that involved teaching children word-picture relations, and then testing whether they would extend newly-learned labels to referent objects. In these paradigms, children with ASD tended to map associative word-picture relations and rarely generalised labels to depicted objects, suggesting that they failed to recognise the intended picture-referent relations. One reason why children with ASD may perform atypically in these tasks, but succeed in the search task, is that their difficulties in the pictorial domain relate primarily to *word*-picture-object mapping, rather than picture-object mapping *per se*. More specifically, due to impairments in their referential understanding of language (Baron-Cohen et al., 1997; Frith & Happé, 1994; Kanner, 1946; Preissler, 2008; Preissler & Carey, 2005), low-functioning children with ASD may not know intuitively *what* words relate to when paired with pictures. In support of this theory, there is growing evidence that children with ASD misunderstand the rules governing word-picture-object-relations; children with ASD map words onto pictures themselves (rather than depicted referents) when word-picture pairings are reinforced (Hartley & Allen, in press (a); Preissler, 2008), and in conditions that foster referential word learning, children with ASD are equally likely to map labels onto both the shape *and* colour of depicted objects (Hartley & Allen, in press (b)). However, in situations that do not involve word learning, such as the present search task and Experiment 2 of Hartley and Allen (in press (a)), children with ASD are able to perceive and correctly map picture-object relations.

Furthermore, these results demonstrate that greater iconicity facilitates picture comprehension in children with ASD and TD children when picture and referent are not viewed concurrently, and mapping is based on a mental representation of the depicted object. It is likely that errorless retrieval rates were highest in Colour Photograph trials because their corresponding mental representations could be matched to potential referents on two resemblance properties (shape and colour), whereas in Line Drawing and Abstract Picture trials they could only be matched to referents on one resemblance property (shape or colour respectively). Thus, the greater degree of picture-referent resemblance in Colour Photograph trials may have increased the salience of symbolic relations, leading to an improvement in children's ability to contextualise the depicted information. Interestingly, both groups performed equally in Abstract Picture trials and Line Drawing trials. I expected that the lack of shape-based resemblance in Abstract Picture trials would place increased pressure on children's ability to infer picture-referent relations from the experimenter's communicative intentions, leading to reduced performance in children with ASD. However, it is possible that their difficulties in intention-reading (e.g. Charman et al., 1997; Griffin, 2002; Mundy & Willoughby, 1996) were offset by their heightened attention to perceptual detail (Mottron et al., 1999; O'Riordan et al., 2001; Plaisted et al., 1998), which may have enabled them to map picture-referent relations based purely on colour. Additionally, it may be that sameness of colour plays a more fundamental role in referential picture-object mapping in children with ASD (see Hartley & Allen, in press (a), (b)).

The finding that low-functioning children with ASD were most successful at contextualising colour photographs has important implications for picture-based communication interventions. Currently, there are no data-grounded guidelines regarding what types of pictures are best suited for interventions such as PECS, and it not uncommon for children with ASD to receive training with relatively abstract black-and-white line drawings and symbols (see Participant information; also see Hartley & Allen, in press (a)). Although picture comprehension of children with ASD in the present study was not *contingent* on a high degree of iconicity, the associated benefit was statistically significant. Moreover, previous research has shown that iconic colour pictures promote the extension of verbal information to referent objects in children with ASD (Hartley & Allen, in press (a)). Thus, because iconic colour pictures facilitate both picture-object and word-picture-object mapping, there may be benefits to their use when implementing picture-based communication training with low-functioning children with ASD. Indeed, future training studies should directly assess whether iconic colour pictures facilitate symbolic understanding within the context of the PECS training programme.

Alongside iconicity, the results clearly identify receptive language as a factor that mediates children's ability to contextualise pictorial symbols. Both groups' errorless retrieval rates were significantly predicted by receptive language in all three Iconicity conditions, with higher receptive language eliciting more errorless retrievals. The lack of a referent Familiarity effect for either children with ASD or TD children suggests that neither group relied exclusively on labelling depicted objects as a strategy for solving the task. Therefore, it is likely that children's general understanding of language had a passive, yet critical, impact on their ability to utilise pictures in the search task. Socio-cultural theorists, such as Callaghan and Tomasello (Callaghan, 2000, 2008; Carpenter et al., 1998; Tomasello, 1999, 2003) argue that language, the most important and privileged symbol system, develops first from early dyadic and triadic social behaviours (e.g. gaze following, imitation, pointing, declarative gestures), and subsequently mediates the acquisition of other symbol systems. Indeed, studies specifically investigating how linguistic and pictorial development interrelate have confirmed that language emerges before picture comprehension, and also predicts children's ability to create representational drawings (Callaghan & Rankin, 2002; Kirkham et al., 2012). In the context of the present study, those children with higher receptive language may have approached the search task with a more nuanced understanding of how objects in the world can be represented through pictures. By contrast, those children with lower receptive language, and therefore a potentially weaker scaffolding base for their pictorial understanding, may have been increasingly reliant on perceptual resemblance when mapping picture-referent relations.

Of course, alternative accounts for the performance of children with ASD and TD children must be addressed. One explanation for the lack of a referent Familiarity effect is that children may have labelled the colours of occluders, rather than the individuating objects, meaning that linguistic scaffolding was possible in both Familiar and Unfamiliar trials. If children were relying on this strategy, errorless retrieval rates would have been significantly lower in the non-colour Line Drawing trials than in the two colour picture conditions. As performance rates were equal in Line Drawing and Abstract trials, and significantly higher in Colour Photograph trials, it is clear that children were attending to both the shape and colour of depicted occluders when these cues were selectively available. Regarding the influence of receptive language on children's ability to contextualise pictures, perhaps those participants with low receptive language simply did not understand the requirements of the task. However, contrary to this reasoning, Suddendorf (2003) demonstrated that TD children aged just 24-months could perform above-chance in an arguably more complex search task, and every participant in the present study had a receptive language age of at least 24-months.

It is possible that symbolic understanding in the low-functioning children with ASD was facilitated by the extremely favourable experimental conditions. It is clear from the low rates of perseverative responding across groups and conditions that the carefully designed stimuli effectively minimised proactive interference from prior representations of hiding locations, and encouraged children to approach each trial as if it was a novel problem that demanded the computation of a novel solution (Aguiar

& Baillargeon, 2000). Furthermore, each trial included an extensive Orientation Stage in which the experimenter highlighted the iconic correspondence between the real and depicted occluders *and* clearly asserted the intended purpose of the pictures. Thus, the instructions received by participants were optimally conducive of correct task understanding (Salsa & Peralta de Mendoza, 2007). Future studies of symbolic understanding in children with ASD should examine how the manipulation of search task features (e.g. instructions, similarity of hiding locations within and between trials, explicit labelling of pictures and hiding locations) impacts on their errorless retrieval rates.

Overall, the present study has shown that low-functioning children with ASD can contextualise symbolic information communicated by pictures in favourable experimental conditions. I have reported evidence that greater iconicity facilitates picture comprehension in both children with ASD and language-matched TD children when picture and referent are not viewed simultaneously, and mapping is based on an internal representation of the viewed symbol. Furthermore, regression analyses highlighted receptive language skills as an important predictive influence on pictorial understanding in children with ASD, as they are for TD children (Callaghan & Rankin, 2002; Kirkham et al., 2012). Together with previous research (Hartley & Allen, in press (a), (b)), these findings provide a data-grounded rationale for utilising iconic colour symbols when delivering picture-based communication interventions, such as PECS.

Chapter Five: **Intentions vs. resemblance: Understanding pictures in typical development and autism.**[9]

Little is known about picture comprehension in autism, and the question of *how* TD children and children with ASD map pictures to objects remains unanswered. Some theorists contend that *resemblance* (i.e. similarity of perceptual features) defines picture-referent relations (e.g. Hopkins, 1995, 1998; Hyman, 2006; Peacocke, 1987), while others claim that a picture's referent is determined by the *intentions* of the artist and that intention-monitoring skills are critical to picture comprehension (e.g. Bloom, 1996; Bloom & Markson, 1998; Preissler & Bloom, 2008; Taylor, 1998). The purpose of the present study was to establish which of these two theories best explains how TD children and low-functioning children with ASD map picture-object relations; do they relate pictures to objects based exclusively on shape, or do they map pictures to objects that they are intended to represent? A novel way of teasing apart these hypotheses is to compare how TD children and low-functioning children with ASD, who often have difficulty understanding the intentions of others (Baron-Cohen, 1995; D'Entremont & Yazbek, 2007; DSM-IV: American Psychiatric Association, 1994; Kanner, 1943), comprehend *abstract* pictures that relate to referents *only* by virtue of representational intent. Given the social-cognitive deficits experienced by many children with ASD, this comparison may yield the first evidence that TD children and children with ASD derive meaning from different cues when mapping picture-object relations. Mapping abstract pictures to objects based on resemblance, despite its inadequacy as a cue to intended referential meaning, would be consistent with naïve

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[9] Based on Hartley, C., & Allen, M. (2014). Intentions vs. resemblance: Understanding pictures in typical developmental and autism. *Cognition, 131*, 44–59. doi:10.1016/j.cognition.2013.12.009.

realism – a non-intentional theory of picture interpretation that privileges perceptual similarity and neglects external sources of meaning that are not immediately perceptible (e.g. the artist's intentions, whether the picture was created accidentally, expectations of the viewer; Freeman, 1991; Freeman & Sanger, 1995).

Several studies have examined young children's sensitivity to referential intentions when comprehending pictures. Bloom and Markson (1998) asked 3- and 4-year-olds to draw pairs of objects that closely resembled each other, such as a balloon and a lollipop. The pairs of pictures were virtually indistinguishable, and therefore could not be accurately matched to their original referents based on resemblance alone. When asked to name their drawings after a distracter task, both 3- and 4-year-olds correctly and consistently discriminated based on their original representational intentions. Even more remarkably, 2- and 3-year-old children have been shown to perform mentalistic reasoning when interpreting ambiguous pictures created by others. In one study, Gelman and Ebeling (1998) showed 2- and 3-year-olds a series of line drawings roughly shaped like familiar nameable objects (e.g. a kite). Some children were informed that the pictures had been created intentionally (e.g. someone painted a picture), while others were told that the pictures had been created accidentally (e.g. someone spilled some paint). Children were more likely to name the ambiguous pictures according to shape (thus regarding them as symbolic representations) when they believed the pictures were intentional creations. In another study, 2-year-olds watched an experimenter produce an ambiguous line drawing that looked equally like two unfamiliar objects (Preissler & Bloom, 2008). When asked to extend a novel label from the picture, the majority of children generalized the word to the object that the artist had been gazing at whilst drawing, suggesting that they perceived this object to be the picture's intended referent. Together these studies indicate that, by 2-years of age, TD children consider intentional information when comprehending pictures created by themselves and by others.

Although TD children are capable of using intentional information to decipher ambiguous visual representations, it is undeniable that resemblance plays a vital role in children's picture comprehension. Numerous studies have demonstrated that young children's ability to map picture-referent relations is facilitated by high levels of iconicity – the extent that a picture resembles its referent (Callaghan, 2000; Ganea et al., 2008; Simcock & DeLoache, 2006). Intentional theorists, such as Bloom and Markson (1998), claim that iconicity is beneficial because resemblance provides a window to an artist's intentions – "children might call a picture that looks like a bird "a bird" not merely because it looks like a bird, but because its appearance makes it likely that it was created with the intent to represent a bird" (Bloom & Markson, 1998, p. 203). However, there is some evidence that children's picture comprehension is governed *primarily* by resemblance, including when a picture's appearance is in conflict with its creator's intentions. When Browne and Woolley (2001) presented 4-year-olds, 7-year-olds, and adults with a puppet show in which the protagonist announced his intention to draw a bear, but actually produced a picture resembling a rabbit, all groups named the picture according to its appearance (e.g. a rabbit) rather than the artist's stated intentions (e.g. a bear; also see Richert & Lillard, 2002).

The preceding results suggest that if a picture is sufficiently recognisable, resemblance rather than referential intent determines what it represents for both children and adults. However, as it is extremely irregular to encounter a drawing that is intended to represent X, but uniquely resembles Y, participants in these studies may have disregarded the artists' intentions in an attempt to reconcile the conflicting cues. While it is doubtful that an artist would draw one thing whilst intending to represent something else, it is culturally acceptable to assign meaning to pictures that do not have a clearly recognisable referent (e.g. abstract art, infantile scribbles). Therefore, studying how children interpret *abstract* pictures can provide a more ecologically valid method of assessing the relative importance of resemblance and representational intent to picture comprehension.

To date, very few studies have examined children's comprehension of abstract pictures, with Bloom and Markson (1998) being a notable exception. In their "Size Task", 3- and 4-year-olds were shown pairs of differently-sized scribbles that had been 'drawn' by a child with a broken arm. For each pair of scribbles, the experimenter explained that the artist had attempted to draw two objects, such as an elephant (large) and a mouse (small). Crucially, the pictures looked nothing like the named objects, and could only be matched to their intended referents based on relative size. At test, children mapped labels for large and small objects to the abstract pictures based on relative size, which the authors interpreted as evidence for TD children inferring the artist's representational intent. However, a more stringent test of intention reading in the domain of pictures would require children to map pictures to actual referent objects in the absence of resemblance.

Research investigating the development of pictorial understanding has shown that social-cognitive skills (e.g. intention reading and imitation) enable TD children to learn about pictures through interactions with symbolically-experienced adults (Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Callaghan et al., 2004; Rochat & Callaghan, 2005). However, many low-functioning children with ASD show deficits in the social-cognitive skills that underlie pictorial development (Baron-Cohen, 1989, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996). If a nonverbal child with autism is unable to infer representational intentions from a social partner's communicative actions involving pictures, they may fail to learn that pictures are symbolic. Instead, that child may treat pictures as *signs*, perhaps learning that viewing a certain picture precedes receiving a certain object and that particular pictures can be used to direct others' behaviour in different ways, without understanding that pictures symbolise their referents. As a result, low-functioning children with ASD may not realise that information directed at pictures (e.g. verbal labels) actually relates to their real-world referents. Indeed, when the degree of resemblance between picture and referent is low, this population tends to form associative mappings between pictures and verbal labels (Preissler, 2008). However, when a picture is highly-iconic (e.g. a colour photograph), children with ASD are much more likely to treat it as a symbol (Hartley & Allen, in press (a)). Thus, it appears that picture comprehension in low-functioning children with ASD may be contingent on a high-degree of perceptual resemblance.

If low-functioning children with ASD rely on resemblance to guide their mapping of picture-referent relations, we would expect to observe differences in the way these individuals comprehend abstract pictures. Whereas TD children might infer an artist's intentions when iconicity is a poor cue to a picture's referential meaning, the social-cognitive deficits that characterize autism (Baron-Cohen, 1989; Charman et al., 1997; Hobson, 2002; Mundy & Willoughby, 1996; Tomasello, Carpenter, Call, Behne & Moll, 2005) may prevent low-functioning children with ASD from utilising this strategy. Children with ASD also demonstrate a strong tendency to focus on localised perceptual elements when processing visual stimuli (Frith, 2003; Happé, 1999; Happé & Frith, 2006; Mottron et al., 2003; Mottron et al., 2006). Theoretically, an impaired ability to reason about others' mental states coupled with a preference for fine-grained detail would make the comprehension of abstract pictures extremely difficult. Consequently, it may be that children with ASD derive meaning from abstract pictures based entirely on resemblance, despite its inadequacy as a referential cue.

As yet, no research has investigated how children with ASD comprehend abstract pictorial representations. However, Allen (2009) examined how children with ASD interpret ambiguous pictures that could not be matched to referents based on resemblance alone. Participants with a mean mental age of 4.5-years watched an adult turn towards one of two objects and produce a drawing. The representation resembled both objects on the table equally. When asked to label the picture, children with ASD named the object that was in the experimenter's line of sight on just 25% of trials, whereas TD children made the same response on 75% of trials. These findings suggest that, unlike TD children, children with ASD do not use intentional information to decode the referents of ambiguous pictures drawn by others.

The objective of the present study was to establish whether low-functioning children with ASD and young TD children derive referential meaning from abstract pictures based on resemblance or communicative intentions. While adults may call an arbitrary shape "an elephant" if they believe that its creator intended the image to represent an elephant, it is currently unknown whether these developmental populations also hold the view that representational intent, rather than resemblance, determines the referents of non-iconic pictures. In Experiment 5, participants received a modified version of Bloom and Markson's (1998) Size Task, which assessed whether they would map words and objects to abstract drawings based on intentional cues. Test trials comprised of a Picture Selection Stage (based on Bloom and Markson's original procedure) followed by a novel Object Selection Stage. At the Picture Selection Stage, children were required to map object names to abstract pictures based on inferred referential intentions, in the absence of resemblance. Based on previous findings, it was predicted that TD children would reliably use intentional cues to guide their mapping of words to abstract pictures (Bloom & Markson, 1998; Gelman & Ebeling, 1998; Preissler & Bloom, 2008). By contrast, low-functioning children with ASD were expected to have difficulty mapping correct word-picture relations in the absence of resemblance. At the Object Selection Stage, children were asked to link an abstract picture to a real 3-D referent. Participants selected from an 'Intended Referent' (an object that matched the artist's representational intentions), a 'Perceptual Referent' (an object that resembled the picture) and a distracter. If, as Bloom and Markson (1998) suggest, 3-year-olds understand that resemblance is not necessary for a picture-referent relation to exist, we would expect TD children to select the object that corresponds with the artist's intentions and ignore the closer perceptual match. Contrastingly, I anticipated that resemblance would guide picture-object mapping in children with ASD, and that they would more frequently select the Perceptual Referent regardless of the artist's intentions, making them naïve realists (Freeman, 1991; Freeman & Sanger, 1995).

Experiments 6 and 7 rule out alternative explanations for the response patterns of TD children and children with ASD on the Size Task and provide further evidence that these populations differ in their understanding of pictorial representations. Importantly, the results of these experiments will contribute to our understanding of symbolic development by clarifying whether TD children and children with ASD derive meaning from abstract pictures using different cues.

5.1 Experiment 5

5.1.1 Method

Participants

Fifteen children with ASD (15 male; *M* age: 9.7 years, range: 5.3–13.8 years) and fifteen TD children (10 males, 5 females; *M* age: 3.3 years, range: 2.5–5.3 years) were matched on receptive vocabulary as measured by the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton & Burley, 1997).[10] Children were recruited from a preschool, a mainstream school and two specialist schools in Kendal and Preston, United Kingdom. All children with ASD received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord et al., 2002; Lord et al., 1994) and expert judgment. Autism diagnoses were confirmed via the Childhood Autism Rating Scale (CARS; Schopler et al., 1980), which was completed by each participant's class teacher (*M* score: 42.7, range: 31.5–55.5).

Materials

Pictures in the Abstract condition were black-and-white line drawings of four different shapes. Two versions of each shape were created – one small (4 x 4 cm) and one large (10 x 10 cm). Pictures in the Realistic condition were detailed black-and-white line drawings of 8 different objects (see Fig. 11). Four depicted large objects

[10] Nine children with ASD achieved BPVS scores with standardised age equivalents (*M* ability: 3.8 years, *SD*: 1.1) which were matched to those of TD children as closely as possible (*M* ability: 3.7 years, *SD*: 0.9). The BPVS scores of 3 children with ASD did not have age equivalents (they were too low), and so they were matched to 3 TD children based on their raw scores. Another three children with ASD were unable to complete the BPVS due to behavioural issues, thus they were conservatively matched to 3 TD children who each had a receptive language age of 3-years. Although it would have been desirable to acquire a measure of receptive language from every autistic child, it is important to note that this research is particularly relevant to nonverbal individuals who tend to have difficulty with standardardised assessments, display challenging behaviours, and receive picture-based communication training.

(an elephant, a house, a tree, a car) and four depicted small objects (a mouse, a dog, a spider, a flower). Drawings of large and small objects were roughly the same size as the large and small shapes in the Abstract condition. Pictures were printed on individual laminated sheets of white paper.

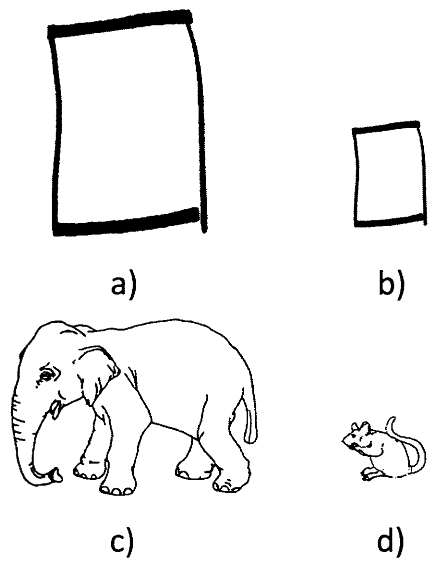

Figure 11. Sample abstract and realistic pictorial stimuli used in Experiment 5; a) abstract large, b) abstract small, c) realistic large, d) realistic small.

Several objects were used as stimuli in both conditions. Eight objects were detailed models of the large and small objects depicted in the realistic pictures (see Fig. 12). Dimensions of models were equivalent to their pictorial counterparts. Another eight objects were 3-dimensional versions of the Abstract shapes (e.g. a sphere, a pyramid, a cuboid and an ovoid; see Fig. 12). Large and small versions of each 3-D shape were created. Large and small 3-D shapes approximately matched the dimensions of their pictorial counterparts. Eight familiar household objects were distracters (see Fig. 12).

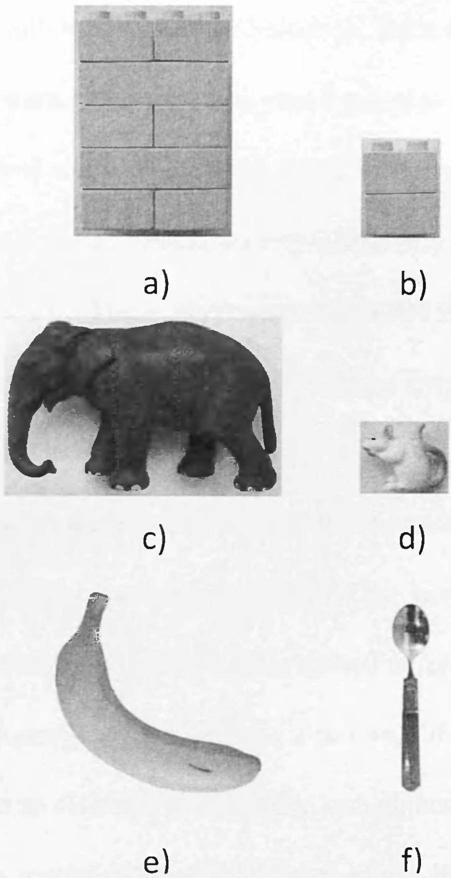

Figure 12. Sample object stimuli used in Experiment 5; a) abstract large, b) abstract small, c) realistic elephant, d) realistic mouse, e & f) example distracters.

Procedure

Participants were tested individually in their own schools. They were seated opposite the experimenter and the materials were placed within their reach. The Abstract condition was always administered first, followed by the Realistic condition approximately one week later. The rationale behind this fixed order was that children would be expected to succeed in the Realistic condition regardless of whether it was received first or second, whereas it is possible that children's responding in the Abstract condition could be contaminated if it was received second.

Each condition consisted of 4 trials and trials included two stages: Picture Selection immediately followed by Object Selection. Prior to receiving the Abstract condition, participants were given the same introduction as children in Bloom and Markson's (1998) original study. The experimenter informed children that they would be shown some pictures that had been drawn by a little boy or girl (same sex as the child) who had a broken arm. The experimenter explained that the artist had tried very hard to draw good pictures, but because of their broken arm, their pictures did not always look how they had wanted.

Abstract Picture Selection. Following the procedure of Bloom and Markson (1998), before each trial, the experimenter informed the participant that they would be shown pictures of a pair of objects which were named twice, once in each order (e.g. "Louise has drawn pictures of an elephant and a mouse. I'm going to show you her pictures of a mouse and an elephant"). Crucially, one object in each pair was relatively large, and the other was relatively small (mouse-elephant, dog-house, tree-spider, flower-car). The experimenter then presented the Abstract pictorial stimuli – one large and one small line drawing of the same abstract shape (e.g. a rectangle) – and announced the names of the referents two more times, once in each order (e.g. "Look, Louise has drawn an elephant and a mouse. These are drawings of a mouse and an elephant"). At this point, the procedure deviated slightly from that of the original study; in order to make the paradigm accessible to nonverbal children with ASD, the experimenter pointed to the pictures and asked the participant to identify which one represented either the small or the large named object (e.g. "Can you show me a mouse?"), rather than to generate their own verbal descriptions of the pictures. The phrasing of this test question was based on the prompts used by Bloom and Markson (1998) when children in their study did not respond spontaneously. If the experimenter named the small (large) referent, a correct response would be to select the small (large) shape. The size of the named object was counterbalanced between trials. If the participant produced the correct response, the experimenter issued praise and confirmed the referential identity of the target picture. If the participant responded incorrectly, the experimenter explained that the other picture represented the named object and reinforced its referential identity (e.g. "Actually, this is a mouse. Can you touch the mouse? Well done, you touched the mouse!"). The experimenter then removed the non-named picture from the child's view so that its presence did not interfere with the following Object Selection stage.

Abstract Object Selection. Participants were presented with an array consisting of three objects. One object was a 3-D representation of the 'Intended Referent' (e.g. a model mouse). Another object was a 'Perceptual Referent' – a 3-D size-matched representation of the pictured shape (e.g. a small cuboid). The final object was a familiar household item which served as a distracter. The positioning of the objects in the array was counterbalanced. Whilst pointing to the array and the target picture, the experimenter asked the child "What was Louise trying to draw?" The participant's response was recorded and the next trial was initiated (starting with the Picture Selection stage).

Realistic Condition. Trials in the Realistic condition followed the "Picture Selection before Object Selection" format described above. The only differences were that the initial instructions did not state that the artist had a broken arm and the pictures were detailed depictions of their intended referents (i.e. the same pairs of objects that were named in the Abstract condition). This condition was included to confirm that participants could discriminate between pictures that resembled the named objects and could form picture-object mappings when the referential relation was transparent.

5.1.2 Results

Abstract Picture Selection

The number of trials (out of 4) in which participants selected the correct picture (e.g. large shape if the large object was requested) was calculated. TD children used relative size to identify the picture of the named object on 88% of trials ($M = 3.53$, $SD = 0.92$; see Fig. 13), significantly greater than chance, $t(14) = 6.49$, $p < .001$, $d = 1.66$. Surprisingly, children with ASD selected the correct picture on 68% of trials ($M = 2.73$, $SD = 1.27$; see Fig. 13), a rate that also significantly exceeded chance, $t(14) = 2.22$, $p = .044$, $d = 0.57$. TD children tended to select the correct picture more frequently than children with ASD, but this trend only bordered on significance, $t(28) = 1.97$, $p = .059$, $d = 0.74$. Performance was not significantly correlated with age for TD children or children with ASD.

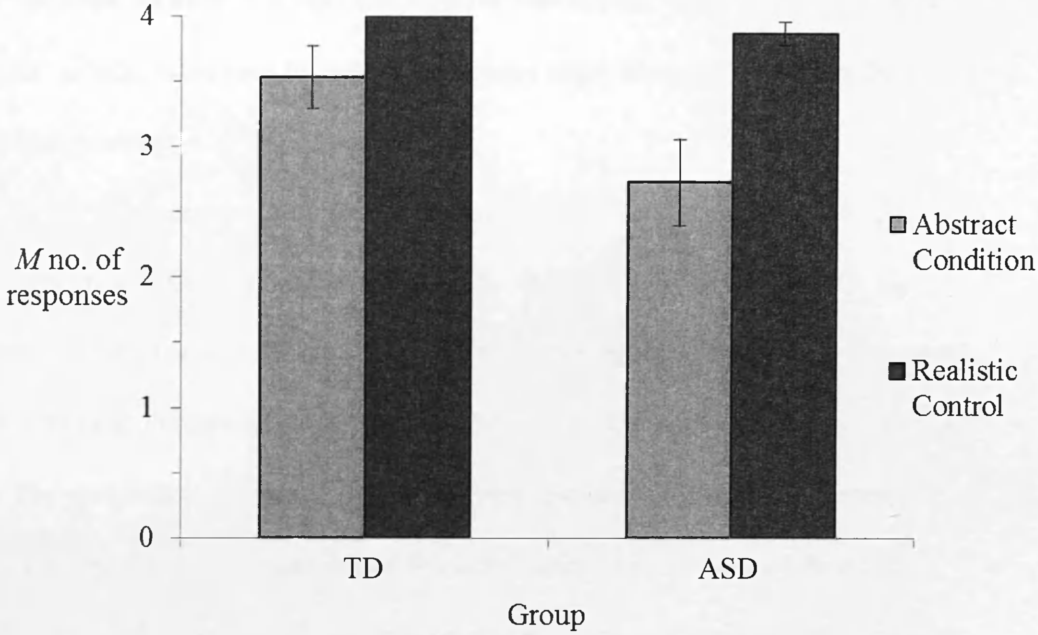

Figure 13. Mean number of correct responses by typically developing children (TD) and children with autism (ASD) at the Picture Selection stage of the Abstract condition and Realistic condition (Experiment 5). Bars represent standard error of the mean.

Abstract Object Selection

The number of Intended Referent and Perceptual Referent responses were summed, yielding two scores per participant (both out of 4). In the 60 trials received by each group, children with ASD failed to respond on 5 trials (8%). While the TD children responded on every trial, they selected the distracter object on 4 trials (7%). The fact that the distracter object was never selected by the children with ASD and selected very rarely by the TD children suggests that the numerical difference in response choices between the Picture Selection (2 choices: large or small picture) and Object Selection (3 choices: Intended referent or Perceptual Referent or distracter) stages had no effect. It is likely that children ignored the distracter when deciding on their response, as there is no theoretically-relevant reason why participants would select it. Hence, these very infrequent responses were excluded from the subsequent statistical analyses.

TD children selected Intended Referents on 85% of trials ($M = 3.4$, $SD = 0.91$) and Perceptual Referents on 8% of trials ($M = 0.3$, $SD = 0.62$; see Fig. 14). By contrast, children with ASD selected Intended Referents on 27% of trials ($M = 1.07$, $SD = 1.28$) and Perceptual Referents on 65% of trials ($M = 2.6$, $SD = 1.24$; see Fig. 14). The proportion of trials in which children selected the Intended Referent was calculated by dividing the number of Intended Referent responses by their total number of valid responses. These proportion data were entered into an independent samples t-test (participant Group was the between-subjects factor), which revealed that TD children selected the Intended Referent significantly more often than children with ASD who, by extension, selected the Perceptual Referent significantly more often than TD children, $t(28) = 6.55$, $p < .001$, $d = 2.36$. Single sample t-tests on the proportion data showed that TD children selected the Intended Referent significantly above-chance (and therefore selected the Perceptual Referent significantly below-chance), $t(14) = 7.94$, $p < .001$, $d = 2$, while children with ASD selected the Intended Referent significantly below-chance (and therefore selected the Perceptual Referent significantly above-chance), $t(14) = -2.82$, $p = .014$, $d = -0.72$. Together, these findings clearly illustrate two contrasting response patterns; TD children selected the Intended Referent much more frequently than the Perceptual Referent, while children with ASD selected the Perceptual Referent much more frequently than the Intended Referent. Chronological age was not correlated with proportion of Intended Referent selections for either TD children or children with ASD.

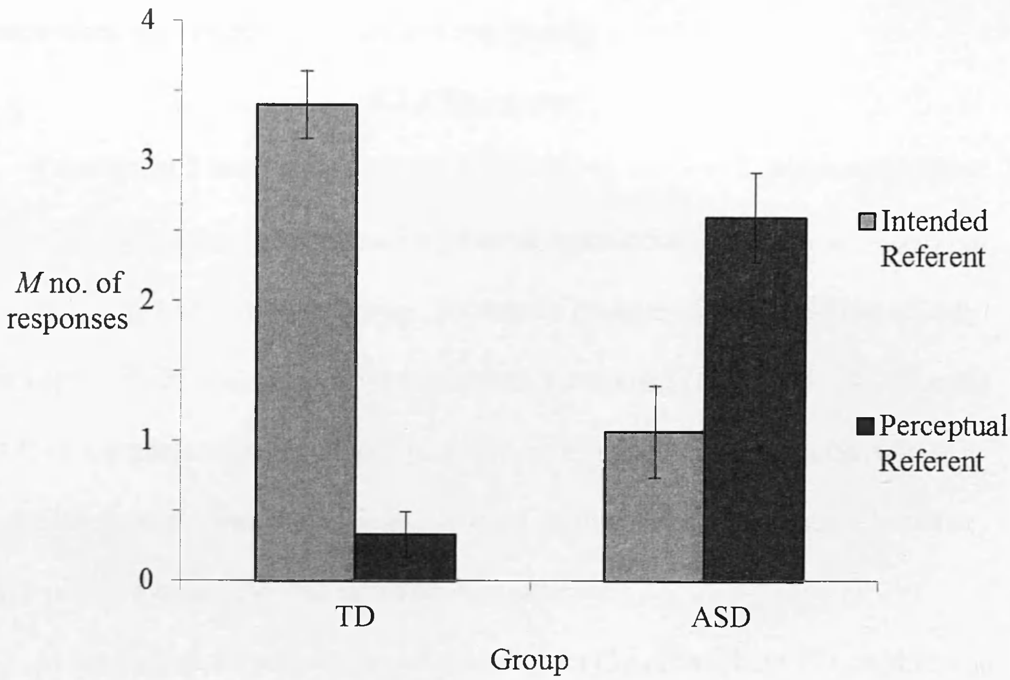

Figure 14. Mean number of Intentional and Perceptual Referent responses made by typically developing children (TD) and children with autism (ASD) at the Object Selection stage of the Abstract condition (Experiment 5). Bars represent standard error of the mean.

Realistic condition

TD children and children with ASD selected the correct picture in 100% (M = 4, SD = 0) and 97% of trials (M = 3.87, SD = 0.35) respectively (see Fig. 13), indicating that both groups comprehended the test question correctly and could discriminate the 8 named objects. Children with ASD selected the correct picture significantly more often in the Realistic condition than in the Abstract condition, $t(14) = -3.24$, $p = .006$, $d = 0.95$. The between-condition difference was borderline and in the same direction for TD children ($p = .07$). TD children and children with ASD selected the correct 3-D referent of requested pictures on 97% and 95% of trials respectively, demonstrating that both groups could match pictures to their intended referents when the symbolic relation was transparent.

5.1.3 Discussion

Experiment 5 investigated whether TD children and low-functioning children with ASD derive meaning from abstract pictorial representations based on intentional information or perceptual resemblance. The results indicate that TD children reliably assign verbal labels to abstract pictures based on intentional cues, which subsequently direct their mapping of picture-object relations. Surprisingly, children with ASD assigned labels to abstract representations based on intentional information, but then mapped picture-object relations based on resemblance.

At the Picture Selection Stage of the Abstract Condition, both TD children and children with ASD appropriately mapped labels for large and small objects to abstract pictures based on relative size (e.g. large drawing as elephant and small drawing as mouse when presented together). Although a predictable result for the TD children (based on Bloom & Markson, 1998), it was surprising that children with ASD could also make this distinction. Given the impairments that many children with ASD have in intention-monitoring (e.g. Baron-Cohen, 1995; Bloom, 2000; Charman, 2000; Griffin, 2002), which may be particularly severe in a low-functioning population as tested here, it is possible that these children used a different strategy to discern the identity of the pictures. For example, it may be that children with ASD recognised the parallel between the relative sizes of the named objects and the sizes of the abstract drawings, then, when asked to show the experimenter the named object, they simply selected the appropriate size match without considering the artist's referential intentions.

While it is possible that TD children and children with ASD solved the task through intentional and non-intentional reasoning respectively, the Picture Selection data do not allow us to make this distinction. The Object Selection data do, however, allow this comparison. The results show that TD children form relations between abstract pictures and real-world referents based on artists' intentions, even when they conflict with perceptual resemblance. This supports Bloom and Markson's (1998) claim that children understand the intentional origins of pictures by 3-years, and argues against both Browne and Woolley (2001) and Richert and Lillard (2002). It should be noted that the latter two studies employed iconic pictures that unambiguously resembled familiar nameable objects other than their intended referents, thus presenting participants with an unusual and potentially confusing test situation. This problem is avoided here by using non-iconic abstract pictures. In summary, TD children acknowledged that a picture's communicative meaning is determined by notional external properties, namely the referential intentions of the artist, rather than properties of resemblance which are highly salient and immediately perceptible.

By contrast, children with ASD were much more likely to select a resemblance-based match when asked to link an abstract picture with an object. The fact that children with ASD had difficulty using artists' intentions to map picture-object relations is consistent with prior empirical work documenting their impaired ability to infer referential intent when mapping words to objects (Baron-Cohen et al., 1997; Preissler & Carey, 2005) and interpreting drawings (Allen, 2009). These results indicate that, for low-functioning children with ASD, picture-object relations are determined by resemblance rather than referential intentions (e.g. if a picture resembles X, it *is* X, even if the artist meant to draw Y). This non-intentional interpretation of pictures conforms to the theory of naïve realism (Freeman, 1991; Freeman & Sanger, 1995), suggesting that children with ASD and TD children differ in their fundamental understanding of pictorial representation.

However, there are alternative explanations for the differing response patterns of children with ASD and TD children at the Object Selection Stage. One may contend that TD children generally consider artistic intentions, but at the Object Selection Stage they adopted the less demanding strategy of simply selecting the referent that matched the verbal label. Experiment 6 addresses this possibility by testing whether TD children use intentional cues to assign referential identities to abstract pictures that have not been verbally labelled. In this experiment, children observed an artist with a (supposedly) broken arm create abstract pictorial representations of pairs of visible objects that differed in size. As in Experiment 5, children were required to reason that the large abstract picture was intended to represent the large object and the small abstract picture was intended to represent the small object. However, unlike in Experiment 5, the objects were not named, thus preventing children from adopting a word-picture matching strategy. Instead, they had to abstract the intended referential relations from other cues, namely the inferred communicative intentions of the artist. Data from the children with ASD will be addressed in Experiment 7.

5.2 Experiment 6

5.2.1 Method

Participants

Participants were fourteen typically-developing 3-year-olds (6 males, 8 females; *M* age: 3.3 years, range: 3.0–3.6 years), with a mean BPVS receptive language age of 3.7 years (*SD*: 0.57). TD children in Experiment 6 did not differ from

TD children in Experiment 5 on chronological age ($t = 0.24, p = .81$), or receptive vocabulary ($t = -1.44, p = .16$). Children were recruited from a day nursery in Kendal, United Kingdom.

Materials

Object stimuli were the large and small Intended Referents (3-D objects) used in Experiment 5, plus two differently-sized unfamiliar objects (large: Aztec musical wind instrument; small: garden hose pipe connector). Pictorial stimuli were created during the test session using white A4 paper and a black felt-tip pen. The experimenter wore a triangular arm sling during test sessions.

Procedure

Participants were tested individually in their own schools. They were seated opposite the experimenter and the materials were placed within their reach. Testing was completed in a single session lasting approximately 10 minutes.

The test session comprised of two stages: an Introduction Stage, followed by a Test Stage. The purpose of the Introduction Stage was to highlight that the experimenter was unable to produce realistic drawings due to their "broken arm". After introducing himself, the experimenter conveyed his passion for drawing and directed the child's attention to the sling they were wearing on their right arm (e.g. "I love to draw things! Drawing is my favourite thing to do and I make drawings every day. In fact, I'm going to make some drawings now! But oh no, I've broken my arm and I can't draw very well. I'll try really hard to draw good pictures, but because of my broken arm, my pictures might not look right…"). The experimenter then stated that he would create a drawing of his "mummy" (mother). The resulting picture resembled a scribble and the experimenter emphasised its referential identity (e.g. "This is my mum! It's not very good because of my broken arm, but it's still my mum!"). The Test Stage began after this point. The experimenter stated that he would make some more drawings, and administered 5 trials in which he produced abstract pictures of pairs of objects that differed in size. At the start of each trial, the experimenter presented 2 objects – one was relatively small and one was relatively large – and positioned them side-by-side (approx. 15cm apart) in front of the child. In the first 4 trials, children were presented with the same pairs of familiar objects as in Experiment 5 (elephant-mouse, dog-house, tree-spider, car-flower). In the fifth trial, they were presented with two differently-sized unfamiliar objects. These were included to rule out the possibility that children's performance was related to object familiarity. The presentation order of the four pairs of familiar objects was randomised, and the positioning of small and large objects to the left and right was counterbalanced. The experimenter then stated that he would draw the two objects that were present (e.g. "I'm going to draw these!"). The experimenter proceeded to create two differently-sized scribbles roughly resembling familiar nameable shapes, one above the other on the same sheet of paper. The drawings were positioned in this way to prevent children from making inferences about referential identity based on relative positioning of pictures and objects. While drawing, the experimenter gazed *between* the two objects so that children were not provided with an additional intentional cue to picture-referent relations that was not present in Experiment 5. The order in which the small and large objects were drawn by the experimenter was counterbalanced, as was their positioning on the page. Once the drawings were complete, the experimenter held up the sheet of paper, pointed to each picture in turn and asked the child "what is this?" If the child did not respond immediately, either by pointing to their chosen referent or verbalising their answer, the experimenter drew the child's attention to the pair of objects and asked again "what is this?" Once children had identified a referent for the two pictures, the experimenter removed the objects and began the next trial.

5.2.2 Results

Children were scored on the number of times they correctly matched the experimenter's scribbles to their intended referents. For example, on an elephant-mouse trial, a child would score 2 if they correctly identified the large scribble as "an elephant" and the small scribble as "a mouse". The maximum scores for familiar and unfamiliar objects were 8 and 2 respectively. Remarkably, in trials involving familiar objects, children mapped 96% of the experimenter's scribbles to their intended object referents ($M = 7.71$, $SD = 0.83$). Children correctly decoded 100% of the experimenter's scribbles of unfamiliar objects.

5.2.3 Discussion

The results of Experiment 6 conclusively demonstrate that TD children are both able and willing to map picture-object relations based purely on intentional cues, in the complete absence of perceptual resemblance. It is apparent that, by 3-years of age, TD children understand that pictures are created with the intention of representing real-life referents, even if it is unclear what those referents actually are. Although the abstract pictures shared more perceptual features with familiar nameable shapes than the objects that were present during drawing, children almost always identified them as representations of the objects that were perceived to be their intended referents. Thus, when iconicity is an inadequate cue to a picture's referent, TD children will spontaneously derive meaning by inferring the communicative intentions of the artist. It is likely that the communicative intentions underlying the abstract pictures in this experiment were more salient than in Experiment 5, as children observed the picture creation process. Furthermore, these findings suggest that TD children who selected the Intended Referent in Experiment 5 may have been reflecting on the symbolic picture-referent relation, rather than simply following a label-object matching strategy.

The preferential selection of the Perceptual Referent by children with ASD in Experiment 5 allows us to rule out explanations based on label-object matching and chance responding (the group selected the Perceptual Referent significantly more often than the two other objects). One possibility is that children with ASD selected Perceptual Referents because they find coloured 3-D geometric shapes novel and interesting. This, however, is unlikely because these objects were never selected in the Realistic condition where they were included as distracters. Two further explanations for the preferential selection of the Perceptual Referent by children with ASD implicate perseveration and associative word learning respectively. Previous research has shown that children with ASD can have difficulty disengaging from previously reinforced responses due to impairments in frontal lobe functioning (e.g. Shu et al., 2001). Thus, it is possible that children with ASD selected the Perceptual Referent because they had just received reinforcement for selecting a picture that was the same shape, without reflecting on the symbolic picture-referent relation. Alternatively, the well-documented tendency of children with ASD to associate words and stimuli that are experienced simultaneously (Baron-Cohen et al., 1997; Frith & Happé, 1994; Kanner, 1946; Preissler, 2008; Preissler & Carey, 2005) may have caused the temporary re-mapping of object labels. Repeatedly hearing the word "elephant" paired with a rectangle during the Picture Selection Stage may have taught children with ASD to associate the label with objects resembling the abstract picture (e.g. "elephant" was re-mapped to rectangular objects). Although the Realistic Condition demonstrated that children with ASD knew what all of the named objects looked like, and each array included an object that resembled the conventional referent of the label (e.g. a model elephant) which could have cued the correct word-referent relation, associative word learning cannot be definitively rejected.

The primary objective of Experiment 7 was to conclusively rule out perseveration and associative word learning as explanations for resemblance-based picture-object mapping in children with ASD. In this experiment, a new sample of low-functioning children with ASD received a modified version of the paradigm in Experiment 5 that included controls for these two phenomena. A secondary objective of Experiment 7 was to corroborate my argument that performance of children with ASD at the Object Selection Stage could be due to impairments in understanding intentionality. This goal was addressed by assessing participants on a separate, well-established, measure of intention reading. The task was based on a procedure developed by Carpenter, Akhtar and Tomasello (1998) to assess typically-developing infants' ability to discriminate intentional from accidental actions, which has since been administered with young children with ASD with delayed language development (D'Entremont & Yazbek, 2007). In this task, TD children as young as 14-months selectively imitate actions that are perceived to be intentional and thus meaningfully related to the model's goal (Carpenter et al., 1998; Olineck & Poulin-Dubois, 2005; D'Entremont & Yazbek, 2007). By contrast, young children with ASD reproduce intentional and accidental actions at equal rates, often mimicking the two-action sequences exactly as modeled, regardless of whether one action was accidental (D'Entremont & Yazbek, 2007). These findings indicate that children with ASD are oriented towards reproducing goals, but unlike TD children, they are not sensitive to the intentions underlying goal-directed actions.

The selection of this particular intention-reading task was motivated by several factors. One problem with alternatives, such as the unfulfilled intentions task (see Meltzoff, 1995), is that children can produce target actions without reflecting on the model's intentions (see Carpenter, Pennington & Rogers, 2001). The imitation task negates the possibility that children succeed due to limited affordances of objects, or because the model "spotlights" particular actions. It is also suitable for nonverbal children and places low cognitive demands on participants, making it ideal for children with ASD. Also, by using the imitation task, I can draw direct comparisons with an existing body of literature that already documents differences in the responding of TD children and children with ASD (Carpenter et al., 1998; D'Entremont & Yazbek, 2007; Olineck & Poulin-Dubois, 2005).

5.3 Experiment 7

5.3.1 Method

Participants

Participants were 17 low-functioning children with ASD (all male; *M* age: 9.7 years, range: 4.1–16.1 years) recruited from a specialist school in Preston, United Kingdom. None of these children participated in Experiment 5. All children received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord et al., 2002; Lord et al., 1994) and expert judgment. Diagnosis was confirmed using the CARS (Schopler et al., 1980), which was completed by a class teacher (*M* score: 41, range: 31.5–51.5). Children's receptive vocabulary was measured by the BPVS (Dunn et al., 1997; *M* ability: 3.6

years, SD: 1.3).[11] Children with ASD in Experiment 5 and Experiment 7 did not differ on chronological age ($t = 0.01, p = .99$), receptive vocabulary ($t = -1, p = .325$) or CARS score ($t = 0.64, p = .53$). Also, children with ASD in Experiment 7 and TD children in Experiment 5 did not differ significantly on receptive vocabulary ($t = -0.49, p = .63$).

Materials

Size Task. Stimuli were the same abstract pictures and referent objects as used in Experiment 5. Four familiar household objects were used as distracters.

Imitation Task. Two training objects and six test objects were made from metal boxes as per D'Entremont and Yazbek (2007). The test objects and one training object had two moving components (e.g. buttons, dials, switches) and the other training object had a single moving component (a button). All eight objects had a reward outcome (e.g. a flashing light, a spinning propeller, a small balloon inflating). The outcomes of the two training objects and four test objects were activated via a remote control button box. The outcomes of the other two test objects (inflating party balloons) were activated by squeezing a turkey baster, which pumped air down a length of plastic tubing. All objects were activated secretly by the experimenter, thus providing full experimental control over which action sequences elicited reward outcomes. See Table 4 for descriptions of individual toys and their outcomes.

[11] The BPVS scores of 4 children with ASD were marginally below the lowest raw score with a standardised age equivalent (of 2.3-years). Consequently, we conservatively assigned these 4 children a receptive language ability of exactly 2-years.

Table 4

Descriptions of objects, actions performed and reward outcomes in the Imitation Task

Object	Actions	Reward Outcome
Practice objects		
Green button box	Press large green button	Light switches on
Spinning bunny box	Turn dial/press button	Rabbit picture spins
Test objects		
Blue balloon box	Press button/flick switch	Balloon inflates
Red balloon box	Turn dial/flick switch	Balloon inflates
Propeller box	Press green button/press red button	Propeller spins
Lighthouse	Turn knob/flick switch	Light switches on
Kitten box	Press button/flick switch	Cat picture spins
Apple box	Press button/flick switch	Image lights up

Procedure

Participants were tested individually on two different days (approx. 1 week apart) in their own schools and were always accompanied by a familiar adult. They were seated at a table opposite the experimenter and the materials were placed within their reach. Participants received the Size Task in the first session and the Imitation Task in the second session.

Size Task. The Size Task was a modified version of the Abstract Condition described in Experiment 5. Children completed 4 trials, with each trial involving two stages: Picture Selection immediately followed by Object Selection. The task began with the experimenter informing the child that they would be shown some pictures that had been drawn by a little boy or girl (same sex as the participant) who had a broken arm. The Picture Selection Stage was exactly as described in Experiment 5, and the only difference in the Object Selection Stage was the number of questions asked by the experimenter. Participants in this experiment were asked 3 questions

(Perseveration Control, Test Question, Associative Learning Control) in one of two possible orders (order A and order B). Both question orders began with the Perseveration Control – children were first asked to identify the familiar distracter object (e.g. "show me the spoon") in order to rule out the possibility that their initial object selection was perseverative. Children receiving question order A were then asked the Test Question followed by the Associative Learning Control, whereas children receiving question order B were asked the Associative Learning Control followed by the Test Question. Questions were asked in the same order in all 4 trials. Nine children received question order A over 4 trials, and 8 children received order B. These groups did not differ on chronological age ($t = 0.56, p = .59$), receptive language ability ($t = -0.04, p = .97$) or CARS score ($t = 0.23, p = .82$). The Test Question was the same as in Experiment 5 – children were asked to identify the intended referent of the abstract picture (e.g. "what was Joe/Louise trying to draw?"). The Associative Learning Control asked children to identify the referent of the verbal label assigned to the abstract picture (e.g. "show me an elephant"), and was included to rule out the possibility that children had re-mapped the object name to the Perceptual Referent. If the responding of children with ASD is due to differences in their understanding of artistic intentionality rather than associative word learning, we would expect them to select the Perceptual Referent in response to the Test Question and the Intended Referent in response to the Associative Learning Control.

Imitation Task. The general procedure involved an experimenter modelling a two-action sequence on an object that included either an accidental action and an intentional action, or two intentional actions. There were three within-subjects conditions – Accidental-Intentional (A-I), Intentional-Accidental (I-A) and Intentional-Intentional (I-I). If children understand the intentions underlying goal-directed actions, in the A-I and I-A conditions they should only reproduce intentional actions, regardless of whether they are performed first or second. The I-I condition was included to reduce the frequency of consecutive accidents, and to further test children's ability to discriminate intentional and accidental actions. If children reproduced both actions at an equivalent rate across all three conditions, this would indicate an inability to discriminate intentional from accidental actions. For every child, two objects were randomly assigned to each condition. The order of conditions was randomised, with the stipulation that the same condition was not experienced consecutively. The two actions modelled on each object were always the same, but their order and condition (accidental or intentional) were randomised. Accidental actions were vocally marked by the exclamation "Whoops!" and intentional actions were marked by the declaration "There!", both accompanied by appropriate facial expressions. Each object was involved in two successive trials (i.e. the experimenter modelled the two-action sequence, allowed the child to respond, modelled the two actions again in the same order and manner, and then gave the child another opportunity to respond). In total, children completed 12 test trials (4 trials per condition).

The imitation task began with a Training Stage during which the experimenter modelled one- and two-action sequences on two training objects. None of the actions modelled during the Training Stage were vocally marked, but it was clear that all actions were intentional. The first training object, the "green button" toy (a white box with a large green button and a light bulb on its surface) was placed in front of the child and the experimenter said "Watch, I'm going to show you how this works". The experimenter then pressed the green button and secretly activated the light bulb using a remote control button box concealed underneath the table. Once the light had switched off, the experimenter encouraged the child to interact with the object (e.g. "Now you try. Can you make it work?"). All children in the current sample reproduced the correct action immediately. The experimenter then retrieved the first object and replaced it with the second object. The experimenter then demonstrated a two-action sequence (turned the dial and pressed the button) before activating the outcome via the remote control button box. The child was then asked to make the object work. In order to activate the outcome, children were required to perform both actions in the correct sequence (i.e. dial first, button second). Overall, the Training Stage familiarised children with the general procedure and confirmed that children could reproduce two-action sequences, without eliciting a one- or two-action response bias.

Twelve test trials immediately followed the second training trial. The experimenter presented the first test object and modelled a two-action sequence that corresponded to one of the three experimental conditions (I-A, A-I, I-I). The experimenter activated the reward outcome within one second of completing the second modelled action. Thus, for the I-A and A-I conditions, children had to decipher which one of the two actions was responsible for activating the reward outcome. In the I-I condition, children had to recognise that the reward outcome was contingent on both actions being performed in the correct order. After the demonstration, children were encouraged to respond (e.g. "Can you make it work?"). If children did not respond immediately, they were prompted verbally and nonverbally to interact with the object (this was required for very few trials). Activation of the reward outcome following children's actions varied slightly across conditions. In I-A and A-I conditions, the outcome was activated if the child reproduced the intentional action, irrespective of whether or not they also reproduced the accidental action. For I-

A trials, activation of the reward outcome occurred after a 2s delay, thus giving the child time to produce the second accidental action. In I-I trials, the outcome was activated after the child's second action, but only if they correctly reproduced the two-action sequence in the modelled order. After the child's first response, the experimenter provided a second demonstration of the same two-action sequence, before giving the child another opportunity to respond. Thus, for each of the 6 objects, children experienced 2 consecutive trials, each consisting of a demonstration and a response period.

5.3.2 Results

Size Task

Picture Selection. The number of trials (out of 4) in which participants selected the correct picture (e.g. large shape if the large object was requested) was calculated. Children with ASD selected the correct picture on 81% of trials ($M = 3.24$, $SD = 0.9$), a rate that significantly exceeded chance, $t(16) = 5.64, p < .001, d = 2.82$. The success rate of children with ASD in Experiment 7 was not significantly different from the success rate of children with ASD ($M = 2.73$, $SD = 1.27$; $t(30) = -1.29, p = .21$) or TD children ($M = 3.53$, $SD = 0.92$; $t(30) = 0.93, p = .36$) in the Abstract Condition of Experiment 5. As in Experiment 5, performance of children with ASD was not significantly correlated with age.

Object Selection. Four scores were calculated for every child. One score corresponded to the number of times (out of 4 trials) they responded correctly to the Perseveration Control (i.e. by selecting the familiar household item when requested). One score corresponded to the number of times (out of 4 trials) they responded correctly to the Associative Learning Control (i.e. by selecting the Intended Referent when asked to identify the referent of the verbal label). The remaining two scores (both out of 4) corresponded to the number of Intended Referent and Perceptual Referent responses to the Test Question. All children responded to all three questions on every trial.

Children with ASD responded correctly to the Perseveration Control on 97% of trials ($M = 3.88$, $SD = 0.33$), a rate significantly greater than chance, $t(16) = 31.81$, $p < .001$, $d = 15.91$. This finding suggests that the selection of Perceptual Referents by children with ASD in Experiment 5 was not caused by an inability to disengage from a reinforced response.

Children with ASD responded correctly to the Associative Learning Control on 94% of trials ($M = 3.76$, $SD = 0.66$), a rate that significantly exceeded chance, $t(16) = 15.18$, $p < .001$, $d = 7.59$. This finding suggests that the Picture Selection Stage did not direct children with ASD to re-map the object name onto the depicted shape through associative pairing.

In response to the Test Question, children with ASD who received question order A (Test Question first, Associative Learning Control second) selected Intended Referents on 22.3% of trials ($M = 0.89$, $SD = 1.36$) and Perceptual Referents on 77.7% of trials ($M = 3.11$, $SD = 1.36$). Children with ASD who received question order B (Associative Learning Control first, Test Question second) selected Intended Referents on 25% of trials ($M = 1$, $SD = 1.51$) and Perceptual Referents on 75% of trials ($M = 3$, $SD = 1.51$). The proportion of trials in which children selected the Intended Referent was calculated by dividing the number of Intended Referent responses by their total number of valid responses. These proportion data were entered into an independent samples t-test (Question Order was the between-subjects factor), which confirmed that question order had no influence on children's responding to the Test Question. A single sample t-test was performed on the proportion data (question order conditions were collapsed), which showed that children with ASD selected the Intended Referent significantly below-chance (and therefore selected the Perceptual Referent significantly above-chance), $t(16) = -3.14$, $p = .006$, $d = -0.74$. This finding replicates the response pattern of children with ASD in Experiment 5. Chronological age was not correlated with proportion of Intended Referent selection for children with ASD in this experiment.

Imitation Task

Every child completed 4 trials in each of the 3 conditions (Intentional-Accidental, Accidental-Intentional, Intentional-Intentional). For I-A and A-I trials, children's responses were allocated to one of the following categories: Intentional Action Only (only the intentional action reproduced), Accidental Action Only (only the accidental action reproduced), Intentional-Accidental (child reproduced the intentional action followed by the accidental action), or Accidental-Intentional (child reproduced the accidental action followed by the intentional action). For I-I trials, children's responses were allocated to one of the following categories: Intentional 1 Only (only the first intentional action reproduced), Intentional 2 Only (only the second intentional action reproduced), Intentional 1-Intentional 2 (child reproduced the first intentional action followed by the second intentional action), or Intentional 2-Intentional 1 (child reproduced the second intentional action followed by the first intentional action). Every response made by children in this experiment could be unambiguously allocated to one of these categories.

Every child reproduced the single action required to pass Training Trial 1 at their first attempt. Nine children correctly reproduced the two-action sequence required to pass Training Trial 2 at their first attempt. The remaining 8 children required between 2 and 5 ($M = 2.75$) experimenter demonstrations before they reproduced the two-action sequence correctly.

My analyses parallel those reported by Carpenter et al. (1998) and D'Entremont and Yazbek (2007). The first analysis compares the tendency of children with ASD to reproduce intentional and accidental actions in general. I-I trials were omitted as no accidental actions were modelled in this condition. The frequencies of intentional and accidental actions reproduced by children in I-A and A-I trials were calculated, yielding four scores per child, each out of 4 (the experimenter modelled 4 intentional actions and 4 accidental actions in each condition). In I-A trials, children with ASD reproduced 85.3% of intentional actions ($M = 3.41$, $SD = 0.94$) and 88.2% of accidental actions ($M = 3.53$, $SD = 0.62$). In A-I trials, children with ASD reproduced 89.7% of intentional actions ($M = 3.59$, $SD = 0.8$) and 86.8% of accidental actions ($M = 3.47$, $SD = 1.01$). These data were entered into a 2(Condition: I-A, A-I) x 2(Reproduced Actions: Intentional, Accidental) repeated measures ANOVA. There was no effect of Condition ($F = 0.17, p = .68$), Reproduced Actions ($F = 0, p = 1$), and no interaction ($F = 0.23, p = 0.64$). These results show that children with ASD were just as likely to reproduce intentional and accidental actions, regardless of their modelling order.

The second analysis examined the prevalence of different response categories across the three conditions. If participants understood the model's intentions, they should not reproduce accidental actions. The mean number of trials in each condition that children with ASD produced each response type are displayed in Figure 15. Wilcoxon signed-rank tests comparing the frequencies of each response category in I-A trials showed that children with ASD made significantly more Intentional-Accidental responses than Intentional Action Only ($z = -2.9, p = .004$), Accidental

Action Only ($z = -2.5$, $p = .013$) and Accidental-Intentional responses ($z = -2.36$, $p = .018$). In A-I trials, children with ASD made significantly more Accidental-Intentional responses than Intentional Action Only ($z = -2.59$, $p = .01$), Accidental Action Only ($z = -2.71$, $p = .007$) and Intentional-Accidental responses ($z = -2.16$, $p = .031$). In I-I trials, children with ASD made significantly more Intentional 1-Intentional 2 responses than Intentional 2-Intentional 1 ($z = -3.13$, $p = .002$), Intentional 1 Only ($z = -3.37$, $p = .001$) and Intentional 2 Only responses ($z = -3.04$, $p = .002$).

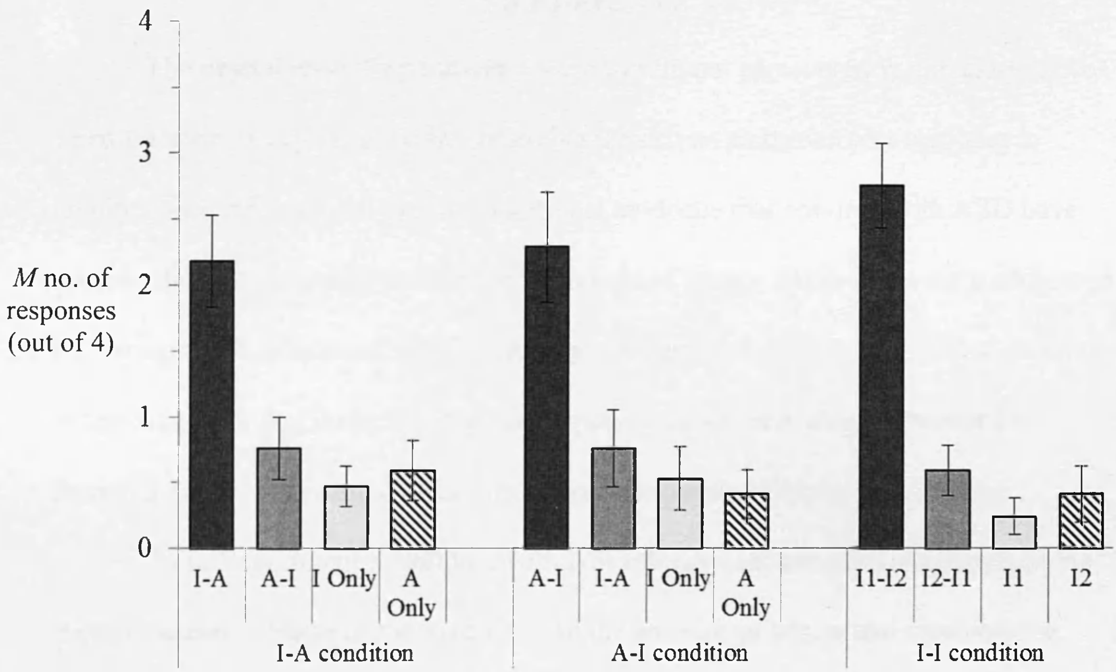

Figure 15. Response rates of children with ASD in the Imitation Task (Experiment 7). Bars represent standard error of the mean.

Overall, these responses suggest that children with ASD were mimicking the model's actions without reference to his intentions. In all three conditions, the statistically most frequent response was to copy exactly the two-action sequence demonstrated by the experimenter. The frequencies of these mimicking responses were not statistically different across conditions – children with ASD were just as likely to reproduce a two-action sequence that included an accidental action, as one that was completely intentional. Furthermore, the rates of mimicking responses observed here are highly similar to those reported by D'Entremont and Yazbek (2007). In their study, children with ASD produced 53% of Intentional-Accidental responses in the I-A condition, 60% of Accidental-Intentional responses in the A-I condition and 62% of Intentional 1-Intentional 2 responses in the I-I condition.

5.3.3 Discussion

The objectives of Experiment 7 were to rule out perseveration and associative word learning as explanations for resemblance-driven picture-object mapping in children with ASD, and to provide additional evidence that children with ASD have specific difficulties understanding the intentions of others. These goals were addressed by testing a new sample of low-functioning children with ASD on a modified version of the Size Task that included controls for perseveration and associative word learning, and by assessing children on a separate measure of intention-reading.

As in Experiment 5, children with ASD showed an unexpected aptitude at the Picture Selection Stage of the Size Task; in the absence of perceptual resemblance, they appropriately mapped labels for large and small objects to pictures based on an intentional cue (relative size). Indeed, the Picture Selection performance of children with ASD in Experiment 7 was not statistically different from that of TD children in Experiment 5. However, at the Object Selection Stage, children with ASD mapped abstract pictures to objects based on perceptual resemblance rather than the artist's symbolic intentions. This response pattern mirrored that of children with ASD in Experiment 5, and contrasted with the responding of TD children, who formed relations between abstract pictures and objects based on artistic intentions. The Perseveration Control at the start of the Object Selection Stage showed that children with ASD could disengage from selecting objects that matched the abstract picture's shape. This suggests that children with ASD in Experiment 5 were not selecting the Perceptual Referent simply because they had received reinforcement for selecting a similarly-shaped picture. Likewise, the Associative Learning Control confirmed that the Picture Selection Stage did not direct children with ASD to re-map object names onto depicted shapes. Despite hearing the word "elephant" repeatedly paired with a rectangle, children with ASD clearly retained their correct understanding of the word-referent relation, rather than re-associating the label with rectangular-shaped entities. Thus, selection of the Perceptual Referent by children with ASD in Experiment 5 cannot be explained by associative word learning.

The Imitation Task revealed that children with ASD in Experiment 7 were equally likely to reproduce intentional actions and accidental actions, regardless of their modelling order. Across all three conditions, their most frequent response was to reproduce two-action sequences exactly as demonstrated, suggesting that children with ASD do not reflect on the intentions underlying the goal-directed behaviour of social partners. These results were remarkably similar to those reported by D'Entremont and Yazbek (2007), suggesting that the inability to discern intentionality from others' social-communicative behaviour is a reliable characteristic of low-functioning children with ASD. By contrast, it is well-established that TD children as young as 14-months selectively imitate intentional actions in I-A and A-I trials, and produce significantly more two-action sequences in I-I trials (Carpenter et al., 1998; D'Entremont & Yazbek, 2007; Olineck & Poulin-Dubois, 2005), thus demonstrating an early sensitivity to intentions. Furthermore, the Imitation Task has provided explicit evidence that children with ASD in the present study have an impaired understanding of intentionality, supporting my argument that their resemblance-based comprehension of abstract pictures may be related to social-cognitive deficits.

5.4 General Discussion

This study investigated whether low-functioning children with ASD and young TD children derive referential meaning from abstract pictures based on resemblance or communicative intentions. Experiment 5 assessed whether these developmental populations would a) assign object names to abstract pictures based on an intentional cue (relative size), in the complete absence of resemblance, and b) map abstract pictures to real objects based on artists' intentions or resemblance. Although both groups mapped object names to abstract pictures based on relative size, TD children mapped picture-object relations based on the artist's intentions, while children with ASD disregarded the artist's intentions and mapped picture-object relations based on resemblance.

This study is the first to directly compare how TD children and children with ASD form relations between abstract pictures, verbal labels, and real referent objects. The results from these experiments show that, when iconicity is a poor cue to a picture's symbolic meaning, young TD children map relations to real-world referents based exclusively on artists' intentions. This ability is not driven by a priori naming, as in Experiment 6, TD children spontaneously mapped abstract pictures to familiar objects in the absence of labelling. These findings support Bloom and Markson's (1998) claim that, by 3-years of age, TD children understand that communicative intentions underlie the meaning of pictures, and that resemblance is not necessary for a symbolic picture-referent relation to exist. Nevertheless, it is indisputable that resemblance is an important influence on children's picture comprehension. The majority of pictures that children encounter (e.g. in picture books) look unambiguously like their intended referents, and can be interpreted based on appearance. Indeed, the appearance of a picture is often highly congruent with an artist's referential intentions (e.g. if a picture is shaped like a car, it is probably intended to represent a car), making resemblance an excellent cue to symbolic meaning (Bloom, 2000; Bloom & Markson, 1998). However, in situations where resemblance is an inadequate cue (e.g. when an artist has a broken arm), young TD children are able to derive meaning exclusively from an artist's intentions, and will selectively ignore any coincidental resemblance to non-intended referents.

In both Experiments 5 and 7, children with ASD appropriately mapped labels for large and small objects to abstract pictures based on an intentional cue, but subsequently mapped picture-object relations based on resemblance. The finding that children with ASD with intention reading difficulties (as confirmed in Experiment 7) can "solve" the Picture Selection Stage suggests that Bloom and Markson's (1998) original paradigm may not require children to reflect on artists' intentions. I propose that children with ASD were able to "hack out" a solution to the Picture Selection Stage using non-intentional reasoning – an ability that is well-documented in the theory of mind literature (see Happé, 1995). This theory is supported by the fact that children with ASD failed to consider artists' intentions when mapping picture-referent relations at the Object Selection Stage. Instead, they mapped abstract pictures to objects that were perceptually similar, despite the inadequacy of resemblance as a cue to referential meaning. The Imitation Task in Experiment 7 confirmed that children with ASD do not reflect on the intentions underlying goal-directed actions, and this deficiency may impact on their symbolic understanding of pictures. Creating a picture is a goal-directed action – the goal being to communicate information about an independently existing referent – but socio-cognitive impairments may inhibit children with ASD from considering the intentions that underlie the process of pictorial representation. Consequently, some low-functioning children with ASD may not reflect on pictures as creations of other humans with psychological relations to the world. To these individuals, pictures relate to objects because they resemble them – they do not consider the mind behind the symbol.

Unlike TD children, some children with ASD may comprehend pictures purely at face value, relying heavily (if not exclusively) on the analysis of immediately perceptible resemblance properties, without reflecting on factors external to the visual image (e.g. the artist's intentions, whether the picture was created accidentally, expectations of the viewer). Thus, if a picture looks like X, it is X. This resemblance-based processing style conforms to the theory of naïve realism (Freeman, 1991; Freeman & Sanger, 1995) which, when coupled with deficits in category formation (Tek et al., 2008), may impact on their ability to learn from pictures. For example, if a low-functioning child with autism learned that a photograph of a sailboat was "a boat", they may not generalise the label to real boats that do not share key perceptual similarities with the picture (e.g. those without masts and sails). Alternatively, the inability to infer referential intentions could impact on pictorial development more fundamentally by preventing some children with ASD from understanding the representational nature of picture-referent relations (Preissler, 2008). Such a deficit may cause children with ASD to regard pictures as signs rather than symbols, which in turn may inhibit the generalisation of information from pictures to referent objects.

At present, there are no data-grounded guidelines regarding what types of pictures are best suited for educational and communication interventions, and it is not uncommon for children with autism to be taught using relatively abstract black-and-white line drawings that share few perceptual features with their intended referents (Hartley & Allen, in press (a)). However, the finding that children with ASD tend to map picture-object relations based exclusively on resemblance supports the argument that educators and therapists should deliver picture-based treatments using highly-iconic visual symbols, as these would appeal most to recipients' picture-processing style.

As TD children and children with ASD in the present study were matched pair-wise on receptive language, their contrasting responses at the Object Selection Stage of the Size Task cannot be explained by general differences in language comprehension. If children with ASD could not understand the test question, it is likely that their responding would have been directed by the object name which they definitely could understand (e.g. matching the verbal label "elephant" to the model elephant). Preferential selection of the Perceptual Referent by children with ASD in both Experiments 5 and 7 confirms that they were reliably interpreting the test question, however, it is possible that the two populations interpreted the question differently. Critics may claim that, due to difficulties understanding intentional language, children with ASD may have been answering a different question, such as "what did Joe draw?" The test question was specifically worded to tap children's understanding that social-communicative intentions underlie the act of drawing. Therefore, even if children with ASD interpreted the question as above, their selection of the Perceptual Referent indicates that they are not reflecting on pictures as intentional creations, and are instead viewing pictures from a realist perspective (Freeman & Sanger, 1995).

Again, I must caution against generalising the results of these experiments across the autism spectrum. Higher-functioning individuals with superior linguistic skills may develop a symbolic understanding of picture-object relations that is similar to typical development. However, it is important to state that the children with ASD who participated in this study are representative of a vast population of individuals with impaired language development who rely on pictures as an alternative means of functional communication. Thus, the finding that low-functioning children with ASD map picture-object relations based purely on resemblance informs theoretical knowledge of picture comprehension and also has valuable clinical and educational implications.

In summary, this study is the first to present evidence that low-functioning children with ASD and ability-matched TD children derive meaning from different cues when comprehending non-iconic pictures. From 3-years of age, TD children map abstract pictures to referent objects based on artists' intentions, demonstrating their understanding of the social-communicative function of pictorial symbols. By contrast, children with ASD map abstract pictures to referent objects based on resemblance, despite its inadequacy as a cue to referential meaning. Thus, resemblance is not criterial to picture comprehension in TD children, but it is vital for children with ASD. I propose that the inability of children with ASD to reflect on artists' intentions is a consequence of social-cognitive impairments that inhibit typical development of pictorial understanding. The finding that children with ASD are naïve realists (Freeman, 1991; Freeman & Sanger, 1995), who evaluate pictures based exclusively on their perceptual features, also has important implications for picture-based communication interventions.

Chapter Six: **The influence of representational status on children's naming and drawing of pictures: Evidence from typical development and autism.**[12]

As pictures are intended to symbolise real objects, it is the cultural norm to assign object names to 2-dimensional representations (i.e. real monkeys and monkey pictures can be referred to with the word "monkey"). Previous research has debated over the cues that direct word-picture mapping in developmental populations – some theorists argue that children map labels to pictures based purely on shape (i.e. if a picture is shaped like a cat, it is "a cat"; Browne & Woolley, 2001; Richert & Lillard, 2002), while others claim that they name according to the artist's referential intentions (i.e. a picture is "a cat" only if it was created with the intention of representing a cat; Bloom & Markson, 1998; Gelman & Ebeling, 1998).

Studies have sought to clarify the relative importance of referential intentions and shape to picture naming by pitting these cues in direct conflict. Browne and Woolley (2001) showed 4- to 7-year-old typically developing (TD) children and adults a puppet show in which the protagonist announced his intention to draw a bear, but actually produced a picture that resembled a rabbit. Subsequently, the majority of each age group named the picture according to its shape (e.g. a rabbit) rather than the artist's stated intentions (e.g. a bear). In another study by Richert and Lillard (2002), TD children aged 4- to 8-years watched a toy troll create a picture that looked exactly like a fish, but were informed that the troll had neither seen nor heard of fish before. When asked whether the troll was drawing "a fish", all but the eldest children responded in the affirmative, thus failing to consider the mental state of the artist (one

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[12] Based on Hartley, C., & Allen, M. (under review). Is children's naming and drawing of pictures mediated by representational status? Evidence from typical development and autism. *Journal of Cognition and Development*.

cannot draw a fish if one does not know what a fish is). Together, these studies suggest that when a picture is sufficiently recognisable, naming in TD children is directed by shape rather than intentions. However, by employing pictures that unambiguously resembled familiar nameable objects other than their intended referents, these studies presented participants with an unusual and potentially confusing test situation. As it is extremely irregular to encounter a drawing that is intended to represent X, but uniquely resembles Y, participants in these studies may have disregarded the artists' intentions in an attempt to reconcile the conflicting cues.

Other studies show that shape alone does not determine the names assigned to pictures by TD children. Bloom and Markson (1998) asked 3- and 4-year-olds to draw pairs of objects that closely resembled each other, such as a balloon and a lollipop. Predictably, the pairs of pictures produced by the young children were virtually indistinguishable, and thus could not be accurately matched to their original referents based on shape. Nevertheless, when asked to name their drawings after a distracter task, both age groups correctly and consistently discriminated based on their original representational intentions. Bloom and Markson (1998) propose that "children might call a picture that looks like a bird "a bird" not merely because it looks like a bird, but because its appearance makes it likely that it was created with the intent to represent a bird" (p. 203). In other words, these authors claim that TD children name shape only insofar as it provides an index of representation.

Gelman and Ebeling (1998) tested Bloom and Markson's (1998) theory by investigating whether children's naming of depicted shapes depends on whether those shapes are *intended* to be representational. Two-and 3-year-old TD children were shown a series of line drawings roughly shaped like familiar nameable objects (e.g. a kite). Some children were informed that the pictures had been created intentionally (e.g. someone painted a picture), while others were told that the pictures had been created accidentally (e.g. someone spilled some paint). At test, children were asked to name the pictures. Children were more likely to name according to shape when they believed that pictures were intentional creations, and provided more literal non-symbolic responses (e.g. naming the materials used to create the pictures) when the pictures were made accidentally. Thus, the tendency of TD children to name a picture's shape is influenced by representational status, which is ultimately determined by the intentions of its creator. That is, TD children are very likely to name a kite-shaped picture "a kite" if it was created with the intention of representing a kite, however, they are much less likely to name a kite-shaped paint spill "a kite" because it does not represent the object it happens to resemble.

It is notable that the studies reviewed above all tested the influence of resemblance and communicative intentions by asking children to label ambiguous figures. However, a novel and potentially insightful method of assessing the referential meaning derived from such images involves asking children to graphically reproduce stimuli. If a child believes an ambiguous collection of lines was created with the intention of representing a familiar object, they might embellish their copies with details that correspond with their associated mental representation, but are absent in the perceived stimuli. Increasing the level of resemblance between depiction and referent could be taken as further confirmation that the child genuinely regards the image to be a symbol, despite the relatively low degree of resemblance. Conversely, if a different child believed that the same collection of lines was created by accident, and therefore was not intended to be representational, their graphic reproduction may be more faithful to the perceived stimuli.

There is also evidence that children's graphic reproductions can be influenced by whether or not the to-be-copied items are named (Krascum, Tregenza & Whitehead, 1996; Lee, 1989; Lewis, Russel & Berridge, 1993; Pickard & Vinter, 1999). In one study, Lewis, Russell and Berridge (1993) asked 5-year-olds to draw a tankard from an unusual perspective (its handle was occluded), after an experimenter referred to the object as either "a mug", "a glass" or "this". They found that the label attached to the object significantly influenced the nature of children's drawings; children included the occluded handle in their drawings on 69% of "mug" trials, 48% of "this" trials and 27% of "glass" trials. It is likely that the labels "mug" and "glass" directed children's attention away from the perceived stimuli, and towards conceptual knowledge about the object referents of the labels (Toomela, 2002). Hence, children in the "mug" condition were more likely to make commission errors because a handle is a category-defining feature of a mug, whereas those in the "glass" condition were less likely to make commission errors because glasses do not usually have handles. Furthermore, once children acquire the goal of depicting a familiar named object, they may become conscious that viewers will not recognise the intended referent of their drawing unless they include the category-defining features associated with the label, regardless of whether they are visible in the present drawing situation (Bremner & Moore, 1984).

To my knowledge, no study has investigated whether children's graphic reproduction of pictures is influenced by representational status or children's *own* naming. However, given that referential meaning directly impacts on the visual realism of children's drawing, a relation may exist. For example, if a child names an ambiguous figure "a sun" because they inferred that it was created with the intention of representing a sun, one may expect that the child would attempt to increase the resemblance between the stimuli and intended referent by creating a more canonical drawing.

If intention reading is an important process in children's picture comprehension, one might predict that an impaired ability to understand intentionality would elicit differences in the pictorial domain. Autism is a pervasive neurodevelopmental disorder that is characterised by profound social-cognitive deficits (Baron-Cohen, 1995; DSM-IV: American Psychiatric Association, 1994; Frith, 2003; Kanner, 1943). Many children with Autism Spectrum Disorder (ASD) have great difficulty understanding the intentions of others (Baron-Cohen, 1989, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996) and, perhaps relatedly, there is growing evidence that this population may have an atypical understanding of pictures (Allen, 2009; Hartley & Allen, 2014; Hartley & Allen, in press (a), (b); Preissler, 2008). More specifically, it appears that referential word-picture-object mapping in children with ASD is contingent on a high degree of iconicity (the perceptual resemblance between a picture and referent), with colour being an important mapping cue (Hartley & Allen, in press (a); Hartley & Allen, under revision). One possibility is that picture comprehension in children with ASD conforms to the theory of naïve realism (Hartley & Allen, 2014) – a non-intentional theory of picture interpretation that privileges perceptual similarity and neglects external sources of meaning that are not immediately perceptible (e.g. the artist's intentions, whether the picture was created accidentally, expectations of the viewer; Freeman, 1991; Freeman & Sanger, 1995). That is, to a naïve realist, a picture represents "a cat" because it resembles a cat, even if the artist intended to represent a dog.

The objectives of the present study were a) to replicate Gelman and Ebeling's (1998) finding that young TD children reflect on representational status when assigning labels to ambiguous pictures, b) to examine whether their graphic reproduction of 2-D shapes is influenced by representational status and/or naming, and c) to identify whether representational status influences how children with ASD, a population characterised by social-cognitive difficulties (Baron-Cohen, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996), name and reproduce ambiguous pictures. In Experiment 8, two groups of TD children (2-3 year-olds and 4-5-year-olds) received a modified version of Gelman and Ebeling's (1998) paradigm. Participants were shown a series of line drawings roughly shaped like familiar nameable objects. Half the children in each age group were informed that the pictures had been created intentionally, and half were informed that the pictures had been created accidentally. At test, children were asked to name the pictures, and then to draw them.

It was predicted that, as in Gelman and Ebeling (1998), naming of shape in TD children would be influenced by whether or not those shapes were created intentionally, and thus inferred to be symbolic. Hence, I expected a high rate of shape-naming responses in the Intentional condition, and a reduced rate of naming responses (balanced by an increase in non-symbolic responses, such as "paint") in the Accidental condition. In addition, the graphic reproductions of TD children could be influenced by 3 factors: chronological age, representational status of the to-be-copied picture, and children's naming. Independent of other factors, I expected to observe an increase in the frequency of faithful drawings with age, as children begin to draw in an increasingly realistic manner (Luquet, 2001; Cox, 1992, 2005; Golomb, 2002, 2004; Jolley, 2010). Regarding representational status, I expected that children might create more canonical reproductions of symbolised referents when stimuli were believed to be intentional creations, and more faithful reproductions when stimuli were created accidentally and inferred to be non-symbolic. Lastly, it was anticipated that children's naming of shape could induce the creation of more canonical reproductions of stimuli. In Experiment 9, I investigate how children with ASD name and reproduce ambiguous pictures that are believed to be created intentionally or accidentally.

6.1 Experiment 8

6.1.1 Method

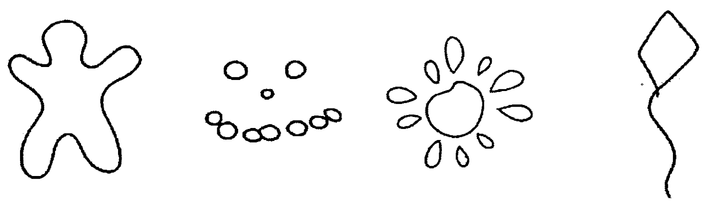
Participants

Participants were typically developing children aged between 2- and 5-years of age. In one group were 32 2- to 3-year-olds (17 males, 15 females; *M* age = 3.1 years, range: 2.1–3.9 years, *SD* = 0.6), and in another group were 32 4- to 5-year-olds (16 males, 16 females; *M* age = 4.9 years, range = 4–5.8 years, *SD* = 0.5). Children were recruited from primary schools, nurseries and preschools in Kendal, United Kingdom. Half of the children in each age group were randomly assigned to the Intentional condition and half to the Accidental condition.

Materials

The stimuli were four black-and-white pictures (see Fig. 16) selected from the 8 pictures used in Gelman and Ebeling's (1998) Study 2. As children were required to draw each picture, more than 4 items would have been too demanding for participants in a single session. The drawings were scanned from the original paper onto a computer and made approximately 4 times larger. The digital stimuli were printed by a high-quality laser printer and laminated. Each drawing had two accompanying stories – one for each condition. These were identical to those used in the original study, except for a small number of cultural adjustments (e.g. replacing 'art class' with 'art lesson'). In one story, it was suggested that the picture had been created intentionally. In the other story, it was suggested that the same picture had been created accidentally. As in the original study, the target picture was said to have been created using the same material in both stories. See Appendix B for a full listing of the stories.

The participants drew the pictures using a selection of coloured felt-tip pens and crayons on white A4 paper.



Picture 1.	Picture 2.	Picture 3.	Picture 4.
man	face	sun	kite

Figure 16. Ambiguous figures viewed by children in Experiment 8 and Experiment 9.

Procedure

Participants were tested individually in their own schools and were always accompanied by a familiar adult. They were seated at a table next to or opposite the experimenter and the materials were placed within their reach. Children were reinforced throughout the session for attention and good behaviour, but the experimenter never indicated whether their responses were correct or incorrect.

Children received either the Intentional Condition or the Accidental Condition. Both conditions consisted of 4 trials. At the start of each trial, the experimenter read aloud a brief story explaining how a fictional character had created a picture intentionally or accidentally (dependent on condition). The corresponding picture was then presented and the experimenter asked, "what is this?" If the participant responded with "I don't know", one additional prompt was provided. After their response had been recorded, the experimenter presented the participant with a piece of white A4 paper and a packet of colouring pens and asked, "can you draw this?" Once the participant had finished drawing, the paper was removed from sight by the experimenter. The order in which the four items were presented was counterbalanced between participants.

6.1.2 Results

Two sets of analyses were conducted on children's data. The first addresses children's naming responses, while the second focusses on their drawing responses.

Naming

Coding

Following Gelman and Ebeling's (1998) scheme, the verbal responses of children were coded as belonging to one of four mutually-exclusive categories:

a) 'Naming' – the child named an object that was not mentioned in the experimenter's story, and that corresponded to the shape of the picture (e.g. "a gingerbread man", "a kite", "a face", "a sun"). This response indicated that the child regarded the picture as a symbol.

b) 'Material' – the child named the material that the picture had supposedly been made from (e.g. "paint", "mud", "string") or referred to it in non-symbolic terms (e.g. "a puddle", "a splat"). This response indicated that child did not regard the picture as a symbol.

c) 'Do Not Know' – the child indicated that they did not know what the picture was, or simply did not respond.

d) 'Other' – the child mentioned physical resemblance (e.g. "it looks like a x") or provided the name of an object/material that was not mentioned in the experimenter's story nor corresponded to the shape of the picture (e.g. "kangaroo").

Analyses

All responses could be unambiguously allocated to one of the four categories detailed above. For every child, the number of responses belonging to each category was calculated (out of 4). For ease of interpretation, the descriptive statistics are presented in subsections corresponding to each age group (see Fig. 17).

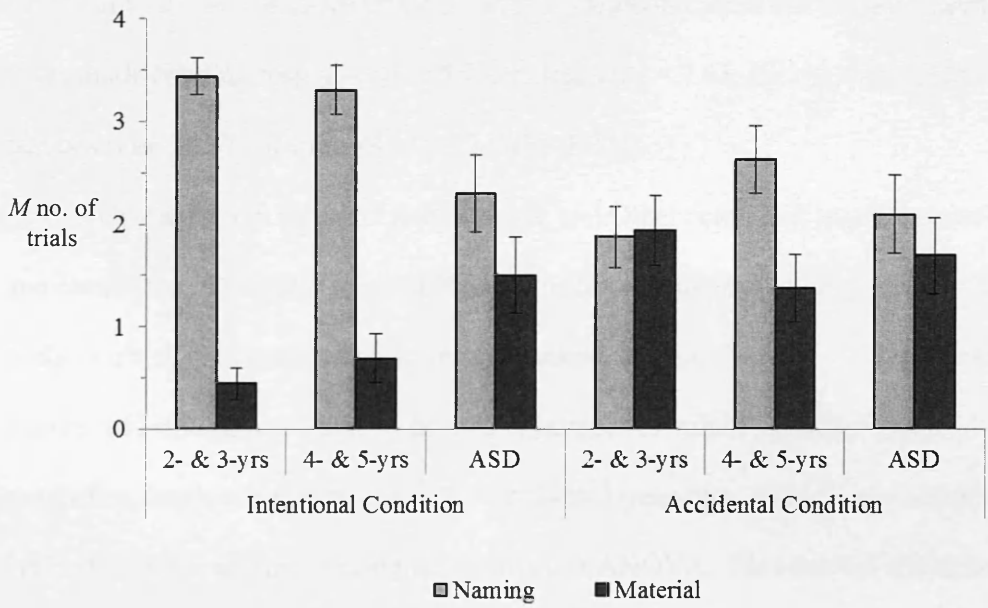


Figure 17. Mean number of trials (out of 4) that typically developing children aged 2-3 years and 4-5 years (Experiment 8) and children with autism (ASD; Experiment 9) made Naming and Material verbal responses. Bars represent standard error of the mean.

2- and 3-year-olds. In the Intentional condition, children aged 2-3 years made Naming responses on 86% of trials ($M = 3.44$, $SD = 0.73$), Material responses on 11%

of trials ($M = 0.44$, $SD = 0.63$), Do Not Know responses on 1.5% of trials ($M = 0.06$, $SD = 0.25$) and Other responses on 1.5% of trials ($M = 0.06$, $SD = 0.25$). In the Accidental condition, children aged 2-3 years made Naming responses on 47% of trials ($M = 1.88$, $SD = 1.2$), Material responses on 48.5% of trials ($M = 1.94$, $SD = 1.34$), Do Not Know responses on 1.5% of trials ($M = 0.06$, $SD = 0.25$) and Other responses on 3% of trials ($M = 0.12$, $SD = 0.34$).

4- and 5-year-olds. In the Intentional condition, children aged 4-5 years made Naming responses on 82.8% of trials ($M = 3.31$, $SD = 0.95$) and Material responses on 17.2% of trials ($M = 0.69$, $SD = 0.95$). In the Accidental condition children aged 4-5 years made Naming responses on 65.7% of trials ($M = 2.63$, $SD = 1.31$) and Material responses on 34.3% of trials ($M = 1.37$, $SD = 1.31$).

Given the low rates of Do Not Know and Other responses across age groups and conditions, these data were omitted from subsequent analyses. The proportion of trials in which children made Naming responses was calculated by dividing their number of Naming responses by their total number of valid responses. These proportion data were entered into a 2(Age: 2- to 3-year-olds, 4- to 5-year-olds) x 2(Condition: Intentional, Accidental) univariate ANOVA. The analyses identified a main effect of Condition, $F(1, 60) = 16.05$, $MSE = .08$, $p < .001$, $\eta p^2 = .21$, indicating that children across age groups made significantly more Naming responses in the Intentional condition (and therefore made significantly more Material responses in the Accidental condition). There was no effect of Age and no interaction.

Drawing

Coding

After labelling each ambiguous figure, children were asked to create their own graphic copy. Coding schemes were created for each figure that enabled raters to categorise children's reproductions as either Representational (drawing more closely resembled the symbolised referent than the stimuli), Faithful (drawing more closely resembled the stimuli than the symbolised referent) or Uncodable (drawing resembled neither the stimuli nor the symbolised referent). Each coding scheme included a list of key features, and coders judged according to criteria whether or not a child's drawing reproduced each feature in either a faithful or canonical fashion. This coding method yielded two scores per drawing (each out of 5) reflecting how Representational/Faithful it was. Drawings were *categorised* based on which score – Representational or Faithful – was higher (i.e. if more features were represented canonically than faithfully, a drawing was categorised as Representational; see Fig. 18 for example drawings). Not all features were weighted equally – for each ambiguous figure a key detail was identified that served as a clear indicator of whether a child's drawing was a Representational or Faithful reproduction (e.g. drawing the "mouth" of the face-like figure as a horizontal line curving upwards at both ends, as children tend to represent smiles, versus drawing a row of individual circular shapes as displayed in the stimuli), and this feature was allocated more Representational/Faithful points. An example coding scheme (for the ambiguous figure resembling 'a man') is described below (all coding schemes are documented in Appendix C).

Example coding scheme - Man

1. 'Uncodable'

Drawing does not, in any way, share perceptual similarity with either stimuli or symbolised referent (e.g. drawing is a scribble or series of randomly-placed disconnected shapes). If the drawing does not fulfil criteria for Uncodable classification, proceed with coding.

If not Uncodable:

2. 'Head'

a) Enclosed circular shape located at the top of the drawing. May be attached to a central shape or a vertical line. Score: 1 Representational point.

b) A single "protrusion" extends upwards from a centre point and is not individuated or enclosed. Score: 1 Faithful point.

3. 'Arms'

a) Two lines or separate enclosed shapes (e.g. ovals) extend outwards from the sides of a central shape or a vertical line (one either side of centre). Score: 1 Representational point.

b) Two protrusions extend outwards (one each side) of a central mass and neither are individuated/enclosed. Score: 1 Faithful point.

4. 'Legs'

a) Two lines or separate enclosed shapes (e.g. ovals) extend downwards from the bottom of a central shape or vertical line. Score: 1 Representational point.

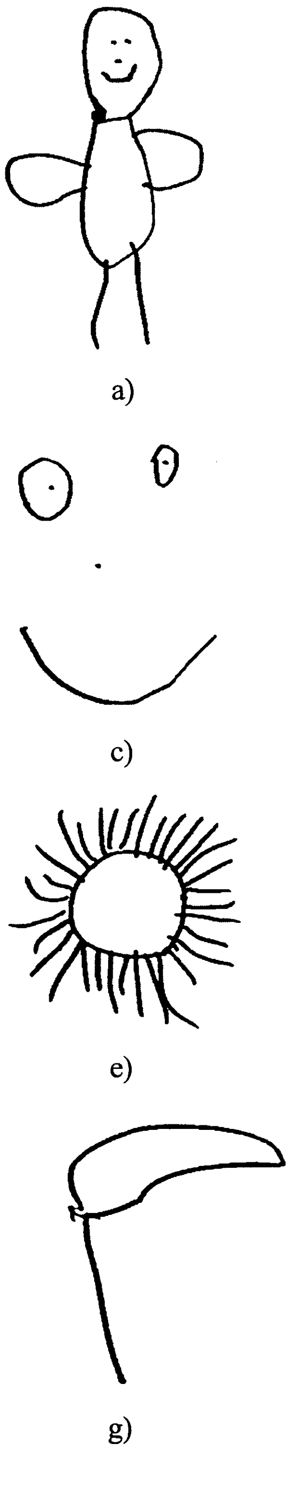
b) Two protrusions extend downwards from the bottom of a central mass and neither are individuated/enclosed. Score: 1 Faithful point.

5. 'Face'

a) Drawing includes internal detail resembling a facial configuration (i.e. 2 eyes, nose and mouth). Detail must be located either in enclosed 'head' at the top of the drawing, or in the central shape if no 'head' is present. Score: 2 Representational points.

b) Drawing does not contain any internal detail. Score: 2 Faithful points.

As almost every drawing produced by 2-year-old participants was rated as Uncodable, this age group was omitted from the subsequent analyses. Thus, the drawings of 3-, 4- and 5-year-olds were compared. Every child from these three age groups produced drawings of all 4 ambiguous figures, with the exception of one 3-year-old who did not draw the figure resembling a man.



a) b)

c) d)

e) f)

g) h)

Figure 18. Sample drawing responses from Experiment 8; a) Representational man, b) Faithful man, c) Representational face, d) Faithful face, e) Representational sun, f) Faithful sun, g) Representational kite, h) Faithful kite.

Reliability

Every drawing was coded by the first experimenter and an independent rater with postgraduate experience of coding children's drawings. The second rater was blind to the objectives of the experiment and the details of each artist (e.g. their age, experimental condition, whether or not they named the stimuli). Reliability of coding schemes was assessed via Cohen's Kappa, which was calculated based on the two raters' categorical classifications (i.e. whether a drawing was Representational, Faithful or Uncodable). High interrater reliability was achieved for all coding schemes (man: $\kappa = .84$, $p < .001$; face: $\kappa = .93$, $p < .001$; sun: $\kappa = .84$, $p < .001$; kite: $\kappa = .8$, $p < .001$). Disagreements in categorical classifications (e.g. Faithful vs. Uncodable) were resolved by consensus between the two coders.

Analyses

In total, children produced 191 drawings. Of the drawings created by 3-year-olds, 46% were categorised as Representational, 8% were Faithful and 46% were Uncodable. For 4-year-olds, 48.5% of their drawings were Representational, 35.9% were Faithful and 15.6% were Uncodable. For 5-year-olds, 29.7% of their drawings were Representational, 64.1% were Faithful and 6.2% were Uncodable.

My first objective was to identify whether children's creation of Representational and Faithful drawings varied as a function of Age or Condition. The proportion of trials in which children created Representational drawings of stimuli was calculated by dividing their number of Representational responses by their total number of valid (i.e. not Uncodable) responses. These proportion data were entered into a 3(Age: 3-year-olds, 4-year-olds, 5-year-olds) x 2(Condition: Intentional, Accidental) univariate ANOVA. The analysis revealed a main effect of Age, $F(2, 42) = 4.23$, $MSE = .09$, $p = .021$, $\eta p^2 = .17$. Pairwise comparisons subjected to the

Bonferroni correction showed that 5-year-olds created significantly fewer Representational drawings (and therefore more Faithful drawings) than 3- (p = .02) or 4-year-olds (p = .05), whose responding did not differ. There was also a main effect of Condition, $F(1, 42) = 9.44$, $MSE = .09$, $p = .004$, $\eta p^2 = .18$, indicating that across age groups, children created significantly more Representational drawings in the Intentional condition than the Accidental condition and, by extension, created significantly more Faithful drawings in the Accidental condition than the Intentional condition. There was no interaction between Age and Condition.

My second objective was to identify whether children's creation of Representational or Faithful drawings was *related* to their previous verbal response. A 4-way (Age x Condition x Verbal Response x Drawing Response) hierarchical loglinear analysis was conducted to determine which combination of interactions among the variables provided the best fit to the data. Drawings rated as Uncodable and those that were preceded by either a Do Not Know or Other verbal response were omitted, leaving 146 drawings in the analysis. The loglinear model is a widely-used and statistically-sound method of analysing contingency tables that include more than 2 categorical factors (Stevens, 1992). Loglinear analysis involves an algorithmic search process, known as backward elimination, which sequentially removes terms from the most complex model until it provides the closest approximation to the data with the smallest number of parameters. With each iteration, the term that has the least effect on the fit of the model is removed. Backward elimination ceases when the removal of another experimental terms would create a significantly worse-fitting model. The associated test statistic is likelihood ratio chi-square (G^2); higher G^2 values indicate poorer-fitting models, while lower values (with higher p values) indicate better-fitting models.

Table 5 displays the partial chi-square for each effect. A significant partial chi square indicates that the effect explains significant variance beyond that explained by all other effects in the model. Table 5 shows that only 2 first order terms (Age, Verbal response) and 3 second order terms (Condition x Verbal Response, Age x Drawing Response, Condition x Drawing response) were significant. The subsequent explanation will focus on the second order effects, as these are most theoretically interesting. The final model is displayed in Table 6. This was the least complex model which did not differ significantly from the saturated model (which includes all terms and interactions).

Table 5

Partial Associations for all terms by loglinear analysis (Experiment 8)

Effect	df	Partial χ^2	Probability
A x C x VR x DR	0	0	1
A x C x VR	2	2.29	.32
A x C x DR	2	3.39	.18
A x VR x DR	2	0.6	.74
C x VR x DR	1	0.22	.64
A x C	2	0.68	.71
A x VR	2	0.43	.81
C x VR	1	5.81	.016*
A x DR	2	26.74	< .001*
C x DR	1	4.45	.035*
VR x DR	1	.04	.84
A	2	9.52	.009*
C	1	.44	.51
VR	1	51.43	< .001*
DR	1	.69	.41

Note. A: Age (3, 4, 5 years); C: Condition (Intentional, Accidental); VR: Verbal Response (Naming, Material); DR: Drawing Response (Representational, Faithful). Statistical significance indicated by *

Table 6

Final model: Difference estimation from saturated model (Experiment 8)

Model	df	Likelihood ratio G^2	Probability
A x DR, C x VR, C x DR	14	9.39	.81

Note. A: Age (3, 4, 5 years); C: Condition (Intentional, Accidental); VR: Verbal Response (Naming, Material); DR: Drawing Response (Representational, Faithful)

Explanation of the model. 1) Age x Drawing Response (See Table 7): Three-year-olds produced relatively more Representational drawings and relatively few Faithful drawings. Four-year-olds produced roughly the expected frequencies of Representational and Faithful drawings. Five-year-olds produced relatively more Faithful drawings and relatively few Representational drawings. 2) Condition x Verbal Response (See Table 8): Children in the Intentional Condition produced more Naming and fewer Material responses than expected, while children in the Accidental condition produced fewer Naming and more Material responses than expected. 3) Condition x Drawing Response (See Table 9): Children in the Intentional condition produced more Representational drawings and fewer Faithful drawings than expected, while children in the Accidental condition produced fewer Representational drawings and more Faithful drawings.

In summary, the loglinear model captures the same key findings as the preceding parametric analyses: children's naming of ambiguous pictures is influenced by whether or not they are created intentionally, and their graphic copying is also influenced by underlying intentionality and chronological age. Contrary to my expectations, the model did not identify a significant relationship between children's verbal response and their drawing response.

Table 7

Significant loglinear analysis term: Age x Drawing Response (Experiment 8)

Drawing Response		Age		
		3-year-olds	4-year-olds	5-year-olds
Representational	Observed	28	31	19
	Expected	17.1	28.8	32.1
Faithful	Observed	4	23	41
	Expected	25.2	25.2	27.9

Table 8

Significant loglinear analysis term: Condition x Verbal Response (Experiment 8)

Verbal Response		Condition	
		Intentional	Accidental
Naming	Observed	67	48
	Expected	60.7	54.3
Material	Observed	10	21
	Expected	16.3	14.7

Table 9

Significant loglinear analysis term: Condition x Drawing Response (Experiment 8)

		Condition	
Drawing Response		Intentional	Accidental
Representational	Observed	49	29
	Expected	41.1	36.9
Faithful	Observed	28	40
	Expected	35.9	32.1

6.1.3 Discussion

The results of Experiment 8 suggest that picture comprehension in TD children is not mediated exclusively by shape; both their verbal and drawing responses were significantly influenced by representational status. The Naming analyses replicate the findings of Gelman and Ebeling (1998) almost perfectly. As in the original study, TD children provided more Naming than Material responses overall, however, their relative proportions varied between conditions. Children in the Intentional condition produced Naming responses very frequently and Material responses very rarely, while those children in the Accidental condition provided Naming and Material responses at similar rates. Hence, these data support the theory that children tend to name shape only in so far as it provides an index of representation (Bloom & Markson, 1998; Gelman & Ebeling, 1998). Children are very likely to name shape when they believe it to be a reliable cue to referential intentions, but they can refrain from naming the shape of images that they infer to be non-symbolic (e.g. children are much more likely to name a car-shaped drawing “a car” than a car-shaped paint spill).

The results of the Drawing analyses suggest that children's graphic copying is mediated by both chronological age and the referential intentions underlying the to-be-copied picture. In keeping with previous drawing research documenting the realism of children's drawings (see Cox, 1992), the data indicate that children increasingly focus on creating accurate copies of stimuli with age. Between the ages of 3- and 5-years, participants in this experiment transitioned from drawing what pictures symbolised, to drawing what they saw. However, the proportions of Representational and Faithful drawings produced by children were also influenced by representational status. Across age groups, children created a relatively higher proportion of Representational drawings in the Intentional condition (versus the Accidental condition), and a relatively higher proportion of Faithful drawings in the Accidental condition (versus the Intentional condition). Therefore, when children were copying pictures that were intentionally created, they were increasingly likely to draw more canonical representations of symbolised referents.

The findings reported above suggest that communicative intentions play an important role in children's naming and reproduction of pictures. This is consistent with previous evidence that social-cognitive skills mediate the acquisition of pictorial understanding and picture-referent mapping in TD children (Bloom & Markson, 1998; Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Callaghan et al., 2004; Rochat & Callaghan, 2005; Salsa & de Mendoza, 2007). Hence, in Experiment 9, I expected that deficits in intention reading (Baron-Cohen, 1989, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996) coupled with an overreliance on picture-referent iconicity (Hartley & Allen, 2014; Hartley & Allen, in press (a)) would elicit differences in how children with autism name and draw ambiguous pictures.

It was predicted that difficulties reflecting on the communicative intentions underlying pictures may cause children with ASD to respond in either of two ways at the naming stage of the paradigm. Firstly, the naïve realist style of picture comprehension may cause some children with ASD to consistently name shape, irrespective of whether those shapes were created with the intention of representing the objects they resemble. Secondly, due to the low degree of picture-referent iconicity, some children with ASD may fail to map picture-referent relations at all, and instead name material consistently. Given that children with ASD have a strong tendency to focus on localised perceptual detail of visual stimuli (Frith, 2003; Happé, 1999; Happé & Frith, 2006; Mottron et al., 2003; Mottron et al., 2006), I anticipated that they would produce more Faithful than Representational drawings across experimental conditions.

6.2 Experiment 9

6.2.1 Method

Participants

Participants were 20 children with autism (19 males, 1 female; *M* age = 9.7 years, range = 4.9–16.2 years) recruited from specialist schools in Kendal and Preston, United Kingdom. All children were functionally verbal and had varying degrees of expressive language ability, as is consistent with this clinical population. Every child received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord et al., 2002; Lord et al., 1994) and expert judgment. Autism diagnoses were confirmed via the Childhood Autism Rating Scale (CARS; Schopler et al.,1980), which was completed by each participant's class teacher (*M* score: 38.75, range: 31.5–51.5). In order to make ability-based comparisons with TD children in Experiment 8, children's receptive language ability was measured by the British Picture Vocabulary Scale (BPVS; Dunn et al., 1997).[13] Mean receptive vocabulary of children with ASD was 4.3 years (range: 2–6.4 years), making this sample comparable in terms of ability to the TD children in Experiment 8.

Half of the children with ASD were randomly assigned to the Intentional condition and half to the Accidental condition. Children with ASD in the two conditions did not vary significantly on chronological age (Intentional: $M = 10$ years, $SD = 3.3$ years; Accidental: $M = 9.4$ years, $SD = 3.8$ years), CARS score (Intentional: $M = 40.05$, $SD = 7.75$; Accidental: $M = 37.45$, $SD = 3.8$) or receptive vocabulary (Intentional: $M = 4.2$ years, $SD = 1.3$ years; Accidental: $M = 4.4$ years, $SD = 1.2$ years).

Materials

The same pictures and stories were used as in Experiment 8.

Procedure

The procedure was identical to that described in Experiment 8.

6.2.2 Results

Naming

Coding

All responses could be unambiguously allocated to one of the four categories described in Experiment 8 (Naming, Material, Do Not Know, Other).

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[13] The BPVS score of one child with autism was marginally below the lowest raw score with a standardised age equivalent (of 2.3-years). Consequently, we conservatively assigned this child a receptive language ability of exactly 2-years.

Analyses

For every child, the number of responses belonging to each category was calculated (out of 4; see Fig. 2 for descriptive statistics). In the Intentional Condition, children with ASD made Naming responses on 57.5% of trials ($M = 2.3$, $SD = 1.16$), Material responses on 37.5% of trials ($M = 1.5$, $SD = 1.18$) and Do Not Know responses on 5% of trials ($M = 0.2$, $SD = 0.42$). In the Accidental Condition, children with ASD made Naming responses on 52.5% of trials ($M = 2.1$, $SD = 1.52$), Material responses on 42.5% of trials ($M = 1.7$, $SD = 1.49$) and Do Not Know responses on 5% of trials ($M = 0.2$, $SD = 0.63$).

As in Experiment 8, the infrequent Do Not Know and Other responses were omitted from the following analysis. The proportion of trials in which children with ASD made Naming responses was calculated by dividing their number of Naming responses by their total number of valid responses. These proportion data were entered into an independent samples t-test (Condition was the between-subjects factor), which showed that Condition did not influence the Naming responses of children with ASD. In other words, the proportions of Naming and Material responses made by children with ASD did not differ between the Intentional and Accidental conditions. Furthermore, inspection of the descriptive statistics suggests that these children did not have a strong shape naming bias in either condition (unlike the TD children in Experiment 8).

Drawing

Coding

Drawings were rated using the same coding criteria and in the same fashion as in Experiment 8. Three children with ASD provided verbal responses but refused to make drawings, and one more child did not draw the figure resembling a man.

Reliability

As in Experiment 8, every drawing was coded by the first experimenter and an independent rater with postgraduate experience of coding children's drawings. The second rater was blind to the objectives of the experiment and the details of each artist (e.g. their group, experimental condition, whether or not they named the stimuli). Reliability of coding schemes was assessed via Cohen's Kappa, which was calculated based on the two raters' categorical classifications (i.e. whether a drawing was Representational, Faithful or Uncodable). High interrater reliability was achieved for all coding schemes (man: $\kappa = .83$, $p < .001$; face: $\kappa = .92$, $p < .001$; sun: $\kappa = .85$, $p < .001$; kite: $\kappa = .92$, $p < .001$). Disagreements in categorical classifications (e.g. Faithful vs. Uncodable) were resolved by consensus between the two coders.

Analyses

Of the 67 drawings created by the children with ASD, 32.8% were Representational, 41.8% were Faithful and 25.4% were Uncodable. As in Experiment 8, the first objective was to identify whether children's creation of Representational and Faithful drawings varied as a function of Condition. The proportion of trials in which children created Representational drawings of stimuli was calculated by dividing their number of Representational responses by their total number of valid (i.e. not Uncodable) responses. These proportion data were entered into an independent samples t-test (Condition was the between-subjects factor), which proved to be nonsignificant ($t = -.5$, $p = .62$). Thus, children with ASD created roughly the same proportions of Representational and Faithful drawings across conditions. Moreover, the descriptive statistics indicate that these children did not have a strong bias for creating either Representational or Faithful drawings in general.

As the verbal responding of children with ASD was not mediated by representational status, it is unsurprising that their drawings were not influenced by Condition either. However, it is possible that their drawings were related to their verbal responding. A 3-way (Condition x Verbal Response x Drawing Response) hierarchical loglinear analysis was conducted to determine which combination of interactions among the variables provided the best fit to the data. Drawings rated as Uncodable and those that were preceded by either a Do Not Know or Other verbal response were omitted, leaving 49 drawings in the analysis.

Table 10 displays the partial chi-square for each effect, and shows that only 1 second order term (Verbal Response x Drawing Response) was significant. The final model is displayed in Table 11. This was the least complex model which did not differ significantly from the saturated model (which includes all terms and interactions).

Table 10

Partial Associations for all terms by loglinear analysis (Experiment 9)

Effect	df	Partial χ^2	Probability
C x VR x DR	0	0	1
C x VR	1	0.57	.45
C x DR	1	.42	.52
VR x DR	1	11.72	.001*
C	1	1.00	.32
VR	1	2.49	.12
DR	1	0.51	.48

Note. C: Condition (Intentional, Accidental); VR: Verbal Response (Naming, Material); DR: Drawing Response (Representational, Faithful). Statistical significance indicated by *

Table 11

Final model: Difference estimation from saturated model (Experiment 9)

Model	df	Likelihood ratio G^2	Probability
VR x DR	4	1.9	.76

Note. VR: Verbal Response (Naming, Material); DR: Drawing Response (Representational, Faithful)

Explanation of the model. 1) Verbal Response x Drawing Response (see Table 12): After giving a Naming verbal response, children with ASD produced more Representational drawings and fewer Faithful drawings than expected. After giving a Material verbal response, children with ASD produced more Faithful drawings and fewer Representational Drawings.

In summary, the loglinear model captures the same findings as the preceding parametric analyses: children with ASD were not sensitive to representational status when naming or drawing ambiguous pictures. However, the model did identify a significant relation between Verbal Response and Drawing Response. That is, children with ASD were significantly more likely to produce Representational drawings after naming shape, and Faithful drawings after naming material.

Table 12

Significant loglinear analysis term: Verbal Response x Drawing Response (Experiment 9)

		Drawing Response	
Verbal Response		Representational	Faithful
Naming	Observed	19	11
	Expected	13.5	16.5
Material	Observed	3	16
	Expected	8.5	10.5

6.2.3 Discussion

The Naming data suggest that children with ASD are equally likely to regard an ambiguous line drawing as a symbolic or non-symbolic object, irrespective of whether it was created intentionally or accidentally. In line with my predictions, 75% of children with ASD showed a preference for naming either shape or material (independent of condition). This suggests that some children with ASD consistently named shape without considering whether those shapes were intended to be representational, while others did not regard the perceptually ambiguous figures to be symbols at all (perhaps because the degree of picture-referent iconicity was insufficient). By contrast, TD children in Experiment 8 almost always regarded ambiguous pictures as symbols when they were intentional creations, and were increasingly likely to perceive them as non-symbolic objects when they were accidental. Thus, if a 2-D image is created intentionally, TD children infer that it is a symbolic representation and name it according to its shape (the best cue to referential meaning; Bloom & Markson, 1998). However, if the same image is created by accident, TD children are much less likely to adopt a symbolic perspective as they understand that the shape is not intended to represent the entity it resembles. Together, the results of Experiments 8 and 9 suggest that TD children are sensitive to the intentions underlying pictures created by others, whereas children with ASD are not.

As children with ASD often exhibit impairments in intention reading (Baron-Cohen, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996), it is unsurprising that their naming and copying of pictures were not mediated by the artists' underlying intentions. Interestingly, however, the loglinear analysis revealed that the drawings of children with ASD were influenced by their verbal labelling. This response pattern contrasts with that of TD children in Experiment 8, who were influenced by inferred representational intentions, but not their own verbal labelling, when reproducing ambiguous pictures. The theoretical implications of these findings are addressed below in the General Discussion.

6.3 General Discussion

The present study investigated whether children's naming and drawing of pictures is influenced by representational status, as determined by the artists' underlying intentions. In Experiment 8, TD children aged 2-3 years and 4-5 years were shown a series of line drawings roughly shaped like familiar nameable objects, and children were informed that the pictures had been created intentionally or by accident. At test, participants were asked to name the pictures, and then draw them. Examination of the naming data showed that children in the Intentional condition made a significantly higher proportion of Naming responses (assigning object names that corresponded with shape) and a significantly lower proportion of non-symbolic Material responses (naming the materials that pictures were supposedly made from, e.g. paint) than children in the Accidental condition. The drawing data revealed that children tended to create more Faithful reproductions with age, however, children in the Intentional condition were more likely to produce Representational drawings than peers in the Accidental condition. In Experiment 9, verbal children with ASD were equally likely to name shape or material irrespective of Condition. Parametric analyses on the drawing data revealed no Condition differences, but a loglinear model identified that children with ASD were more likely to produce Representational drawings after naming shape, and Faithful drawings after naming material. Overall, the findings of these experiments suggest that representational status impacts on how TD children, but not children with ASD, name and draw ambiguous pictures.

At a theoretical level, the data suggest that TD children as young as 2-years reflect on whether a 2-D series of markings is intended to be representational before assigning an object name based on shape. When such markings are created by accident, TD children infer that they are not intended to be representational, and can refrain from naming shape. The effect of representational status on children's picture naming replicates Gelman and Ebeling's (1998) findings almost perfectly, and supports Bloom and Markson's (1998) claim that TD children name shape only insofar as it provides an index of representation. In other words, TD children do not simply name shape – they name the *referents* that those shapes are intended to represent. Conversely, this study argues against Browne and Woolley (2001) and Richert and Lillard (2002) who propose that picture comprehension in TD children is entirely resemblance-based. However, it is noteworthy that these studies employed iconic pictures that unambiguously resembled familiar nameable objects other than their intended referents, thus presenting participants with an unusual and potentially confusing test situation. This problem is avoided here by using ambiguous pictures; while each figure resembled a familiar nameable object, the degree of iconicity was low enough for it to be believable that resemblance was incidental. Consequently, children in the Accidental condition, who experienced conflict between shape and representational status, were not biased towards resemblance-based naming.

As predicted, and in line with previous descriptions of children's drawing development (Luquet, 2001; Cox, 1992, 2005; Golomb, 2002, 2004; Jolley, 2010), TD children in Experiment 8 showed an age-related transition from drawing what they *know* to drawing what they *see* when reproducing ambiguous figures. It is well-documented that young toddlers tend to draw familiar objects independent of perspective (a drawing style known as intellectual realism; Luquet, 2001). That is, they will typically represent an object in its most canonical orientation, ensuring that all category-defining features are included, irrespective of their visibility from the child's drawing perspective. However, by 5-years of age, children can create more visually realistic drawings of objects that only include details that are perceptible from a given viewpoint (Bremner & Moore, 1984; Lewis et al., 1993; Sitton & Light, 1992). In the present study, the 3-year-olds may have demonstrated a preference for intellectual realism by creating a much higher frequency of Representational drawings than Faithful drawings, while the 5-year-olds' preference for visual realism may have elicited their creation of more Faithful drawings.

In addition, the drawings created by TD children in Experiment 8 were influenced by the representational status of copied stimuli, but not children's own naming. As anticipated, children were increasingly likely to draw pictures that more closely resembled the referents of ambiguous figures when they were believed to be intentional, symbolic, creations. Conversely, they were increasingly likely to produce Faithful drawings of stimuli when they were thought to be accidental, non-symbolic, creations. By effectively drawing the referents that shapes were intended to represented, rather than the shapes themselves, children provided converging evidence that they derive referential meaning from artists' intentions. The fact that children's verbal labelling did not mediate the way they represented pictures conforms with the theory that, by early childhood, children understand that a symbol's meaning is determined by the intentions of its creator, rather than the perception of the viewer (Bloom & Markson, 1998; Callaghan & Rochat, 2008).

In stark contrast to TD children, children with ASD were not sensitive to representational status when naming or drawing ambiguous figures. Regardless of whether a picture was created intentionally or by accident, children with ASD provided similar frequencies of symbolic Naming responses and non-symbolic Material responses. The fact that intentionality did not increase shape naming in children with ASD suggests that this population may not understand that communicative intentions confer symbolic status to visual representations. Research investigating the acquisition of pictorial understanding has shown that social-cognitive skills (e.g. intention reading and imitation) enable TD children to learn about pictures through interactions with more experienced symbol-users (Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Callaghan et al., 2004; Rochat & Callaghan, 2005). However, many children with ASD show deficits in the social-cognitive skills that underlie pictorial development (Baron-Cohen, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996), possibly preventing them from inferring representational intentions from others' communicative actions involving pictures. Therefore, if children with ASD cannot acquire pictorial understanding through social interactions, perhaps they develop an understanding of pictures via an alternative non-intentional pathway. More specifically, it may be that children with ASD learn how pictures relate to the world through the recognition of perceptual resemblances.

I propose that some children with ASD may comprehend pictures purely at face value, relying heavily (if not exclusively) on the analysis of immediately perceptible resemblance properties, without reflecting on factors external to the visual image (e.g. the artist's intentions, whether the picture was created accidentally, expectations of the viewer; for further evidence see Allen, 2009 and Hartley & Allen, 2014). Thus, if a picture looks like X, it is X. This resemblance-based processing style conforms to the theory of naïve realism (Freeman, 1991; Freeman & Sanger, 1995). In support of this account, there is growing evidence that successful picture comprehension in autism is dependent on a high degree of resemblance (Hartley & Allen, 2014; Hartley & Allen, in press (a); Hartley & Allen, under revision). Indeed, the reliance of children with ASD on resemblance would explain their relatively high rate of Material responses across conditions; perhaps the ambiguous figures were not iconic enough for children to recognise picture-referent relations. Also, the finding that the drawings of children with ASD were influenced by their verbal responding, rather than representational status, provides converging evidence that this population derive meaning from pictures in an egocentric, non-intentional, manner. Unlike TD children, who tended to create Representational drawings in the Intentional condition (i.e. they drew a more face-like picture when they inferred that a figure's *creator* had intended to represent a face), children with ASD tended to create Representational drawings after naming shape (i.e. they drew a more face-like picture when they *themselves* decided that a figure was a face).

Of course, the limitations of this study must be addressed. My sample sizes were fairly modest, and reduced in the drawing analyses by the frequencies of Uncodable drawings, so a replication with greater numbers of children could establish the reliability of these findings. It is also possible that children's creation of Representational and Faithful drawings was more closely related to their interpretation of the test question "can you draw this?" than their understanding of the intentional origins of pictures. Those children who created Representational drawings may have taken the word *this* to mean the symbolised object (i.e. "can you draw a kite?"), while those who created Faithful drawings may have interpreted *this* more literally (i.e. "can you draw this specific picture that only slightly resembles a kite?"). Although the drawing data were not definitively clear-cut, the naming data unambiguously demonstrate that TD children understand that communicative intentions make a 2-D shape representational, while children with ASD do not.

Overall, the present study has shown that representational status significantly mediates how TD children, but not children with ASD, name and draw ambiguous pictures. The tendency of TD children to name a picture's shape is influenced by whether or not the artist *intended* that shape to be representational. Additionally, TD children were increasingly likely to produce canonical drawings of symbolised referents when they believed that stimuli were intended to be symbolic, further demonstrating their sensitivity to referential intentions. Thus, picture comprehension in TD children is not driven entirely by shape-based resemblance – the meaning of a given shape is determined by the intentions of its creator. By contrast, the naming and drawing responses of children with ASD were not influenced by the social-communicative intentions underlying pictures. This finding strengthens my theory that picture comprehension in children with ASD is entirely resemblance-based, thus conforming with the naïve realist account.

Chapter Seven: **General Discussion**

This thesis has investigated how low-functioning children with autism comprehend pictorial symbols. Chapters Two, Three and Four examined their ability to use pictures as a source for deducing information about the world, in particular, as a medium for learning novel words (Chapters Two and Three) and as contextualised cues about specific events (Chapter Four). Chapters Five and Six examined whether children with ASD and TD children differ in their understanding of what fundamentally relates a picture to its referent. More specifically, they addressed whether communicative intentions or resemblance guide children's mapping of word-picture and picture-object relations (Chapter Five), and whether artists' intentions influence children's own naming and reproduction of pictures (Chapter Six).

In Chapter Two (pp. 47-81), referential word-picture mapping in children with ASD was facilitated by iconicity, but not verbal labelling. In Experiment 1, children were taught novel words paired with target pictures of unfamiliar objects that varied in iconicity. At test, they were asked to identify the referents of newly-learned words when presented with target pictures paired with depicted objects and then differently-coloured category members. Children with ASD tended to form associative word-picture relations, however, they extended verbal labels to target objects (and sometimes differently-coloured category members) approximately twice as often in colour picture trials relative to non-colour picture trials (48.6% vs. 25.7%). By contrast, TD children almost always extended labels to depicted objects and also generalised those labels to differently-coloured variants matching on shape. In Experiment 2, children with ASD categorised a non-colour line drawing with its referent (rather than another picture), regardless of whether it was verbally labelled. This finding shows that children with ASD can map picture-object relations even when iconicity is low, and that verbal naming does not direct children with ASD to view pictures as symbols. By comparison, TD children tended to categorise line drawings with referent objects in the Labelled Condition and other drawings in the Unlabelled condition, thus demonstrating that verbal naming directs them to view pictures as symbols.

In Chapter Three (pp. 82-99), children with ASD formed referential relations between words and colour photographs in conditions that did not foster associative learning, however, they often generalised labels based on incorrect perceptual dimensions. Children were taught novel words paired with photographs of unfamiliar target objects and were required to sort items into two buckets according to whether or not they were also referents of the newly-learned labels. Children with ASD almost always extended labels to items (pictures and objects) that matched depicted objects on shape and colour, but also frequently generalised to items that matched only on shape *or* colour (i.e. they did not demonstrate a shape bias). This atypical pattern of responding indicates that some children with ASD fundamentally misunderstand the rules that govern symbolic word-picture-object relations, perhaps due to deficits in category abstraction (Gastgeb et al., 2006; Klinger & Dawson, 2001; Plaisted, 2000; Tek et al., 2008). Contrastingly, TD children only generalised labels to items that belonged to the same category as depicted objects, as indicated by sameness of shape, rather than sameness of colour.

Chapter Four (pp. 100-131) examined whether children with ASD could solve a search task by contextualising symbolic information communicated by pictures. Out of the participant's view, a small toy was concealed underneath one of 4 unique occluders that were individuated by familiar nameable objects or unfamiliar unnameable objects. Children were shown a picture of the hiding location (which varied in iconicity over sessions) and then searched for the toy. Unlike the paradigms employed in Chapters Two and Three, this task did not involve word learning and children could not simultaneously view depicted and real hiding locations while searching – they had to generate a mental representation of the picture and then identify the corresponding 3-D referent. The results revealed zero group differences; neither children with ASD nor TD children were influenced by occluder familiarity, and both groups' errorless retrieval rates were above-chance with all picture types. However, both groups made significantly more errorless retrievals in the most-iconic photograph trials, and performance was universally predicted by receptive language. Therefore, children with ASD can contextualise pictures and use them to adaptively guide their behaviour in real time and space, however, this ability is significantly influenced by receptive language development and pictorial iconicity.

Collectively, Chapters Two, Three and Four inform our understanding of how children with ASD comprehend pictures by highlighting the importance of iconicity and the role of verbal labelling. Experiment 2 (pp. 70-76) and the Line Drawing condition of Experiment 4 (pp. 109-125) demonstrate that children with ASD are able to map perceptual relations between objects and pictures of relatively low iconicity (e.g. black-and-white line drawings), however, greater iconicity facilitates *both* their ability to contextualise mental representations of pictures *and* their mapping of referential word-picture-object relations. It is likely that children with ASD were better able to contextualise iconic colour photographs because their corresponding mental representations could be matched to potential referents on two resemblance properties (shape and colour), whereas the less iconic pictures could only be matched to referents on one perceptual property (shape or colour). One reason why children with ASD were increasingly likely to generalise labels to objects depicted in colour pictures is that sameness of colour makes picture-referent relations more transparent. For those children with ASD in Chapter Two, perhaps the viewing of a colour picture alongside its colour-matched referent served to highlight the symbolic relationship, increasing the likelihood that they would extend information from picture to referent in a manner consistent with symbolic understanding.

Although children with ASD in Chapter Two were twice as likely to generalise labels from colour pictures (relative to non-colour pictures), they generalised much less frequently than language-matched TD children. This between-group difference indicates that verbally labelling pictures has a contrasting effect on these two populations. In typical development, linguistic symbols are mastered earlier in development and henceforth serve as a scaffolding base for other symbolic domains (Kirkham et al., 2012). Once TD children learn that verbal labels refer to objects in the world, they may infer that pictures also relate to independently existing objects when they are named. Thus, when TD children in Chapters Two and Three heard a label paired with a picture, their attention may have been directed to its symbolic status, increasing the probability that they would successfully map the picture-referent relation. Indeed, in Experiment 2, a single word-picture pairing was sufficient to direct TD children to view a line drawing from a symbolic perspective and categorise it with its object referent, rather than another picture. By contrast, low-functioning children with ASD show profound linguistic impairments (Anderson et al., 2007; Lord, Risi & Pickles, 2004) and tend to learn words associatively rather than referentially (Baron-Cohen et al., 1997; DSM-IV: American Psychiatric Association, 1994; Frith & Happé, 1994; Preissler, 2008; Preissler & Carey, 2005). Consequently, one-off naming did not bias children with ASD towards viewing pictures from a symbolic perspective (Experiment 2, pp. 70-76), and they required significantly more pairings than TD children to learn word-picture relations (Experiment 1, pp. 51-70). However, the repeated reinforcement involved in the training procedure of Experiment 1 may have narrowed the referential relation to the extent that the picture itself (rather than the depicted object) was considered the referent of the word.

Conversely, Chapter Three demonstrated that low-functioning children with ASD can learn referential word-picture relations. In this study, children heard labels paired with photographs multiple times, but children were not required to actively and repeatedly pair words and pictures themselves (nor did they receive reinforcement for doing so). It is likely that this difference in training procedure fostered the learning of non-associative word-picture relations, enabling children with ASD to generalise labels from pictures to other objects in the world. It is important to note that children with ASD in Chapters Two and Three were extremely similar in terms of chronological age and receptive language ability, so it is highly unlikely that the two samples differed in their fundamental understanding of pictures. In any case, although children with ASD in Chapter Three frequently generalised words from photographs, they often did so based on incorrect perceptual dimensions. More specifically, they generalised labels based on the non-adaptive cue 'sameness of colour' just as often as the adaptive cue 'sameness of shape'. This finding suggests that deficits in category formation (Gastgeb et al., 2006), which prevent children with ASD from identifying shape as the key constraint underlying referential word-object relations (Tek et al., 2008), also impact on their pictorial understanding.

Taken together, Chapters Two, Three and Four indicate that the difficulties of children with ASD in the pictorial domain relate primarily to *word*-picture-object mapping, rather than picture-object mapping *per se*. Due to impairments in their referential understanding of language (Baron-Cohen et al., 1997; Frith & Happé, 1994; Kanner, 1946; Preissler, 2008; Preissler & Carey, 2005), low-functioning children with ASD may not know intuitively *what* words relate to when paired with pictures. Chapter Three showed that children with ASD are just as likely to map labels onto the shape *and* colour of depicted referents, and Chapter Two documented that children with ASD tend to map labels onto pictures themselves (rather than symbolised referents) when learning conditions foster associative pairing. Although verbal labelling does not trigger shape-based referential mapping of picture-object relations in children with ASD, as it does for TD children, Chapter Four provided some evidence that language skills do influence their pictorial understanding. The ability of TD children and children with ASD to correctly search for a hidden toy using a picture as a cue was significantly predicted by receptive language; children with relatively low receptive language were less likely to make errorless retrievals. These findings suggest that language comprehension has an important influence on how children with ASD understand pictures, but naming does not directly scaffold their mapping of picture-object referential relations. It may be that those children with higher receptive language approached the search task with a more nuanced understanding of how objects in the world can be represented, while those with lower receptive language had a generally weaker understanding of representation, and may therefore have been increasingly reliant on picture-object resemblance.

From an applied perspective, the findings documented in Chapters Two, Three and Four have important implications for picture-based communication interventions, such as the Picture Exchange Communication System (Frost & Bondy, 2002). There are many symbol sets designed for use with PECS that provide graphic representations of vocabulary (e.g. Blissymbols, Picsyms, Picture Communication Symbols), but the pictures within and between these sets vary considerably along the continuum of iconicity (Bloomberg, Karlan & Lloyd, 1990; Mirenda & Locke, 1989). At present, there are no guidelines regarding what types of pictures are best suited for PECS-like interventions, and it is not uncommon for children with ASD to be taught using relatively abstract black-and-white line drawings and symbols (see participant information in Chapters Two, Three and Four). Although it is clear that many children with ASD have general difficulties understanding symbols (Jarrold, Boucher & Smith, 1993; Stanley & Konstantareas, 2007; Happé, 1995; Wetherby & Prutting, 1984; Preissler, 2008), this thesis has shown that their picture comprehension is facilitated by greater iconicity and, in particular, colour. Children with ASD were significantly better at contextualising colour photographs (Chapter Four), and they were much more likely to generalise labels to objects depicted in iconic colour pictures than non-colour pictures (Chapter Two; also see Chapter Three). Thus, because iconic colour pictures facilitate *both* picture-object and word-picture-object mapping, these findings provide educators and therapists with a data-grounded rationale for delivering picture-based communication training with highly-iconic colour pictures.

While this thesis has demonstrated that iconic colour pictures facilitate symbolic understanding in children with ASD under experimental conditions, it is important that future studies empirically validate the benefits of their use when delivering PECS (see below). It is possible that the repetition and reinforcement involved in the PECS protocol fosters extremely narrow, associative, word-picture and picture-object relations, thus limiting children's ability to generalise from pictures irrespective of colour. Also, the findings of Experiment 3 demonstrate that photographs may not necessarily elicit adaptive referential mapping, as children often generalised on the incorrect basis of colour. Another issue that could reduce the applied value of these findings is that the studies reported in this thesis only investigated children's understanding of pictures that symbolise concrete objects. Recipients of PECS training are required to comprehend pictures that symbolise verbs and adjectives which typically share fewer resemblance properties with their referents. Therefore, studies evaluating the influence of iconicity on PECS delivery could provide insight into children's ability to comprehend these infrequently-studied picture types.

Chapter Five (pp. 132-173) investigated whether children with ASD and TD children hold the view that communicative intent, rather than perceptual resemblance, determines the referents of abstract pictures. In Experiment 5, children received a modified version of Bloom and Markson's (1998) Size Task, which assessed whether they would map words and objects to abstract pictures based on resemblance or intentional cues. At the Picture Selection Stage, both children with ASD and TD children mapped familiar object names onto abstract pictures based on an intentional cue, however, they related the same representations to different 3-D referents at the Object Selection Stage; TD children linked abstract pictures to objects based on artists' intentions, while children with ASD mapped picture-object relations based on resemblance, despite its inadequacy as a cue to referential meaning. Experiment 6 showed that intention-based picture-object mapping in TD children was not directed by linguistic cues, and Experiment 7 confirmed that the resemblance-based responding of children with ASD was not due to perseveration or associative word learning. These findings suggest that resemblance is not criterial for picture comprehension in young TD children – they understand the intentional-communicative function of pictures by 3-years of age – but it is vital for children with ASD. It may be that social-cognitive impairments prevent children with ASD from reflecting on artists' communicative intentions, making them naïve realists, who evaluate pictures based exclusively on their perceptual features.

Chapter Six (pp. 174-210) showed that representational status – as determined by an artist's communicative intentions – significantly influences how TD children, but not children with ASD, name and reproduce ambiguous pictures. TD children and functionally verbal children with ASD were shown a series of line drawings roughly shaped like familiar nameable objects, and children were informed that the pictures had been created intentionally or by accident. The tendency of TD children to name pictures according to shape was influenced by whether or not the artist *intended* that shape to be representational. Additionally, TD children were increasingly likely to produce canonical drawings of symbolised referents when they believed that stimuli were intended to be symbolic, further demonstrating their sensitivity to referential intentions. By contrast, the naming and drawing responses of children with ASD were not influenced by the social-communicative intentions underlying pictures. Children with ASD provided similar proportions of symbolic and non-symbolic verbal responses irrespective of representational status, and they were more likely to produce canonical drawings after they themselves named shape, rather than when shapes were intended to be representational. These findings suggest that picture comprehension in TD children is not driven entirely by shape-based resemblance (the meaning of a shape is determined by the intentions of its creator), whereas picture comprehension in children with ASD is entirely resemblance-based, thus conforming with naïve realism.

Together, Chapters Five and Six indicate that TD children and children with ASD fundamentally differ in their understanding of what *relates* pictures to referents in the world. Chapter Five showed that TD children will map object names to abstract pictures that correspond with their creator's referential intentions, despite the lack of resemblance, and Chapter Six showed that TD children only evidence a preference for resemblance-based naming when pictures are intended to be representational. Furthermore, Chapter Five also demonstrated that TD children are willing to map picture-object relations based entirely on artists' representational intentions. Thus, TD children can derive referential meaning from pictures in the complete absence of resemblance, based entirely on notional external properties – namely the artists' communicative intentions. In addition, TD children can reject resemblance as a cue to referential meaning when it is considered to be incidental. Overall, these studies suggest that picture comprehension in TD children is not driven exclusively by resemblance, as hypothesised by Browne and Woolley (2001) and Richert and Lillard (2002) (also see Hopkins, 1995, 1998; Hyman, 2006; Peacocke, 1987). From 2- to 3-years of age, TD children can reflect on the communicative intentions underlying pictures, and they privilege resemblance as a basis for word-picture-object mapping only insofar as it provides as reliable cue to intended symbolic meaning. Hence, young TD children understand that pictures are human creations with an intended communicative meaning and, in order to derive that meaning correctly, they are able to reflect on the mind behind the symbol.

However, it is important to contextualise these findings in terms of children's general pictorial experiences, and it is indisputable that resemblance is an important influence on day-to-day picture comprehension. The majority of pictures that children encounter (e.g. in picture books) look unambiguously like their intended referents, and thus can be interpreted based on appearance. Indeed, the appearance of a picture is often highly congruent with an artist's referential intentions (e.g. if a picture is shaped like a car, it is probably intended to represent a car), making resemblance an excellent cue to symbolic meaning (Bloom, 2000; Bloom & Markson, 1998). However, my studies have shown that in situations where resemblance is an inadequate or unreliable cue (e.g. when an artist has a broken arm, or an image is made by accident), young TD children are able to derive meaning from artists' intentions, and can selectively ignore any incidental resemblance to non-intended referents.

By contrast, my findings show that artists' intentions do not influence picture comprehension in children with ASD. Although children with ASD responded similarly to TD children at the Picture Selection Stage of the Size Task in Chapter Five, I argue that this component of the paradigm did not necessitate reflection on the artist's intentions, enabling children with ASD to "hack out" a solution via non-intentional reasoning (see Happé, 1995). Had the responding of children with ASD at the Picture Selection Stage been driven by their consideration of the artists' intentions, they would have surely responded based on those same intentions at the Object Selection Stage. Instead, when explicitly asked to consider the artists' intentions, children with ASD mapped picture-object relations based on resemblance. For children with ASD in Chapter Six, intentional representational status did not increase shape-based naming or canonical drawing of symbolised referents. These findings provide converging evidence that artists' social-communicative intentions do not influence the meaning that children with ASD derive from pictures.

Callaghan's research investigating the mechanisms underlying pictorial development has shown that social-cognitive skills (e.g. intention reading and imitation) enable TD children to acquire the picture symbol system through social interactions with adults (Callaghan & Rankin, 2002; Callaghan & Rochat, 2008; Callaghan et al., 2004; Rochat & Callaghan, 2005). However, many children with ASD show deficits in the social-cognitive skills that underlie typical pictorial development (Baron-Cohen, 1995; Charman et al., 1997; Griffin, 2002; Hobson, 2002; Mundy & Willoughby, 1996), perhaps preventing them from identifying the causal link between communicative intentions and the representational meaning of pictures. If children with ASD are unable to infer that a picture is a symbol for X because it was created with the intention of representing X, they may develop a non-intentional theory of how pictures relate to the world. Instead of reflecting on pictures as creations of other humans with psychological relations to the world, they may view pictures as non-intentional artefacts that relate to other objects purely by virtue of resemblance.

I propose that some children with ASD may comprehend pictures at face value, relying heavily (if not exclusively) on the analysis of immediately perceptible resemblance properties, without considering factors external to the visual image (e.g. the artist's intentions, whether the picture was created accidentally, expectations of the viewer). Thus, if a picture looks like X, it is X, even if the artist intended to represent Y. This resemblance-based processing style conforms to the theory of naïve realism (Freeman, 1991; Freeman & Sanger, 1995). In support of this account of pictorial understanding, Chapters Two and Four report evidence that picture comprehension in children with ASD is significantly influenced by iconicity. Furthermore, the finding in Chapter Five that children with ASD tend to map abstract pictures to objects based on resemblance, despite its inadequacy as a referential cue, affirms the argument that picture-based communication interventions should be delivered with highly-iconic symbols, as these appeal most to recipients' picture processing style. Indeed, it is clear from Chapters Five and Six that children with ASD find it more difficult to comprehend the intended meaning of less transparent visual symbols. It is also noteworthy that both nonverbal (Chapter Five) and verbal children with ASD (Chapter

Six) failed to consider the communicative intentions underlying pictures, therefore strengthening the case that many children with ASD are naïve realists.

Of course, the theoretical conclusions drawn by this thesis must be weighed against its limitations. The samples of children with ASD involved in each experiment were fairly modest, ranging between 15 and 21 individuals. Many children with ASD who had consent to participate in these experiments were rejected either because they were too high-functioning relative to their peers, or because their cognitive development was too immature and they simply could not engage with the tasks. Additionally, some children were omitted due to extremely challenging and aggressive behaviours that made testing impossible. Nevertheless, it is important to note that the individuals who did participate in these experiments were highly-representative of low-functioning children with ASD who receive and, typically benefit from, picture-based communication training (excluding those in Chapter Six who were verbal). Every child in Chapters Two to Five had impaired expressive language – many had no functional language, while others could speak very short utterances – and all children had received PECS training for varying timespans. Furthermore, the fact that each of these studies generated significant findings, despite the modest sample sizes, could be viewed as a testament to the robust nature of the effects in question.

Another issue associated with investigating a profoundly low-functioning population concerns standardised testing. In each study, it was impossible to ascertain an accurate measure of receptive language for a very small minority of children with ASD. This was either because a child's BPVS score was marginally below the lowest score with a standardised age equivalent or, more rarely, because the child did not complete the measure due to challenging behaviour. While it would have been desirable to acquire an accurate measure of receptive language from every child, this research is especially relevant to nonverbal children who have difficulty with standardised assessments, display challenging behaviours, and require alternative communication training. Relatedly, due to their linguistic difficulties, critics may question whether the children with ASD in these studies understood the instructions and contextual information provided by the experimenter (e.g. in Chapters Four, Five and Six). However, in each experiment, children with ASD and TD children were matched extremely closely on receptive language, making it difficult to attribute contrasting response patterns to between-group differences in language comprehension. Moreover, there is extensive evidence that very young TD children (e.g. aged 2-years and younger), with lower language comprehension abilities than the children with ASD tested here, can succeed in very similar paradigms (e.g. Ganea et al., 2009; Preissler & Bloom, 2007, 2008; Simcock & DeLoache, 2006; Suddendorf, 2003).

It is possible that the results reported in this thesis are an effect of limited cognitive abilities rather than autism *per se*. I acknowledge that the inclusion of samples of children with major learning difficulties matched to children with ASD on nonverbal intelligence would have eliminated this confound. Importantly, the children with ASD who participated in these studies were representative of the population that this research is most relevant to: low-functioning individuals with impaired language development who receive picture-based communication training. Therefore, this research has both direct theoretical and applied value. It is, however, inadvisable to generalise the results of these experiments (particularly those reported in Chapters Two, Three and Four) across the autism spectrum. It may be that high-functioning children with ASD who are more linguistically developed have an understanding of word-picture-object relations that is similar to typical development. That being said, the results of Chapter Six suggest that even children with ASD who are functionally verbal may have a fundamentally different understanding of pictorial representation.

Lastly, I cite social-cognitive impairments and the absence of referential linguistic scaffolding as potential causes of atypical picture comprehension in autism without providing direct evidence of causal relations. This hypothesis is based on the fact that a) there is an extensive body of research documenting the mediating roles of imitation, intention-reading and language in pictorial development (Callaghan, 2000; Callaghan et al., 2004; Callaghan & Rankin, 2002; Kirkham et al., 2012; Salsa & de Mendoza, 2007), and b) low-functioning children with ASD show impairments in all of these areas (Anderson et al., 2007; Baron-Cohen, 1989, 1995; Baron-Cohen et al., 1997; D'Entremont & Yazbek, 2007; Griffin, 2002; Hobson, 2002; Lord, Risi & Pickles, 2004). Nonetheless, this explanation is hypothetical and requires validation in future research. The overarching objective of my studies was to simulate novel picture comprehension scenarios and to inform our understanding of *how* children with ASD derive meaning from pictures. Having demonstrated that picture comprehension in children with ASD is different in a number of important ways, definitively answering the question *why* is an objective that I intend to follow-up (see below).

Despite the popularity of picture-based communication interventions, and the ubiquitous use of visual supports in classroom settings, surprisingly little research to date has investigated how children with ASD comprehend pictures. Hence, there are numerous ways in which future research could build on the findings reported in this thesis. One avenue would be to investigate whether the PECS training programme is facilitated by the use of iconic colour photographs. A study could compare how rapidly children with ASD reach learning criterion for each stage of PECS training using photographs and less iconic picture types, and also include tests of symbolic understanding and generalisation to identify whether children genuinely understand the referential relation between pictures and the objects they represent. If it proved to be the case that progression through PECS training and symbolic understanding both benefited from the use of colour photographs, subsequent studies could assess the relative benefits of delivering training with personalised versus standardised photograph sets.

A second avenue for future research would be to examine whether it is possible to train symbolic understanding of pictures in children with ASD. Following Callaghan and Rankin's (2002) training protocol, some children with ASD would be assigned to a treatment group that would receive weekly training sessions intended to facilitate picture comprehension and production over a 4-month period, while a control group would receive an equivalent number of "placebo" training sessions over the same time frame. In each training session, children in the treatment group would select objects which the experimenter would draw, before highlighting the picture-referent correspondences. By contrast, children in the control group would simply select objects and watch the experimenter position them in a line (i.e. they would not observe drawing). Children's picture comprehension and production abilities would be assessed at monthly intervals. The original study reported that TD children in the treatment group experienced significant improvement in their picture comprehension and production after 2 and 3 months' training respectively, demonstrating that pictorial development can be accelerated by providing children with frequent opportunities to infer the referential intentions of experienced picture-users. Given the social-cognitive deficits experienced by many children with ASD, it would be interesting to discover whether this population could deduce the knowledge and rules that underlie pictorial representation from the behaviour of others. Importantly, the lack of significant improvement in the treatment group would suggest that children with ASD may not acquire symbolic understanding of pictures from others as TD children do.

A third avenue for future research would be to investigate how the developmental trajectories of different symbolic domains interrelate in children with ASD, particularly when language is not available as a scaffolding mechanism. Following Kirkham, Stewart and Kidd (2012), a longitudinal study could measure children's comprehension and production abilities in various symbolic domains (e.g. language, play and pictures) at intervals over an extended period and test for predictive relations at each time point. Furthermore, by taking additional measurements of the various social-cognitive skills that are known to be involved in typical symbolic development (e.g. imitation, gaze-following, intention reading, declarative pointing, joint attention; see Callaghan et al., 2011), it may be possible to identify which skills are most associated with relatively adaptive and maladaptive development in children with ASD. As many children with ASD suffer from profound linguistic impairments, and often perceive words to be non-referential auditory stimuli (Baron-Cohen et al., 1997; Preissler, 2008; Preissler & Carey, 2005), one might predict that the lack of conventional symbolic scaffolding directly impacts on development in other symbolic domains, such as pictorial understanding and play.

Collectively, the studies comprising this thesis have demonstrated that low-functioning children with autism and language-matched typically developing children differ in their symbolic understanding of pictures. Although children with ASD can recognise perceptual similarities between pictures and objects, they do not understand the rules that constrain symbolic word-picture-object mapping. Across studies, iconicity emerged as an important factor that mediates their ability to contextualise symbolic information communicated by pictures and generalise labels to depicted objects. Furthermore, unlike their typically developing peers, children with ASD do not reflect on the social-communicative intentions underlying pictures when naming, drawing or identifying referent objects. Instead, they derive meaning based exclusively on resemblance, making them naïve realists (Freeman, 1991; Freeman & Sanger, 1995). At a theoretical level, this thesis contributes to the field of psychology by informing how low-functioning children with ASD, an extremely under-researched population, comprehend relations between words, pictures and the objects they represent. The ability to transmit and derive information from symbols is at the core of human cognition, and this research has shown that children with ASD are fundamentally impaired in several key respects. Also, from an applied perspective, the results reported in this thesis (particularly those pertaining to iconicity) have important implications for the design and delivery of picture-based communication interventions.

Appendix A. Detailed participation information for children with autism

Inclusion criteria for children with autism (ASD)	
Experiments 1, 2, 3, 4, 5 & 7	Experiment 9
Children with ASD in the final samples for these experiments were characterised by the following criteria at the time of testing: a) Autism diagnosis – children received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (e.g. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord et al., 2002; Lord et al., 1994) and had this diagnosis confirmed via an above-threshold score on the Childhood Autism Rating Scale (CARS; Schopler et al., 1980). b) Severely impaired language – children's expressive language development was profoundly delayed. The majority of children were functionally nonverbal. Some spoke short utterances between 1 and 3 words in length. A minority of participants were capable of producing non-echolalic utterances over 4 words in length, but the language of these children was heavily scaffolded by pictures, particularly when learning new concepts. There was also a large disparity between children's receptive language level and their chronological age. c) Current PECS-user – due to the above criteria, all children were users of the Picture Exchange Communication System (PECS). Children either used PECS as their only form of functional communication, or were heavily dependent on the system as a scaffold for their limited verbal utterances. There were no criteria concerning amount of PECS experience or training progress. d) Task completion – in addition to completing the relevant experimental task(s), the child also i) achieved a standardised score on the British Picture Vocabulary Scale (BPVS), ii) achieved a BPVS raw score that was marginally below the lowest score with a standardised age equivalent, or iii) demonstrated an ability to comprehend and respond to the BPVS, but failed to complete the measure due to challenging behaviour. * Note: There were no inclusion criteria relating to chronological age.	Children with ASD in the final sample of this experiment were characterised by the following criteria at the time of testing: a) Autism diagnosis – children received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (e.g. Autism Diagnostic Observation Scale and Autism Diagnostic Interview - Revised; Lord et al., 2002; Lord et al., 1994) and had this diagnosis confirmed via an above-threshold score on the Childhood Autism Rating Scale (Schopler et al., 1980). b) Verbal naming ability – children were able to spontaneously label the relevant stimuli using verbal language, in the absence of modelling. c) Receptive language threshold – children's receptive language ability was comparable to the developmental level of the TD children in Experiment 8. d) Task completion – children had to at least provide naming data, and i) achieve a standardised BPVS score, or ii) achieve a BPVS raw score that was marginally below the lowest score with a standardised age equivalent. * Note: There were no inclusion criteria relating to chronological age.

Exclusion criteria for children with autism	
Experiments 1, 2, 3, 4, 5 & 7	Experiment 9
Children were excluded from the final sample if they met any of the following criteria: a) Diagnosis – a child's CARS score was below the threshold for autism, thus failing to confirm their clinical diagnosis. b) Language – a child could speak fluently and/or had age-appropriate expressive or receptive language. c) PECS use – the child was not a current PECS-user. d) Task completion – the child could not understand the experimental task (or the BPVS) due to inadequate cognitive development. e) Behaviour – the challenging/aggressive nature of the child's behaviour made testing impossible and/or dangerous.	Children were excluded from the final sample if they met any of the following criteria: a) Autism diagnosis – a child's CARS score was below the threshold for autism, thus failing to confirm their clinical diagnosis. b) Task completion – the child could not understand the experimental task (or the BPVS) due to inadequate cognitive development. c) Behaviour – the challenging/aggressive nature of the child's behaviour made testing impossible and/or dangerous.

Number of children with autism with parental consent excluded from each experiment

Basis of exclusion	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 7	Exp. 9
a) Diagnosis	3	3	0	0	2	0	2
b) Language	0	0	1	1	0	1	N/A
c) PECS use	1	1	1	1	1	1	N/A
d) Task completion	7	7	5	5	7	5	36*
e) Behaviour	1	1	1	2	1	1	2

* *Note:* The frequency of children unable to complete Experiment 9 was high due to the verbal responding demands. Many children who provided data for other experiments were unable to participate.

Participation of children with ASD across multiple experiments							
Participant	Exp.1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 7	Exp. 9
1	✔	✔	✖	✖	✔	✖	✔
2	✔	✔	✖	✖	✔	✖	✔
3	✔	✔	✖	✖	✔	✖	✖
4	✔	✔	✖	✖	✔	✖	✖
5	✔	✔	✖	✖	✔	✖	✖
6	✔	✔	✖	✖	✖	✖	✖
7	✔	✔	✖	✖	✔	✖	✔
8	✔	✔	✖	✖	✔	✖	✔
9	✔	✔	✖	✖	✖	✖	✖
10	✔	✔	✖	✖	✔	✖	✖
11	✔	✔	✖	✖	✔	✖	✖
12	✔	✔	✖	✖	✔	✖	✖
13	✔	✔	✖	✖	✔	✖	✖
14	✔	✔	✖	✖	✔	✖	✔
15	✔	✔	✖	✖	✖	✖	✖
16	✔	✔	✖	✖	✖	✖	✖
17	✔	✔	✖	✖	✔	✖	✔
18	✔	✔	✖	✖	✔	✖	✖
19	✔	✔	✖	✖	✖	✖	✔
20	✔	✔	✖	✖	✔	✖	✖
21	✖	✖	✔	✔	✖	✔	✔
22	✖	✖	✔	✔	✖	✔	✖
23	✖	✖	✔	✔	✖	✔	✖
24	✖	✖	✔	✖	✖	✔	✖
25	✖	✖	✔	✔	✖	✔	✔
26	✖	✖	✔	✔	✖	✔	✔
27	✖	✖	✔	✔	✖	✔	✖
28	✖	✖	✔	✔	✖	✔	✖
29	✖	✖	✔	✔	✖	✔	✔
30	✖	✖	✔	✔	✖	✔	✖
31	✖	✖	✔	✔	✖	✔	✖
32	✖	✖	✔	✔	✖	✔	✖
33	✖	✖	✔	✔	✖	✔	✔
34	✖	✖	✔	✔	✖	✔	✔
35	✖	✖	✔	✔	✖	✔	✖
36	✖	✖	✔	✔	✖	✔	✖
37	✖	✖	✔	✔	✖	✔	✖
38	✖	✖	✖	✖	✖	✖	✔
39	✖	✖	✖	✖	✖	✖	✔
40	✖	✖	✖	✖	✖	✖	✔
41	✖	✖	✖	✖	✖	✖	✔
42	✖	✖	✖	✖	✖	✖	✔
43	✖	✖	✖	✖	✖	✖	✔
44	✖	✖	✖	✖	✖	✖	✔

Appendix B. Stories corresponding to each ambiguous picture (I = Intentional; A = Accidental) (see Fig. 16)

Picture 1 (man). I: When John was painting in an art lesson, he used some paint to make something for his teacher. This is what it looked like.

A: When John's dad was painting the house, John accidentally spilled some paint on the floor. This is what it looked like.

Picture 2 (face). I: Tommy had peas with his dinner one night. He didn't like the way they tasted, so he pushed them around on his plate to make a picture. This is what it looked like.

A: Tommy had peas with his dinner one night. He tried to eat them with a fork, but some of them rolled off his fork onto the floor. This is what it looked like.

Picture 3 (sun). I: One day, while he was in an art lesson, Mike got to use mud to make an art project. Mike carefully put the mud on the paper until he was finished. It looked like this.

A: One day, while he was playing, Mike saw a big puddle. Mike jumped in the puddle and the mud splashed on his shirt. It looked like this.

Picture 4 (kite). I: While looking through a scrap box, Dave found some string and decided to make an art project. It looked like this.

A: While walking through his front yard, David found some string caught on a bush. It looked like this.

Appendix C. Coding schemes for children's drawings

Picture 1 (man).

1. 'Uncodable' – drawing does not, in any way, share perceptual similarity with either stimuli or symbolised referent (e.g. drawing is a scribble or series of randomly-placed disconnected shapes). If drawing does not fulfil criteria for Uncodable classification, proceed with coding.

2. 'Head'

a) Enclosed circular shape located at the top of the drawing. May be attached to a central shape or a vertical line. Score: 1 Representational point.

b) A single "protrusion" extends upwards from a centre point and is not individuated or enclosed. Score: 1 Faithful point.

3. 'Arms'

a) Two lines or separate enclosed shapes (e.g. ovals) extend outwards from the sides of a central shape or a vertical line (one either side of centre). Score: 1 Representational point.

b) Two protrusions extend outwards (one each side) of a central mass and neither are individuated/enclosed. Score: 1 Faithful point.

4. 'Legs'

a) Two lines or separate enclosed shapes (e.g. ovals) extend downwards from the bottom of a central shape or vertical line. Score: 1 Representational point.

b) Two protrusions extend downwards from the bottom of a central mass and neither are individuated/enclosed. Score: 1 Faithful point.

5. 'Face'

a) Drawing includes internal detail resembling a facial configuration (i.e. 2 eyes, nose and mouth). Detail must be located either in enclosed 'head' at the top of the drawing, or in the central shape if no 'head' is present. Score: 2 Representational points.

b) Drawing does not contain any internal detail. Score: 2 Faithful points.

Picture 2 (face).

1. 'Uncodable' – drawing does not, in any way, share perceptual similarity with either stimuli or symbolised referent (e.g. drawing is a scribble or series of randomly-placed disconnected shapes). If drawing does not fulfil criteria for Uncodable classification, proceed with coding.

2. 'Eyes/nose'

a) Three markings (e.g. combination of circles, ovals, lines and dots) positioned in an inverted triangle configuration. If the top two markings are circles, they must include internal detail (e.g. dots). Score: 1 Representational point.

b) Three circles positioned in an inverted triangle configuration. Circles contain no internal detail. Score: 1 Faithful point.

3. 'Mouth'

a) An unbroken line is positioned below the inverted triangle markings. The line curves upwards at both ends. Score: 4 Representational points.

b) An unbroken line is positioned below the inverted triangle markings. The line is flat (horizontal). Score: 2 Representational points.

c) A row of individual, enclosed, rounded shapes or dots are positioned in a row below the inverted triangle markings. The row is flat (horizontal). Score: 2 Faithful points.

d) A row of individual, enclosed, rounded shapes or dots are positioned in a row below he inverted triangle markings. The row is horizontal and curves upwards at both ends. Score: 4 Faithful points.

Picture 3 (sun).

1. 'Uncodable' – drawing does not, in any way, share perceptual similarity with either stimuli or symbolised referent (e.g. drawing is a scribble or series of randomly-placed disconnected shapes). If drawing does not fulfil criteria for Uncodable classification, proceed with coding.

2. 'Central shape'

a) Central shape is uniformly rounded (e.g. circle, oval) with no internal detail or detail resembling a facial configuration. Score: 1 Representational point.

b) Central shape is not smoothly rounded (i.e. it's "dented") and contains no internal detail. Score: 1 Faithful point.

3. 'Outer shapes'

a) The outer shapes are wiggly or straight lines that extend outwards from the central shape. Score: 4 Representational points.

b) The majority of the outer shapes are roughly circular and are attached to the central shape. Score: 2 Representational points.

c) The majority of the outer shapes are roughly circular and are detached from the central shape. Score: 2 Faithful points.

d) The majority of the outer shapes are ovals or tear-drops and are detached from the central shape. Score: 4 Faithful points.

Picture 4 (kite)

1. 'Uncodable' – drawing does not, in any way, share perceptual similarity with either stimuli or symbolised referent (e.g. drawing is a scribble or series of randomly-placed disconnected shapes). If drawing does not fulfil criteria for Uncodable classification, proceed with coding.

2. 'Kite'

a) Drawing includes an enclosed shape that does not have 4 sides (e.g. circle, oval). Must be connected to a line extending away/downwards from the shape. Score: 3 Representational points.

b) Drawing includes an enclosed shape that has 4 straight sides. Must be connected to a line extending away/downwards from the shape. Score: 3 Faithful points.

3. 'String

a) Line extending downwards from enclosed shape is straight. Score: 2 Representational points.

b) Line extending downwards from enclosed shape has 1-2 undulations. Score: 2 Faithful points.

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