WORD LEARNING FROM OBJECT, SPEAKER AND ENVIRONMENTAL CUES IN TYPICALLY DEVELOPING CHILDREN, CHILDREN WITH AUTISM SPECTRUM DISORDER AND CHILDREN WITH OTHER DEVELOPMENTAL DISORDERS

by

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Declaration

I declare that this 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 explored whether children with Autism Spectrum Disorder (ASD) learn the names of artefacts when abstracting information from the objects themselves (Studies One and Two: shape and function bias), a speaker (Study Three: gaze and pointing cues) or the environment (Study Four: arrow and light cues). A final study assessed the relative weighting of conflicting speaker and environmental cues (Study Five). Control groups of typically developing (TD) children and children with other developmental disorders (DD) were also included. In order to tease apart whether word learning is delayed or deviant in ASD and if this extends to DD children, each study recruited participants with a wide range of receptive language abilities. The participants were subdivided into 'high verbal mental age' (VMA) and 'low VMA' categories. Children with ASD were found to be delayed in some aspects of language acquisition; specifically in showing a shape bias and learning words from eye gaze and pointing. They failed to learn words from one type of associative cue (light), but learnt words from a directional arrow at the same age as their TD peers. Furthermore, they showed a function bias at an *earlier* age than TD children. Interestingly, the DD cohort also showed substantial word learning deficits. They were delayed learning words from eye gaze and deviant learning words using functional information and some types of social and associative cues. Overall, this research contributes to our understanding of the pathways of language acquisition across typical and atypical development.

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Dedication

This thesis is dedicated to the loving memory of my paternal grandfather,

Clarence Frederick Field – or Fred, as he was better known (24/01/1931 – 02/09/2015).

‘It’s fantastic what you’ve achieved, Charlotte… I’m so proud of you’

Publications

Field, C., Allen, M. L., & Lewis, C. (in Press). Are children with autism spectrum disorder initially attuned to object function rather than shape for word learning? *Journal of Autism and Developmental Disorders.* doi:10.1007/s10803-015-2657-5

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List of Symbols and Abbreviations

Symbol	Definition
ALA	Attentional-Learning-Account
ASD	Autism Spectrum Disorder
BPVS	British Picture Vocabulary Scale
CA	Chronological Age
CARS	Childhood Autism Rating Scale
DD	Developmental Disorders
MA	Mental Age
NVMA	Non-Verbal Mental Age
SAC	Shape-As-Cue
SCQ	Social Communication Questionnaire
TD	Typically Developing
VMA	Verbal Mental Age

Chapter One: **General Introduction**

1.1 General introduction to the thesis

Typically Developing (TD) children's vocabulary develops rapidly during the first few years of their life. When overhearing speech, there may be both numerous possible referents for each individual novel word (Quine, 1960) and potentially a variety of novel words per utterance for children to decode (Monaghan & Mattock, 2012). Take the seemingly simple example of hearing the object label 'cup' for the first time. To decipher the meaning of the word, infants must determine that 'cup' does not refer to other novel objects or actions within their current viewpoint. They must also establish that 'cup' names the object in its entirety rather than simply its handle or design and can be generalised from this particular object to others into the same object class. Furthermore, there are the added difficulties of how infants interpret the novel word if they are not focused upon the cup or if the cup is not even physically present when the word is spoken. These are just a few of the challenges children face when learning object labels. Yet TD children show remarkable skill at the task of linking a sound to a class of objects (e.g. Bloom, 2000; Quine, 1960).

One way in which children acquire vocabulary is by using word learning constraints (e.g. Markman, 1989). These are innate or learned biases, which constrain possible word meanings by highlighting attention towards one object or one aspect of an object, while restricting other artefacts as being the referent. For example, children tend to believe that novel labels refer to the whole object rather than individual component parts (the whole object assumption), link objects within the same taxonomic category together, such as a toy dog with a toy cat rather than bone (the taxonomic assumption) and assume that objects have only one name, thus new words must refer to new objects (mutual exclusivity). Although there are occasional exceptions to these assumptions (sometimes new words *do* refer to an individual component of an object and some objects have more than one name), in general, word-learning constraints facilitate children's language by narrowing the range of potential referents for the novel word. Other word learning biases include the shape bias (assuming that objects with the same shape have the same name) and the function bias (assuming that objects performing the same function have the same name), which are the focus of Chapters Two (Shape Bias) and Three (Function Bias).

Yet learning a new concrete noun does not rely only on the ability to generalise from, for example, the shape or function of objects. TD children also learn words from social cues, such as the speaker gazing or pointing towards an object (e.g. Baldwin, 1991; 1993; Briganti & Cohen, 2011; Gliga & Csibra, 2009) and associative cues, such as cross-situational consistency (e.g. Saffran, Aslin & Newport, 1996; Smith & Yu, 2008; Yu & Smith, 2007) and perceptual salience (e.g. Axelsson, Churchley & Horst, 2012). According to the social pragmatic account (e.g. Akhtar, Carpenter & Tomasello, 1998; Baldwin, 1991; 1993; Bloom, 2000; Briganti & Cohen, 2011; Gliga & Csibra, 2009; Tomasello & Akhtar, 1995; Tomasello & Barton, 1994) children learn words from understanding the *referential intent* of the speaker, assuming that people intend to name objects that they point or gaze towards. The associative account (e.g. Monaghan & Mattock, 2012; Saffan, Aslin & Newport, 1996; Smith & Chen, 2008; Smith, Jones &

Landau, 1996; Suanda, Magwanya & Namy, 2014) argues instead that children learn words from processes of attention, memory and perception; as eye gaze and pointing highlight attention towards objects, children simply associate these gestures with the object they refer to, without any referential intent inference.

Although these three processes (word learning constraints, social pragmatics and association) might be thought to work in competition with each other, hybrid theories such as the emergentist coalition model of word learning stress that a range of cues are important for helping children learn words (e.g. Golinkoff & Hirsh-Pasek, 2006; Hollich et al., 2000). Rather than word learning being controlled by *either* social cues *or* association, the emergentist coalition model emphasises that social and associative cues interlink together to facilitate children's word learning, along with other types of cue. For example, *word learning biases* such as the *shape bias* and the *function bias* enable children to generalise the label 'ball' to objects with the same circular shape, which share the function of bouncing or being thrown or kicked. However, in addition to these generalisations, children may follow the speaker's *social* cues, such as eye gaze and pointing to a nearby novel object as the speaker declares *'it's a ball!'* Furthermore, after repeatedly hearing the label 'ball' paired with the stimuli, using *association* helps the child maintain the word-object mapping over time.

The emergentist coalition model stresses that children use various social, attentional, cognitive and linguistic processes for language acquisition. Children have access to multiple cues and learn best when these cues interlink and when children have access to all types of cue (Hollich, Hirsh-Pasek & Golinkoff, 2000). Research has supported these two views. When an adult looks at and labels a perceptually salient object, rather than a perceptually boring distractor, TD infants form correct word-object mappings from as early as ten-months-old. From eighteen-months, children still form correct word-object mappings even when the speaker labels the perceptually boring object (Hollich, 2000). It is also at this age that children form word object mappings to the object of the speaker's focus, even if this differs from the object that the child themselves is fixated upon (Baldwin, 1991; 1993).

Further, children utilise word learning constraints, social cues and associative cues at different developmental time points. For example, TD infants learn words through association, while older children (18-24 months onwards) employ social cues (Baldwin, 1991; 1993; Foudon et al., 2008; Hollich et al., 2000; Pruden, Hirsh-Pasek, Hennon & Golinkoff, 2006). Therefore, it is important to investigate word learning biases, social cues *and* associative cues in order to build up an accurate and all-encompassing picture of how children learn words.

These three approaches to word learning (constraints/biases, social pragmatics and association) emphasise different attributes as important for children's language acquisition. According to the emergentist coalition model, theories of word learning can be separated into those that support Quine's (1960) approach to word learning (i.e. word learning constraints) and those that reject it (i.e. the social pragmatic and associative accounts). When a speaker utters 'gavangai' as a rabbit scuttles part, according to the word learning constraints theory the child focuses on key attributes and restrict others, which helps them determine what 'gavangai' refers to. As previously discussed, it is usually presumed that the speaker refers to the whole object, rather than individual components of the object, that each object has only one name and that objects possessing the same shape and performing the same function have the same name. All of these heuristics help children determine the referent of the novel word.

Word learning constraints focus on characteristics of the object for children's word learning (i.e. the object as a whole, its shape, function etc.) While this undoubtedly facilitates word learning for artefacts, it does not explain how children learn words for other types of noun or verbs and adjectives. Furthermore, although aspects of the object are useful for naming, other factors are also important. These include the speaker (which social cues emphasise) and the environment (which associative cues emphasise). According to the social pragmatic account, rather than children trying to work out what the speaker is naming, the speaker themselves tries to work out what the child is focused upon (Nelson, 1988) or is of relevance to the child (L. Bloom, 1993; 2000) and then names this. According to the association account, the environment is important for word learning; children name objects by attending to cues which highlight attention towards specific artefacts, such as the object lighting up (Axelsson et al., 2008).

Therefore, TD children form word-object mappings through an interaction between the object, speaker and environment. Naming is facilitated by object characteristics such as familiarity (mutual exclusivity), component parts (whole object assumption), form (shape bias) and the role the object fulfils (function bias). Naming is also aided by speaker characteristics, such as facial and emotional expression (e.g. Tomasello & Barton, 1994), involvement or disinterest in the word learning situation (e.g.

Baldwin et al., 1996), prior knowledge (Akhtar et al., 1996; Tomasello & Haberl, 2003) eye gaze (Baldwin, 1991; 1993; Baron-Cohen, Baldwin, & Crowson, 1997; Houston-Price, Plunkett & Duffy, 2006; Lee, Eskritt, Symons & Muir, 1998) and pointing (Briganti & Cohen, 2011; Gliga & Csibra, 2009; Paulus & Fikkert, 2014; Tomasello, Carpenter & Liszowski, 2007). Finally, the environment helps naming; perceptual salience, cross-situational consistency and linking new words with cues such as arrows, which highlight attention, helps children's naming (See Figure One).

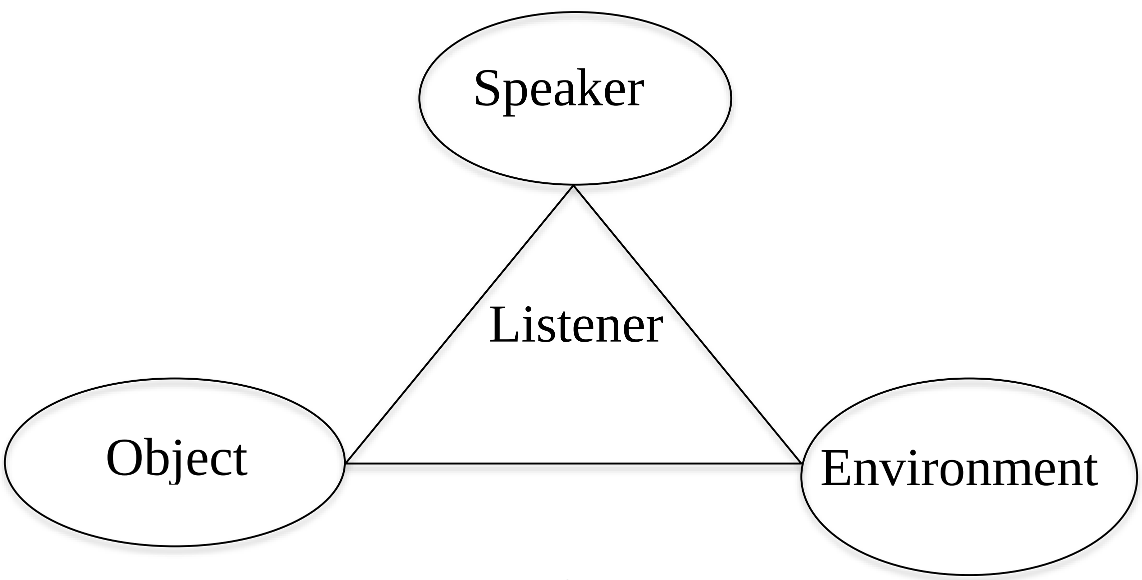

Figure 1.1: Visual interpretation of the speaker – object environment interaction for word learning. Children (listeners) learn words through characteristics of the speaker (such as pointing, gaze, head direction and language), object (such as context, size, texture, shape, function and colour) and environment (such as an arrow positioned towards the object, perceptual salience, the object lighting up and cross-situational consistency and co-variation).

Although TD children learn words with relative ease, individuals with Autism Spectrum Disorder (ASD) have difficulties with language acquisition (e.g. Boucher, 2012; Eigsti, de Marchena, Schuh, & Kelley, 2011; Mundy, Sigman, & Kasari, 1990; Noterdaeme, Wriedt & Hohne, 2010; Peppe, McCann, Gibbon, O'Hare, & Rutherford, 2007). Children with ASD generally learn to speak later than TD children (De Giacomo & Fombonne, 1998; Howlin, 2003, Lord & Paul, 1997). They also may show a restricted vocabulary and idiosyncratic speech (Brehme, 2014), such as echolalia (Grossi, Marcone, Cinquegrana & Gallucci, 2012; Rydel & Mirenda, 1994; Tager Flusberg & Calkins, 1990) and have difficulties with the pragmatics of language (Lam &Yeung, 2012; Ozonoff & Miller, 1996).

About 80% of children with ASD in special education cannot functionally communicate (Bondy & Frost, 1994) and approximately 30% of children with ASD are nonverbal at nine years of age (Anderson et al., 2007). About a quarter of individuals with ASD remain functionally non-verbal (Volkmar, Lord, Bailey, Schultz & Klin, 2004). However, the further three quarters of children with ASD do learn how to talk (Lord, Risi & Pickles, 2004). This suggests that children with ASD are able to use some cues to facilitate word learning, like TD children. It is also true that even some non-verbal children with ASD have adequate comprehension of speech, enabling them to partake in tasks involving receptive language, such as written and gestural communication, listening and understanding instructions and pointing towards pictures or objects. However, there is evidence that the receptive language of children with ASD is even more impaired than their expressive communication skills (Hudry et al., 2010; Ellis Weismer, Lord & Esler, 2010).

In addition to impaired language, children with ASD have difficulties with social pragmatics (Dawson, Meltzoff, Osterling, Rinaldi & Brown, 1998; Osterling & Dawson, 1994), including comprehending referential intent (e.g. D'Entremont & Yasbek, 2007; Hartley & Allen, 2014; Preissler & Carey, 2005; Prizant & Wetherby, 1987), problems with theory of mind, or an understanding that others' viewpoints may differ from one's own (Baron-Cohen, Leslie & Frith, 1985; Colle, Baron-Cohen & Hill, 2006; Leslie & Frith, 1988; Schneider, Slaughter, Bayliss & Dux, 2013), and social aloofness (Borden & Ollendick, 1994; Scheeren, Koot & Begeer, 2012; Wing & Gould, 1979). These difficulties may be both caused by and contribute to language impairment. With no or limited language it is hard for children with ASD to express their needs, wants and desires and to fully take part in social activities. Without completely engaging in the social world, children are not exposed to as much language as is usual and have limited opportunity to develop their own linguistic skills.

As mentioned by Golinkoff and Hirsh-Pasek (2006), according to the emergentist coalition model, children with ASD experience the dampening of one type of word learning cue; social pragmatics. However, other information within the language system (including perceptual and attentional elements) compensate for the deficient social component. Children with ASD may therefore rely on these other cues for word learning – particularly association – well after the usual infancy period, instead of becoming sensitive to the social pragmatic cues which older TD children easily and rapidly use to facilitate language acquisition. Although this paper draws attention to this assumption, this has only been briefly explored once before (Hennon, 2003). It was found that three-year-old children with ASD behaved much like twelve-month-old TD children; forming word-object mappings towards perceptually salient objects, even when the speaker was gazing towards a different artefact.

Therefore, the suggestion that children with ASD are not able to access social pragmatic word learning cues needs further investigation with other kinds of social cues and participants with a wider range of chronological age (CA) and verbal mental age (VMA) than Hennon (2003) previously investigated. The studies included within this thesis investigate the emergentist coalition model with regards to ASD by exploring the three main processes the model identifies (word learning constraints, social pragmatics and association) within typical and atypical development. The model provides a starting point for the basis of this thesis; seeing when and how these processes arise in relation to ASD.

Despite findings that children with ASD have deficits in language and socialisation, it is important to note that most studies investigating word learning in ASD only test a specific age or VMA range of children (Baron-Cohen et al., 1997; Jing & Fang, 2013; Norbury, Griffiths & Nation, 2010). For example, Baron-Cohen et al., (1997) only looked at children with ASD who had a mean language expressive and receptive comprehension age of just over two. Therefore, if this particular group of children do not show a skill, it is unclear whether this ability will eventually develop (i.e. it is delayed) or the children will have a lifelong deficit (i.e. it is deviant). In contrast, even if the cohort of participants tested pass a particular task, it is possible that test success would not be achieved by children who are younger or have less advanced verbal abilities. Thus, it is important to recruit children with ASD who have a range of ages and verbal capabilities.

The present thesis explores whether children with ASD are delayed or deviant in five areas relating to word learning: the shape bias, the function bias, social cues, associative cues and conflicting social and associative cues. Unlike TD two-year-olds, young children with ASD do not appear to show a shape bias (Hartley & Allen, 2014; Potrzeba, Fein & Naigles, 2015; Tek, Jaffery, Fein & Naigles, 2008). The function bias has never been explored in ASD. Children with ASD have difficulties with understanding social cues, such as eye gaze (Baron-Cohen et al., 1997; Preissler & Carey, 2005), although evidence suggests that they have a better understanding of associative cues, such as arrows (Baron-Cohen, Campbell, Karmiloff-Smith, Grant & Walker, 1995; Senju, Tojo, Dairoku, & Hasegawa, 2004). Although association can help children learn how to speak, it is not always the most interesting or perceptually salient object being labelled. Thus, the word learning process of a child relying purely on associative cues would be slow, difficult, frustrating and full of word-object mapping errors. This could help explain some of the language acquisition deficits shown by individuals with ASD.

Studying how children with ASD use word learning constraints, social cues and associative information sheds further light on theories of both typical and atypical child development. Of course, it may be the case that children with ASD are poor at learning new words because they have intellectual impairments, rather than their autism per se.

Therefore, in addition to exploring how children with ASD learn words relative to TD children, this thesis investigates word learning in children with other developmental disorders (DD), but who do not have ASD. Word learning difficulties have also been found in this population (Franken, Lewis, & Malone, 2010; Rice, Warren, & Betz, 2005), although others argue that language impairment is specific to ASD (Menyuk, 1978; Rutter, 1978).

To summarise, this thesis investigates word learning in TD children, children with ASD and children with DD. The role of word learning biases (the shape bias and function bias), social cues (eye gaze and pointing) and associative cues (arrow and light) are all detailed. The next few sections will explore in more detail the shape bias and the function bias in TD children, children with ASD and DD children. Social and associative cues are described in the following sections.

1.2. Word learning from the shape bias: TD children

Word learning constraints and biases involve object characteristics, which help children eliminate potential referents of novel words. The shape bias is one example of a word learning constraint, which refers to the assumption that objects with the same shape have the same name. For example, when TD children form the word-object mapping ‘spoon’ they generalise this label according to the objects’ spherical shape, rather than other perceptual features such as size (Landau, Smith & Jones, 1988), texture (Jones, 2003; Landau et al., 1988) or colour (Baldwin, 1989; Jones, 2003).

As different exemplars of many common object categories tend to have the same shape, using the shape bias helps children quickly classify similarly shaped artefacts as being within the same class of object. Children need only learn the word '*spoon*' as applying to one instance of the category, instead of having to undergo the laborious process of having every new spoon labelled for them. There are two competing theories regarding the process underlying children's understanding of the shape bias: the shape-as-cue (SAC) account and the associative-learning-account (ALA). Chapter Two (Study One) specifically tests these two hypotheses and will explore their role in word learning.

It has long been known that TD children form word-object mappings according to salient perceptual features such as shape (Brown, 1957; Clark, 1973). Following these initial studies, the term 'shape bias' was coined by Landau et al., (1988), who presented two-year-olds, three-year-olds and adults with a novel object followed by seven test objects. One test object was an identical replica of the novel object and the other six test objects differed from the novel object on one dimension; shape, colour or size. Two objects differed on shape to different degrees (with the same texture and size), two objects differed on texture (with the same shape and size) and two objects differed on size (with the same shape and texture).

In the 'naming' condition, the novel object was given a label (e.g. '*this is a dax*'). Following this, the participant was asked either whether each of the test objects was also a '*dax*' (the 'yes or no' task) or to select from pairs of objects presented which one was the other '*dax*' (the 'forced choice procedure'). In the 'non naming' condition, the object was merely shown to the child (e.g. '*look at this*') before participants were asked which of the test objects 'went with' the novel object.

Results across the experiments suggested that TD adults categorise objects according to shape in both lexical and non lexical tasks. However, the children's pattern of performance was less straightforward. In a lexical condition ('*this is a dax, can you give me another dax*') children only rejected the objects which differed the most in terms of shape for the yes/no procedure. For the forced choice procedure, they chose objects with texture changes instead of size changes but in all other analyses performed at chance. In the non naming condition, same shaped objects were chosen more than same texture objects but not same size objects. When the values were more extreme in subsequent experiments (e.g. bigger size changes, more salient textures and more extreme shape changes) children generalised by shape more strongly. However, the shape bias was more lexically specific for the children than the adults, with children tending to generalise by shape only when exposed to a novel word and not in other contexts.

Since Landau et al.'s (1988) work, the shape bias has been extensively studied by both the original authors themselves (e.g. Jones, 2003; Jones, Smith & Landau, 1991; Landau, Smith & Jones, 1992; 1998; Smith, Jones & Landau, 1996) and other researchers (e.g. Diesendruck & Bloom, 2003; Hupp, 2008; Markson, Diesendruck & Bloom, 2008; Samuelson, Horst, Schutte & Dobbertin, 2008; Tek et al., 2008; Tek, Jaffery, Swensen, Fein & Naigles, 2012). TD children employ a shape bias from approximately two-years-old, suggesting that it is both caused by acquiring language (i.e. children learn while beginning to speak that same shaped objects are likely to have the same name) and then later facilitates the word learning process (by generalising objects according to shape, children learn to categorise them in this way) (Tek et al., 2008). The shape bias appears to strengthen during children's development, so that by adulthood individuals are more stringent in using shape to form word-object mappings (Horst & Twomey, 2013; Landau, et al., 1988).

Although the shape bias often facilitates language acquisition, children are usually aware that shape is not *always* a reliable cue to object name. Additional cues such as the context in which the object is named (Landau et al., 1992), the type of thing being named (Soja, Carey & Spelke, 1991) and other characteristics of the objects being labelled (Horst & Twomey, 2013; Jones, et al., 1991; Samuelson & Horst, 2007; Tek et al., 2012) can weaken or diminish children's shape bias. As well as perceptual cues, conflicting conceptual information, such as object function, can also override shape in children's naming (e.g. Diesendruck, Markson & Bloom, 2003; Gentner, 1978; Merriman, Scott & Marzita, 1993). This is further discussed in section 1.5 and in Chapter Three (Study Two).

While other factors are also important for naming, the shape bias remains a good heuristic for enabling TD children to quickly and easily generalise object labels. A shape bias deficit might be one factor contributing to why children with ASD find word learning difficult. Due to their impairments with understanding referential intent, studying children with ASD also provides a good opportunity to establish if the shape bias is controlled by the SAC account, which relies upon referential intent (in which case, they would not be expected to show the heuristic) or ALA, which relies upon statistical and associative processes (in which case, they would be predicted to possess it). The next section will cover the shape bias in children with ASD.

1.3. Word learning from the shape bias: Children with ASD

While word learning constraints and biases have been extensively explored in relation to typical development (e.g. Au & Glusman, 1990; Diesendruck & Bloom, 2003; Halberda, 2003; Horst, Samuelson, Kucker & McMurray, 2011; Hupp, 2008; Jaswal, 2010; Landau et al., 1988; 1998; Markman, 1989; Samuelson & Horst, 2007; Tek et al., 2012), with a few notable exceptions (e.g. Preissler & Carey, 2005; Tek et al., 2008; Williams, 2009), they have not been so thoroughly studied in relation to children with ASD. However, investigating word learning constraints and biases in this population informs about the underlying mechanisms controlling them. The shape bias might be considered difficult for children with ASD due to the categorisation it requires; different exemplars of the same type of object are classified together based on shape. Some aspects of categorisation may be impaired for children with ASD, such as their organisation of semantic knowledge (Tek et al., 2008). This is more fully discussed in Study One (Chapter Two).

On the other hand, children with ASD have a preference for detailed, local processing (Frith, 1989; McGregor & Bean, 2012), excelling at tasks which require attention to small details such as block design and embedded figures tests (Happé & Frith, 2010). Thus, it may be expected that children with ASD easily notice details such as object form, which facilitates showing the shape bias. Therefore, there are two contrasting hypotheses about whether children with ASD generalise object labels according to shape. Their deficit in abstract category formation may lead to an impairment in this area. Alternatively, their focus on details may enable them to make shape-based word-object mappings easily.

The shape bias has been investigated within the ASD literature four times before (Field, Allen & Lewis, in Press; Hartley & Allen, 2014; Potrzeba et al., in Press; Tek et al., 2008). Field et al., (in Press) forms Chapter Two of this thesis, thus will not be discussed here. Hartley and Allen (2014) found that children with ASD (mean VMA of 3) generalised object labels for pictures according to shape but also colour, whereas TD children of the same VMA only generalised by shape. Conversely, Tek et al., (2008) found that infants with ASD generalised according to shape rather than colour in both a name (‘*point to the dax*’) and no name (‘*point to the same*’) condition across four sessions of word learning activities. More recently Potzreba et al (in Press) found that TD children looked longer at a shape match than colour match test object in a name condition than no name condition, although children with ASD looked equally long in both conditions. If the shape bias is taken to be lexically specific, this suggests that TD children but not children with ASD possess the heuristic.

However, no ASD literature has investigated age or receptive language differences in an explicit pointing shape bias task. These differences are important to explore in terms of testing the delay vs. deviance hypothesis. It might be, for example, that older children with ASD than those tested by Hartley and Allen (2014) only use shape – and no longer also use colour – for their picture based generalisations of object labels. Further, none of the previous research regarding the shape bias in ASD has included a subgroup of children with DD, meaning that it is unclear whether the findings are specific to ASD. Chapter Two (Study One) aims to fill this gap, by investigating the shape bias in TD children, children with ASD and children with DD who have varied chronological ages (CA) and receptive language abilities.

1.4. Word learning from the shape bias: DD children

There is conflicting evidence regarding whether children with DD use word learning constraints and biases. Children with intellectual disability show mutual exclusivity, or the assumption that each object only has one name (Wilkinson & Albert, 2001; Wilkinson, 2005). However, these children have difficulty with fast mapping, or learning labels for objects based on just a single exposure to the word, and are less able than TD children to maintain labels over time (Wilkinson, 2005). The shape bias has only been investigated in relation to children who have language difficulties; specifically, late talkers (Jones, 2003) and children with Specific Language Impairment (SLI) (Collisson, Grela, Spaulding, Rueckl & Magnuson, 2015). Neither group of children possessed the heuristic, which provides further support for the theory that the shape bias facilitates children's language acquisition.

The shape bias may be related to count noun vocabulary (e.g. Gershkoffe-Stowe & Smith, 2004; Graham & Diesendruck, 2010), with some studies suggesting that children need to know at least 50 words before showing a shape bias (Jones, 2003; Smith, Jones, Landau, Gershkoffe-Stowe & Samuelson, 2002). Therefore, it is perhaps unsurprising that late talkers do not show the heuristic, although the participants in Jones (2003) had all acquired over 50 count nouns. Interestingly, half of the late talkers possessed a ‘texture bias’, or formed word-object mappings according to texture, rather than shape. This implies that children with language delays might fixate on irrelevant object characteristics when learning words, which may contribute to their language delay.

In addition to this, children with SLI performed more poorly than TD children on a simple paired visual association task, which involved remembering which symbols were previously paired together (Collison et al., 2015). Performance on this task predicted shape bias performance, suggesting that visual memory is important for showing the heuristic. Children with impairments such as developmental delay (Perna & Loughan, 2012) and Williams Syndrome (Bellugi, Lichtenberger, Jones, Lai & George, 2000) have difficulties with visual memory, perhaps indicating that these children would have a shape bias deficit. However, to my knowledge, this has yet to be explored.

1.5. Word learning from the function bias: TD children

As summarised in the previous sections, shape is an important cue for word learning. However, other object features, such as the function the object fulfils, are also helpful in enabling children to decipher the names of objects, categorising according to their functional properties and classifying them according to like kind. Object function and object shape are intrinsically connected; same shaped objects often perform the same function and shape provides salient immediate perceptual cues as to an object’s functional properties (Bloom, 2000; Landau et al., 1998). For example, square objects cannot roll, while pointed objects would be uncomfortable to sit on (Landau et al., 1988).

Even young TD children are aware of the relationship between shape and function, with 17-month-olds only showing a shape bias after being previously familiarised with an objects shape based function and three-year-olds generalising certain properties across objects according to similarity in shape (Diesendruck & Bloom, 2003). As well as the shape bias aiding children's understanding of function, there is evidence that when an object's function is shape based, learning about this function helps infants establish a shape bias (Ware & Booth, 2010). One group of 17-month-old participants learnt about the object's shape-based function, such as scooping a substance into a round container, while another group of children did not receive this prior training. When children were asked to find 'another one' from a shape, colour and texture match, the former group of participants showed a shape bias, although the latter group of children did not.

Although function and shape often interlink, there are situations where they conflict; same shaped objects can possess different functions (e.g. oranges and footballs) and differently shaped objects can possess the same function (e.g. chairs). It is also the case that objects used as containers, such as gloves and violin cases are the same shape as the artefacts they hold simply in order to store them. When children are given an explanation for why similarly shaped objects are intended to be different kinds, the shape bias disappears (Diesendruck et al., 2003), suggesting that children understand that there are circumstances where similarly shaped objects have a different name. Furthermore, showing a shape bias is particularly helpful with objects of the same basic level category (such as cups), but may not apply with subordinate (such as sippy cup) or superordinate (such as drinking utensil) categories, which can sometimes take on different forms from each other. Thus, the shape bias does not always aid word learning and could actually *hinder* children's deeper understanding of hierarchical object categorisation. For example, using purely the shape bias as a word learning strategy, a child who knows the basic level category label 'chair' may neglect to extend this label to a beanbag chair as it is a different shape to the other category exemplars the child is used to associating with the label.

On these occasions, possessing a function bias facilitates naming; chairs come in various different shapes but they all afford the function of providing a seat for someone to sit down upon. Unlike shape, however, function is not usually an immediately obvious perceptual quality and could be considered a more higher-level property. While the form of an object is instantly apparent, the function an object fulfils has to be directly observed or inferred. Children easily see the round, circular shape of a ball, for instance, but have to either watch someone else use the ball or 'try it out' themselves before they realise that one of its functions is to bounce.

Therefore the function bias may not be as intuitive for children to possess as the shape bias. Thus, it may emerge later on in development than the shape bias does. There is evidence both for and against function overriding shape in children's name generalisations. Some studies have found that children show a function bias rather than shape bias when the function of the object is emphasised (e.g. Diesendruck et al., 2003;

Kemler-Nelson, 1995), while others argue that children classify only by shape (e.g. Graham, Williams & Huber, 1999; Smith et al., 1996).

Interestingly, and perhaps surprisingly, an early study exploring whether children and adults generalise objects by form or function found a U-shaped developmental curve (Gentner, 1978); both young children (two-five-year-olds) and adults named an object according to similarity in shape with a previously viewed artefact while older children (five-fifteen-years-old) named it according to similarity in function. However, numerous later researchers, although agreeing that young children name objects according to their shape rather than function when the two are pitted together, argue that adults show a function bias (Graham et al., 1999; Imai, Gentner & Uchida; Kemler-Nelson, Frankenfield, Morris & Blair, 2000; Landau et al., 1998; but see Golinkoff, Shuff-Bailey, Olguin & Ruan, 1995). A possible explanation for Gentner's (1978) conflicting results compared with other research could be that the shape match in her study shared not only shape but other perceptual features such as colour and texture in common with the original, while the function match shared no perceptual features. In more recent studies, the shape match tends to match only on shape in order to tease apart attention to shape from other object properties, such as overall similarity.

Despite this general agreement that TD children do not show a function bias in early childhood but the function bias is present by adulthood, there is controversy regarding the exact developmental time point the function bias emerges. Categorising objects according to their function may occur later in children's development than shape based categorisation as older children become more exposed to differently shaped objects performing the same function and have more experience with the function objects are intended to fulfil. For example, children may gradually realise that although many chairs have a dissimilar shape to each other, they are all designed to be sat upon. Thus, children are unsurprised when both a beanbag chair and an armchair are labelled as '*chairs'*, assuming that they share this common function.

As early as two-and-a-half years-old, children understand that objects are designed to fulfil a specific function (Casler & Kelemen, 2005). Nevertheless, it is not until about preschool age that children become sensitive to design information (Kelemen, 1999). There is evidence suggesting that, while 3 and 4-year-olds form word-object mappings according to shape, by six-years-old children are more sensitive to object function when naming artefacts (Merriman et al., 1992; see also Matan & Carey, 2001, who found increased attention to function in 6-year-olds relative to 4-year-olds and Gathercole & Whitfield, 2001, who found that 9-year-olds but not 3-year-olds or 4-year-olds extend labels for objects based on function).

In Merriman et al., (1992), participants were presented with a novel object, which was given a name (e.g. '*a dax*!') and its function was described and demonstrated. A shape match (the same shape as the original but possessing a different function) and a function match (a different shape from the original but possessing the same function) were introduced and it was demonstrated that the function match performed the same role as the original object but the shape match did not. Participants were then asked whether the shape match or function match was the other referent. Children were also shown known objects which had the appearance of something else (e.g. an eraser shaped like a pencil) and the function of these objects (e.g. erasing) was demonstrated. For both the novel and familiar objects, the six-year-olds named the test object according to its functional properties significantly more than the two younger groups, who did not differ from each other.

Conversely, attention to object function has also been found in younger children (e.g. Casler & Keleman, 2005; 2006; Diesendruck et al., 2003; Gelman & Markman, 1986; Kemler-Nelson et al., 1995). Possible reasons for the conflicting findings include more complicated, realistic, familiar and specific stimuli in studies which find a function bias at earlier ages compared with studies which do not find a function bias until later in childhood (Bloom, 2000). Furthermore, an understanding of referential intent might underlie function bias understanding (Diesendruck et al., 2003). Diesendruck et al., (2003) claim that simply identifying and demonstrating an object's possible function is not enough for children to override the shape bias. However, when participants are also given a description and demonstration of how a same shaped object performs a different function and a differently shaped object performs the same function, TD children show a function bias rather than shape bias (see also Bloom, 2000, and Butler & Markman, 2012; 2014 for more information about the importance of intended function).

Although numerous studies have explored the function bias in TD children, it has never been investigated in participants with ASD. Investigating the function bias within this population helps provide further information about their word learning and categorisation abilities. The next section explores functional understanding in children with ASD.

1.6. Word learning from the function bias – Children with ASD

Although the function bias has not been empirically explored in ASD, these children can categorise objects by function (Ungerer & Sigman, 1987). There is also various evidence suggesting that some children with ASD partake in functional play, or interacting with an object as its function denotes, such as sweeping the floor with a toy broom (Baron-Cohen, 1987; Leslie, 1987). However, other research has noted differences between the functional play of children with ASD compared with TD children.

For example, some studies have found that children with ASD spend less time engaging in functional play than TD children and children with learning difficulties (e.g. Jarrold, Boucher & Smith, 1996; Sigman & Ungerer, 1984). The functional play of TD children and children with Down Syndrome has also been found to be more complex than the functional play of children with ASD (Williams, Reddy & Costall, 2001). Furthermore, children with ASD have impairments with higher-level classification tasks. This includes selecting dot patterns according to a prototype (e.g. Church et al., 2010), classifying atypical members of a category (Gastgeb et al., 2006) and categorising according to prototypes, rather than rules (Klinger & Dawson, 2001).

Therefore, there is conflicting information regarding functional understanding of objects in children with ASD. Being able to categorise objects according to function and engage in functional play suggests some understanding of the role objects fulfil. However, the functional play of children with ASD is characteristically shorter in duration (Jarrold et al., 1993) and lacking complexity (Williams, Reddy & Costall, 2001) relative to TD children. This, along with their difficulties with higher-level categorisation tasks (e.g. Church et al., 2010; Gastgeb et al., 2006; Klinger & Dawson, 2001) suggests impaired awareness of object function relative to their TD peers. Chapter Three (Study Two) explores categorisation of objects and functional play in ASD in more detail.

If children with ASD do show a function bias, this may inform word-learning interventions in children with ASD, suggesting that function should be emphasised. Furthermore, it might suggest that they learn words through conceptual rather than perceptual characteristics, such as the shape bias. However, there is some evidence that children with ASD have difficulties with understanding conceptual information (e.g. Fyffe & Prior, 1978; Frith, 1969; Hermelin & O'Connor, 1967; Menyuk, 1970; Fay & Schuler, 1980; Wolff & Barlow, 1979) such as how verbal material is semantically related and using this knowledge to help them remember the material. Ricks and Wing (1976) found that children with ASD have impairments with more abstract categorisation, such as generalisations that cannot be made based on perceptual characteristics.

A function bias deficit might mean that children with ASD have trouble with object generalisation, such as subordinate and superordinate categories, which cannot be so easily classified according to perceptual characteristics such as shape. This would suggest a very long-winded approach to word learning and a lower level understanding of function. For example, children would not easily be able to label a beanbag chair as 'chair', lacking the deeper understanding that this shares the characteristic of sitting down upon with other 'chairs'.   Therefore, it is important to study the function bias in this population in order to further inform theories of language acquisition in ASD.

1.7. Word learning from the function bias – DD children

Past literature has also neglected to explore the function bias in DD children, meaning that investigating this heuristic is completely novel for both children with ASD and children with DD. Children with intellectual disability categorise objects by function (Ungerer & Sigman, 1987) and children with Williams Syndrome are able to engage in colour categorisation (Farran, Cranwell, Alvarez & Franklin, 2013). Further, Costanzo et al., (2013) found that both children with Williams Syndrome and children with Down Syndrome have intact verbal categorisation skills (as measured by the Category Fluency Test, Mantyla, Carelli & Forman, 2007). This might be relevant to showing a function bias, as the heuristic involves classification of objects according to similarity in function. DD children also take part in functional play (Malone & Langone, 1998; Sigafoos, Roberts-Pennell, & Graves, 1999).

Therefore, it might be expected, based on previous research suggesting some understanding of function and categorisation skills, that DD children show a function bias. However, children with Williams Syndrome are impaired at visual categorisation (as measured by the Weigl Colour Form Test, Spinnler & Tognoni, 1987) (Costanzo et al., 2013). Furthermore, recall from section 1.4 that DD children have deficits maintaining labels over time (Wilkinson, 2005) and children with language difficulties do not show the shape bias (Collisson et al., 2015; Jones, 2003), perhaps suggesting that they also have a function bias deficit. Whether or not children with DD show a function bias is further explored in Study 2 (Chapter Three).

The past few sections have explored word learning from the shape bias and function bias, in TD children, children with ASD and DD children. However children's word learning depends on additional cues, such as social pragmatics and association. These will be explored within the next few sections.

1.8. Word learning from associative and social cues: TD children

As well as word learning constraints, children learn words from social pragmatics and associative cues. Although word learning constraints emphasise the importance of the object, association emphasises the importance of the environment and social pragmatics emphasise the importance of the speaker. The associative learning account proposes that children acquire language through 'dumb attentional mechanisms' (Smith et al., 1996), which help them notice perceptually salient objects within their environment and associate the novel label with the most exciting object (Hirsh-Pasek et al., 2000).

According to this account of word learning, words are learnt best when they are explicitly labelled (Skinner, 1957; Smith, 2000). Children may come to learn these object labels through a stimulus-response process, remembering which word corresponds to which object. Through statistical co variation and regularities, children learn to associate '*X*' with the referent of '*X*'. For example, repeatedly hearing the word 'book' paired with books leads to correctly mapping the word 'book' onto the object (e.g. Smith & Yu, 2008; Suanda, Mugwanya & Namy, 2014).

The social pragmatic account (e.g. Baldwin, 1991; 1993; Baldwin & Moses, 1996; Grosse, Behne, Carpenter & Tomsello, 2010; Moore, Angelpoulos, & Bennett, 1999;

Tomasello & Barton, 1994), instead argues that children come to form word-object mappings through a process of discerning the *referential intent* of the speaker, rather than cross-situational statistics. For example, upon observing a speaker looking at, pointing to and labelling a novel object as a 'book', an infant may come to learn the label 'book' through noticing the speaker's social cues of eye gaze and pointing (Tomasello, 1999; 2003). The child assumes that the speaker *intended* to look at or point towards a specific object, therefore it is relevant and it must be that specific object being named.

Proponents of association counter argue that rather than attributing children's word-object mappings to an understanding of the referential intent of the speaker, they can often be more accurately explained by attention, memory and perception (e.g. Samuelson & Smith, 1998; Smith et al., 1996). For example, Samuelson and Smith (1998) disputed the previous judgment of Akhtar et al., (1996), who claimed that two-year-old children form word-object mappings according to which object is new for the speaker. In Akhtar et al. (1996) (Study Two), the child and experimenter played with three novel objects together, then the child played with a fourth novel object while the experimenter was out of the room. All objects were then placed inside a box. When the experimenter returned, she looked inside the box and labelled one object. The child assumed that the experimenter was referring to the object they had not previously seen.

This would seem to suggest that children form word-object mappings according to the referential intent of the speaker – and not simply their own viewpoint. However, according to Samuelson and Smith (1998), it is *discourse novelty* that is important for the child. The context in which the children themselves played with the target object in

Akhtar et al., (1996) was different from the context where they played with the other objects as the experimenter was not present. Thus, the object came to be mapped onto the novel word through a process of memory, attention and association. Samuelson and Smith (1998) further tested their theory by having the experimenter present while the child played with all four objects but by changing the context in which they played with the fourth object; at a table covered with a glittery blue tablecloth as opposed to on the floor. Children formed word-object mappings towards the object that they played with in this different context, supporting Samuelson and Smith's (1998) hypothesis.

There is much evidence that TD children learn words from association during infancy, even at an earlier age than studied by Samuelson and Smith (1998) and Akhtar et al., (1996) (Foudon et al., 2008; Hollich et al., 2000). Eight-month-old infants segment words from fluent speech when hearing a continuous stream of four novel words, which are repeated in randomised order (Saffran et al., 1996). By 12-14 months, infants' sensitivity to statistical regularities helps them learn word-object mappings (Smith & Yu, 2008). By eighteen-months old, toddlers are also able to form word-object mappings according to frequency of occurrence when a novel word is usually paired with one object but occasionally paired with another (Vouloumanos & Werker, 2009). This is reflective of real life, where the speaker is not always looking at the object they are naming.

It can be hard to disentangle social from associative cues. For example, when learning the names of objects, children are more likely to retain the word-object mapping over time when their attention is directed towards the artefact by the experimenter's ostensive labelling, such as pulling back, holding, pointing to and naming the target referent (Horst & Samuelson, 2008). One explanation for this is that children encoded the experimenter's social pragmatic cues. They may have interpreted the experimenter's pointing by a process of referential intent or believed that the object must have been special to the experimenter in order for them to direct so much attention to it.

Axelsson et al., (2012) argue, however, that children recall the word through a process of association. They presented 24-month-olds with a target object and two distracters. Following this, infants saw the target object illuminated only, both the target object illuminated and the distracter objects covered over to make them less salient, the distracter objects covered only or a pointing gesture towards the target object. Although all four groups of infants formed the correct word-object mapping, only the first and second group maintained this over time. This suggests that, while social cues such as pointing help children initially form correct word-object mappings, highlighting attention towards the target object – an associative cue - is more effective at helping children remember these words (Axelsson et al., 2012).

While this would provide evidence that children learn words through association, others argue that understanding referential intent is vital for children's language acquisition. For example, Diesendruck, Markson, Akhtar & Reudor (2004) disagreed with Samuelson and Smith's (1998) theory that the participants in their study learnt words from memory, attention and association. Diesendruck et al., (2004) suggested that the children assumed that the change in context (playing with the target object at a table, rather than on the floor) implied that the target object was in some way *special* to the experimenter and therefore children were still using referential intent when generalising the label. Supporting this claim, their study found that children formed the word-object mapping to the target when the change in context was perceived as being intentional (the experimenter invited the child to play with the fourth object at a table, rather than on the floor) but not when the change in context was perceived as being accidental (the experimenter pretended to drop the fourth object and then decide to play with it at the table, as this was near where it landed) (Diesendruck et al., 2004).

Further, social pragmatics help children to *avoid* word-object mapping errors. For example, 18-20-month-old children do not form a word-object mapping when a speaker who is obviously uninvolved with the word-learning situation utters a novel label, such as someone speaking on the telephone (Baldwin et al., 1996; Bannard & Tomasello, 2012). Children also label ambiguous drawings differently according to the referential intent of the creator (Preissler & Bloom, 2008). Participants followed an experimenter's eye gaze towards one out of two novel objects while she produced an ambiguous drawing and later named the object she had gazed at as the referent of the drawing. However, children chose the referent at chance between the two objects when the experimenter pretended to discover an identical drawing after she had directed her eye gaze towards the object, but without engaging in a drawing act.

TD 14, 18 and 24-month-old children also only used an actor's eye gaze and pointing as an indicator to where an object was hidden when it appeared intentional and not when it appeared accidental (e.g. when the actor pointed while pretending to be inspecting his watch) (Behne, Carpenter & Tomasello, 2005). Further, twelve-month-old infants pointed more towards an object when the experimenter did not know its location than when the experimenter knew where it was (Liszkowski, Carpenter & Tomasello, 2008). Taken together, these findings (Baldwin et al., 1996; Bannard & Tomasello, 2012; Behne et al., 2005; Liszkowski et al., 2008; Preissler & Boom, 2008) suggest that children understand eye gaze and pointing from a process of referential intent, not just perceptual salience.

A further complication with the idea of word learning being purely associative is that, while this may help explain how children learn the names of nouns, it does not account so well for how children learn the meaning of verbs and adjectives, which are often less directly described (Bloom, 2000; Snedeker, 2008). Although cross situational learning does aid children's language acquisition, in more complicated word learning situations, social learning may help children learn words faster and more accurately (Belpaeme & Morse, 2012). The evidence suggests that, while young TD children learn words by association (e.g. Foudon, 2008; Hollich et al., 2004), they learn words from social pragmatics from as early as eighteen-months-old (e.g. Baron-Cohen et al., 1997; Briganti & Cohen, 2011). It is also from this age that infants use the 'speaker's direction of gaze' (Baron-Cohen et al., 1997), forming word-object mappings to the object of the speaker's focus even when they themselves are attending to a different object from the speaker (Baldwin, 1991; 1993). Sixteen-seventeen-month-old infants look at the object in the speaker's focus but map the novel word to the object in their own focus, while 14-15 month-olds look up to the speaker but choose objects at chance.

In addition to gaze following, TD infants follow pointing from 9-12 months old (Tomasello et al., 2007). Both 14 and 18-month-old infants look longer at the target object than a distractor novel object when the speaker points while naming it, although only the 18-month-olds form word-object mappings (Briganti & Cohen, 2011). Taken together, the findings of Baldwin (1993) and Briganti and Cohen (2011) suggest that younger infants are aware of social cues (their failure to form the correct word-object mapping in the paradigms cannot be due to not having identified that the speaker is gazing or pointing at the object) but it is not until 18 months old that infants use these cues to help them learn words.

Therefore, there is evidence both that TD children learn words from social cues (e.g. Baldwin, 1991; 1993; Briganti & Cohen, 2011; Gliga & Csibra, 2009; Graham, Nilsen, Collins & Olineck, 2010) and that they learn words from association (e.g. Axelsson et al., 2012; Saffran et al., 1996; Smith et al., 1996; Smith & Yu, 2008). However, some argue that only younger TD children utilise association in their word learning, with older children relying on social cues (e.g. Hollich et al., 2000) when the two are directly pitted against each other. One way in which to further tease apart whether children's language acquisition is controlled by social or associative cues is to directly pit the two together within the same paradigm, with a social cue occurring towards one object and an associative cue occurring towards the other. There is evidence (Hollich, 2000; Moore, 1999; Moore et al., 1999) that TD two-year-olds form word-object mappings according to the referential intent of the speaker (i.e. to an object the speaker gazes at and/or turns towards), rather than perceptual salience (i.e. a colourful or moving object).

Taken together, the evidence suggests that more sophisticated social mechanisms than mere association are needed in order to extend and enrich children's word learning. Gradually, children learn that it is not constantly the most exciting or salient object being labelled. Further, some studies claim that two-year-olds use the perspective of the speaker to help them learn the names of new toys. They choose the toy that is novel (Akhtar et al., 1996) or most interesting (Diesendruck et al., 2004) from the *speaker's* perspective as the referent of a novel word, even if this is not new or exciting for the child themselves.

Therefore, there is evidence that TD children learn words from both social pragmatics and association, but prioritise social cues over associative cues when the two conflict. On the contrary, there is evidence that children with ASD learn words and infer a characters desire from association, rather than referential intent (e.g. Baron-Cohen et al., 1997; Hennon, Hirsh-Pasek & Golinkoff, 2003). Although this might occasionally facilitate word learning, in the main this could lead to frequent word-object mapping errors, as it is not always the most salient object being named. This will all be discussed further in the next section.

1.9. Word learning from associative and social cues: Children with ASD

Children with ASD can learn words from association (Mayo & Eigsti, 2012; McGregor, Rost, Arens, Farris-Trimble & Stiles, 2013; Preissler, 2008). School aged children and adolescents with ASD use the statistical regularities of a speech stream to determine word boundaries to the same extent as TD children (Mayo & Eigsti, 2012). In

Mayo and Eigsti (2012), participants listened to a 21-minute continuous stream of speech, previously used in Saffran et al., (1997). Six combinations of syllables formed trisyllabic words, which had high internal transitional properties.

After listening to the speech stream, children were tested to see if they could identify 'words' compared with 'non-words'. They listened to 'words' (three syllables with high transitional properties) and 'non-words' (three syllables which had not previously occurred), followed by choosing the item which sounded most like the language they had heard. Both TD children and children with ASD had a high degree of accuracy for identifying the 'words'.

Furthermore, children with ASD track cross-situational information such as earlier frequency of gaze cues towards a specific object to help them learn words (McGregor et al., 2013*)*. TD children and children with ASD viewed photographs of a woman with an object to her left, right and centre, at the same time as hearing a word. For one type of trial (neutral unfamiliar), the objects and novel words were unfamiliar and the speaker gazed directly ahead, without looking at any of the objects. Both TD children and children with ASD scored above chance detecting the target object for the neutral unfamiliar trials, by tracking cross-situational information (gaze cues and word-to-object co-occurences).

The results of Mayo & Eigsti (2012) and McGregor et al., (2013) suggest that the language difficulties of children with ASD do not stem from impairments in detecting statistical covariance and association. However, several factors need to be taken into consideration before coming to this conclusion. Firstly, the children with ASD in both of the two studies were quite old. The participants in Mayo and Eigsti (2012) had a mean age of thirteen years and verbal IQ, non-verbal IQ and full scale IQ of eleven, while the participants in McGregor et al., (2013) had a mean age of just over eleven (no mental age given, just standard scores). It may be that younger children would struggle more at the task relative to chronological age (CA) and receptive age matched TD peers.

It is also the case that the participants with ASD in both studies were mildly affected individuals; therefore it is unknown whether more severely autistic children would perform the same. Finally, the artificial speech used by Mayo and Eigsti (2012) and the still photographs used by McGregor et al., (2013) were arguably less intricate than the language that children are bombarded with in daily life. McGregor et al., (2013) also emphasise that the ability of the children with ASD to learn from statistical co-variation was related to their language ability (although this effect was not found for the TD children), implying that learning in this way may be impaired in less verbal children with ASD. Therefore, these findings indicate that older children and adolescents with ASD learn words from association but the results are not necessarily generalisable to the greater ASD population.

Despite this evidence suggesting that children with ASD learn words through association, these individuals have much documented social difficulties (e.g Baron-Cohen et al., 1985; Dawson, Toth, Abbot, Osterling & Munson, 1994; Frith, 1989; Osterling & Dawson, 1994; Wing, 1981). During infancy, they smile and point less than TD children and often fail to respond to their own name (Osterling & Dawson, 1994). Children with ASD show impairments in following eye gaze (Baron-Cohen et al., 1997; Baron-Cohen et al., 1995; Carpenter, Pennington & Rogers, 2002; Charman, 2003; Riby, Hancock, Jones & Hanley, 2013) and even adults with ASD have difficulty following a speaker's pointing to determine the focus of the speaker's interest (Klin, Jones, Schultz, Volkmar & Cohen, 2002).

Furthermore, individuals with ASD fixate on the speaker's mouth and peripheral details in the background when viewing a social situation, while TD people focus on the speaker's face, eyes and the central part of the scene (Klin et al., 2002; Merin, Young, Ozonoff & Rogers, 2006; Norbury, Brock, Cragg, Einav, Griffiths & Nation, 2010; Spezio, Adolphs, Hurley & Piven, 2007). Further, unlike their TD peers, children with ASD are not distracted by an irrelevant face distractor in a visual search task (Riby, Brown, Jones & Hanley, 2011). This suggests abnormal processing of faces.

As has been discussed earlier, while forming word-object mappings according to the more salient object may sometimes lead to the correct word-object mapping, the most exciting stimulus is not always the object being named. TD children may realise this during infancy and employ social cues to help them learn words when social and associative cues conflict (e.g. Hollich et al., 2000; Moore et al., 1999). By contrast, the reliance of older children with ASD in attending to associative information might lead to word-object mapping errors and word learning confusion (Foudon et al., 2008).

There is some evidence that, like 16-17 month-old TD children, children with ASD use the listener's direction of gaze after hearing the speaker's utterance, forming word-object mappings according to the object of *their* own focus, rather than the speaker's (Akechi, Senju, Kikuchi, Tojo, Osanai & Hasegawa, 2011; Baron-Cohen et al., 1997; Preissler & Carey, 2005; Walton & Ingersoll, 2013, but see Luyster & Lord, 2009). For example, in Baron-Cohen et al., (1997), the experimenter and child were focusing on different objects. The experimenter named the object within either their own or the child's focus. Children with ASD who had a mean verbal mental age (VMA) of two formed correct word-object mappings only when the speaker named the object that the child themselves was focused on. In contrast, VMA matched TD children and children with intellectual disability formed correct word-object mappings in both conditions.

This implies that, although children with ASD are able to form an associative mapping between the new word and a novel object, they fail to use the social cue of eye gaze to correctly infer which object is being named. It has been suggested that children with ASD are often less likely to gaze at the speaker as the novel word is uttered (Preissler & Carey, 2005), which suggests that they might not even notice the speaker's eye gaze. However, other studies suggest that children with ASD *do* learn words from eye gaze (e.g. Bani Hani, Gonzalez Barrero & Nadig, 2012; Luyster & Lord, 2009; Mcgregor et al., 2013; Norbury et al., 2010). This is more fully discussed in Study Three (Chapter Four).

While using the speaker's direction of gaze is a more effective word learning strategy than using the listener's direction of gaze, word learning can still progress, albeit slowly, if only the latter method is employed (Baron-Cohen et al., 1997). In cases of follow-in labelling, where the listener is focused on the same object as the speaker, using either the speaker's or the listener's direction of gaze will lead to the correct word-object mapping inference. Even in discrepant looking conditions, associative processes can help children clarify which object is being named. For example, if a child using the listener's direction of gaze hears the word 'shoe' for the first time when they are focused on a toy doll, they may originally make the incorrect mapping that the word 'shoe' refers to the doll. However, later, the child may hear the word 'shoe' again, when no doll is in sight. Through repeated occasions of hearing the word 'shoe', the child may scan their memory to correctly associate the word with the only common object across the situations in which the word has been heard (Baron-Cohen et al., 1997).

However, using the listener's direction of gaze leads to more word-object mapping errors than using the speaker's direction of gaze. There are a few anecdotal examples within the literature about children with ASD making these kinds of errors. Baron-Cohen et al., (1997) mention a child with ASD who referred to his toy train as a 'sausage', seemingly because his mother had told him to come and eat his sausage while he was looking at the toy train but she was looking at his plate of food. They also note Kanner's (1943) original article mentioned a boy with ASD who used the term 'Peter Eater' to talk about saucepans. The boy's mother had been reciting the song 'Peter, Peter Pumpkin Eater' to him just as she dropped the saucepan she was holding. Presumably the loud noise the saucepan made as it fell to the floor caused the boy to look at the saucepan and hence the word-object mapping error occurred. Nonetheless, if children with ASD are using the listener's direction of gaze, there should be more evidence in the literature of these kinds of mapping errors than the two anecdotal examples provided above.

Children with ASD tend to find pointing easier to follow than gaze (Travis & Sigman, 2001, but see, e.g., Carpenter et al., 2002). Indeed, the speaker pointing as well as gazing at the target object helps children with ASD interpret the gaze (Akechi, Kikuchi, Tojo, Osanai & Hasegawa, 2013). However, as has been previously discussed, the process by which children with ASD interpret pointing may be different from the referential intent processes used by TD children. Pointing is visibly salient and therefore highlights attention (Lee et al., 1998; Parish-Morris, Hennon, Hirsh-Pasek, Golinkoff & Tager Flusberg, 2007). Thus, children with ASD may interpret pointing through association. If this is the case, then it is not the pointing *per se* which is important; other perceptually salient cues such as observing an arrow positioned by an object or the object lighting up may also lead to a word-object mapping. Therefore, if a speaker appears to be accidentally pointing at an object while it is obvious that they are focused elsewhere, TD children should infer that the pointing is coincidental. By contrast, children with ASD should fail to notice that the speaker is preoccupied with something else and continue to choose the object the speaker is pointing to as the referent.

As previously discussed within Section 1.8, one useful way of establishing whether children with ASD (as well as TD children and children with DD) learn words by social pragmatics or association is to directly pit the two together. This has previously been done in studies of referential intent inference (Baron-Cohen et al., 1995; Pellicano & Rhodes, 2003; Rombough & Iarocci, 2013) by showing children an image of a character whose eye gaze is directed towards one of four sweets, at the same time as an arrow is directed towards another sweet. It is generally found that TD children assume that the character wants the sweet suggested by the direction of eye gaze (although see Pellicano

& Rhodes, 2003) but children with ASD want the sweet the arrow is positioned towards (Baron-Cohen et al., 1995; Rombough & Iarocci, 2012).

Contrary to these findings, children with ASD have been found to follow eye gaze to the same extent as TD children in Posner-type cueing tasks (Sweetenham, Condie, Campbell, Milne & Coleman, 2003). This includes when an arrow as well as eye gaze was used for the tasks (Kuhn et al., 2010). Therefore, previous research is inconclusive. Hence Study Five (Chapter Six) more fully explores the effect of conflicting social and associative cues on word learning.

1.10. Word learning from associative and social cues: DD children

There is a lack of research regarding how children with DD learn words from associative cues. However, one study modelled on Behne et al., (2005) suggests that, like TD children, children with Down Syndrome and Williams Syndrome use referential intent to understand a speaker's eye gaze and pointing gestures (John & Mervis, 2010). When an actor appeared to be 'intentionally' gazing and pointing at one of two boxes, the children looked in the box the gesture had occurred towards to locate a hidden toy. However, when the actor appeared to be 'accidentally' gazing and pointing (for example, while pointing, looking down at their watch, as though distracted) the children chose each box equally often to look inside (John & Mervis, 2010).

The evidence is mixed regarding understanding of social cues in children with DD. Some studies suggest that they understand referential intent (John & Mervis, 2010; Landry & Loveland, 1988; Loveland & Landry, 1986) on a par with TD children and to a greater extent than children with ASD (D'Entremont & Yazbek, 2007). In contrast, other research suggests that children with Williams Syndrome are impaired in both producing and following pointing gestures relative to mental age matched TD children (Laing et al., 2002) and that children with moderate learning difficulties are actually *worse* than children with ASD at learning words after objects are ostensively labelled (Franken et al., 2010).

It is also the case that caregivers of children who have ASD *or* are intellectually handicapped are more likely than caregivers of TD children to try to elicit eye gaze during child-caregiver interactions (Kasari, Sigman, Mundy & Yirmiya, 1988). A possible reason for this is that DD children, not just children with ASD, make less spontaneous eye contact than TD children, hence their caregivers need to encourage this more than in TD children. Supporting this proposal, non-speaking infants at risk for having a DD showed a lack of understanding and use of gaze during a free play session with their caregivers (Arens, Cress & Marvin, 2005). Furthermore, children with Down Syndrome showed fewer social referencing looks during semi-structured adult-child like interactions and an ambiguous situation than TD children (Kasari, Freeman, Mundy & Sigman, 1995).

Therefore, the sparse available prior research is contradictory regarding word learning from social cues in DD children. More information about how children with DD understand social, associative and conflicting cues is given in Studies Three, Four and Five (Chapters Four, Five and Six).

1.11. Is language delayed or deviant in ASD?

As mentioned within section 1.1, previous studies have tended to conclude that children with ASD have a word learning deficit if they do not possess certain linguistic abilities at a specific age. However, unless a varied CA and VMA range of children with ASD are studied, it is unknown whether or not children with ASD would eventually acquire skills they are claimed to lack, just at a later age than usual. Thus, language acquisition may be delayed or deviant in ASD.

If delayed, the word learning of children with ASD follows the same developmental trajectory as TD children, although the former group acquire language at a later age than the latter group. If deviant, however, the language acquisition of children with ASD follows a different developmental trajectory from usual (see Figure Two). For example, it might be that children with ASD need a higher level of language understanding than TD children to learn words from social cues, rather than association. Conversely, it is possible that they *never* develop this ability and always learn words from association.

Supporting the delay hypothesis, Kanner's (1943) original definition of autism noted delayed language acquisition as a symptom. Although children with ASD do not generally speak their first words until three years old, compared with just 8-14 months old in TD children (Eigsti et al., 2011), many children with ASD do learn to speak eventually, again supporting the delay hypothesis. Some children with ASD, although possessing severely limited spoken language, have adequate language comprehension.

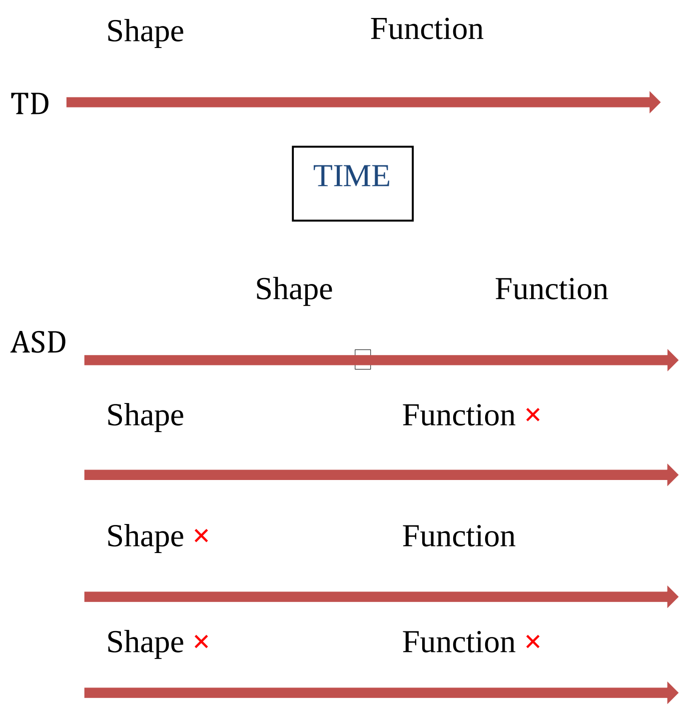

Figure 2: Visual interpretation of the delay (left) vs. deviance (right) hypothesis. Within typical development (see the top row), TD children acquire a shape bias before they acquire a function bias, being able to use both heuristics by adulthood. If the shape bias and function bias are delayed in ASD (see the second row) then they acquire the shape and function bias later than TD children. Alternatively, it may be the case that the function bias (see third row), shape bias (see fourth row) or both (see fifth row) are deviant in ASD, in which case they never develop (or develop *earlier* than in TD children). The understanding of social cues by children with ASD might also take place through a similar process of delay or deviance.

Furthermore, some aspects of socialisation, such as following eye gaze (Leekam, Hunniset, & Moore, 1998), emotion recognition (Yirmiya, Sigman, Kasari & Mundy, 1992) and theory of mind (Eisenmajer & Prior, 1991; Frith, Morton & Leslie, 1991;

Happé, 1995; Prior, Dahlstrom & Squires, 1990) are delayed in ASD, but develop in a typical fashion once present. Perhaps children with ASD use different processes to achieve certain tasks from TD children and therefore require more sophisticated abilities, such as enhanced VMA (Happé, 1995) or cognitive skills (Yirmiya et al., 1992). This may help them to explicitly 'hack out' solutions, in contrast to TD children's intuitive reasoning, which might be more unconscious (Frith et al., 1991).

Therefore, there is evidence that language is delayed in ASD. However, other studies suggest it is deviant (e.g. Van meter, Fein, Waterhouse & Allen, 1997). As stated in Van Meter et al., (1997), language deviance does not necessarily mean 'language that never emerges' but may also apply to *differences* within language relative to TD children. Uneven language development, such as intact or even advanced language production but delayed language comprehension would indicate a deviance in language overall as this differs from most children, with intact language production and comprehension. Furthermore, some children with ASD possess language oddities that are not seen in TD children. These include echolalia (Grossi et al., 2013; Kanner, 1946) and idiosyncratic use of words (Eigsti, Bennetto & Dadlani, 2006; Lord & Paul, 1997; Tager-Flusberg & Calkins, 1990).

Despite these differences, the word learning of children with ASD has a few similarities with the word learning of TD children. For example, like their TD peers, children with ASD comprehend words (Charman, Drew, Baird & Baird, 2003; Swensen, Kelley, Fein & Naigles, 2007) and 'wh' questions, such as 'what hit the book?' (Goodwin, Fein & Naigles, 2012) before they are able to produce them. Furthermore, like TD children, children with ASD have a default assumption that new words refer to nouns rather than adjectives (Swensen et al., 2007), are more likely to learn names of novel objects if these are labelled (Mcduffie, Yoder, & Stone, 2006) and show syntactic alignment, mirroring the language of a conversational partner (Allen, Haywood, Rajendran & Branigan, 2011). Therefore, although delayed, some aspects of language follow the usual developmental trajectory in children with ASD relative to TD children.

1.12. Contributions of this thesis to the literature

Overall, this thesis attempts to make several novel contributions to the ASD and child language acquisition literature. Firstly, each study investigates the delay vs. deviance hypothesis by including a broad CA and VMA range of children and splitting these into ‘high’ and ‘low’ receptive vocabulary subgroups. Most previous studies have included just one overall group of children with ASD, of a similar CA or VMA (e.g. Baron-Cohen et al., 1997; Hartley & Allen, 2014; Luyster & Lord, 2009; Mayo & Eigsti, 2012; Preissler & Carey, 2005). This means that if any differences occur in ASD it is hard to establish whether eventually these differences disappear. It is unwise to match the sample according to CA in ASD studies, as this population often has a lower mental age (MA) than CA. Thus the CA matched TD group often become an inadequate control group for the children with ASD. Matching on MA is generally preferred (Hermelin & O’Connor, 1970) and many word learning studies match on measures of language ability (e.g. Baron-Cohen et al., 1997; Hartley & Allen, 2012; Luyster & Lord, 2009) such as VMA.

If high VMA but not low VMA children with ASD show word learning skills on a par with low VMA TD children, this suggests a delay effect. In contrast, if even high VMA children with ASD show impaired word learning relative to low VMA TD children, this suggests that language is deviant. Note, however, that in the latter case it is not *certain* whether children with ASD will eventually acquire the skill. For example, if investigating language acquisition in children with VMAs of three and six, even if the six-year-old children with ASD do not show the ability, they might eventually develop it, for example at nine-years, rather than six. Nevertheless, including participants with a broader range of receptive vocabulary ability than previously studied and subcategorising these participants according to their VMA makes it more likely that any differences between high and low VMA children can be fully uncovered.

Note that, if it is the case that children with ASD have word learning delays, the underlying mechanism controlling this is not certain. It might be, for example, that possessing a higher VMA facilitates their language acquisition. Alternatively, it is possible that factors such as increased life experience and years of interventions which emphasise word learning are contributing factors. It could even be the case that children with ASD who have a higher VMA are better able to ‘hack out’ solutions to tasks via associative processes.

This thesis includes an additional control group of participants with DD in every study. Children with DD are frequently not included as an additional control group in studies of word learning in ASD, with numerous research paradigms only recruiting TD children alongside the ASD cohort (e.g. Akechi et al., 2013; Baron-Cohen et al., 1997;

Jing & Fang, 2014; Luyster & Lord, 2009; Mcgregor et al., 2013; Norbury et al., 2010; Parish-Morris et al., 2007; Tek et al., 2008). However, it is desirable to include control groups of TD *and* DD children; TD children to establish any differences relative to children with ASD on a task (Burack, Iarrocci, Bowler & Mottron, 2002) and DD children to help determine whether these difficulties are specific to ASD or simply the consequence of having any developmental disability (Burack et al., 2002; Tager Flusberg, 1999). The performance of the DD children is also interesting in its own right; as a population, they have been somewhat neglected within the research literature, therefore it is beneficial to explore their word learning performance.

1.13. General Conclusions

Three principal ways in which children learn words for objects; word learning biases, social pragmatics and association have been described. Although these three processes may be thought of as distinct, the emergentist coalition model stresses that they interact together to facilitate language acquisition in TD children. TD children also utilise different types of cues at different developmental time points, with infants relying on association, while older children employ social cues (e.g. Hollich, 2000).

However, unlike TD children, individuals with ASD have been found to struggle to learn words from social cues (e.g. Baron-Cohen et al., 1997; Preissler & Carey, 2005) and from some types of word learning constraints, such as the shape bias (e.g. Hartley & Allen, 2014; Portzeba et al., in press; Tek et al., 2008). This means that they depend on a more restricted number of indicators than TD children to help them learn words, including other word learning constraints (e.g. mutual exclusivity, see Preissler & Carey, 2005) and association (e.g. Hennon, 2003). Their dependence on association for language acquisition extends past the age at which TD children learn words from this type of cue.

The present thesis investigates how word learning biases, social cues and associative cues aid word learning for novel objects in TD children, children with ASD and children with other developmental disorders, but who do not have ASD (DD). Studies One and Two explore the shape bias (Study One) and the function bias (Study Two). Studies Three, Four and Five investigate social cues (Study Three), associative cues (Study Four) and conflicting social and associative cues (Study Five). For all studies, children are subdivided into 'high VMA' and 'low VMA' categories in order to investigate the delay vs. deviance hypotheses in ASD. The studies within this thesis investigate the emergentist coalition model; themes embedded within the thesis are how characteristics of the object (Shape Bias and Function Bias), speaker (eye gaze and pointing) and environment (arrow and light) all help facilitate word learning and how word learning constraints, social cues and associative cues interlink to help children's language acquisition.

Studies Three, Four and Five are also the first to thoroughly investigate the emergentist coalition model in relation to ASD, by establishing if children with the disorder show a similar pattern to that seen within typical development; first using association and then using social cues for word learning when the two conflict. Previous research exploring this in ASD (Hennon, 2003) found that three-year-old children with ASD prioritise salience (a perceptually interesting object) over social pragmatics (the speaker's gaze) when the two conflict. However, as previously discussed, TD children learn words from the social cue from eighteen-months-old. This suggests that children with ASD learn words from association for longer than TD children when this is pitted against social pragmatics. However, it does not inform whether older children with ASD would still form word-object mappings from association (i.e. word learning from social cues is deviant in ASD) or whether they would now form word-object mappings from social cues (in which case word learning from social cues is merely delayed).

For all five studies, children have a VMA of two-years-old or above. This was necessary in order for children to fully understand the tasks and complete the cognitive assessments. However, within the case of typical development, this is over the age at which children start using social rather than associative cues for word learning when the two are directly pitted together, according to the emergentist coalition model (at 18-24 months old). Therefore, it would be hypothesised that both the low and high VMA TD children recruited as participants within this thesis would use social cues for word learning.

However, as has already been discussed, unlike TD children of the same age, three-year-old children with ASD learnt words from the associative rather than social cue when the two conflicted (Hennon, 2003). This suggests that it is acceptable to test the emergentist coalition model in ASD with older children than two-year-olds. ASD often involves a delay in word learning (e.g. Eigsti et al., 2011; Kanner, 1943) and other aspects of social skills (Eisenmajer & Prior, 1991; Frith et al., 1991; Happé, 1995; Leekam et al., 1998; Prior et al., 1990; Yirmiya et al., 1992). This implies that it might be expected for the low VMA children with ASD to rely on association but the high VMA children with ASD to rely on social cues to facilitate word learning when the two conflict.

Chapter Two: **Attentional learning helps language acquisition take shape for atypically developing children, not just children with ASD.**[1]

2.1. Introduction to the next two chapters

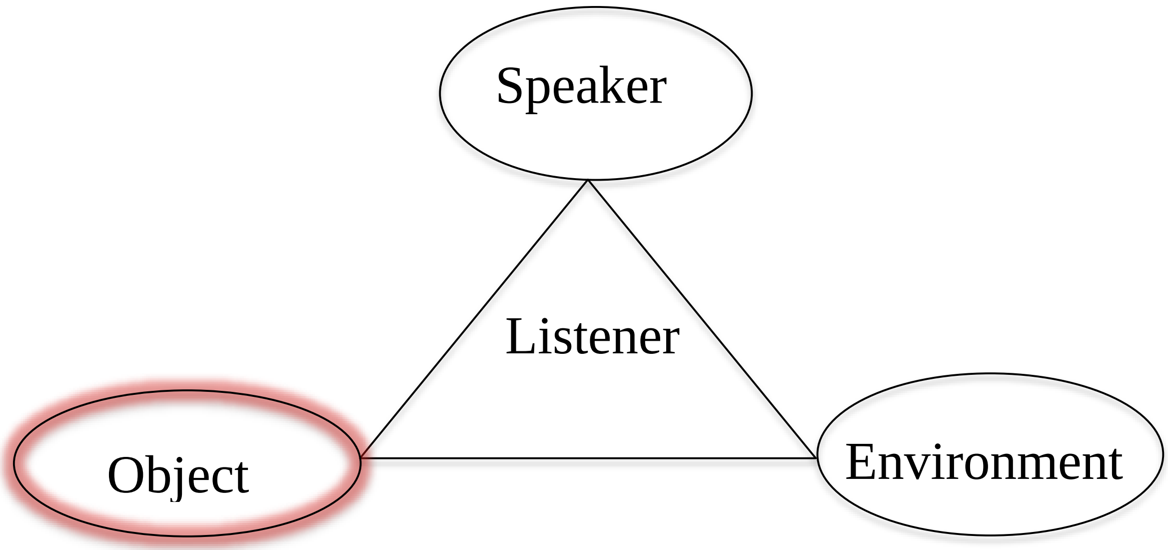

Figure 2.1: Visual interpretation of the speaker – object – environment interaction for word learning. The next two chapters will focus on the 'object' aspects of the triad.

The next two chapters explore the object aspect of the emergentist coalition model. Both perceptual (shape bias) and conceptual (function bias) factors are investigated. Specifically, this Chapter explores the shape bias (or assumption that

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[1] This chapter is based on Field et al., (in press). Attentional learning helps language acquisition take shape for atypically developing children, not just children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*. Minor changes have been made in order to help with consistency in terms of the structure and flow of the thesis.

objects with the same shape have the same name) and the following chapter explores the function bias (or assumption that objects with the same function have the same name).

2.2. Introduction to the shape bias study

As mentioned within Section 1.2 of Chapter One, the shape bias helps children rapidly categorise objects as belonging to the same class, meaning that object labels can be quickly and easily generalised based on their characteristic shape. TD children intuitively know that a big, shiny multi coloured beach ball, for example, has the same name as a small, rough, green tennis ball. From as young as two years old, TD children generalise the word-object mapping 'ball' according to the circular shape of balls rather than other perceptual features such as size, texture (Landau et al., 1988) or colour (Baldwin, 1989). It has been claimed (Hartley & Allen, 2014; Potrzeba et al., 2015; Tek et al., 2008) that children with ASD do not show a shape bias, which might help explain their word learning difficulties.

There are two competing theories regarding how TD children are able to show a shape bias, which revolve around whether the heuristic is controlled by social (shape-as-cue, or SAC, account) or associative (attentional-learning-account, or ALA) processes. The SAC account (e.g. Bloom, 2000) proposes that object shape provides a good indicator as to the referential intent of the object's creator, who deliberately constructed the same kinds of objects to be of the same form. According to the SAC account, children become sensitive to the shape of objects before they have acquired much receptive vocabulary and this sensitivity extends to non-naming tasks, such as being asked whether similarly shaped objects are the 'same' or 'like each other'. Operation of the SAC account is guided by general intuitions about referential intent and therefore necessitates intact referential monitoring abilities. This account suggests that the shape bias helps children rapidly acquire words, particularly count nouns (Graham & Diesendruck, 2010; Markson et al., 2008).

By contrast, the ALA (e.g. Smith et al., 1996) proposes that the shape bias arises due to children simply learning to associate same shaped objects with the same name. This association develops through frequent co-occurrences between objects with specific shapes having specific labels. Therefore, the shape bias is exclusive to naming without extending to non-lexical classification tasks (e.g. Landau et al., 1988; Smith et al., 1996; but see Samuelson & Smith, 2005). According to the ALA, children have already acquired a considerable amount of language, particularly count nouns (50+), prior to showing the shape bias. Indeed, this early noun vocabulary facilitates shape bias understanding (Samuelson, 2002; Smith et al., 2002; Tek et al., 2008).

TD children show the shape bias more when the object is named (e.g. Imai et al., 1994; Landau et al., 1988; Smith et al., 1996), which supports the ALA. However, there is also evidence that TD children possess a shape bias in some non-lexical situations (e.g. Diesendruck & Bloom, 2003), such as when the test question is worded *'pick another object like this',* rather than when the test question is worded '*pick the object that goes together with this'* which supports the SAC account. It has been suggested that the shape bias begins as a word learning strategy for TD children and then extends to other forms of object classification by adulthood (Landau et al., 1988). As children with ASD have difficulties inferring referential intent (D’Entremont &Yazbek, 2007; Preissler & Carey, 2005; Prizant & Wetherby, 1987), the SAC account would hypothesise that they do not possess the shape bias. Conversely, as children with ASD are able to learn words via association (Parish-Morris et al., 2007; Preissler, 2008), the ALA would hypothesise that they show a shape bias in naming activities.

However, abstracting commonality in shape involves both categorisation skills and the ability to attend to the global shape of objects. These abilities are both impaired in ASD, given evidence for difficulties with prototype formation (Klinger & Dawson, 2001) and a preference for local rather than global processing (e.g. Frith, 1989; Happé & Frith, 2006), unless explicitly instructed to attend to global properties (Koldewyn, Jiang, Weigelt & Kanwisher, 2013; Plaisted, Swettenham & Rees, 1999). Individuals with ASD often show superior performance on activities requiring attention to detail, such as block design (Shah & Frith, 1993) and embedded figures tasks (Joliffe & Baron-Cohen, 1997). This latter behaviour is typically described as weak central coherence and would predict that children fixate on parts of objects rather than the object as a whole (but see Mottron, Burack, Iarocci, Belleville & Enns, 2003, who acknowledge that children with ASD have skills at embedded figures tests but claim that they also show typical global processing).

This could contribute to a shape bias deficit, as well as difficulties with the whole object assumption (Markman, 1989) and word-object mapping errors. For instance, focusing on the stem of an apple when the word ‘apple’ is overheard may cause children to map the word ‘apple’ only to the stem, instead of the global shape of the object. Due to these underlying differences in cognitive style, it is possible that children with ASD may *never* acquire a shape bias. An alternative possibility is that children with ASD simply have a shape bias delay, showing the heuristic only after explicitly learning certain rules.

This argument is not new; many researchers have previously investigated delay or deviance accounts of word learning in ASD (e.g. Bartolucci, Pierce, Streiner & Eppel, 1976; Eigsti & Bennetto, 2009; Howlin, 1984; Mitchell et al., 2006; Van Meter et al., 1997). A delay account would predict that children with ASD may eventually learn to use the shape bias heuristic, but not until they have more experience with objects (i.e. a higher chronological age, or CA) and/or superior receptive language (i.e. a higher verbal mental age, or VMA) than is usual. If the shape bias is deviant, however, children with ASD may never use the familiar form of an object to facilitate their word learning. To investigate these hypotheses, it is necessary to include a group of children with wide variability in language skills, specifically to test whether the shape bias emerges at a later point in development.

Three studies to date (Hartley & Allen, 2014; Potrzeba et al., 2015; Tek et al., 2008) have investigated the use of the shape bias in children with ASD. Tek et al., (2008) compared the performance of 14 children with ASD and 15 TD children during four different developmental time points over a year-long period. At the initial session, the TD children had a mean CA of 20.5 months and the children with ASD had a mean CA of 33.2 months. Both implicit (Intermodal Preferential Looking, or IPL) and explicit (pointing) measures were used to track performance in a name and no name condition. In ‘name’ trials, a novel object was named (e.g. ‘*this is a zup*’), and children were asked to look at or point to the '*zup*' from one similarly shaped and one similarly coloured object in the test trials. The 'no name' trials followed a similar procedure but children were just told '*look at this'* and were then required to either look at or point towards '*the same*' during the test trials. In the IPL trials, the TD group looked longer at the shape match in name trials (but equally long at both objects in no name trials) from 24 months old, although the children with ASD showed no preference for the shape match across all four sessions in either condition.

More recently, a longitudinal study of a larger and more heterogeneous sample of children with ASD replicated this finding with TD children from as young as 20 months, although children with ASD did not look longer at the shape match in the name than no name trials even with a mean CA of four-and-a-half (Potrzeba et al., 2015). Tek et al's (2008) pointing trials showed a different pattern of results; here, both groups selected the shape match more often than the colour match, but in both conditions. The authors concluded that the shape bias was not present in the children with ASD, due to their failure in the IPL trials and lack of discernible difference between the name and no name conditions in the pointing task. One perplexing possibility is that both the ASD and TD groups seem to be operating via the SAC account in the pointing trials, as they showed a general preference for shape across lexical and non-lexical situations.

Additional evidence for a difference in using shape as a cue for lexical extension in ASD was recently provided by Hartley and Allen (2014), in a study about pictorial reference. Children with ASD with a verbal mental age (VMA) of 3 were able to extend labels learnt for images to novel pictures and objects of the same shape and colour.

However, they also extended labels to stimuli that shared the same shape *or* colour. Thus, Hartley and Allen (2014) proposed that the children with ASD showed a ‘fundamental misunderstanding of the rules that govern symbolic word-picture-object relations’ (p. 2069), and suggest that they were unable to use shape correctly to constrain lexical generalisation.

2.3. Description of the present study

The current study extends the past research carried out on the shape bias. First, older children than those previously recruited by Tek et al., (2008) are included in the sample, considering that Tek et al., (2008) left open the possibility that the children in their study may simply have been too young to consistently use the shape bias for word learning. As the shape bias is considered to be completely developed in TD children by 2-years-old (Jones, 2003; Landau et al., 1988; Tek et al., 2008) children with a VMA above 2 participate in the present experiment. To investigate the delay vs. deviance hypothesis, each group is split into a ‘high VMA’ and ‘low VMA’ category based on the median VMA of the sample, as measured by the British Picture Vocabulary Scale-Second Edition (BPVS) (Dunn, Dunn, Whetton & Burley, 1997).

A second aim of this study is to investigate the shape bias not only in children with ASD, but in children with developmental disorders (DD) excluding ASD, because word learning difficulties have also been documented in this population (e.g. Franken et al., 2010; Rice et al., 2005). Interestingly, ‘late talkers’, or children who are delayed in learning how to speak, fail to show the shape bias, sometimes forming word-object mappings according to texture (Jones, 2003). Thus, it is important to establish whether children with other developmental difficulties also have a shape bias deficit, and this can furthermore reveal whether any deficits or differences are autism-specific, or are instead a result of cognitive delay.

Finally, I aim to test whether the shape bias can be explained by the SAC account or ALA across our three populations (TD, ASD and DD). This study is based on the pointing task of Tek et al., (2008), as the effects for the IPL task have already been replicated (Potrzeba et al., 2015), the pointing task is more age appropriate for the children in my sample than the IPL task, and because the results obtained in that condition require further investigation and leave open the possibility that the SAC account drives the shape bias in explicit tasks. To avoid potential bias between conditions, a between subjects design is adopted. Across four trials, a novel object is presented and either named (e.g. *'this is a dax!*') or described (*'this is nice'*). As 'late talkers' sometimes generalise words to objects of the same texture (Jones, 2003), I add a texture match to the test array, which also consists of a shape match and a colour match. Children are simply asked to give the experimenter the other *'dax'* (name condition) or the other *'one'* (no name condition).

If the shape bias is controlled by the SAC account, TD children and children with DD are predicted to select the shape match in both the name and no name condition, but children with ASD are not predicted to select the shape match in either condition. However, given Tek et al.'s (2008) results in the pointing task, an alternative possibility is that the ASD group select the shape match in both conditions. If the shape bias is explained by the ALA, all groups of children are expected to select the shape match in the name condition but not the no name condition. However, due to the difficulties children with ASD experience with categorisation and global processing they might not select the shape match in either condition. If the shape bias is delayed in ASD, high VMA children with ASD are hypothesised to show the shape bias, although low VMA children with ASD are not. If the shape bias is deviant in ASD, both high and low VMA children with ASD are hypothesised to have a shape bias deficit.

Overall, this study adds to the growing literature investigating categorisation impairment (Gastgeb et al., 2006; Gastgeb, Wilkinson, Minshew & Strauss, 2011; Klinger & Dawson, 2001) and lexical biases (Hartley & Allen, 2014; Preissler & Carey, 2005; Tek et al., 2008) in ASD. It helps uncover whether the underlying mechanisms controlling the shape bias are social (SAC) or associative (ALA). The aim is to inform theories of word acquisition and provide evidence for the developmental trajectory of the emergence of the shape bias across atypical development, not just ASD.

2.4. Method

2.4.1 Participants

Participants were recruited from three mainstream schools and six day nurseries (TD children), fourteen specialist schools, one ASD unit within a mainstream school, two parental support groups and word of mouth (children with ASD and children with DD) and tested in North West England. Ethical permission had been granted from Lancaster University to carry out the research. Informed consent was obtained from children's parents. Demographic details for participants are provided in Table 1, which shows the children's mean chronological age (CA), verbal mental age (VMA) (as measured by the BPVS), Raven's raw score (maximum = 36) and scores on two questionnaire scales which were given to the children's teachers (on the CARS, a score of 30+ is the cut-off point for ASD, on the SCQ, a score of 15+ is the cut-off point for ASD).

One-hundred-and-ninety-nine children were recruited for this study, although 27 participants were excluded from the final sample, leaving a total of 172 children (66 TD, 62 ASD, 44 DD). Reasons for excluding children were non-compliance (N = 13; 1 TD, 7 ASD, 5 DD), parental interference (1 TD child), refusal to complete the BPVS (N = 9; 1 TD child, 4 ASD children and 4 DD children), having an undetermined VMA as it did not reach the minimum age on the BPVS (1 DD child)[2] and not having received an official diagnosis of their disorder and/or parental concerns that the child may also have undiagnosed ASD (N = 3, all DD). One hundred and thirteen participants were male (35 TD, 52 ASD, 26 DD) and 59 were female (31 TD, 10 ASD, 18 DD). There were 88 children in the name condition and 84 in the no name condition.

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[2] Two low VMA children with ASD also had a raw score on the BPVS below the basal start point of 2.33. However, as both children were very close to this start point, they were conservatively assigned VMA's of 2.25 and 2.00 based upon their raw score. For example, the child who was assigned a VMA of 2.25 had a raw score of 14 on the BPVS, where a raw score of 15 equates to a VMA of 2.33. As the shape bias is present by two-years-old in TD children, these participants were not excluded from the study.

Table 1:

Participant demographic details

	TD		*ASD*		*DD*	
	Low VMA N = 35 17 name	*High VMA N = 31 16 name*	*Low VMA N = 28 14 name*	*High VMA N = 34 18 name*	*Low VMA N = 22 11 name*	*High VMA N = 22 11 name*
Mean CA (SD)						
Name	3.35	5.20	7.80	11.54	8.38	9.34
	(.70)	(1.36)	(2.97)	(3.28)	(2.41)	(1.85)
No Name	3.54	5.73	9.56	9.59	8.62	10.02
	(.54)	(1.45)	(3.61)	(2.36)	(1.71)	(3.41)
Mean VMA (SD)						
Name	3.49	6.73	3.64	6.46	3.15	5.93
	(.52)	(1.76)	(.65)	(1.78)	(.40)	(1.26)
No Name	3.58	7.35	3.54	6.84	3.13	5.60
	(.45)	(2.07)	(.63)	(1.50)	(.57)	(1.04)
Mean Ravens (SD)	8.39	18.52	13.95	20.18	7.25	14.65
	(3.18)	(6.88)	(7.09)	(7.88)	(3.17)	(7.82)
Mean CARS (SD)	15.80	17.27	36.16	31.65	24.73	22.80
	(1.44)	(4.09)	(8.08)	(6.45)	(4.77)	(4.83)
Mean SCQ (SD)	3.00	3.78	18.87	16.19	8.50	8.12
	(2.74)	(3.42)	(6.73)	(6.95)	(6.01)	(5.43)

All children with ASD had received a clinical diagnosis of autism by 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.[3] The children with DD had various conditions, including learning difficulties, Down Syndrome and rarer chromosomal disorders. Participants were grouped according to their diagnostic category. In order to investigate the delay vs. deviance hypothesis, they were then further subcategorised within their diagnostic category according to the median VMA of the sample (Table 1), totalling six groups: TD-low VMA, TD-high VMA, ASD-low VMA, ASD-high VMA, DD-low VMA and DD-high VMA.

2.4.2. Design

Although Tek et al., (2008) used a within subjects design, the present study employed a between subjects design. It was anticipated that if each child took part in both the name and the no name condition, their responses to one trial type might bias their responses to

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[3] With two exceptions, all of the DD children had also received a formal diagnosis of their disorder. The data were not excluded from the study from the two DD-low VMA children who had not been officially diagnosed with any DD because, in addition to attending a specialist school, their VMA (3.67 and 3.75 respectively) was considerably younger than their CA (10.75 and 10.83 respectively). The possibility that these children had undiagnosed ASD was ruled out by both children scoring below the clinical threshold for ASD on both the CARS and SCQ questionnaires.

the other. Which condition children were allocated to (name or no name) was counterbalanced.

2.4.3. Cognitive Tests

Children's VMA was determined by administering the BPVS. Their nonverbal reasoning was assessed by administering Raven's Coloured Progressive Matrices (Raven, 2003), which has a minimum raw score of 0 and a maximum of 36. See Tables 2 and 3 for the VMA's (*p* values obtained from conducting a one-way ANOVA). The three groups had equivalent VMA's. The TD-high VMA children had an older VMA than the DD-high VMA children, although ASD-high VMA and DD-high VMA were VMA matched, as were ASD-high VMA and TD-high VMA. There were no within group differences in VMA between participants in the name and the no name condition (all *p* >.05).

Table 2:

VMA p values for the three groups of participants. The three groups were matched in terms of VMA.

	TD	***ASD***	***DD***
TD	.-	.97	.16
ASD	.	-	.11
DD	-	-	-

Table 3:

VMA p values for the participants split by VMA. This group comparison was carried out for matching purposes.

		TD		***ASD***		***DD***	
		Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
TD	*Low VMA*	-	<.001***	>.999	<.001***	.95	<.001***
	High VMA	-	-	<..001***	.64	<.001***	.27
ASD	*Low VMA*	-	-	-	<.001***	.94	<.001***
	High VMA	-	-	-	-	<.001***	.92
DD	*Low VMA*	-	-	-	-	-	<.001***
	High VMA	-	-	-	-	-	-

***p<.001

2.4.4. CARS and SCQ

The Childhood Autism Rating Scale (CARS; Schloper, Reichler & Rochen Renner, 1988) and the lifetime version of the Social Communication Questionnaire (SCQ; Rutter, Bailey, Berument, Lord & Pickles, 2003) were completed for the majority of children (CARS: 39 TD, 48 ASD, 29 DD. SCQ: 34 TD, 51 ASD, 32 DD) by their parent or teacher to confirm or rule out ASD. Scores on the CARS range from 15-60, with scores of 30 or above in the ASD range. Scores on the SCQ range from 0 – 39, with scores of 15 or above in the ASD range. The vast majority of children scored according to their diagnosis on at least one of the questionnaires, with only 9 children (7 ASD, 2 DD) not scoring according to their diagnosis on either questionnaire. As removing these children from the analyses led to almost identical results, and considering that they had all been officially diagnosed with their developmental disorder, they were not excluded from the sample.

2.4.5. Materials

A total of sixteen objects were presented to the children across four trials (see Figure 3). Fourteen out of the sixteen stimuli had been modified from household equipment (e.g. covering a bowl scraper with pink tissue paper, see Figure 3), thus would not have been seen by any of the children before. The two remaining stimuli consisted of unusual kitchen equipment, which children were very unlikely to be familiar with (the lemon juicer included in Figure 1 and a utensil hook). No child volunteered a name for any of the stimuli. Thus, the objects were highly likely to be novel to the children.

At the beginning of each trial, children were shown a novel object, which was either named (name condition) or described as being '*nice*' (no name condition). Participants were then presented with three test objects per trial: one shape match, one colour match and one texture match.

Figure 3: Example object set. The novel object is a sink stopper covered in orange tissue paper, the shape match test object is a sink stopper covered in blue cotton, the colour match test object is an orange lemon squeezer and the texture match test object is a bowl scraper covered with pink tissue paper.

2.4.6. Procedure

2.4.6.1. Test Trials

Participants completed the experimental and background measures in a quiet area of their school, day nursery, parental support group or Lancaster University. Task order was counterbalanced. In some cases, the child's parent or a member of staff at their school or nursery was also present in the room. Adults in attendance were instructed simply to watch the study and avoid intervening in any way.

The experimenter presented the novel object. In the name condition, she said *'see this one? This is a dax (parlu/wug/gazzer). It's a dax'.* In the no name condition, she said *'see this one? This is nice. It's nice.'* The experimenter then placed the novel object on the table. Following this, she showed the child the three test objects, which she laid on the table. These were placed directly in front of the child, with the original object still in view, behind the test objects. The positioning of the three test objects (left, centre or right), the order that the four object sets were shown and, for the name condition, the word uttered to refer to the novel object, were all counterbalanced.

In the name condition, the experimenter asked *'can you give me the other dax?'* In the no name condition, she asked *'can you give me the other one?'* Only intentional responses (purposefully giving or sliding an object towards the experimenter, clearly pointing towards an object or providing an unambiguous description of the object) were scored (see Preissler & Carey, 2004). Six children (2 TD, 2 ASD, 2 DD) completed only three out of the four trials and two children (1 TD, 1 ASD) completed only two out of the four trials, due to non-compliance.

2.4.6.2. Favourite object control trials

After an unrelated task (e.g. the BPVS or Raven's), the child was presented with the test objects again and asked to give the experimenter their favourite one. The objects were presented one set at a time in the same sequential order and position as they had appeared during the experimental phase. The experimenter asked the child *'can you give me your favourite one? Which is the one that you like the best?'* These trials took place in order to see if the test objects chosen for each set were of relatively equal saliency, thus chance performance was expected. If for some reason children *were* more attracted to some objects than others, the favourite object trials helped establish whether children were simply picking the object they were most attracted to during the test trials.

2.5. Results

2.5.1. SAC vs. ALA

If the SAC account is correct, the TD and DD children would be expected to select the shape match test object in both conditions but the children with ASD would not be expected to select the shape match more than the other two test objects in either condition. If the ALA is correct, all three groups of children are expected to select the shape match in the name condition but not in the no name condition. Alternatively, due to children with ASD having categorisation impairments and a preference for local processing, children with ASD may not select the shape match in either condition.

Children's shape match choices were summed over trials from 0 (did not choose the shape match on any trial) to 1 (chose the shape match on every trial) and then converted into proportions. Proportions were used instead of frequencies, as a small minority of children did not complete all trials. Table 4 shows the proportion of times children selected the shape match test object in the name and no name condition.

One-sample t-tests were run for the three groups of children to establish if participants chose the shape match test object as the referent above a chance level of .33. All three groups of children selected the shape match in the name condition (TD, $t(32) = 7.14$, $p < .001$, $d = 1.23$: ASD, $t(31) = 5.84$, $p < .001$, $d = 1.03$: DD, $t(22) = 5.38$, $p < .001$, $d = 1.12$), although in the no name condition, only the TD children ($t(32) = 6.29$, $p < .001$, $d = 1.09$) selected the shape match. A 3 (Group) × 2 (Condition) between subjects ANOVA compared the proportion of shape match choices for the three groups of children. There were significant main effects of Group ($F(2) = 6.20$, $p = .003$, $\eta p^2 = .07$)

and Condition ($F(1) = 21.61$, $p < .001$, $\eta p^2 = .12$) and a significant interaction ($F(2) = 3.17$, $p = .044$, $\eta p^2 = .04$) (see Figure 4).

Post hoc tests (Tukey Kramer) confirmed that the TD children chose the shape match more than both the ASD ($p = .014$) and DD ($p = .011$) participants. Examining the children's mean proportion of shape bias responses for the name (TD = .76, ASD = .70, DD = .71) and no name (TD = .70, ASD = .41, DD = .35) condition suggests that the two clinical groups selected the shape match more in the name than no name condition, supporting the ALA. However, the TD children selected the shape match in both the name and no name condition, supporting the SAC account. This pattern of responses was confirmed by performing three one-way ANOVAs (TD, $F(64) = .61$, $p = .439$: ASD, $F(60) = 13.49$, $p = .001$, $\eta p^2 = .18$: DD, $F(42) = 11.62$, $p = .001$, $\eta p^2 = .22$) (see Table 4).

Table 4:

Mean proportion of shape match, colour match and texture match responses (SD) for three groups of participants

		TD	***ASD***	***DD***
Shape	*Name*	.76 (.35)*	.70 (.36)*	.71 (.34)*
	No Name	.70 (.34)*	.41 (.26)	.35 (.37)
Colour	*Name*	.14 (.23)	.20 (.29)	.14 (.20)
	No Name	.21 (.29)	.31 (.22)	.39 (.32)
Texture	*Name*	.10 (.20)	.10 (.15)	.15 (.27)
	No Name	.09 (.21)	.28 (.25)	.26 (.23)

* $p < .05$ higher than chance (.33)

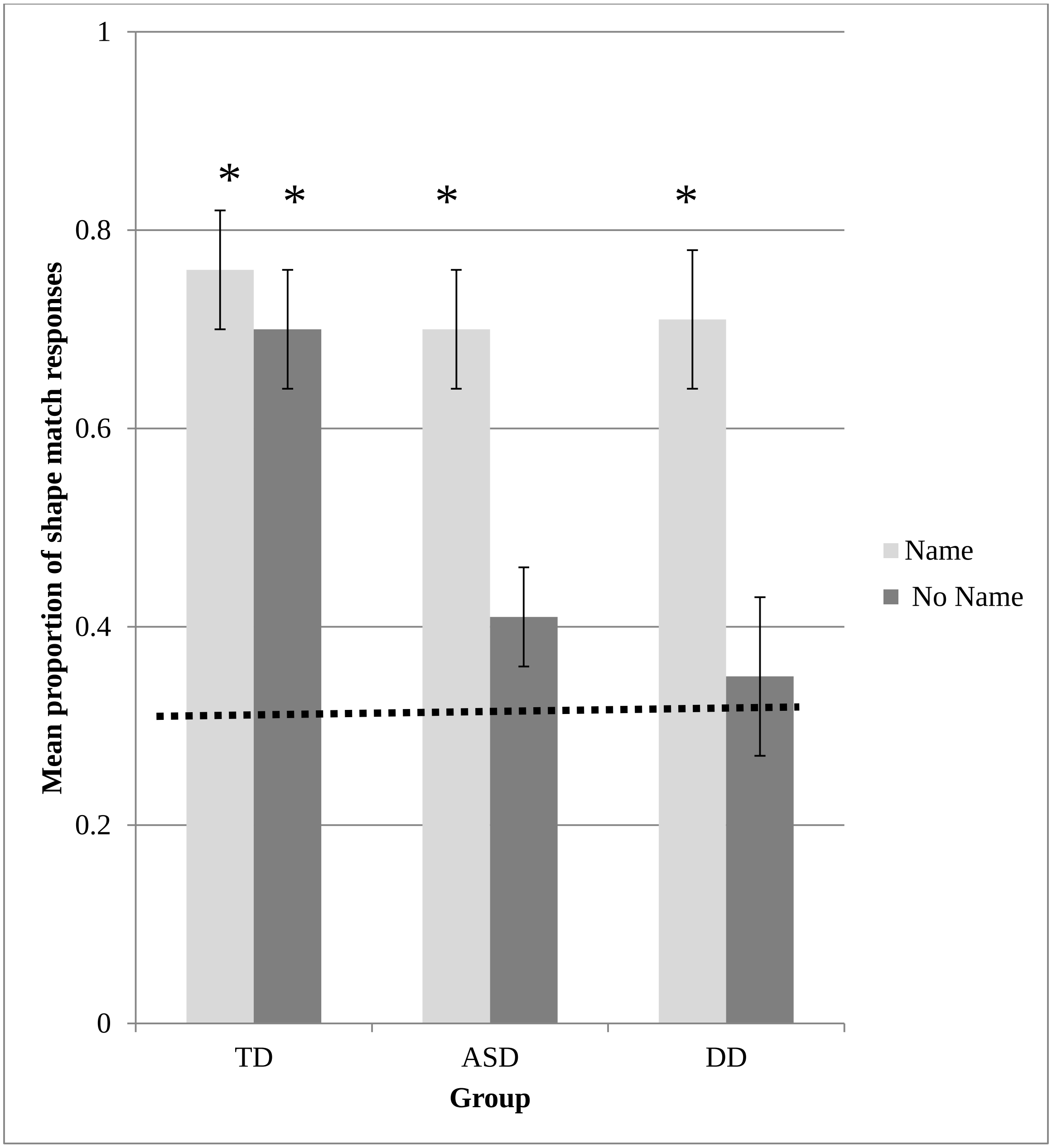

Figure 4: Mean proportion of shape match responses per three groups and condition

2.5.2. Relation between shape bias performance, CA, VMA and Raven's

For TD children in the no name condition and children with ASD in the name condition, selecting the shape match test object was positively correlated with both CA (TD: $r(33) = .35$, $p = .045$. ASD: $r(32) = .35$, $p = .049$) and VMA (TD: $r(33) = .43$, $p = .012$. ASD: $r(32) = .51$, $p = .003$). Raven's score was also positively correlated with shape match responses for the TD children in the no name condition ($r(31) = .40$, $p = .026$). Selecting the shape match was also positively correlated with VMA ($r(21) = .47$, $p = .031$) and Raven's ($r(17) = .56$, $p = .021$) for DD children in the no name condition. When partial correlations controlling for CA were performed, VMA and shape match responses remained significant for the ASD and DD groups (ASD, name: $r(29) = .42$, $p = .018$. DD, no name: $r(18) = .62$, $p = .003$) and Raven's remained significant for the DD children ($r(14) = .66$, $p = .005$).

A stepwise linear regression analysis entering CA, VMA and Raven's score as predictor variables was performed separately for the three groups (TD, Adj R^2=.07, $F(1,53) = 5.16$, $p = .027$: ASD, Adj R^2=.08, $F(1) = 5.61$, $p = .022$: DD, Adj R^2=.19, $F(1) = 9.06$, $p = .005$). Only VMA significantly predicted shape match responses for all groups (TD: β=.298, $p = .027$; ASD: β=.309, $p = .022$; DD: β=.464, $p = .005$). Thus, the correlation and regression analyses provide converging evidence that VMA is related to shape match performance across groups.

2.5.3. Delay vs. Deviance

From the aforementioned results, it would appear that TD children select the shape match in both conditions, supporting the SAC account, but children with ASD *and* with DD only select the shape match in the name condition, supporting the ALA. However, the overall median VMA of the sample is 4.6 (TD, median VMA = 4.29: ASD, median VMA = 4.91: DD, median VMA = 4.42), whereas TD children show the shape bias from as early as two years old (Landau et al., 1988). There is no way of establishing from the above data whether children with ASD show a shape bias in the name condition at the usual developmental time point or whether the shape bias is delayed in ASD. Hence, each group was split into 'low VMA' (<4.6) and 'high VMA' (>4.6) subcategories to test the delay vs. deviance hypotheses.

One sample t-tests showed that both TD groups chose the shape match above chance levels (.33) in both conditions (TD-low VMA: name, $t(16) = 3.91$, $p = .001$, $d = .95$. No name, $t(17) = 3.40$, $p = .003$, d = .80. TD-high VMA: name, $t(15) = 6.69$, $p = <.001$, $d = 1.67$. No name, t(14) = 6.17, $p = <.001$, $d = 1.59$). The ASD-high VMA children and both DD groups selected the shape match in the name condition (ASD-high VMA: $t(17) = 10.02$, $p = <.001$, $d = 2.36$: DD-high VMA, $t(11) = 6.04$, $p = <.001$, $d = 1.74$: DD-low VMA, $t(10) = 2.33$, $p = .042$, $d = .70$)[4]. All other results were not

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[4] If the more stringent Bonferroni correction is applied, using the alpha value of .008 for three groups and .004 for six groups, the results for seventeen of the eighteen comparisons remain significant, the only exception being the results for the DD-low VMA children. However, we did not do this following recent

significant. A 3 (Group; TD, ASD, DD) × 2 (VMA; low vs. high) × 2 (Condition; name vs. no name) factorial ANCOVA was carried out, using CA and Ravens score as continuous covariates, in case either of these factors had an influence on shape bias responses. There were main effects of Group ($F(2) = 3.83$, $p = .024$, $\eta p^2 = .06$), VMA ($F(1) = 9.95$, $p = .002$, $\eta p^2 = .07$) and Condition ($F(1) = 27.18$, $p < .001$, $\eta p^2 = .17$) and an interaction between Group and Condition ($F(2) = 3.27$, $p = .041$, $\eta p^2 = .05$). Neither CA nor Ravens had an impact on children's shape match choices.

Pairwise comparisons (with Bonferroni adjustments) showed that the TD children chose the shape match test object more than the children with ASD ($p = .028$). High-VMA children chose the shape match test object more than the low-VMA children ($p = .002$). All three groups and two VMA ranges of children chose the shape match more in the name than no name condition ($p < .001$). An independent samples t-test showed that the TD children did not differ in terms of shape match responses between the two conditions, but the children with ASD ($t(56.15) = 3.71$, $p < .001$) and DD ($t(42) = 3.41$, $p = .001$) chose the shape match more in the name than no name condition.

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criticism against correcting for multiple t-tests on the grounds that this procedure inflates the risk of type 11 errors (e.g. Nakagagawa, 2004; Rothman, 1990) or is simply not necessary (Perneger, 1998).

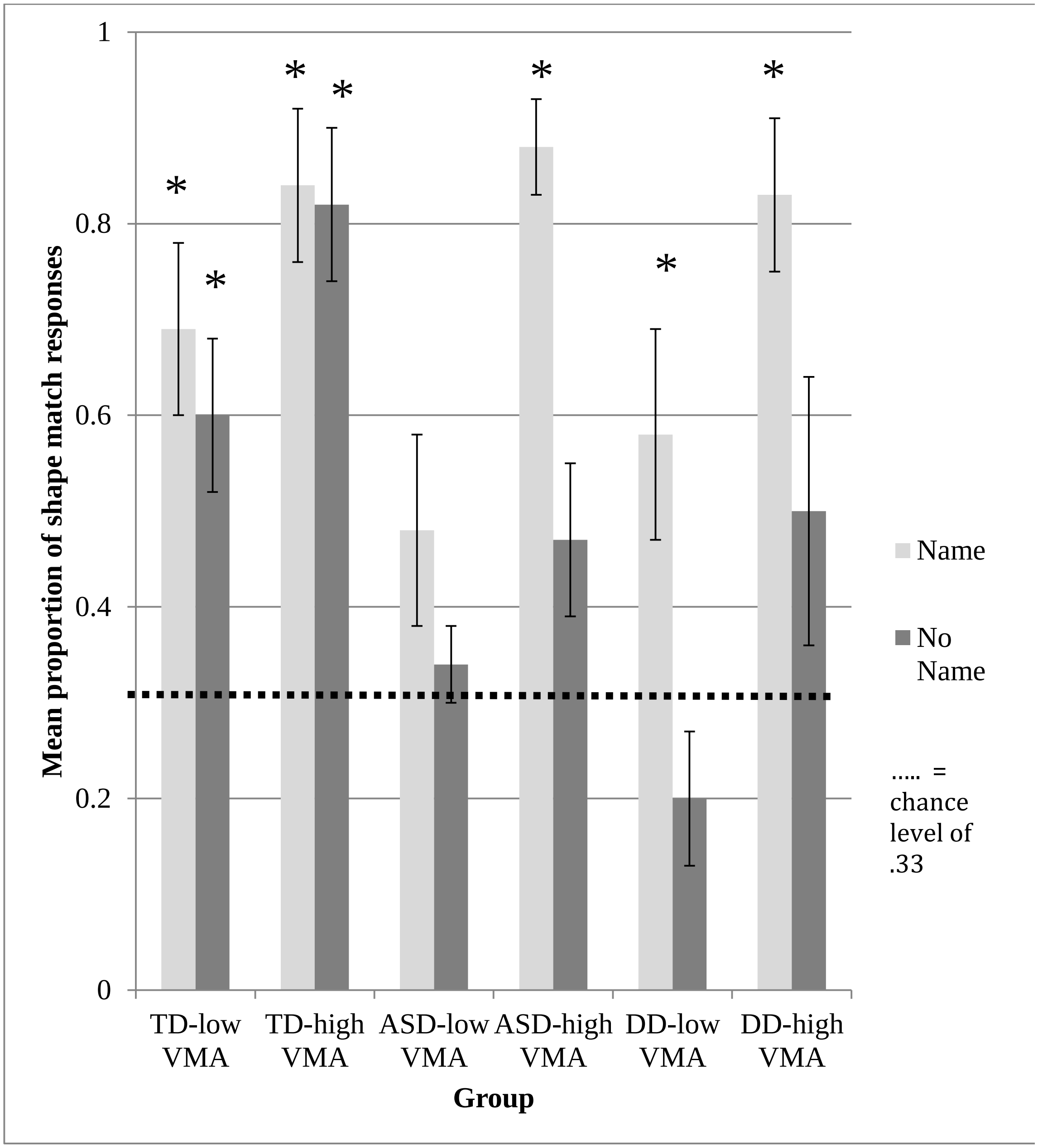

Figure 5: Mean proportion of shape match responses per six groups and condition

Table 5:

Mean proportion of shape match, colour match and texture match responses (SD) for six groups of participants

		TD		***ASD***		***DD***	
		Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Shape	*Name*	.69 (.38)*	.84 (.30)*	.48 (.39)	.88 (.23)*	.58 (.36)*	.83 (.29)*
	No Name	.60 (.33)*	.82 (.31)*	.34 (.16)	.47 (.31)	.20 (.22)	.50 (.46)
Colour	*Name*	.16 (.25)	.11 (.21)	.38 (.35)	.06 (.11)	.20 (.17)	.09 (.22)
	No Name	.32 (.33)	.08 (.15)	.34 (.23)	.28 (.22)	.50 (.30)	.27 (.32)
Texture	*Name*	.15 (.20)	.05 (.19)	.14 (.16)	.06 (.14)	.22 (.32)	.08 (.22)
	No Name	.08 (.15)	.10 (.26)	.32 (.23)	.25 (.27)	.30 (.25)	.23 (.22)

* p <.05 higher than chance (.33).

2.5.4. Favourite object control trials

The shape match test object was never chosen as the favourite object above chance levels for any of the groups (all p >.05), suggesting that children were not drawn to the shape match in the test trials due to salience or a simple preference.

2.6. Discussion

This study investigated whether TD children, children with ASD and DD children show a shape bias for word learning, in both a naming (*'it's a dax!'*) and non-naming (*'it's nice'*) context. I explored whether the SAC or ALA account underpins shape bias performance across all groups, which allowed me to probe for autism-specific differences. Additionally, splitting each group into younger and older subcategories helped establish whether the shape bias is present at the usual developmental time point for children with ASD, or is delayed. The results suggest that the shape bias is controlled by the ALA for children with ASD and DD but the SAC account for TD children. Furthermore, the shape bias is delayed in ASD. The results are discussed for the three groups individually, then I relate children's overall performance to the findings of Tek et al., (2008).

With regards to typical development, participants of low and high VMA selected the shape match as the referent in both conditions, which is consistent with several earlier studies that show that children categorise by shape in both lexical and non-lexical contexts (Diesendruck & Bloom, 2003; Graham & Diesendruck, 2010). Crucially, these results are also consistent with Tek et al.'s (2008) pointing task, in which TD children chose the shape match rather than colour match in both naming and non-naming conditions using an explicit measure. Conversely, others argue that the shape bias is specific to naming in young children (e.g. Imai et al., 1994; Landau et al., 1988; Smith et al., 1996). One possible reason for these conflicting findings may be due to variation in the way the test question is phrased. Children are more likely to choose the shape match in non-lexical situations if category membership (e.g. *'pick another object like this'*) rather than perceptual categorisation (e.g. *'pick the object that goes together with this'*) is highlighted, as the former emphasises that the objects are of the same kind and therefore should be classified together (Diesendruck & Bloom, 2003).

It is also the case that the low VMA TD group in the no name condition of the present study were just over 3-and-a-half years old, whereas TD children first start to show a lexical shape bias from as early as 2-years-old (Landau et al., 1988). Previous research (Baldwin, 1989; Landau et al., 1988) suggests that the shape bias strengthens during development. TD individuals may originally only show a shape bias in the name condition, at 2, prior to also showing it in the no name condition, by 3-and-a-half (Baldwin, 1989, but see Diesendruck & Bloom, 2003). The fact that the proportion of shape bias responses was positively correlated with both CA and VMA for the TD children in the no name condition is a further indication that older TD children are more likely than younger TD children to show a non-lexical shape bias.

Unlike both groups of TD children, participants with ASD only displayed a shape bias when the object was named, indicating that the heuristic is controlled by a process of attentional learning and not referential intent for children with ASD. This is consistent with past research suggesting that children with ASD learn words from association (e.g. Baron-Cohen et al., 1997; Norbury et al., 2010; Preissler, 2008; Preissler & Carey, 2005) and have difficulty monitoring referential intent (D'Entremont & Yazbek, 2007; Preissler & Carey, 2005; Prizant & Wetherby, 1987). The shape bias was also delayed for participants with ASD; when the groups were split by VMA only the high VMA children showed a shape bias, supporting previous research suggesting that individuals with ASD have delays in aspects of language acquisition (e.g. Bartolucci et al., 1976; Boucher, 2012; Charman, Drew, Baird & Baird, 2003; Eigsti & Bennetto, 2009; Eigsti et al., 2011).

One possibility for the shape bias delay in ASD is that it is due to weak central coherence (Frith, 1989; Happé & Frith, 2006); young children with ASD may focus more on individual parts of objects than on the object as a whole, leading them to mis-map new labels to parts of objects, neglecting the overall object shape. As children with ASD can attend to global properties of objects when they are explicitly told to do so (Koldewyn et al., 2013; Plaisted et al., 1999), direct instruction may facilitate shape bias understanding in ASD. Future work should investigate this hypothesis.

A further possibility for the shape bias delay in ASD is that these children apply different processes to achieve success in cognitive tests (e.g. Eisenmajer & Prior, 1991; Frith et al., 1991; Happé, 1995; Yirmiya et al., 1992). For example, children with ASD may use explicit verbal mediation and logic to pass false belief tasks, therefore requiring an older VMA than TD children (Happé, 1995). Furthermore, intelligence is positively correlated with performance in empathy and conservation tasks for children with ASD, but not for TD children (Yirmiya et al., 1992). Having a higher VMA, better cognitive skills and experience of intervention programmes such as Applied Behavioural Analysis (ABA; Lovaas, 1987) may all help children with ASD explicitly ‘hack out’ solutions to problems. These children may rote learn certain rules in order to facilitate category formation, instead of extracting a common prototype (Klinger & Dawson, 2001). This is in contrast to TD children's intuitive reasoning, which may be more automatic (Frith et al., 1991).

Although it is not surprising that children with ASD show a shape bias through attentional processes, rather than referential intent, the results for the DD children are somewhat unexpected. When the DD group is considered as a whole, the pattern of results is virtually identical to the ASD group, in that shape is used to constrain lexical, but not non-lexical generalisation. This is the traditional interpretation of what it means to have a 'shape bias' (i.e. it only surfaces in naming situations), and supports ALA based accounts. Of particular interest is that, although the proportion of shape based responses in the naming condition increases between the low VMA and high VMA group with DD, it is still present in the former group. This suggests that the delay seen in the ASD group is autism-specific.

Nevertheless, the DD children's pattern of performance differs from what I found in the TD group, who also used shape for generalisation in the non-naming condition. One possibility is that the unique life experiences that the atypically developing groups have, as a direct consequence of their developmental difficulties, contribute to their different route of language acquisition (Karmiloff & Karmiloff-Smith, 2001; Karmiloff-Smith et al., 2012). It is also possible that children with DD have lower intention monitoring skills than the TD group, and thus do not use shape as a cue to discerning referential intent in pragmatic situations. However, as an independent measure of intention monitoring abilities was not administered to the children in the present study, this claim is simply speculative rather than evidence-based. Future work should include a separate test of intention reading skills.

Although the results show a differential pattern of performance across conditions and groups, they also identify a core commonality in the use of the shape bias. Specifically, the evidence indicates that VMA is related to, and uniquely predicts, shape match performance, not just for children with ASD, but for all three groups of children. This suggests that it is not simply maturation or increased experience with objects that drives the use of the shape bias, but instead language comprehension (as measured here at a somewhat general level by the BPVS). This supports earlier studies that have found that the absence of a shape bias has been linked to possessing a limited vocabulary (e.g. Jones, 2003; Smith et al., 2002), and identifies one common foundation for word acquisition across typical and atypical development.

Overall, the results of this study support Hartley and Allen (2014), who found that children with ASD who had a similar VMA to the younger ASD group in our study generalised object labels according to colour as well as shape. However, the results are in slight contrast to Tek et al., (2008), who found that both TD infants and infants with ASD tended to select the shape match in both a naming and non-naming condition in their pointing paradigm. Despite this, in their intermodal preferential looking (IPL) task, the TD children showed a looking preference for the shape match in the name trials compared with the no name trials, although the children with ASD did not. The authors claim that their participants with ASD did not show a shape bias as it is specific to word learning.

However, by this definition, the TD participants also failed to show a shape bias for the pointing task; for three out of the four testing sessions they selected the shape match for both the name and no name trials.

There are several possible reasons for the discrepancy in findings between this study and Tek et al., (2008). They only used a colour match distractor test object, while I included a texture as well as colour match, decreasing the possibility of children picking the shape match purely due to chance. I also ruled out simple preference for the test objects in the control trials, which found that participants did not choose the shape match as their favourite object above chance levels.

As Tek et al., (2008) did not include a favourite object control task, it may have been the case that (unlike the present study) children with ASD picked the shape match as they found it salient. Tek et al., (2008) consider this possibility, but stress that this explanation does not account for why the children with ASD performed at chance on the IPL task, which used the same objects as the pointing paradigm. The wording of the test question was also different in the no name condition of Tek et al., (2008) (*'point to the same*') from this study (*'give me the other one'*), although this does not explain the differing performance between our younger group with ASD in the name condition and those in Tek et al., (2008).

Perhaps crucially, Tek et al., (2008) employed a within rather than between subjects design. If children completed the IPL task prior to the pointing task, by the time of the pointing task, they would have experienced repeated exposure to the objects.

Research (e.g. Smith et al., 2002; Ware & Booth, 2010) suggests that the shape bias can be facilitated in TD children as young as 17 months old through repeated training. Perhaps the children with ASD's exposure to the novel object and shape match over multiple trials in Tek et al., (2008) heightened their attention towards shape and facilitated the selection of the shape match. Consequently, the performance of the children with ASD in Tek et al., (2008) may simply reflect a learnt response over multiple trials, rather than a strong shape bias.

The sample was also different in Tek et al., (2008) from my study. Firstly, Tek et al., (2008) recruited younger participants. However, it seems unlikely that toddlers with ASD select the shape match in both a name and no name context, lose this ability later on in development and then regain it a few years later, but only when the object is named. Secondly, Tek et al., (2008) admit that they obtained small effect sizes. In contrast, the effect sizes reported here are primarily medium to large across group and chance comparisons. Therefore, I can be reasonably confident that these effects were reliable.

Of course, this study was not without its limitations. Although including the DD participants extends past research investigating the shape bias in ASD (Hartley & Allen, 2014; Tek et al., 2008), the fact that the DD children experienced such a wide variety of types of disabilities means that it is difficult to make inferences about how children with specific disorders would respond. Future research investigating the shape bias in atypical populations should aim to recruit groups of children with particular disorders, such as a whole cohort of children with Down syndrome or a whole cohort of children with intellectual disability in order to tease apart whether children with specific disorders show a shape bias deficit.

Furthermore, a longitudinal study similar to that employed by Tek et al., (2008) may perhaps have been preferable to simply testing the children once. Longitudinal research would have enabled tracking children's behaviour over time, possibly allowing one to pinpoint the exact period at which the shape bias occurs in ASD. Given the division of the children into 'low VMA' and 'high VMA' subgroups, it can be concluded that the shape bias in ASD develops at some point between the VMA of three and six, but the exact age of onset remains undetermined.

In conclusion, by studying children with ASD, who have referential intent difficulties, this research was the first to pit the SAC account directly against the ALA. Interestingly, although low VMA children with ASD do not possess the shape bias, high VMA children with ASD *do* show the heuristic, when the object is named. This study also highlights the importance of recruiting an additional control group of DD children within ASD research. Previous work has largely overlooked the shape bias in relation to DD children (although see Jones, 2003). This research suggests that DD children select the shape match at the usual developmental time point when the object is named but, unlike TD children, do not select the shape match in a non-naming context.

Critically, the SAC account and ALA *both* seem to underlie the shape bias, but for different populations. The data presented here support the SAC account for TD children, as they showed a shape bias in both the name and no name condition and the ALA for children with ASD and DD, as they only showed a shape bias in the name condition. This is more fully explored in the General Discussion. Future research should examine whether this is a robust finding. If so, its implications for the emergence and organisation of word learning in the three populations should be explored, in terms of both a theoretical account of the different routes to word learning and for intervention programs for language training in each of these groups.

Chapter Three: **Are children with Autism Spectrum Disorder initially attuned to object function rather than shape for word learning?**[5]

3.1. Introduction to the function bias

As well as object shape, TD children use object function (the 'function bias', Gentner, 1978) as a basis for lexical extension to other category members. As mentioned in Sections 1.2 and 1.5 of Chapter One, although generally a useful heuristic, there are occasions where the shape bias could actually hinder word learning. An orange and a basketball are both spherical but different types of objects, while a beanbag chair may be round and an armchair may be larger and squarer shaped, despite being the same type of object. What unifies objects is not simply perceptual similarity, but the shared role they fulfil (Bloom, 2004; Keleman, 1999). Thus, a bias that constrains word-object mappings according to similarity in function can be adaptive ('function bias'). An unfamiliar object is called a 'ball' not just because of its appearance, but also because of its role: to bounce, kick or be thrown.

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[5] This chapter is based on Field, Allen, & Lewis (in Press). Are children with autism spectrum disorder initially attuned to object function rather than shape for word learning? *Journal of Autism and Developmental Disorders.* Minor changes have been made in order to help with consistency in terms of the structure and flow of the thesis.

TD children have been found to show a function bias when object shape and function conflict. When a novel object is named and its function is clearly described and demonstrated, children extend the label to a differently shaped object that shares the same function, rather than to a similarly shaped one with a separate function (e.g. Diesendruck et al., 2003; Merriman et al., 1993). This attention to function strengthens with chronological age (CA) in typical development, and may also be dependent on an individual's non-verbal skills or language ability. Specifically, children have to notice both that different objects share the same function, and that these objects also tend to share the same name, which may respectively recruit both these abilities. The role of language and non-verbal skills can be directly addressed by comparing performance of TD children to children who have different developmental trajectories in terms of these skills, particularly children with Autism Spectrum Disorder.

Although four studies have directly addressed the absence of (see Hartley & Allen, 2014; Potrzeba et al., in press; Tek et al., 2008), or delay in acquiring (see Field et al., in press – Study One in this thesis), a shape bias in ASD, to my knowledge no research to date has investigated the function bias in this population. Thus, the current study aims to fill this gap in the literature. There are reasons to believe that children with ASD might show differences with respect to understanding object function. For instance, abundant evidence suggests that children with ASD often demonstrate idiosyncratic, stereotyped and restricted artefact use (Ozonoff et al., 2008; Wulff, 1985). This may include repetitively spinning objects or trickling sand and water between their fingers, lining objects up in rows or piling objects on top of each other, and spinning, rotating, rolling, mouthing and banging artefacts (Leekam, Prior, & Uljarevic, 2011; Ozonoff et al., 2008; Williams, Costall, & Reddy, 1999). These unusual responses to objects may hinder children's discovery of the artefact's proper function (Loveland, 1991; Williams et al., 1999).

As children with ASD have weak central coherence and a preference for component parts rather than the object gestalt (Frith, 1989; Happé & Frith, 2006), they might be so fixated on manipulating the parts of objects that they fail to comprehend the overall role that objects fulfil. For example, repeatedly spinning the wheels on a toy car may distract the child from the car's true function of driving. The function bias also involves attending to and remembering the function of new artefacts and comparing this information to previously stored knowledge about object functions. This may be difficult for children with ASD because of impairments with prototype formation (Klinger & Dawson, 2001) and categorisation (Gastgeb et al., 2006; 2011).

Therefore, it is possible that children with ASD have a function bias delay (develop the function bias later than TD individuals) or deviance (fail to develop the function bias at all). Children with ASD exhibit delay or deviance in other areas of language acquisition (e.g. Bartolucci et al., 1976; Eigsti & Bennetto, 2009; Howlin, 1984; Mitchell et al., 2006; Van Meter, Fein et al., 1997) and, as Study One demonstrated, are delayed showing a shape bias (Field et al., in press). In order to establish if ASD involves a function bias delay or deviance, testing a cohort of children with wide variation in language ability is necessary.

Despite some studies suggesting a function bias deficit in ASD, other evidence suggests children with ASD might show a function bias. For instance, they show other word learning constraints and biases, such as mutual exclusivity (Preissler & Carey, 2005) and the noun bias (Swensen et al., 2007). They also classify objects by function to the same extent as their TD peers (Tager-Flusberg, 1985; Ungerer & Sigman, 1987). In Tager-Flusberg (1985), children viewed a test picture (e.g. a car) then a picture from the same category (e.g. a bus) and a distractor picture from a different category (e.g. an item of clothing). The children with ASD were able to correctly categorise not only perceptually similar objects (such as different types of dogs) but also functionally but not perceptually related objects (such as different types of furniture) into their correct category. Ungerer and Sigman (1987) also found that children with ASD categorised objects according to functional similarity (e.g. different animals, fruits, vehicles and furniture) as well as the more perceptually salient characteristics of colour and form. This suggests that children with ASD have some understanding that the same type of objects have the same function.

Children with ASD also partake in functional play (Baron-Cohen, 1987; Leslie, 1987; Libby, Powell, Messer, & Jordan, 1998; Ungerer & Sigman, 1981), such as brushing one's hair with a toy brush, holding a telephone to one's ear and sweeping the floor with a toy broom. Functional play helps children name things, learn how to use objects appropriately and make associations between the roles of different artefacts (Mastrangelo, 2009). Being able to classify objects by function and take part in functional play suggests that children with ASD have a basic level of understanding about the role objects fulfil.

Therefore, there is conflicting evidence regarding functional understanding in children with ASD. To examine whether any differences which may emerge in terms of showing the function bias in ASD relative to TD children are simply a result of cognitive delay, rather than ASD per se, it is necessary to also examine the function bias in children with other developmental disorders (DD). Like children with ASD, children with DD categorise objects by the function they fulfil (Ungerer & Sigman, 1987) and engage in functional play (Malone & Langone, 1998; Sigafoos et al., 1999), suggesting they have some functional understanding.

However, there is mixed evidence for the use of word learning constraints in this population. Some children with DD show a shape bias in naming contexts (Field et al., in press) and use mutual exclusivity for novel word learning (Wilkinson & Albert, 2001; Wilkinson, 2005). Other studies report that children who are 'late talkers' have a shape bias deficit (Jones, 2003), and children with intellectual disability have difficulty with fast mapping and are less able than TD children to maintain labels when tested 1-3 days later (Wilkinson, 2005). Thus, testing children with DD can inform theories of language acquisition in this population, as well as elucidate whether potential differences in ASD stem from cognitive delay.

3.2. Description of the function bias study

To investigate the function bias, this task was based on Diesendruck et al., (2003), who found that three-year-old TD children form word-object mappings by function rather than shape, but only when object function is explicitly described and demonstrated. In the 'label + intended function' condition, participants were presented with a novel object, which was labelled and its function was clearly articulated and demonstrated to the children. For example, the experimenter stated *'this is a wug and it can hold coins'* and then poured some coins into the object. The function of the novel object and the two test objects were also described and demonstrated (i.e. it was made explicitly clear to the children that the shape match was the same shape as the novel object but performed a different function, while the function match was a different shape but performed the same function). When asked to give the experimenter the other *'wug'*, the children chose the function match test object.

Although the procedure of this study was the same as Diesendruck et al., (2003), I recruited a large sample of participants of varying ages, due to the controversy within the TD literature regarding the precise age of function bias onset. It is generally agreed that by adulthood TD individuals show a function bias rather than shape bias when shape and function conflict (Graham et al., 1999; Jones, 1998; Landau et al., 1998), however it is unknown at what age this ability appears. Although Diesendruck et al., (2003) claim that TD children show a function bias at 3-years-old (see also Kemler-Nelson et al., 2000, who found a function bias in 4-year-old children and Kemler-Nelson, Russell, Duke, &

Jones, 2000 who found a function bias in 2-year-olds), others argue that the function bias does not develop until age 6 (Merriman et al., 1993) or even later (Gathercole & Whitfield, 2001).

In order to explore the role of age in function bias understanding, each group of participants was split into two subgroups. Due to the disparity between the chronological and mental ages of the two clinical groups, the median verbal mental age (VMA) of the sample (4.6) as measured by receptive vocabulary was used, resulting in ‘high VMA’ and ‘low VMA’ subsets of each participant type. The three low-VMA groups had a mean VMA of 3-years-old and the three high-VMA children had a mean VMA of 6-years old. This was consistent with the chronological ages (CA’s) of the TD group, but the ASD and DD groups were predictably older chronologically due to cognitive and linguistic impairment. These age ranges were selected to map onto the debate within typical development regarding the age of onset of the function bias.

It is hypothesised that TD and DD children with a higher VMA will override the shape bias in favour of a function bias. Given the conflicting evidence regarding the age of function bias onset, it is possible that the low VMA TD and DD children will also show a function bias (Diesendruck et al., 2003). Alternatively, this may not develop until they have reached a higher level of receptive understanding (Merriman et al., 1993). Children with ASD are hypothesised to show a function bias deficit, due to their idiosyncratic object use. However, as children with ASD categorise objects by function and engage in functional play, an alternative possibility is that they show a function bias.

3.3. Method

3.3.1. Participants

A total of one-hundred-and-forty-two children were recruited. However, eighteen children were excluded from the analysis, leaving one-hundred and twenty-four children in the final sample. Reasons for excluding children were non-compliance (*N* = 10, 6 ASD, 4 DD), refusal to complete the BPVS (*N* = 4, 3 ASD, 1 DD), having a VMA below the minimum age of 2.33 on the BPVS (1 DD child) [6] and not having received an official diagnosis of their disorder and/or parental concerns that the child may also have undiagnosed ASD (*N* = 3, all DD). The participants were recruited from four mainstream and 12 specialist schools, one ASD class within a mainstream school, two parental support groups and three day nurseries across the North West of England and from a database of parents who had previously expressed an interest in their children participating in psychology research at Lancaster University.

There was some overlap between the participants who also took part in Study One, with 113 participants taking part in both studies. The order in which children took part in Studies One and Two was counterbalanced, with at least 48 hours in between the two testing sessions. A 3 (Group; TD, ASD, DD) × 2 (Order; shape bias first, function

[6] One child with ASD had a raw score on the BPVS slightly below the basal start point of 2.33. However, as he scored 14 on the BPVS, where a raw score of 15 equates to a VMA of 2.33, this child was conservatively assigned a VMA of 2.25 based upon his raw score.

bias first) between subjects ANOVA found that there were no order effects for either the shape bias or function bias study.

Participants were matched according to the group means. Although when included as a whole sample, the DD children had a slightly lower VMA than the other two groups, a one-way ANOVA showed that this was not significant. When the groups were subdivided by VMA, the three high VMA groups all had a VMA of six and the three low VMA groups all had a VMA of three, thus they were well matched (see Table 6). The DD children had various conditions, primarily intellectual disability and rare chromosomal disorders. With two exceptions, all of the DD children had also received a formal diagnosis of their disorder. The data from the remaining two DD children were not excluded from the study because, in addition to attending a specialist school, their VMA (3.67 and 3.75 respectively) was considerably younger than their CA (10.75 and 10.83 respectively). The possibility that these children had undiagnosed ASD was ruled out by both children scoring below the clinical threshold for ASD on both the CARS and SCQ questionnaires.

The participants were VMA matched. The children's mean CA, VMA and Raven's score (maximum = 36) are given in Table 6. The Tables also depict scores on two questionnaire scales which were given to the children's teachers (on the CARS, a score of 30+ is the cut-off point for ASD, on the SCQ, a score of 15+ is the cut-off point for ASD).

Table 6

Participant demographic details

	TD		***ASD***		***DD***	
	Low VMA N = 22 11 males	*High VMA N = 23 11 males*	*Low VMA N = 22 18 males*	*High VMA N = 29 27 males*	*Low VMA N = 18 11 males*	*High VMA N = 10 4 males*
Mean CA	3.45	5.75	8.35	10.55	8.51	10.61
(SD)	(.60)	(1.04)	(3.37)	(3.05)	(2.20)	(1.98)
Mean VMA	3.64	6.95	3.57	6.52	3.26	6.53
(SD)	(.48)	(1.69)	(.59)	(1.68)	(.67)	(1.32)
Mean Ravens	8.37	18.52	14.65	20.74	7.75	15.10
score (SD)	(2.50)	(7.01)	(6.78)	(8.72)	(3.26)	(8.76)
Mean CARS	15.94	17.70	37.30	32.69	24.96	23.13
score (SD)	(1.32)	(3.74)	(7.12)	(7.25)	(4.77)	(5.28)
Mean SCQ	2.33	3.00	20.43	17.16	7.57	6.00
score (SD)	(3.42)	(5.35)	(5.65)	(7.24)	(6.24)	(3.02)

Lancaster University granted ethical permission for the research to take place. Written informed consent was obtained from children's parent or guardian. In order to investigate if only high VMA children show a function bias, and to establish if the function bias is delayed in ASD, the three groups were further divided according to the median VMA of the sample (4.6) into 'high VMA' and 'low VMA' subcategories.

3.3.2. Design

A mixed factorial design was employed; Group (TD, ASD, DD) was between subjects and type of trial was within subjects and counterbalanced.

3.3.3. Cognitive Tests

The British Picture Vocabulary Scale – Second Edition (BPVS-II; Dunn et al., 1997) was administered to determine children's VMA. The Raven's (Raven, 2003) was administered to determine children's nonverbal reasoning abilities.

3.3.4. Clinical Diagnoses

All children with ASD had received a clinical diagnosis of autism by a qualified educational or clinical psychologist, using standardised instruments (i.e. Autism Diagnostic Observation Scale and Autism Diagnostic Interview – Revised: Lord, Rutter et al., 2002; Lord, et al., 1994) and expert clinical judgment. For most children, the CARS (Schloper et al., 1988) and the lifetime version of the SCQ (Rutter et al., 2003) were also completed by a parent or teacher (CARS: 21 TD, 46 ASD, 19 DD. SCQ: 19 TD, 46 ASD, 22 DD). Scores on the CARS range from 15-60, with scores of 30+ in the ASD range. Scores on the SCQ range from 0 – 39, with scores of 15+ in the ASD range. The vast majority of children scored according to their diagnosis on the scales with just four children (3 ASD, 1 DD) not scoring according to their diagnosis on either questionnaire.

As excluding these children from the analyses yielded almost identical results, these participants were included in the final sample.

3.3.5. Materials

A total of twelve objects were presented to the children across four trials (see Figure 6 for an example object set). The functions of the objects largely followed those used by Diesendruck et al., (2003). However, there were some minor adaptions, in order to make the study more culturally relevant. For example, the function of ‘cutting clay’ was changed to ‘cutting playdough’.

Diesendruck et al., (2003) included within their study several objects where the name would already be familiar to the children (e.g. a solid wooden block, a rectangular box and a piece of wood), alongside more novel items (e.g. hanger-like shapes made out of pipe cleaner and wire, a round disk made out of felt). In line with this, some of my objects were more familiar to the children than others, although the objects were used to perform functions that they were not typically associated with. No child in my study volunteered a name for any of the stimuli.

Fig. 6. Example object set. The novel object (centre) is a silver sandpaper covered soap dish, with the function of cutting playdough. The function match test object (left) is a cutter and the shape match test object (right) is a soap dish covered with blue towel (mopping up water).

3.3.6. Procedure

Participants completed the task individually in a quiet place within their setting. The methodology followed Diesendruck et al., (2003), replicating their dialogue when introducing the novel object, function match and shape match. The experimenter presented the novel object and stated *'this is a jop (cheem/kiv/glire) and it was made for cutting playdough (holding coins/dusting/making music). See how it cuts playdough (holds coins/dusts/makes music)'*. The experimenter then demonstrated this function, by producing some playdough and cutting it with the object (pouring a selection of coins into the object/moving the object around on the table in a dusting motion/banging a highlighter against the object to make a sound) and then placed it upon the table.

Introducing the function match test object, the experimenter said *'see this one? It can cut playdough because it was made for cutting playdough.'* The experimenter demonstrated this function, by cutting the playdough, then continued *'see, it doesn't look like this one* [pointing to the original], *they have a different shape. It can cut playdough because it was made for cutting playdough.'* The experimenter demonstrated this function for a second time. Introducing the shape match test object, the experimenter said *'see this one? It can't cut playdough because it was made for mopping up water (sticking/hanging hair ties/holding paperclips)'.* The experimenter demonstrated this function, by pouring a tiny amount of water onto the table and mopping it up, then continued *'See, it looks like this one* [pointing to the original], *they are the same shape. It can't cut playdough because it was made for mopping up water'* [demonstrating this function for the second time]. Following this, the experimenter picked up the novel object and said *'remember I told you that this is a jop and it was made for cutting playdough. One of these* [pointing to the test objects] *is also a jop. Which one of these is a jop?'* The word uttered to refer to the novel object, the order that the test objects were presented, the order that the function match and shape match were introduced and the positioning of the test objects on the table (left or right) were all counterbalanced.

3.4. Results

Following Diesendruck et al., (2003), participants were initially classed as 'function biased' (selected the function match for three or four trials), 'shape biased' (selected the shape match for three or four trials) or 'not biased' (selected the function match and shape match for two trials each) (see Table 7).

Table 7:

Percentage of children who were function biased, shape biased and not biased for six groups

	TD		***ASD***		***DD***	
	Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Function	27.27	77.27***	63.64**	34.48	22.22	30.00
Shape	40.91	18.18	18.18	44.83	44.44	50.00
Not Biased	31.82	4.55	18.18	20.69	33.33	20.00

*** p <.001 ** p <.01

Chi Square Goodness of Fit analyses showed that the TD children (23/44) and children with ASD (24/51), but not children with DD (7/28), were function biased at a rate above chance (TD, ($\chi^2(2, N = 44) = 10.64$, $p = .005$, $w = .49$: ASD, $\chi^2(2, N = 51) = 8.50$, $p = .014$, $w = .41$). To compare and contrast delay vs. deviance hypotheses, 'high VMA' and 'low VMA' subcategories were created for each group according to the median VMA of the combined sample, which was 4.6 years old (see Figure 7).[7]

[7] The same results were obtained for all analyses when the groups were split by their individual median VMA's, which were all very close to the overall median (TD 4.67, ASD 4.91, DD 3.71).

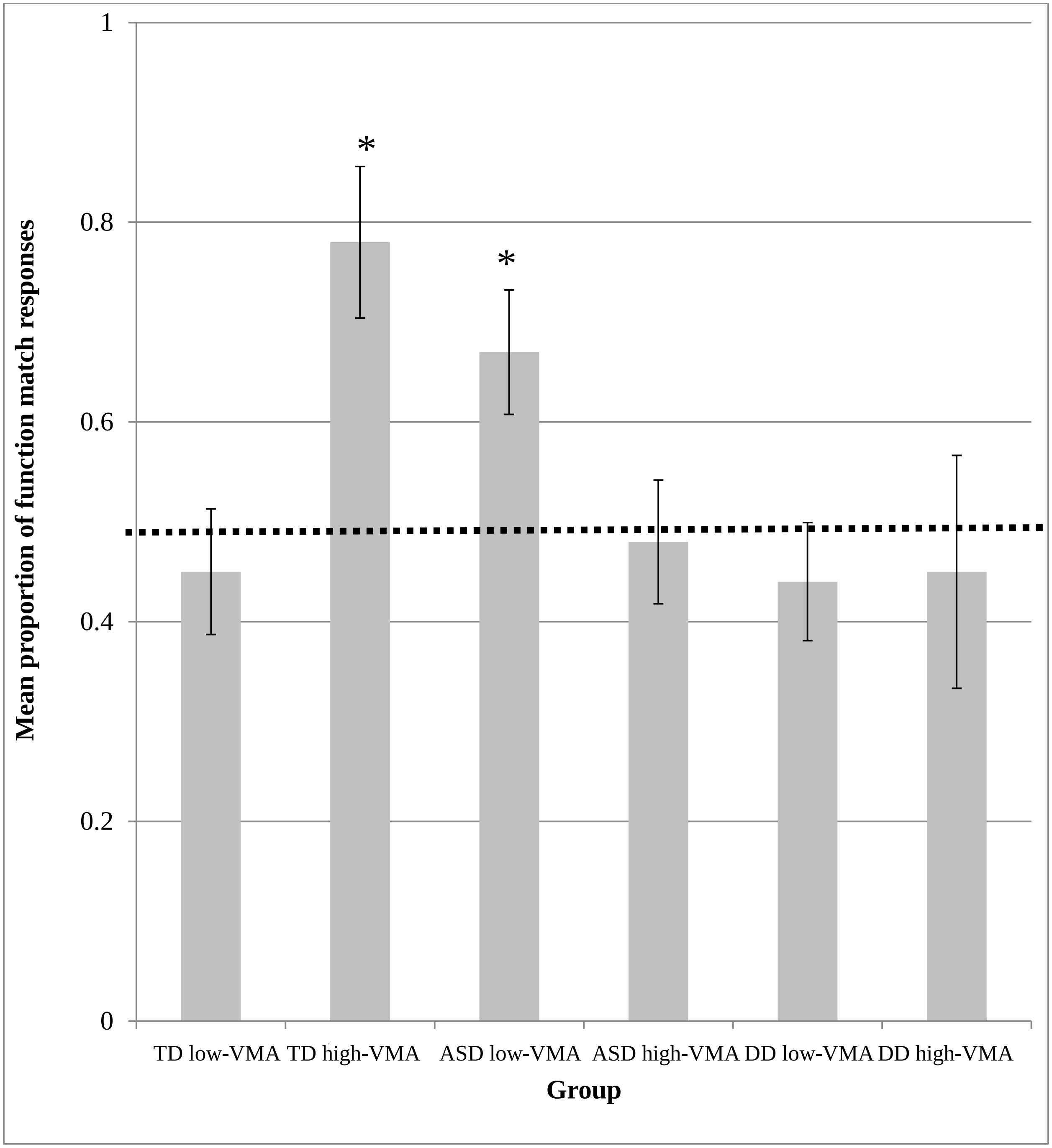

Fig. 7. Mean proportion of function match responses per six groups and condition (with standard error bars) (asterisk denotes significance).

The high VMA TD children (17/22) and *low VMA* children with ASD (14/22) were function biased (TD high VMA, $\chi^2(2, N = 22) = 22.49$, $p < .001$, $w = 1.01$: ASD low VMA, $\chi^2(2, N = 22) = 10.78$, $p = .005$, $w = .70$), although all other groups performed at chance (see Figure 7).

As well as conducting the analyses according to Diesendruck et al.'s (2003) scoring procedure, I explored the proportion of function bias responses across the four trials, for 'high VMA' and 'low VMA' participants. To rule out possible mediating effects of CA or general non-verbal ability, CA and non-verbal mental age (NVMA; as measured by the Raven's) were included in the analysis as covariates. A 2 (VMA; 'high' or 'low') × 3 (Group: TD, ASD, DD) ANCOVA including CA and NVMA as continuous covariates revealed no main effects of Group, VMA, CA or NVMA but an interaction between VMA and Group ($F(2) = 5.99$, $p = .003$, $\eta_p^2 = .11$).

To unpack this interaction, individual independent samples t-tests were performed, comparing the high VMA and low VMA subcategories of each group. These found that the two DD groups did not differ from each other in terms of function match responses (DD low VMA $M = .44$, $SD = .25$. DD high VMA $M = .45$, $SD = .37$) although there were differences between the high VMA ($M = .78$, $SD = .36$) and low VMA ($M = .45$, $SD = .30$) TD children ($t(43) = -3.31$, $p = .002$, $d = -1.00$) and between the high VMA ($M = .48$, $SD = .33$) and low VMA ($M = .67$, $SD = .29$) children with ASD ($t(49) = 2.10$, $p = .041$, $d = .61$). The function bias was present in the high VMA TD children, but the *low VMA* ASD participants.

During the review process for the paper upon which this chapter is based, one referee pointed out that the use of a median split, while common, is open to criticism on statistical grounds (MacCallum, Zhang, Preacher & Rucker, 2002; McClelland et al., 2015). I therefore explored VMA as a continuous measure (with the help of Gareth Ridall, Department of Mathematics, Lancaster University). A robust linear regression using the mass library from the R package confirmed the strong positive relationship between VMA and function bias responses for the TD children and found a weaker negative relationship between VMA and function bias responses for the children with ASD (see Figure 8). Furthermore, a linear mixed effects model using Group (TD, ASD, DD) as a fixed factor and BPVS score as a continuous variable found a Group × VMA interaction ($F(27,32) = 1.90$, $p = .041$, $\eta_p^2 = .62$). This confirmed our findings using the median split analyses.

To check the validity of this interesting group difference, two further checks were carried out on the data. Firstly, I wanted to establish if children's object selection differed across object sets, as the novel objects for the 'holding coins' (green bowl) and 'making music' (jelly mould) trials might have been more familiar to the children than the novel objects for the 'dusting' (duster) and 'cutting playdough' (playdough cutter) trials. Despite this replicating Diesendruck et al., (2003), which contained a mixture of familiar and unfamiliar stimuli, I wanted to ensure that children were responding the same for the 'familiar' and 'novel' object sets. A paired samples t-test found no significant differences between children's responses for the two 'novel' compared with the two 'familiar' object sets for any of the three groups.

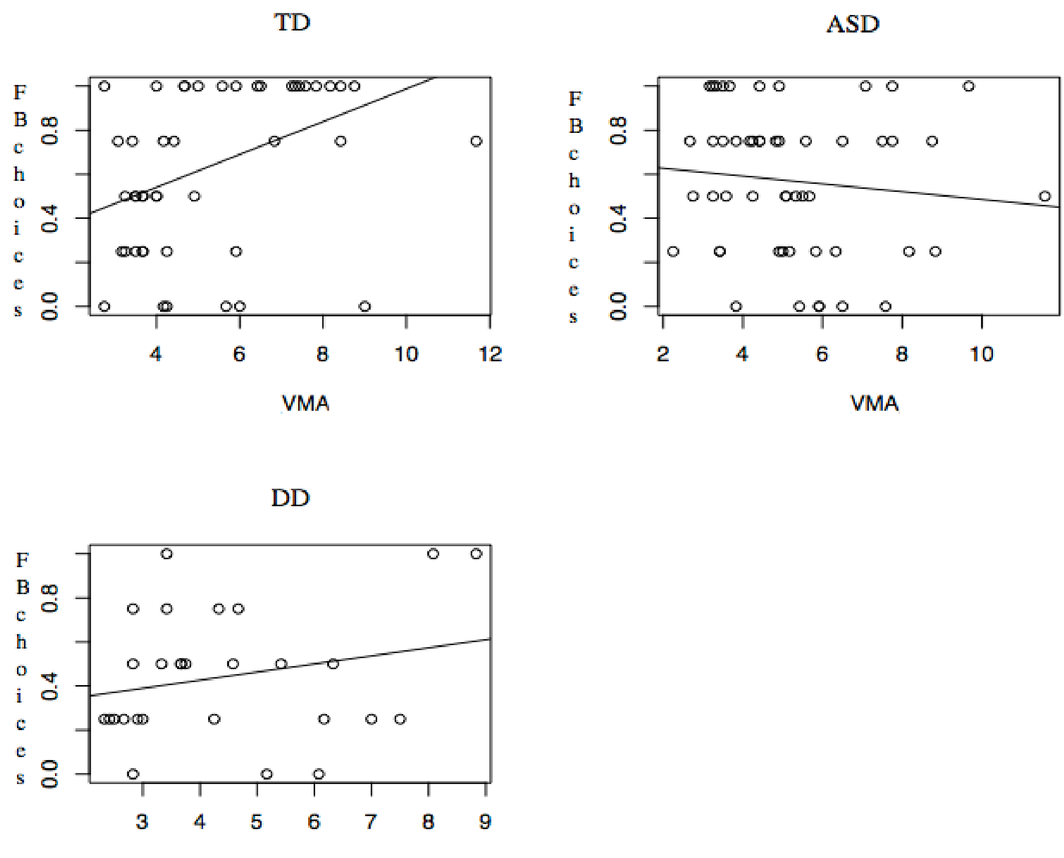

Fig. 8. Scatterplots of VMA by function bias responses for each of the three groups.

As an additional precaution, I investigated if children's responses were consistent across all object sets. Children's responses were categorised for each trial separately as 'shape match' or 'function match'. A Friedman test confirmed that there were no significant differences in terms of children's responses per object set for any of the three groups.

Relation between function bias and background measures

The final analyses explored the relation between background cognitive measures (CA, VMA, NVMA) and function bias performance across the four trials (see Table 8). Pearson's correlation analyses revealed that the proportion of function match choices was positively related to CA ($r(45) = .39$, $p = .008$) and VMA (r (45) = .37, $p = .012$) for the TD children, but VMA was no longer significant in partial correlations controlling for CA. None of the correlations were significant for the ASD or DD groups. A linear regression analysis using CA, VMA and Raven's score as predictor variables found that CA marginally predicted performance for the TD children ($Adj\ R^2$=.11, $F(3,38) = 2.75$, β=.08, $p = .056$). No other significant effects were obtained for the clinical groups, even when they were split into high and low VMA.

Table 8

Correlations between function bias responses and CA, VMA and Raven's

	TD	***ASD***	***DD***
VMA	.37*	-.11	.23
CA	.39**	-.08	.07
Ravens	.26	.06	.32

*p <.05. **p <.01

3.5. Discussion

Function plays an important role in children's artefact categorisation. However, there is debate within the TD literature regarding the age of function bias onset. Furthermore, the function bias has never before been explored in atypically developing participants, such as children with ASD. This study suggests that some TD children and children with ASD show a function bias. Although this effect is driven by the high VMA children within typical development, it appears to be driven by the *low VMA* children within ASD. Thus, children with ASD may have a different route to word learning; forming word-object mappings by function to begin with and then shape. This is in direct contrast to TD children, who form word-object mappings by shape to begin with and then function.

The use of the function bias emerges at a later age in TD children than some research suggests (e.g. Diesendruck et al., 2003), and I will explore this effect first. The results for the DD children reveal a fundamental difficulty with function understanding and inform us about the role of cognitive delay in ASD. The DD findings will be explored before looking specifically how function might facilitate language acquisition in children with ASD.

These findings depart from Diesendruck et al., (2003), who found that three-year-old TD children show a function bias. This ability was not found until the TD cohort had a mean VMA of six and CA just below this age, even though I used identical instructions, albeit with some adapted stimuli. However, these findings support other studies suggesting that TD children do not show a function bias with a CA of three-years-old (e.g. Graham et al., 1999; Imai et al., 1994;; Tomikowa & Dodd, 1980). Specifically, Merriman et al. (1993) found that children did not use function as a cue for word learning until age six, which is consistent with our results. Furthermore, Matan and Carey (2001) found that six-year-olds and adults could categorise objects according to the function they were originally intended to fulfil, but four-year-olds could not.

Diesendruck et al.'s (2003) paradigm contained a great deal of verbal instruction, and children had to retain the pairings between objects and corresponding function in working memory. I chose to remain faithful to the procedure, although future work should consider adapting task instructions to minimise the verbal component, as it is possible that the extent of dialogue was difficult for the low VMA TD children. The likely conclusion here is that the function bias is truly slow to emerge across typical development given the focus that is known to occur on shape and other features of a perceptual array (e.g. Horst & Twomey, 2013; Landau et al., 1988; Landau et al., 1992; Tek et al., 2012).

DD children did not use function for word-object mapping irrespective of their VMA. It is possible that the language used within the procedure was too complex for both groups of DD participants. Although the high VMA DD children were matched on receptive vocabulary as measured by the British Picture Vocabulary Scales (2^{nd} Edition; Dunn et al., 1997) with the high VMA TD children, who succeeded at the task, it is worth noting that VMA was only measured using the BPVS. Past studies within the ASD literature have also used the BPVS as a measure of VMA (e.g. Allen & Chambers, 2011; Hartley & Allen, 2014; Lee & Hobson, 2006; Leekam, et al., 1998).

However, grouping participants by the arbitrary value of median VMA does not represent absolute ability levels. The BPVS only measures single word receptive vocabulary, thus it is unknown if the groups were matched on skills such as pragmatic language, grammar and expressive vocabulary. It might be the case, for example, that the DD high VMA children had inferior pragmatic language understanding compared to the TD high VMA children, which facilitated function bias understanding in the latter group. Future research should aim to measure additional aspects of language than simply receptive language comprehension, in order to tease apart whether other skills are facilitating function bias understanding in the TD high VMA children, relative to the DD high VMA children.

A further possibility is that the DD children show a fundamental impairment in understanding what objects were made for. Although children with intellectual impairment are able to sort objects into categories (Ungerer & Sigman, 1987), they actually perform worse than TD children and children with ASD for superordinate level category matching, particularly for artifactual classification (Tager-Flusberg, 1985). This may pervade other areas of language development, including categorisation and play. Thus, clinical and educational programmes should account for this potential problem. It is also conceivable that differences in information processing abilities amongst individuals with DD (Sperber & McCauley, 1984), which we did not directly measure, underlie the difficulty the DD groups had with understanding the task. There is evidence that individuals with intellectual impairment do not spontaneously abstract relations between pairs of objects (see Paöur, 1992), and have specific difficulties in working memory (Numminen, Service, & Ruoppila, 2002).

The results of the DD group implicate cognitive delay as the primary source of function bias failure, and based upon the cognitive abilities of the ASD sample, it would also be expected to find impairment across the board in this group. However, some of the children with ASD were able to pass this task; paradoxically, the group with the lower VMA were the ones to exhibit success. At first glance, it appears surprising that children with ASD succeed at a word-learning task only passed by TD children with an older VMA. However, repeatedly emphasising and clearly demonstrating the object’s function may have facilitated function bias understanding in the low VMA children with ASD, who might have been more likely to learn through multiple pairings of object and function (Preissler, 2008). It was observed that these children often attended to and repeated the experimenter’s actions as she demonstrated the object’s function, which seemed to help them understand the task more.

Several other reasons might help explain this puzzling finding. First, children with a lower VMA engage in functional play (Baron-Cohen, 1987; Jarrold, Jillchrist & Bender, 1993; Libby et al., 1998), which necessitates understanding of an object’s true or intended function (i.e. flying a toy helicopter in the air). Functional play has been less fully explored in children with ASD who have a higher VMA. These children may engage in symbolic play more than functional play, and thus focus less on the intended role of an object and more on abstract properties. Supporting this claim, children with ASD with higher levels of language comprehension show greater levels of symbolic play skills (Ungerer & Sigman, 1981). A further explanation is that the higher VMA children with ASD may prioritise other word learning strategies when discerning the appropriate referent in the current paradigm. The shape bias, for instance, is a commonly used word learning constraint that is delayed in children with ASD who display a similar cognitive profile to participants in the current study (Field et al., in press, see Study One). The children with higher VMA may therefore focus upon shape as the most relevant cue in any word-learning situation. Although there was no shift towards shape based naming in the current paradigm, it is possible that the heavy task demands and repetition of functional information meant that children were trying to rectify a propensity for utilising shape with the functional information provided, and were ultimately confused. Using a more traditional word generalisation task in which an object is simply named (as in Field et al., see Study One) could reveal a prioritisation of shape as the most relevant feature.

Another potential explanation is that these findings reflect a specific strength in ASD during a critical early period of development. Shah & Frith (1983) identified 'islets of ability' in ASD in terms of relative strengths in block design tasks. It may be the case that during the earlier stages of language acquisition, children with ASD are focusing heavily upon the features of objects, and given the rigorous nature and reinforcement of some early intervention programs (Anderson, Avery, Dipietro, Edwards, & Christian, 1987; Lovaas, 1987; Vernon, Koegel, Dauterman, & Stolen, 2012), are also paying special attention to an adult's instruction.

One area of caution is that although VMA, as predicted, is positively correlated with function bias performance for the TD children, there was not a significant correlation between VMA and function bias performance in children with ASD. However, as expected, this correlation was negative, which was further illustrated with the robust regression scatterplots and justified with the linear mixed effects analysis. One possibility for the lack of correlation between VMA and function bias responses for the ASD subgroup is that children with ASD of different ages receive different types of instruction. For example, the early stages of intervention programs might be more centred around getting children to attend to objects, whereas later stages might focus more on attending to people. Further work is needed both to replicate our findings and explore the emergence of functional understanding for word learning in children with ASD.

Clearly something is emerging in the difference between low and high VMA ASD groups, but this appears to be a categorical rather than linear relation. In typical development, the correlation between VMA and function bias disappears when CA is controlled for, suggesting that CA mediates the use of function. Thus, I may have identified two different processes by which the use of functional information emerges: a linear development in TD compared to a sudden shift in ASD. The idea of a stage-like transition in cognitive skills is not new (Piaget, 1928) and further work is needed to both replicate my findings and explore the emergence of functional understanding for word learning in children with ASD.

Of course, there are limitations to this work. Although I did not find differences between trials that incorporated completely novel objects relative to those that retained some familiarity, future work should utilise a uniform set of stimuli. It would also be advantageous to test more verbally able children with ASD, to generalise these findings across the spectrum and determine whether the function bias is present in individuals whose CA is on a par with their VMA. Furthermore, my DD group included a wide variety of conditions, and future research should aim to explore the function bias in a more homogeneous sample, such as a whole cohort of children with Down Syndrome or a whole cohort of children with intellectual disabilities. This will help tease apart whether subgroups of DD children show the function bias or a function bias deficit is widespread among DD children. Despite these limitations, this study was the first to investigate the function bias in atypically developing children and provides a basis for further work exploring the role of functional information vs. shape-based generalisations across development.

3.6. Evaluating these studies in relation to the emergentist coalition model

Studies One and Two have investigated the role of the object for children's word learning, specifically the shape bias and function bias. Taken together, the results of Studies One and Two suggest that TD children use both the shape bias and, at a later age, the function bias to help them generalise names of objects. This supports past research (e.g. Landau et al., 1988; Merriman et al., 2003) and the claims of the emergentist coalition model (see also Markman, 1989) that TD children use word-learning constraints, among other cues, to facilitate their language acquisition. Further, these results have extended the emergentist coalition theory to include atypically developing children. Study One extended past research (Hartley & Allen, 2014; Tek et al., 2008) by including a more varied CA and VMA range of children with ASD and a DD control group. Study Two was the first to explore the function bias in children with ASD and DD.

Like TD children, children with ASD use word-learning constraints. However, these emerge according to a different developmental process from TD children; children with ASD are delayed showing the shape bias and deviant showing the function bias. Unexpectedly, however, this deviance relates to showing a function bias *earlier* than TD children and then seemingly losing this ability, rather than never showing a function bias at all. Surprisingly, DD children were also deviant showing a function bias but in a different way from children with ASD; neither the low nor high VMA cohort showed the heuristic. These results suggest that the function bias develops *earlier* than typical in children with ASD but might *never* develop in DD children. The General Discussion will explore the results of Studies One and Two in more depth.

As stated within Chapter One, word learning is achieved by an interaction between the object, speaker and environment. The last two chapters have focused primarily on the role the object plays within children's word learning; specifically perceptual (i.e. shape) and conceptual (i.e. function) factors. As the same types of object often possess the same shape, the shape bias is a more useful characteristic than classifying objects according to colour, texture, size or other perceptual attributes. Children also rely on cues which are more conceptual to help them learn words, such as the function bias, categorising objects according to the role they fulfil. This is particularly helpful for facilitating children's language acquisition when the same kind of object possesses a different shape, as is often the case with subordinate and superordinate categories.

Although word-learning constraints such as the shape bias and function bias are important for children's language acquisition, children also use other types of cues to help them learn words. Indeed, while word-learning constraints emphasise characteristics of the object itself (e.g. shape and function), others argue that the speaker is of vital importance; children learn words from social cues produced by the speaker, such as eye gaze and pointing. Others stress the importance of environmental cues, which highlight attention towards the object, such as an arrow positioned towards the object or object illumination. The next three studies investigate the effect of social cues (Study Three), associative cues (Study Four) and conflicting social and associative cues (Study Five) on children's word learning. This begins with the effect of the speaker gazing and pointing at the target object as they name it, which is explored in the next chapter.

Chapter Four: **Word learning from social cues across atypical development: Pathways of delay or deviance?**

4.1. Introduction to studies Three, Four and Five

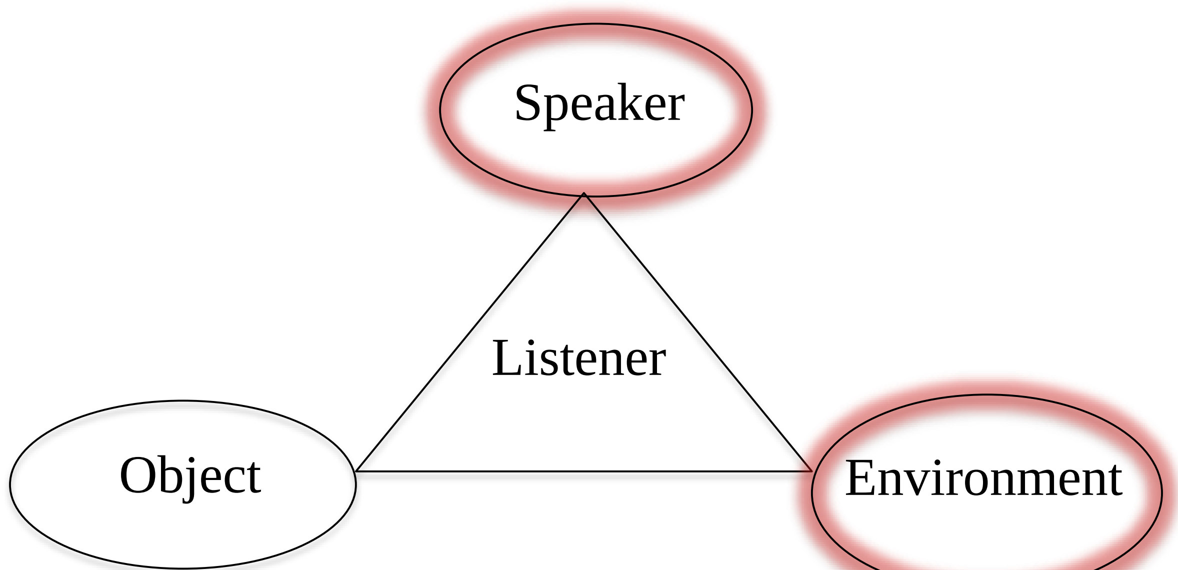

Figure 4.1: Visual interpretation of the speaker – object-environment interaction for word learning. Study Three will focus on the 'speaker', Study Four will focus on the 'environment' and Study Five will focus on both the 'speaker' and 'environment' aspects of the triad.

While the previous two studies have explored the effect of the object (i.e. the shape bias and function bias) on children's word learning, the next three studies explore the effect of the speaker (Study Three), environment (Study Four) and interaction between the speaker and environment (Study Five). The present study investigates how eye gaze and pointing towards an object helps children learn words, the next study investigates how children learn words from an arrow positioned towards an object and the object lighting up and Study Five investigates whether children prioritise one cue over another when a social cue occurs towards one object and an associative cue occurs towards the other (e.g. the speaker looks at one object at the same time as there is an arrow positioned towards the other).

As discussed within Chapter One, the emergentist coalition model stresses that different types of cue interlink to help children learn words and that children manifest these cues at different developmental time points. It predicts that TD infants learn words from association but they prioritise social over associative cues from 18-24 months (Hollich et al., 2000). As the TD children included within this research all have a CA and VMA of two or above, they are all predicted to learn words from social cues within this study and to prioritise social cues over association in Study Five. However, for Study Four they were expected to choose the object suggested by the associative cue, being able to learn via simple associative principles in the absence of any conflicting social pragmatic information.

Although the TD children are predicted to use social pragmatics for word learning, children with ASD show word learning delays relative to their TD peers (e.g. Eigsti et al., 2011). They were also delayed showing a shape bias. Therefore, they are predicted to learn words from association, rather than referential intent for a longer developmental time point than TD children. If word learning from social cues is delayed in ASD, the high VMA children with ASD are predicted to learn words from the social cues in Study Three, but not the low VMA children with ASD. In contrast, if word learning from social cues is deviant in ASD, both high and low VMA children with the disorder are predicted to perform at chance.

Originally, the same hypotheses that were made for the TD children were made for the children with DD. However, the results of the previous two studies suggest that DD children, as well as children with ASD, have difficulties learning words. Along with the ASD cohort, DD children did not choose the shape match test object in the no name condition in Study One. They also showed a function bias deviance in Study Two, with neither the high nor low VMA subcategory choosing the function match. Therefore, DD children are also predicted to have difficulties learning words from Studies Three, Four and Five. If the DD children exhibit word-learning deficits for all studies, this suggests a global impairment in language acquisition for these children.

Taken together, Studies Three, Four and Five aim to explore how children learn words from social cues and association. The emergentist coalition model is extended to include children with ASD and DD. Atypically developing populations have been under researched within the emergentist coalition model, with a few exceptions. For example, Baron-Cohen et al., (1997) found that two-year-old children with ASD form word-object mappings according to the object within their own focus, rather than the speaker's. Further, Hennon (2003) found that three-year-old children with ASD form word-object mappings towards a perceptually salient object, even if the speaker is gazing at another artefact. These studies build on this research, to investigate children's word learning from a wider variety of cues (eye gaze, pointing, arrows and object illumination) and include an additional control group of DD children.

4.2. Introduction to this study

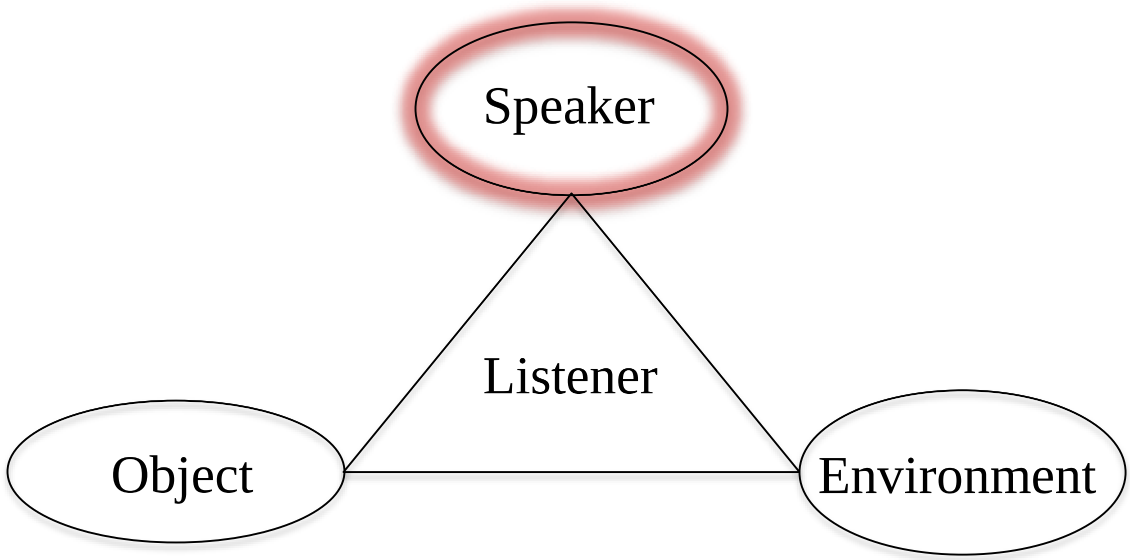

Figure 4.2: Visual interpretation of the speaker – object environment interaction for word learning. This study will focus on the 'speaker' aspect of the triad.

Even from infancy, TD children are very sociable. They prefer to look at faces rather than other objects from birth (Fantz, 1963; Johnson & Morton, 1991), follow the head direction of others from just six-months-old (D'Entremont, Hains & Muir, 1997) and show sensitivity to consistency in terms of people's emotions and actions (e.g. happy people perform positive actions) from as early as fourteen months old (Hepach &

Westermann, 2013). From around eighteen-months-old, cues such as eye gaze and pointing become important social signals for children's word learning (Baldwin, 1991; 1993; Baldwin & Moses, 2006; Baron-Cohen, 1994; Beier & Spelke, 2012; D'Entremont et al., 1997; Kleinke, 1986; Murray & Trevarthen, 1985; Tomasello, 1999; Trevarthen, 2004). When witnessing a speaker utter a novel label (e.g. *'a blicket!'*) who is simultaneously gazing or pointing towards one of several novel objects, a child can discern the referent of that novel label by a process of *referential intent*, assuming that the speaker intends to refer to the object they are gazing or pointing towards (e.g. Baldwin, 1991; 1993; Bloom, 2000; Briganit & Cohen, 2011; Houston-Price et al., 2006; Yale & Mundy, 1998).

In contrast to TD children, some studies suggest that children with ASD do not automatically scan the face and eyes when an actor is viewing an object (Riby et al., 2013) and fail to learn words from eye gaze (Baron-Cohen et al. 1997; Preissler & Carey, 2005). This extends to children at risk for developing ASD (Gliga, Elsabbagh, Hudry, Charman & Johnson, 2012). Conversely, recent studies provide evidence to suggest that children with ASD can attend to (Gillespie-Smith, Doherty-Sneddon, Hancock & Riby, 2014) and form word-object mappings from (e.g. Bani Hani et al., 2012; Bean Ellawadi & McGregor, 2015; Luyster & Lord, 2009; Mcgregor et al., 2013; Norbury et al., 2010) eye gaze, as can adults with ASD (Aldaqre, Paulus & Sodian, in press).

One possibility for these conflicting results, as suggested by Luyster and Lord (2009), is that children with ASD now have greater exposure to word learning interventions, which emphasise the importance of language development (e.g. Rogers, 2006). Furthermore, children with ASD have been found to be better able to form word-object mappings from eye gaze when they are presented with multiple trials, rather than just one trial (Bean Ellawadi & McGregor, 2015). Another explanation is that the variation between studies reflects differences in terms of children's age and language ability. The participants recruited in Baron-Cohen et al. (1997) had mean expressive and receptive language ages of two and the participants in Preissler and Carey (2005) had a mean comprehension vocabulary of 23 months. In contrast, participants in Akechi et al., (2011) had a mean verbal mental age (VMA) of eight and participants in Norbury et al., (2010) had a mean VMA of seven.

Thus, it might be the case that children with ASD learn words from gaze, but only when they have a higher VMA than TD children, suggesting that word learning via this social cue is *delayed* rather than *deviant* in ASD. Supporting this proposal, attention to eyes is positively correlated with socio-communicative skills in children with ASD (Gillespie-Smith et al., 2014). In order to test whether verbal ability facilitates word learning from gaze, it is necessary to recruit participants of different levels of VMA. It is also important to explore children's CA to help tease apart if any differences observed in children with ASD relative to TD children are due to variation in age and/or language ability. My first research hypothesis tests the distinction between delay and deviance in children with ASD. If word learning from social cues is deviant in ASD it may *never* occur, if it is delayed it occurs, but at a later stage than observed in TD children.

Although the evidence regarding whether children with ASD learn words from gaze is conflicting, they can use other social cues to learn words, specifically pointing (e.g. Akechi et al., 2013; Travis & Sigman, 2001). However, the *process* by which children with ASD use and interpret pointing might be through association, simply pairing stimuli in the environment, rather than referential intent (e.g. Samuelson & Smith, 1998). They are able to point to request an object (Baron-Cohen, 1989; Mundy, 1995). Yet, unlike TD children (Baron-Cohen, 1989) or children with developmental (Mundy, Sigman & Kasari, 1994) or language delays (Landry & Loveland, 1988; Loveland & Laundry, 1986), they do not point to share enjoyment or interest in an object with someone else. This suggests that children with ASD may use pointing simply in order to get their needs met, and lack an understanding of its broader social context.

In contrast, TD children point at things not only because they want them but also to influence people's mental states and promote joint attention (Tomasello et al., 2007). From as young as nine-months-old, infants understand the communicative nature of pointing, looking longer when a recipient picks up a different object than the one an actor has previously pointed to. However, they do not show this effect when the recipient has not previously viewed the actor pointing or used a fist instead of a point towards the object (Krehm, Onishi & Voulou-Manos, 2014). This indicates both that infants understand pointing from the perspective of another and that referential intent underlies their comprehension of pointing; other perceptually salient gestures or props do not have the same effect (see also Hala & Russell, 2001).

Furthermore, 1-2 year-old TD infants chose the correct container for a hidden toy when the experimenter ostensively gazed (repeatedly turned her head from the container back to the child) or both gazed and pointed (Behne et al., 2005). However, when the gaze was ‘absent minded’ (glancing at the container with a distracted facial expression) and the point was ‘distracted’ (looking at her hand instead of the child) children chose at chance between the target and distractor container, suggesting that referential intent underlies TD children’s understanding of pointing. However, little is known about the distinction between these scenarios in children with ASD, and thus my second hypothesis addresses this question by comparing different pointing and gaze cues. Specifically, as well as presenting gaze and pointing cues singularly, one type of trial couples the two cues, to establish if the combination of two social cues has an effect on children’s word learning. Furthermore, this study employs two different types of pointing trials; pointing direct, where the speaker looks straight ahead and pointing incidental, where the speaker looks off into the distance, as though momentarily distracted (See Section 4.3).

In order to establish whether any differences in word learning from social cues are specific to ASD it is necessary to also study children with other developmental disorders (DD), just as it was with the shape and function bias in Studies One and Two. Evidence is mixed regarding understanding of social cues in these children. One study (John & Mervis, 2010) replicated the findings of Behne et al., (2005) with children with DD (in this case, Williams Syndrome and Down Syndrome). Other research suggests that children with developmental language delay show significantly more pointing when requesting something than children with ASD (Landry & Loveland, 1988; Loveland & Landry, 1986). In contrast, other studies have found that children at risk for having DD have impairments understanding eye gaze (Arens et al., 2005) and DD children have difficulties understanding pointing (Laing et al., 2002). This raises the question of whether difficulties processing social cues by children with ASD stem from their autism or general cognitive impairment. My third research aim concerns this difference.

One must encode the word-referent links, independent of any environmental or social cues, in order to learn words. For example, infants notice object positioning (Canfield & Haith, 1991; Johnson & Tucker, 1996), and learn words for stimuli with predictable rather than varied locations (Benitez & Smith, 2012). TD infants prioritise goal directed action over consistency of object location (Moore, 1999; Woodward, 1998; Woodward & Guajardo, 2002). Woodward's classic study shows that after originally viewing a hand grasping at a toy, infants looked longer when the hand later reached in the same location for a different toy than when the hand reached in a different location for the same toy (Woodward, 1998). This is useful as location is generally unimportant for naming. A ball is a ball, for example, if it rolls from the left to the right of the floor and a chair does not suddenly become a ball if it moves from one position to another.

Context may play a different role for atypically developing children, who may instead encode more superficial properties such as the consistency between the location and the object. Such associative learning would predict word learning errors (see Baron-Cohen et al., 1997). My fourth hypothesis examines the role of spatio-temporal location for word learning in atypical development by manipulating the final location of a target stimulus. For half of the trials, the target and distractor object are presented in the same position as previously shown, for the other half of the trials, the position of the objects reverses (so the object originally on the left of the screen now appears on the right and the object originally on the right of the screen now appears on the left). It is hypothesised that the TD and DD children form ‘word-to-object’ mappings, performing above chance for both the same and reversed position trials. However, the children with ASD are predicted to form ‘word-to-location’ mappings, only performing above chance for the same position trials.

4.3. Description of the present study

This study investigated word learning from social cues (specifically, eye gaze and pointing) in TD children, children with ASD and those with DD. Participants were shown a video of a speaker uttering a novel word for one out of two objects at the same time as gazing and/or pointing at it. In order to explore my first hypothesis (delay vs. deviance), participants were split into ‘low’ and ‘high’ VMA subgroups according to the median VMA of the sample. To address my second research question regarding the referential nature of pointing, we incorporated trials in which the speaker directed his gaze ahead (Direct Pointing) or away from the point (Incidental Pointing). I also compared pointing to gaze cues, to explore the relative impact of these skills on word learning.

Based upon the possibility that only older and more verbally able children with ASD learn words from gaze (e.g. Luyster & Lord, 2009; Mcgregor et al., 2013; Norbury et al., 2010), children with ASD are predicted to show a unique delay in forming word-object mappings from this cue. I predict that children with ASD will be able to learn from pointing, but they will be unable to distinguish between Direct vs. Incidental Pointing. I also expect that all groups will benefit from the conjunction of gaze with pointing. Indeed, children with ASD have been found to learn words from eye gaze when this co-occurs with other cues (Akechi et al., 2011; Akechi et al., 2013; Parish-Morris et al., 2007). Inclusion of a DD control group will allow me to tease apart the effects of cognitive delay vs. ASD, which is my third aim. If deficits in using social cues are specific to ASD, then the performance of the DD group should mirror the TD counterpart. However, if any social deficits arise due to general cognitive impairment, I expect no difference between our two atypical groups.

With respect to my fourth and final aim, I hypothesise that children with ASD will find word learning particularly difficult when the spatio-temporal position of an object changes. Given that individuals with DD have also been shown to learn via associative properties of stimuli (Remington, 1996), I expect to see deterioration in performance when the object changes location between encoding and test trials in both atypical populations, but not in TD controls. Overall, this study will attempt to elucidate the relative effects of different social cues on word learning in typical and atypical development, and identity whether any differences are specific to ASD.

4.4. Method

4.4.1. Participants

Children were recruited from eight specialist schools (participants with ASD and DD), one ASD unit within a mainstream school (participants with ASD) two mainstream schools and two day nurseries (TD children) and tested in North West England. Lancaster University granted ethical permission to carry out the research. The children's parents gave informed consent for their child to participate. A total of 78 children took part in the study (TD, N = 30: ASD, N = 27: DD, N = 21). Fifty-five participants were male (18 TD, 23 ASD, 14 DD) and 23 were female (12 TD, 4 ASD, 7 DD). An additional five children were excluded from the study for non-compliance and/or insufficient cognitive ability to be able to understand the tasks.

All children with ASD and DD had received a clinical diagnosis by 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 expert clinical judgment. The children with DD had various developmental disabilities, the majority having learning difficulties or developmental delay, sometimes alongside other conditions, such as Down syndrome or rarer chromosomal disorders. Participants were grouped as TD, ASD or DD. In order to establish if word learning from social cues is delayed in ASD, the groups were then further subcategorised according to the median VMA of the sample (4.87) (Table 9), into three 'low VMA' and three 'high VMA' groups.

Table 9

Participant demographic details

	TD		***ASD***		***DD***	
	Low VMA N = 19 10 males	*High VMA N = 11 8 males*	*Low VMA N = 10 9 males*	*High VMA N = 17 14 males*	*Low VMA N = 10 8 males*	*High VMA N = 11 6 males*
Mean CA	3.56	5.13	9.04	10.46	7.47	9.45
(SD)	(.43)	(1.61)	(3.05)	(1.81)	(1.80)	(1.77)
Mean VMA	3.83	6.32	3.87	6.84	3.73	6.11
(SD)	(.61)	(1.50)	(.63)	(1.48)	(.61)	(1.26)
Mean Ravens	10.00	17.82	14.56	21.47	10.40	15.30
(SD)	(2.16)	(6.88)	(6.50)	(8.16)	(5.99)	(8.39)
Mean CARS	15.15	15.13	37.95	31.15	25.14	21.43
(SD)	(.55)	(.25)	(4.98)	(5.84)	(5.37)	(3.74)
Mean SCQ	3.15	1.50	18.20	12.63	10.63	6.86
(SD)	(1.63)	(1.73)	(3.19)	(5.88)	(6.00)	(4.81)

4.4.2. Design

A 3 (Group; TD, ASD, DD) × 4 (Trial Type; Eye Gaze, Direct Pointing, Inconsistent Pointing and Eye Gaze + Pointing) × 2 (Object Position; Same vs. Reversed) Mixed Factorial design was employed.

4.4.3. Cognitive Tests

Children were administered the British Picture Vocabulary Scale – Second Edition (BPVS-II; Dunn et al., 1997) in order to ascertain their VMA. Raven's Progressive Matrices (Raven's; Raven, 2003) was also given in order to ascertain their non-verbal reasoning ability (minimum raw score of 0 and maximum of 36). The three groups had equivalent VMA's (all p >.05). The low and high VMA groups were all matched to each other in term of language ability.

4.4.4. CARS and SCQ scales

For the majority of children, a parent or teacher completed the CARS (Schloper et al., 1988) (17 TD, 20 ASD, 14 DD) and the lifetime version of the SCQ (Rutter et al., 2003) (17 TD, 18 ASD, 15 DD) to confirm or rule out ASD. Scores on the CARS range from 15-60, with scores of 30 or above in the ASD range. Scores on the SCQ range from 0 – 39, with scores of 15 or above in the ASD range. Almost all of the children scored according to their diagnostic category on at least one of the questionnaires, with only one child (ASD) not scoring according to their diagnosis on either scale. However, he had been officially diagnosed with ASD, and removing him from the analyses led to almost identical results, so he was not excluded from the sample.

4.4.5. Materials

The video (see Figure 9 for an example eye gaze + pointing trial) was created which showed a speaker seated at a table covered with a white tablecloth. The novel objects were later superimposed onto the video, using iMovie, with one novel object to the speaker's left and one novel object to the speaker's right. A powerpoint presentation of the two objects side by side, with a white background, was then shown. For half of the trials, the objects appeared in the same spatial location as shown on the previous video, while for the remaining half of the trials, the position of the objects had reversed. The videos were edited and transfered onto a 1090×1080 laptop computer.

Fig. 9. Example image of an eye gaze + pointing trial

4.4.6. Procedure

Participants completed the experimental and background measures in a quiet area of their school or day nursery. Task order was counterbalanced. In some cases, the child's parent or a member of teaching staff was also present in the room. These adults were instructed to simply watch the study and avoid intervening in any way. Participants viewed one of four videos, each containing eight trials but a different task order.

For the first three seconds of the video, the speaker looked directly ahead, with his arms by his side. After three seconds, the speaker uttered '*There's a modi (fep/peri/ zav/toma/riff/tog/neem)*', at the same time as producing a social cue. For two trials, he directed his eye gaze towards the target object, for two trials he 'directly pointed' at the target object (keeping his eye gaze directed straight ahead), for two trials he 'incidentially pointed' (gazing off into the distance in the opposite direction of the point) at the target object and for two trials he directed both his eye gaze and direct pointing at the target object.

The speaker then stated, for instance, '*it's a modi!'* Following this, he stopped gazing and/or pointing at the object. His gaze returned to the centre of the screen and/or his hands returned by his side.

The child then viewed a still image powerpoint presentation of the two objects side by side, with a white background. For half of the trials, the objects appeared in the same spatial location as shown on the previous video, while for the remaining half of the trials, the position of the objects had reversed. The experimenter asked the child to *'show* *me a modi'*. Correct responses were classed as a correct point or verbal description. Once the child had provided their response, the experimenter moved the video on to the next trial.

Due to technical issues, one child with ASD and one child with DD did not complete the reversed direct pointing trial and one child with ASD did not complete the reversed pointing inconsistent trial.

The order the novel words were spoken, the position of the target object (left or right of the speaker) and the object chosen to be the target and distracter were all counterbalanced, although the same two objects were always paired together. Thus, for counterbalancing purposes, four different videos were created.

4.5. Results

Children's responses were summed over trials and converted into proportions, as three children failed to complete all trials. For all analyses, each group was subdivided into 'high' and 'low' VMA to test the delay vs. deviance hypothesis and results for each cue were compared to a chance level of .50 for each trial. I also compared group and level of VMA for each cue type using ANOVA. Results for all four trial types are depicted in Figure 10 (entire sample; TD, ASD and DD). Table 10 depicts results for the high and low VMA groups.

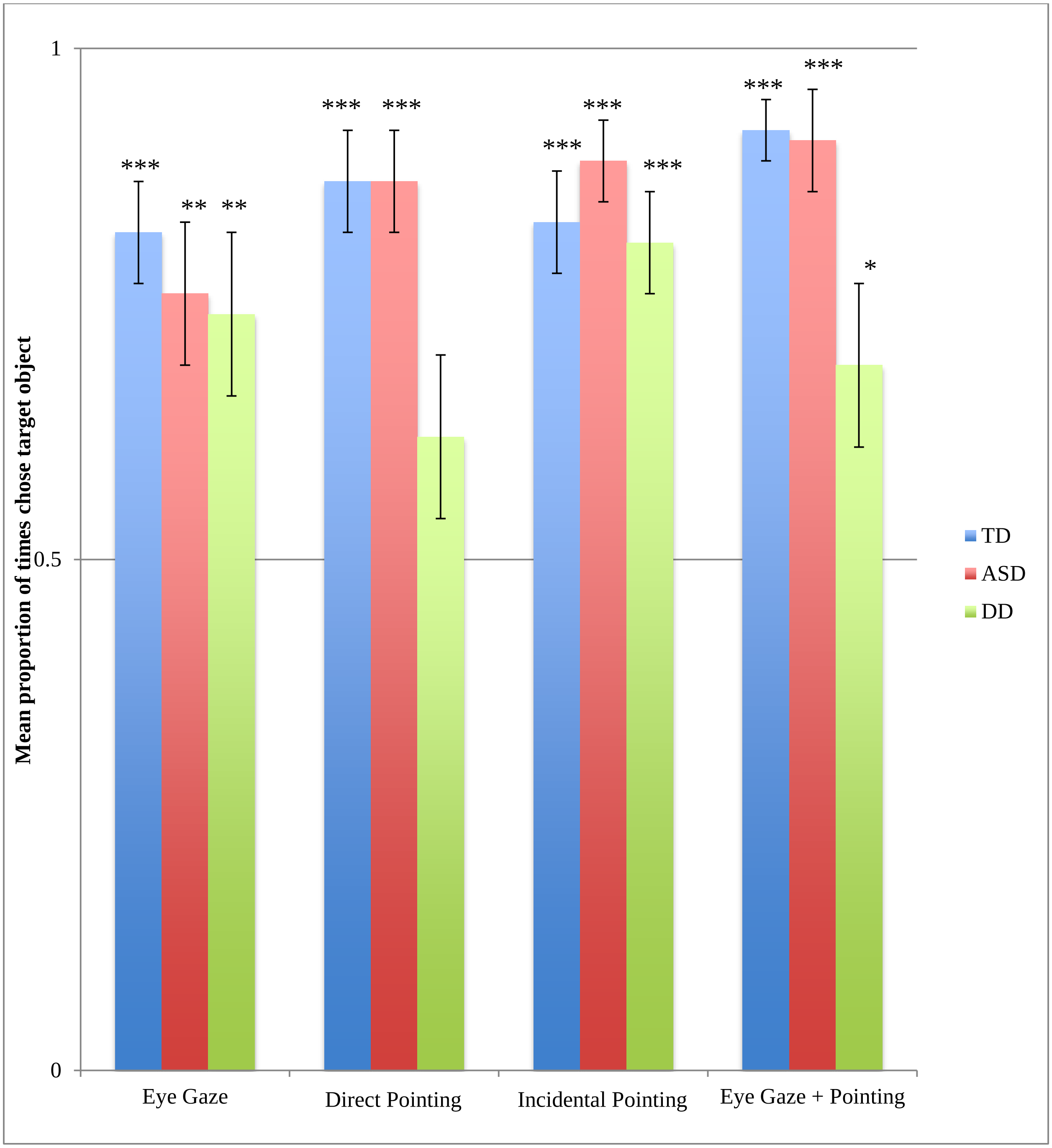

Fig. 10. Mean proportion of times children chose the target object for three groups.

Table 10

Mean proportion of times (SD) children chose the target object for six groups

	TD		***ASD***		***DD***	
	Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Eye Gaze	.84 (.24)**	.77 (.34)*	.55 (.37)	.88 (.28)***	.60 (.46)	.86 (.23)***
Pointing	.87 (.28)***	.86 (.32)**	.75 (.35)	.94 (.17)***	.55 (.44)	.68 (.34)
Pointing inconsistent	.82 (.30)***	.86 (.23)***	.85 (.24)**	.91 (.20)***	.85 (.24)**	.77 (.26)**
Eye Gaze + pointing	.95 (.16)***	.86 (.23)***	.95 (.16)***	.88 (.28)***	.85 (.24)**	.55 (.42)

*p <.05. **p <.01***p <.001.

4.5.1. Eye Gaze

First, I compared performance for each group against chance using one-sample-t-tests.[8] Both groups of TD children (TD low-VMA, $t(18) = 6.25$, p <.001, d = 1.42: TD

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[8] We acknowledge that, if the more stringent Bonferroni correction is applied, using the value of .004 for each of the separate family of six comparisons, the results for four out of the 27 total significant comparisons become non-significant. However, we did not do this following recent criticism against

high-VMA $t(10) = 2.63$, $p = .025$, $d = .79$) chose the target object. However, only the high VMA children with ASD ($t(16) = 5.61$, $p < .001$, $d = 1.36$) and DD ($t(10) = 5.16$, $p < .001$, $d = 1.57$) did so (see Table 10). This suggests that word learning from eye gaze is delayed in ASD *and DD*. In order to further investigate this possibility, a 2 (VMA; High vs. Low) × 3 (Group; TD, ASD, DD) ANOVA was carried out. This revealed a significant main effect of VMA ($F(1, 72) = 5.67$, $p = .002$, $\eta p^2 = .07$). The high VMA children ($M = .85$, $SD = .28$) chose the target object more than the low VMA children ($M = .71$, $SD = .36$). I also found a borderline significant interaction ($F(2, 72) = 3.07$, $p = .052$, $\eta p^2 = .08$). To unpack the interaction, I conducted independent t-tests, which showed that children with ASD with a higher VMA performed significantly better than those with a lower VMA (t(1) = 2.64, p=.014) (see Table 10).

4.5.2. Pointing direct

One sample t-tests against chance showed that the TD-low VMA ($t(18) = 5.72$, $p < .001$, $d = 1.32$) and TD-high VMA ($t(10) = 5.73$, $p = .004$, $d = 1.13$) participants selected the target object, as did ASD-high VMA children ($t(16) = 10.95$, $p < .001$, $d = 2.59$). The results also approached significance for the ASD-low VMA group ($t(9) = 2.24$, $p = .052$, $d = .71$) although neither DD low nor DD high-VMA participants chose the target object.

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correcting for multiple t-tests on the grounds that this procedure inflates the risk of type 11 errors (e.g. Nakagagawa, 2004; Rothman, 1990) or is simply not necessary (Perneger, 1998).

In order to further investigate this deviance for the DD children, a 2 (VMA) × 3 (Group) ANOVA was performed. This revealed a main effect of Group (F(1, 72) = 4.56, p = .014, ηp^2 = .11). Tukey Kramer tests showed that the children with DD performed significantly lower than both ASD (p=.014) and TD groups (p=.007).

4.5.3. Pointing incidental

Contrary to predictions, both groups of TD (low VMA, t(18) = 4.61, p <.001, d = 1.07. High VMA, t(10) = 5.16, p <.001, d = 1.57) and DD (low VMA, t(9) = 4.58, p = .001, d = 1.46. High VMA, t(10) = 3.46, p = .006, d = 1.04) children chose the target object. As predicted, both groups of children with ASD chose the target object (low VMA, t(9) = 4.58, p = .001, d = 1.46. High VMA, t(16) = 8.64, p <.001, d = 2.05) (see Table 10). However, the ANOVA by VMA and Group showed no differences.

4.5.4. Eye gaze and pointing

One sample t-tests showed that the DD-high VMA participants performed at chance, although all other subcategories chose the target object (TD-low VMA, t(18) = 12.37, p <.001, d = 2.81. TD-high VMA, t(10) = 5.16, p <.001, d = 1.57: ASD-low VMA, t(9) = 9.00, p <.001, d = 2.81: ASD-high VMA, t(16) = 5.61, p <.001, d = 1.36: DD-low VMA, t(9) = 4.58, p = .001, d = 1.46) (see Table 10). To test for overall Group or VMA differences, an ANOVA was conducted, which revealed main effects for both Group (F(2,72) = 5.18, p =.008, ηp^2 = .13) and VMA (F(1,72) = 6.41, p = .014, ηp^2 =

.08). The high VMA children chose the target object less often than the low VMA children (*p* <.001). Tukey tests showed that the DD children chose the target object less often than the TD children (*p* = .007) and children with ASD (*p* = .005).

4.5.5. Same position and Reversed position trials

As there was only a single trial of each type within each cue, the trial types were collapsed for this analysis, with the exception of the 'pointing incidental' trials, which were omitted. This was because there was no 'correct' answer for this trial type, with TD and DD children expected to perform at chance. One-sample-t-tests showed that both groups of TD children (TD-low VMA, $t(18) = 13.11$, p <.001, $d = 2.00$, TD-high VMA $t(10) = 4.19$, $p = .002$, $d = 1.25$) and children with ASD (ASD low-VMA: $t(9) = 6.56$, p <.001, $d = 2.00$. ASD high-VMA: $t(16) = 9.16$, p <.001, $d = 2.21$) and the DD-high VMA ($t(10) = 3.06$, $p = .012$, $d = .94$) children chose the target object when the objects were in the same position (see Table 11). Both groups of TD children (TD-low VMA $t(18) = 6.32$, p <.001, $d = 1.48$. TD-high VMA, $t(10) = 4.52$, p <.001, $d = 1.39$) and the ASD-high VMA children also chose the target ($t(16) = 7.68$, p <.001, $d = 1.90$) for the reversed position trials.

Table 11

Mean proportion of times (SD) children chose the target object for the same and reversed position trials for six groups

	TD		***ASD***		***DD***	
	Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Same	.93 (.14)***	.85 (.28)**	.86 (.18)***	.92 (.19)***	.70 (.40)	.79 (.31)*
Reversed	.84 (.23)***	.82 (.23)***	.65 (.32)	.88 (.20)***	.63 (.33)	.59 (.31)

p* <.05. ***p* <.01**p* <.001.

A 2 (Object Position; Same vs. Reversed) × 3 (Group) × 2 (VMA) mixed ANOVA revealed an effect of Object Position ($F(1, 72) = 11.32$, $p = .001$, $\eta p^2 = .14$). Children were more likely to choose the target object for the same ($M = .86$, $SD = .25$) than reversed ($M = .76$, $SD = .28$) position trials. There was no main effect of group, and no interaction.

4.5.6. Correlations between object position, CA, VMA and NVMA

In order to see if word learning from social cues was related to children's CA and NVMA, children were assigned a total proportion of correct responses for all trials combined, except for the pointing incidental cue, as there were no 'correct' answers for these trials.

As children may have differed in terms of their responses to the same and reversed position trials, this analysis was carried out for the same and reversed position trials separately. Thus, children were given a score out of 3, which was converted into a proportion for separate correlations for same and reversed position trials.

For the reversed position trials, the proportion of correct responses was positively correlated with Raven's score for the DD children ($r(20) = .53$, $p = .017$). No other correlations were significant for any groups (see Table 12).

Table 12:

Correlations between proportion of correct responses and CA, VMA and NVMA for same position (top) and reversed (bottom) trials.

	TD	***ASD***	***DD***
VMA	-.04	-.07	-.19
CA	-.07	.21	-.24
Ravens	-.10	-.14	.34

	TD	***ASD***	***DD***
VMA	.14	.32	.34
CA	.12	.09	.10
Ravens	.08	.36	.53*

4.6. Discussion

This study investigated the use of social cues, specifically eye gaze and pointing across typical and atypical development. The main findings indicate that 1) typical and atypical children weighted the distinct social cues in different ways, 2) children with ASD were delayed learning words from eye gaze 3) surprisingly, children with DD were also delayed learning words from eye gaze and were deviant learning words from pointing, and 4) object position affected all three groups. I discuss these findings in turn to provide an integrative account of the role of communicative intent for word learning across atypical and typical development.

Across all groups, there are intriguing comparisons between trials. Children performed well but were not at ceiling in the condition where gaze and pointing were synchronous. Indeed, there was no advantage in this condition over either the pointing alone or gaze (without pointing). This suggests that the one social cue is sufficient, given that in the pointing condition the experimenter is looking directly into the camera and in the gaze condition, the speaker is not providing any gestural information.

Perhaps even more surprising is the finding that incidental pointing is an equally proficient cue as direct pointing, with all three subgroups of children choosing the target object above chance for the incidental pointing trials. This was hypothesised for the children with ASD, who were predicted to not understand that the pointing was unintentional. However, this result is unexpected for the TD children and children with

DD, as previous research has found that these two groups of children ignore pointing and gaze gestures when they appear accidental (Behne et al., 2005; John & Mervis, 2010).

This raises two possibilities: first, children may pick up on the pragmatic cues of a point, even when the speaker is looking away, and this extends even to children with ASD. This is consistent with the more pragmatic accounts of pointing (e.g. Tomasello et al., 2007). Alternatively, the pointing in this (and indeed other conditions) could prompt learning through associative connections (e.g. Samuelson & Smith, 1998). To test these alternative hypotheses, further studies need to present children with a range of pragmatic vs. associative cues. Nevertheless, this study shows that across conditions, typically developing children and their matched peers with ASD appear to respond similarly to a range of attentional cues.

I did find differences in terms of the developmental trajectory of the use of the cues, in that only the children with ASD with a higher VMA were successful using gaze and pointing. These results are consistent with reports showing that younger (Baron-Cohen et al., 1997; Preissler & Carey, 2005) but not older children (Akechi et al., 2011; Norbury et al., 2010) with ASD have difficulties learning words from eye gaze. It is worth noting, however, that the low VMA group had a mean VMA of almost 4 years, which is much greater than the age at which one would expect successful use of these strategies for word learning in typical development. It is also possible that high VMA children with ASD have increased experience with word learning interventions, which focus specifically on joint attention (Prizant et al., 2002; Mundy et al., 1990).

When gaze and pointing were coupled, the performance of the children with ASD mirrored the TD group. Akechi et al (2013) showed that a point in combination with a gaze cue increased word-learning performance in ASD. They leave open the question of whether pointing increases the salience of the speaker's referential intent or whether instead children hone in on the point, to the exclusion of gaze. In our study, we measured pointing when the actor gazed into the camera, therefore providing no gaze information and a direct test of these hypotheses. We found that the older VMA children with ASD were successful, but results from the younger group only approached significance. Children with ASD were able to use a pointing cue when this was decoupled from gaze, but results only approached significance for the lower VMA subset.

A potential reason as to why the results for the low VMA children with ASD only approached significance for the direct pointing but was significant for the incidental pointing is that children with ASD have an aversion to being looked at and looking at others faces (e.g. Dalton et al., 2005; Hanley et al., 2014; Hutt & Ounsted, 1966). The only trials where the speaker looked towards the child as the object was named occurred for the direct pointing; for the gaze and gaze coupled with pointing trials he looked towards the object and for the pointing incidental condition he looked off into the distance. Gaze aversion could be a contributing factor for why the children with ASD performed above chance for the pointing incidental but not pointing direct trials; in the pointing incidental condition the speaker was not looking at them, therefore they may have been able to concentrate more fully on the task, rather than avoiding the speaker's eye gaze.

Perhaps more surprising was that the DD children were so impaired at forming word-object mappings from social cues. It is especially unexpected that they performed worse than the children with ASD for the pointing direct cue, given previous findings that DD children show a better understanding of pointing than children with ASD (Landry & Loveland, 1988; Loveland & Landry, 1986) and children with Down Syndrome and Williams Syndrome attribute communicative intent to gazing and pointing gestures (John & Mervis, 2010). However, the results of this study support Arens et al., (2005), who found a limited understanding of gaze in infants at risk for DD and Laing et al., (2002) who found that children with Williams Syndrome were impaired following pointing.

Several factors may contribute to the DD children's difficulty with using social cues to form word-object mappings. Perhaps children with DD are using different processes from TD children – and even children with ASD – to learn words. Supporting this claim, Raven's score was positively correlated with proportion of correct responses for the pointing consistent trials for the DD children only. This seems to be driven by the reversed position trials, as the DD children's performance on the same position trials was not correlated with the Raven's. Choosing the correct object for the reversed position trials may be related to spatial ability, as DD children possess poor spatial skills (Swanson, 1993).

In addition to poor spatial skills, slow processing speed might contribute to the poor performance of the DD participants. Slow processing speed is common in DD children, having been found to be present in children with Down Syndrome (Silverman, 2007), specific language impairment (Miller, Kail, Leonard, & Tomblin, 2001), fetal alcohol syndrome (Burden, Jacobson & Jacobson, 2005) and who were born pre-term (Mulder, Pitchford & Marlow, 2011). The DD participants in this study might have spent a longer length of time trying to make sense of the visual scene, which moved on too quickly for them to fully process.

Slow processing speed may have particularly affected the pointing trials, as the speaker looked directly ahead while pointing. If the DD children were fixated on the speaker's face, expecting him to look at the object as he spoke, they may not have noticed his pointing gesture. For the pointing inconsistent trials, the DD children may have noticed that the speaker's face was fixating into the distance, without providing any social information and so were able to switch their own gaze to the speaker's point more easily than in the pointing condition. However, note that I did not include any measures of processing speed in this study, therefore this claim requires empirical testing.

It is also the case that the DD children included in this study were very heterogeneous in terms of their disorder. Children with different conditions sometimes show differing performance in tasks involving understanding social cues (John & Mervis, 2005). Thus, it is possible that a deficit in understanding pointing is not universal in DD children, but only occurs in certain DD's. Therefore, future work should aim to include a measure of processing speed and investigate understanding of eye gaze and pointing in groups of children with specific conditions, such as a whole cohort with intellectual disability or a whole cohort with Down Syndrome. The heterogeneity of our sample might also explain why the lower VMA children could utilise synchronous gaze and pointing cues, but the higher VMA children were clearly at chance for these trials. At the same time, the higher VMA children could follow gaze alone. One further explanation of these findings is that children with DD may find it difficult to discern the meaning of and process two simultaneous cues (Kovattana & Kraemer, 1974)

Although both groups of TD children learnt words from both the same and reversed position trials, only the high VMA children with ASD did so for the reversed position trials. Like eye gaze, word learning from reversed position trials appears to be delayed in ASD. This critical result suggests that, unlike TD children, children with ASD originally map words simply to spatial location, instead of taking into account higher-level object properties such as the specific and unique appearance of the object. This may help explain why children with ASD initially find it difficult to form and retain word-object mappings. This is not specific to ASD and may be an effect of more general cognitive delay, as children with DD were also unable to form word-object mappings from the reversed position trials.

In summary, this study has found that TD children learn words from both eye gaze and pointing. Supporting past research, children with ASD learn words from pointing but have a delay learning words from eye gaze. Children with DD also have a delay learning words from eye gaze, but an assumed deviance learning words from pointing. Therefore, these findings suggest that DD children actually have *more* difficulty word learning from social cues than children with ASD and highlight the importance of including an additional control group of DD children in ASD research.

The results for the TD children support the emergentist coalition model, which predicts that TD children learn words from social cues from two-years-old. Surprisingly, however, the TD children also learnt words from the incidental pointing. As previously discussed, this could be because they were learning words through association or because they assumed that the pointing must be intentional. Studies Four (associative cues) and Five (conflicting cues) help explore in more detail whether TD children are associative, as well as social, word learners or whether they simply inferred referential intent from both types of pointing. As the high VMA children with ASD learnt words from the gaze and pointing direct cue but the low VMA children with ASD did not, these results suggest that, like TD children, different cues are important at different developmental time points for children with ASD. The findings also suggest a delay effect for word learning from social cues in ASD. Study Four establishes whether the low VMA children with ASD rely on association rather than social cues for word learning, as the emergentist coalition model would predict.

Chapter Five: **Dumb associative mechanisms? Are some associative cues stronger than others?**

5.1. Introduction to the study

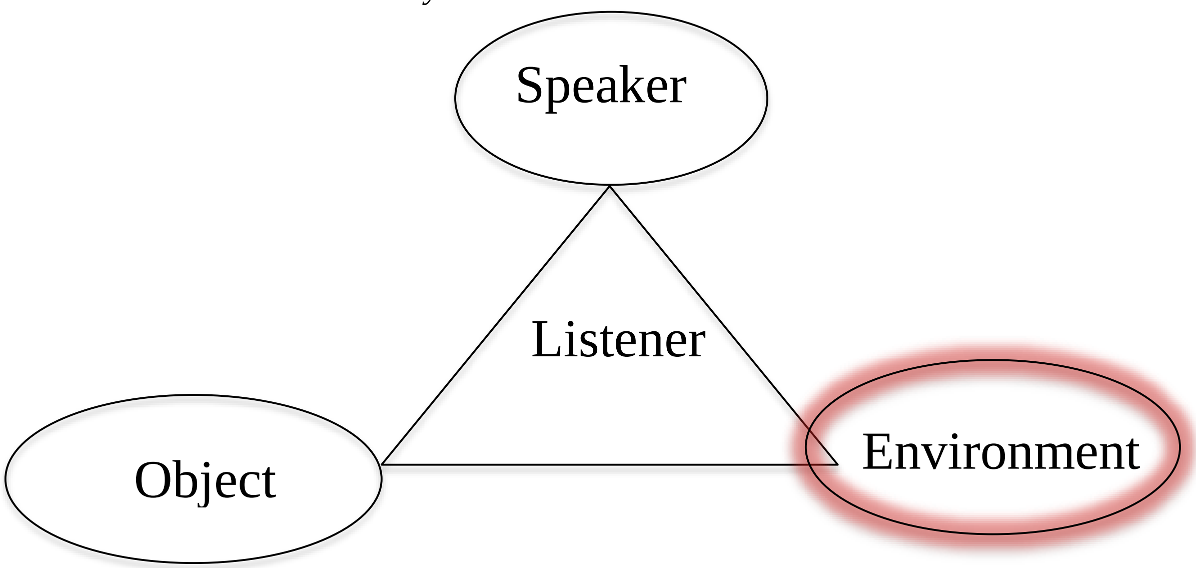

Figure 5.1: Visual interpretation of the speaker – object – environment interaction for word learning. This chapter will focus on the 'environment' aspect of the triad.

Study Three has established that, as expected, both high and low VMA TD children learnt words from social cues but only the high VMA children with ASD learnt words from the speaker's gaze and pointing when the cues were presented singularly. These findings support the delay account of word learning with regards to children with ASD. As the TD children all had a CA and VMA over two-years-old, the results also support past research, which has found that TD children learn words from social cues from 18-24 months old (e.g. Hollich et al., 2000).

In order to further investigate language acquisition in ASD, the current study explored how children learn words from associative cues, specifically an arrow and light, to see if one or both is/are sufficient cues, if they provide differential access to word learning and if word learning from these cues varies according to group (TD, ASD or DD). For example, it might be the case that one cohort of children learn words from the arrow but not light, although the other two groups learn words from both type of cue. This may suggest that the cues differ in how they highlight attention.

Although it is important to study word learning from referential intent, other factors also facilitate language acquisition. Indeed, children cannot acquire words solely through cues such as eye gaze, as an estimated 30-50% of the time the speaker is not looking at the object they are naming (Bloom, 2000). According to the associative learning account (e.g. Axelsson et al., 2012; McMurray, Horst, & Samuelson, 2012; Saffran et al., 1996; Samuelson & Smith, 1998; Smith et al., 1996), when a speaker utters a novel word, the child associates the word with the referent based on relative frequency and similarity with previously stored objects. This theory stresses that children learn words not through referential intent but instead by 'dumb associative mechanisms', such as memory and attention (Samuelson & Smith, 1998; Smith et al., 1996).

Importantly, however, it might not be the case that *any* cue which highlights attention towards an object facilitates children's word-object mappings. Children may weigh some indicators more heavily than others. Two of the studies discussed within the previous chapter; Woodward (1998) and Krehm et al., (2014) provide evidence for this, albeit in goal inference rather than word learning paradigms.

Woodward (1998) showed infants a scene in which an agent's hands reach in either the same or a different location for a toy that has been moved. In a habituation paradigm, infants looked longer when the hand reached in the same location for a different toy than in a different location for the same toy. This effect was not found when inanimate objects, such as rods, were used (Woodward, 1998). Similarly, Krehm et al., (2014) found that infants look longer when a recipient picks up a different object from the one an actor has previously pointed to, but this effect is not found when the actor uses a fist instead of a point.

Taken together, these studies (Krehm et al., 2014; Woodward, 1998) suggest that children do not place equal weighting on all cues within goal inference paradigms, recognising that only humans have goals. In Woodward et al., (1998), the children do not expect non-human agents to reach for the same toy; therefore an associative cue is not sufficient in this scenario. In Krehm et al., (2014), the participants knew that a fist is not a socially conventional cue to indicate an object, thus they were not surprised when the recipient picked up a different object in this context. However, further research is needed, in order to establish if the findings that children attend to some types of associative sign more than others extend to word learning paradigms, older participants than the infants previously tested and atypically developing children.

Just as cues from the speaker can facilitate goal inference, specific cues within the environment are also important in facilitating word-object mappings. Signs act as physical markers, which give a direct indication as to what is being referred to (Syal & Jindal, 2007). Peirce (1931) identified three kinds of sign; icon, index and symbol. Iconic signs possess a resemblance of the thing they portray, such as a picture of a face. Index signs are correlated to the thing that they represent, such as tears indicating sadness. Symbols involve using something to represent something else (DeLoache, 2004). The thing being referred to is connected with the thing doing the referring only by a somewhat arbitrary convention (Bruner, 1966; Peirce, 1931).

Of the three types of sign identified by Peirce (1931), word learning primarily takes place through attending to symbols, although there are occasions where iconic or index cues are involved in language acquisition. Onomatopoeic words, for example, act as icons. Further, someone may utter ‘book’ in the presence of a book, in which case it serves as an index cue, as the word correlates with seeing the object. According to the association account, children learn words from cues such as eye gaze and pointing not due to referential intent, but because they act as directives towards the object being named.

Perceptually salient stimuli may also act as directives between the signifier (e.g. an arrow) and the signified (e.g. novel object) (see Figure 11). Although this relationship could be considered dyadic, consisting only of the relationship between the cue and object (Saussure, 1983), importantly, someone needs to *interpret* these signs as relevant to word learning; otherwise they are meaningless (Peirce, 1931). Therefore, a triadic relationship takes place, between the signifier, signified and person interpreting the sign (see Figure 11). Figure 11 can be read in two ways. If the person is the child, s/he has to link the signifier (arrow) with the signified (starry object). In that sense the relationship between the two need only be an associational one.

Alternatively, Figure 11 can also depict what the child sees on the screen in studies 3-5. The child views a human agent, presumably with referential intent, naming the novel object. The arrow in Figure 11 coincides with this utterance, thus the arrow may not be purely associational in its link with the object. Indeed, an adult observer might infer that the agent is helping them to signal which of the two objects is being identified.

I will return to this issue in the discussion (section 5.5.). For now, I will assume that the child need only link the label, the signifier and the signified. Furthermore, importantly, this paradigm only works if the speaker's naming is perceived as being intentional, as in Studies 3-5; the same effect is not found when the voice is disembodied from the word learning situation, such as someone speaking on the telephone (Baldwin et al., 1996).

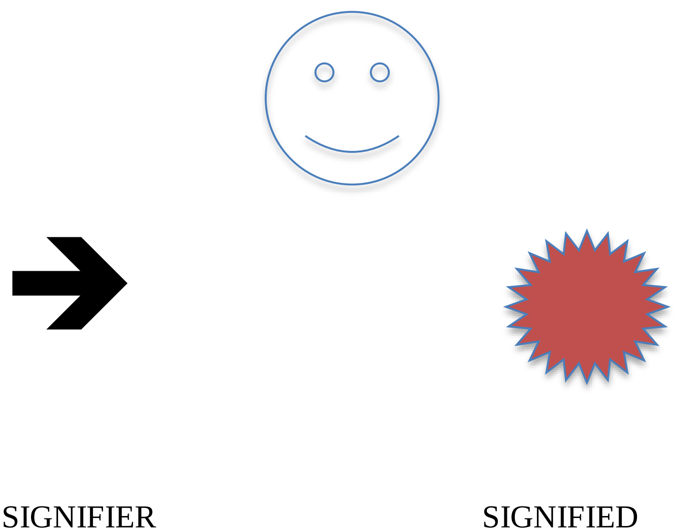

Figure 11: Visual interpretation of how associative cues can facilitate word learning.

Word learning from perceptual salience and cross-situational consistency may help explain how children with ASD are able to acquire language. These children have difficulties inferring referential intent (D'Entremont & Yasbek, 2007; Prizant & Wetherby, 1987) and forming word-object mappings from social cues (e.g. Baron-Cohen et al., 1997; Preissler & Carey, 2005). Study Three showed that they are delayed forming word-object mappings from a speaker's gaze and, to a lesser extent, pointing.

Despite difficulties learning words from social cues, research suggests that children with ASD form word-object mappings from statistical input (Mayo & Eigsti, 2012). Furthermore, they respond to arrows in reflective orienting paradigms (Rombough & Iarocci, 2013; Senju et al., 2004; Vlamings et al., 2005), which measure participants' tendency to look towards a location after it has been cued (correctly or incorrectly) by a stimulus such as an arrow or direction of the interlocutor's eye gaze. As has been stated earlier, children with ASD may even use an arrow, rather than eye gaze, to infer a character's goals and desires (Baron-Cohen et al., 1995). If simple perceptual salience facilitates language acquisition in children with ASD, then it would be predicted that *any* cue drawing attention to a target object would cause children to form word-object mappings towards this object.

However, other than arrows, the question of whether associative signs facilitate word learning in children with ASD has been largely overlooked. One study which contrasted an objects' perceptual salience with a speaker's eye gaze (Hennon, 2003) will be described in the next chapter because it more directly relates to association conflicting with social cues. The role association per se plays in facilitating word learning in children with ASD has previously been explored in both intervention programs, such as Applied Behavioural Analysis or ABA (Lovaas, 1987) and past literature on ASD (e.g. Parrish-Morris et al., 1997; Preissler, 2008; Preissler & Carey, 2005). The present study aimed to extend these earlier studies by investigating different associative indicators (i.e. an arrow and a light), which has not been so fully explored within the ASD literature.

There has been some research exploring word learning from associative cues – other than arrows - in TD children. These include object illumination (Axelsson et al., 2012), object motion (Houston-Price, Plunkett & Duffy, 2006; Moore et al., 1999) and perceptual salience (Hollich et al., 2000). Axelsson et al., (2012) investigated children's word learning and retention in four contexts; a target object was illuminated, a target object was illuminated and two distractor objects were covered over, the distractor objects were covered over, the experimenter pointed at a target object.

Children formed word-object mappings and maintained these over time from object illumination when presented alone and when presented alongside the covering over of the distractor objects. However, children formed word-object mappings but did not maintain these over time when the distractor objects were covered over alone and when the experimenter pointed at a target object. This suggests that, while both pointing and object illumination help TD children initially form word-object mappings, they are more likely to remember the names of target objects when they are highlighted by object illumination, rather than pointing. Hence, in some cases association may facilitate children's word retention more than social cues.

Although it is surprising that the participants did not maintain word-object mappings from pointing in Axelsson et al., (2012), note that the children formed word-object mappings from all four cue types, suggesting that both pointing and object illumination helps children learn words, although only object illumination facilitated children remembering these word-object mappings over time. Further, the children included in Axelsson et al., (2012) were relatively young (24-months-old). Therefore, they may only just have been at the stage where they utilise social cues for word learning (e.g. Hollich et al., 2000; Moore, Angelopoulos & Bennett, 1999), still relying primarily on association for retention. It is possible that older children than the participants in Axelsson et al., (2012) would maintain the word-object mapping from the pointing cue.

Axelsson et al. (2012) only recruited TD children as participants, thus it is unknown whether object illumination would facilitate word learning in children with ASD and DD. Further, although they included a condition where the salience of the *distractors* were dampened, they did not explore the effect of conflicting salience towards *different targets*, such as object illumination towards one object at the same time as an arrow is positioned towards the other. It is important to investigate contrasting associative cues in order to establish if children weigh one type of cue more heavily for word learning than another.

If this is the case, this would suggest that it is not association *per se* that is facilitating children's word object-mappings but something specific about certain indicators. For example, TD children might learn words more easily from positioning an arrow towards an object than simply making an object perceptually salient, due to awareness that objects that are exciting to look at are not necessarily the objects being named. Alternatively, children might learn words from associative cues equally, suggesting that 'dumb associationist mechanisms' facilitate word-object mappings.

Individuals with ASD might be particularly likely to learn words from one type of associative cue but not others. As previously discussed, past research has tended to focus on arrows in this population, finding that they attend strongly to this cue (e.g. Baron-Cohen et al., 1995; Rombough & Iarocci, 2013; Vlamings et al, 2005). It is possible that there is something about arrows per se which children with ASD are attracted to and the same effect would not be found with other associative cues. Children with ASD tend to have unimpaired spatial skills (e.g. Frith, 1989; Joliffe & Baron-Cohen, 1997; Shah & Frith, 1993) and arrows are commonly used to signal directional information. Thus arrows may provide good spatial reference for children with ASD.

Furthermore, arrows are conventional, frequently seen within society and possess a strong spatial meaning (Hommel, Pratt, Colzato & Godijn, 2001). The physical appearance of an arrow bears some resemblance to the physical appearance of a pointing gesture. Therefore, presenting an arrow cue parallels the more human scenario of pointing. Of course, this may apply to all groups, but they need to be compared to explore the issue further.

The present paradigm explores the effect of two types of associative cue – positioning an arrow by the object and the object lighting up - on the word learning of TD children, children with ASD and DD children. I chose to investigate arrows as a baseline, as these are commonly explored within the literature. However, past studies have tended to focus on reflective orienting (e.g. Senju et al., 2004) and inferring a character's goals and desires (e.g. Baron-Cohen et al., 1995), thus this study extends this to word learning. As discussed within the previous paragraph, arrows are also a common directional cue and thus would be easily recognisable and familiar to the children. Furthermore, the arrow used within this study provides a parallel to the direct pointing, which was explored in Study Three.

I also chose to extend the work of Axelsson et al., (2012) by investigating object illumination. This provides a ‘softer’ form of associative cue from the arrow. The light is non-directional but ‘on’ the object, whereas the arrow is purely directional. The stimuli are illustrated in Figure 12 within the methodology section and consist of a red arrow which is slightly curved to reduce perceptual salience, with a patch or red (exactly the same colour) which encircles the object for the same time as the arrow. This way I was able to compare the salience of the two comparable stimuli. The colour of the arrow is also consistent with Baron-Cohen et al., (1997), who used a red arrow in their paradigm.

5.2. Description of the present study

This study investigates word learning from associative cues and whether children’s word learning is facilitated more from one type of cue than another. As with Study Three (see Chapter 4), children are shown a video of a speaker and two objects, with the speaker uttering a novel word to refer to one of the objects (e.g. *‘there’s a kela’*), as a cue is produced. The objects are then shown, side by side, and the children select the *‘kela’*. As in Study Three, for half of the trials the objects are positioned in the same location as in the earlier video, while for the remaining half of the trials, the objects are in reversed position. As explained within Study Three, this manipulation took place in order to establish if children formed word-to-referent mappings (in which case, they would be predicted to choose the target object for both the same and reversed position trials) or word-to-location mappings (in which case, they would be predicted to only choose the target object for the same position trials).

In order to test the delay vs. deviance hypothesis, the children are split into low and high VMA subcategories. Study Three found that children with ASD need a higher VMA than TD children to learn words from social cues, supporting past research (e.g. Akechi et al., 2011; Norbury et al., 2010), although past studies have suggested that children with ASD learn words from association (e.g. Hennon, 2003). Therefore, both groups of children with ASD were predicted to learn words from the associative cues. However, as past research has found that children with ASD attend strongly to arrows (e.g. Baron-Cohen et al., 1995; Rombough & Iarocci, 2013; Vlamings et al, 2005), these children are predicted to form word-object mappings from the arrow to a stronger extent than the light.

As TD children have previously been found to learn words from association from infancy (e.g. Hollich, 2000) and as this study does not include any conflicting social cues, both high and low VMA TD children were hypothesised to form word-object mappings from the arrow and light. The surprisingly poor performance of the DD children for Study Three leaves open the possibility that DD children learn words from association, rather than referential intent, although this cannot be directly tested until Study Five, as this is the only paradigm within this thesis which directly pits social and associative cues together. An alternative hypothesis is that the DD children have a global deficit in word learning, thus are impaired forming word-object mappings from any type of cue, whether it is social or associative.

Evidence in support of the latter possibility comes from Evans, Saffran & Robe-Torres (2009), who found that DD children have difficulty with processing and remembering statistical input, which might suggest a deficit learning words from association. Participants with specific language impairment (SLI), who had a mean CA of nine listened to a new ‘language’ where transitional properties within words were higher than those between words. Following this, children were then played ‘words’, with the same transitional properties and ‘non-words’, with different transitional properties from those previously heard.

Relative to a control group of CA matched TD children, the participants with SLI had difficulties discriminating the transitional properties within and between words. However, note that this study only included DD children with SLI. These children, by definition, have difficulties with language, which likely contributed to their poor performance on this task. Evans et al., (2009) also had a different methodology to the present research, which investigates word learning from two specific associative cues in a more heterogeneous group of DD children.

In addition to presenting the arrow and light cues separately, this study includes ‘arrow vs. light’ (where an arrow occurs towards one object as the other object simultaneously lights up) and ‘arrow + light’ (where the arrow and light occur simultaneously towards the same object) trials. The arrow vs. light cue was included as a baseline, in order to establish if children have a preference for one type of cue over another. The TD and DD children were predicted to choose at chance for this trial type, as there is no ‘correct’ answer for this cue. However, the children with ASD were predicted to choose the object suggested by the arrow, based on their relatively high levels of spatial ability (e.g. Baron-Cohen, 2008; Jarrold et al., 2005; O’Riordan, Plaisted, Driver & Baron-Cohen, 2001; Reser, 2011) and the results of past studies (e.g. Baron-Cohen et al., 1995; Pruet et al., 2011; Rombough & Iarocci, 2012; Senju et al., 2004; Vlamings et al., 2005).

Just as Study Three included a gaze and pointing combined cue, this study includes an arrow and light combined cue, as providing the two cues together may facilitate children choosing the target object. The low VMA children with ASD in Study Three, for example, chose the target object for the gaze and pointing combined cue, but not when the gaze or pointing occurred alone. However, they were borderline above chance for pointing, suggesting that the cue on its own was not quite enough to facilitate word learning, but it was when combined with eye gaze. This study also includes a ‘combined’ cue, as it might have been the case that one or more groups of children do not learn words from the arrow and/or light when they were separately presented but they do when they are presented together.

Consistent with Study Three, this study used same vs. reversed position trials, in order to establish if children were forming word-to-object or word-to-location mappings. Interestingly, for this study, the arrow itself provides a directional cue as to which object is being labelled as it occurs *towards* the artefact, while the light does not as it occurs directly *on* the artefact. As the arrow alerts children to object location, it will be interesting to see if this relates at all to children's performance for the same and reversed position trials. For example, it might be the case that children who form word-object mappings from the arrow trials are more likely to score higher for the same and reversed position trials, as they are able to follow directional indicators.

As Study Three found that children with ASD were delayed forming word-to-object mappings, it is predicted that these results will be replicated; the low-VMA children with ASD were again predicted to learn words from the same but not the reversed position trials. The TD children are predicted to form word-object mappings for both the same and reversed position trials, just as they learnt words from both type of trial in Study Three. Unexpectedly, only the high VMA DD children formed word-object mappings from the same position trials and neither group of DD children formed word-object mappings from the reversed position trials for Study Three. This surprising finding is hypothesised to be replicated in this study.

If the DD children are unimpaired on the same and reversed position trials relative to Study Three, this suggests that there is something specific to word learning from social cues which causes the DD children's deficit. Perhaps they were finding it so hard to learn words from the social cues, particularly pointing, that this also affected their ability to remember the spatial location of the objects. They might, for example, have experienced 'information overload' when the point coincided with the gaze and this might explain their paradoxically poorer performance. However, if the DD children's performance is also impaired for the same and reversed position trials in this study, this suggests that their difficulty is not specific to social cues and thus it is the task itself that they struggle with. This might contribute towards understanding the nature of intellectual disabilities. For example, these children might experience slower processing speed and/or spatial difficulties, which contribute to their poor performance on these kind of paradigms.

5.3. Method

5.3.1 Participants

Children were recruited from the same establishments as in Study Three, with the same ethical permission granted from Lancaster University. All children in the two clinical groups had been diagnosed with their disorder, as in Study Three. Two participants (both ASD) were excluded from the study for non-compliance (N = 1) or refusal to complete the BPVS (N = 1), leaving a total of 85 children participating in the study (TD, N = 32: ASD, N = 31: DD, N = 22). Sixty-one participants were male (19 TD, 27 ASD, 15 DD) and 24 were female (13 TD, 4 ASD, 7 DD). The majority of children (N = 77) also took part in Study 5, with task order counterbalanced for these children. See Table 13 for the participant demographics.

Table 13 Participant demographic details

	TD		*ASD*		*DD*	
	Low VMA N = 18 9 males	*High VMA N = 14 10 males*	*Low VMA N = 12 11 males*	*High VMA N = 19 16 males*	*Low VMA N = 10 8 males*	*High VMA N = 12 7 males*
Mean CA	3.54	5.16	9.40	10.22	7.99	9.21
(SD)	(.44)	(1.60)	(2.73)	(2.05)	(1.75)	(1.87)
Mean VMA	3.77	6.33	3.72	6.65	3.59	6.01
(SD)	(.57)	(1.51)	(.58)	(1.49)	(.53)	(1.25)
Mean Ravens	9.83	19.46	15.55	19.89	10.38	16.18
score (SD)	(2.09)	(9.13)	(8.15)	(8.72)	(4.17)	(8.48)
Mean CARS	15.17	15.08	39.04	32.79	26.63	21.00
score (SD)	(.58)	(.20)	(6.81)	(5.17)	(4.72)	(3.66)
Mean SCQ	3.42	1.00	19.67	14.36	10.89	6.50
score (SD)	(1.38)	(1.55)	(5.48)	(5.82)	(6.13)	(4.57)

5.3.2. Design

A 3 (Group; TD, ASD, DD) × 4 (Trial Type; Arrow, Light, Arrow + Light, Arrow vs. Light) × 2 (Object Position; Same vs. Reversed) Mixed Factorial design was employed.

5.3.3. Cognitive tests and CARS and SCQ scales

The BPVS (Dunn et al., 1997) and Raven's (Raven, 2003) were administered as in the previous studies. For the majority of children, a parent or teacher completed the CARS (Schloper et al. 1988) (18 TD, 24 ASD, 16 DD) and the lifetime version of the SCQ (Rutter et al., 2003) (18 TD, 23 ASD, 17 DD) to confirm or rule out ASD. As with Study Three, only one child (ASD) did not score according to their diagnosis on either questionnaire. That child was not excluded from the study for the same reasons given in the previous three studies for keeping these children in the sample; removing this child from the analyses led to almost identical results and he had been officially diagnosed with ASD.

5.3.4. Materials

The materials used in this study were similar to the materials used in Study Three, although a different speaker and object were used. The video (see Figure 12 for a sample arrow vs. light trial) was created which showed a speaker seated at a table covered with a white tablecloth. The novel objects were later superimposed onto the video, using iMovie, with one novel object to the speaker's left and one novel object to the speaker's right. A powerpoint presentation of the two objects side by side, with a white background, was then shown. For half of the trials, the objects appeared in the same spatial location as shown on the previous video, while for the remaining half of the trials, the position of the objects had reversed. The videos were edited and transfered onto a 1090×1080 laptop computer.

Figure 12: Example image of an arrow vs. light trial

5.3.5. Procedure

The video followed the same format as Study Three, although a different speaker and cues were used (see Figure 12 for an example trial). After three seconds, the speaker uttered '*There's a kela* (*yok/bem/lif/mido/dofa/archo/lepid)*', at the same time as an associative cue was produced.

For two trials, an arrow pointed towards the target object, for two trials a red hue lit up the target object, for two trials the arrow and light co-occured towards the same object and for two trials an arrow was positioned towards one object as the other object lit up.

With the cue still visible, the speaker uttered, for instance, '*it's a kela!*' Following this, the cue disapeared. As in Study Three, four different videos were created, for counterbalancing purposes. Children then viewed the powerpoint presentation of the two objects, either in the same (half of the trials) or reversed (remaining half of the trials) spatial location. Due to non-compliance, one child (ASD) did not complete two trials.

5.4. Results

As with Study Three, proportions were used instead of frequencies as one child (ASD) did not complete the arrow reversed position trial or arrow + light same position trial, due to non-compliance. For all analyses, CA and NVMA (as measured by the Ravens) were included as continuous covariates in ANCOVAs, to control for age and spatial ability having an effect on the tasks.

In order to test the delay vs. deviance hypothesis, the analyses were conducted for three (TD, ASD, DD) and six (TD-low VMA, TD-high VMA, ASD-low VMA, ASD-high VMA, DD-low VMA, DD-high VMA) groups. Results for all trials are depicted in Figure 13 (for three groups) and Table 14 (with the groups split by VMA) and verbally presented below.

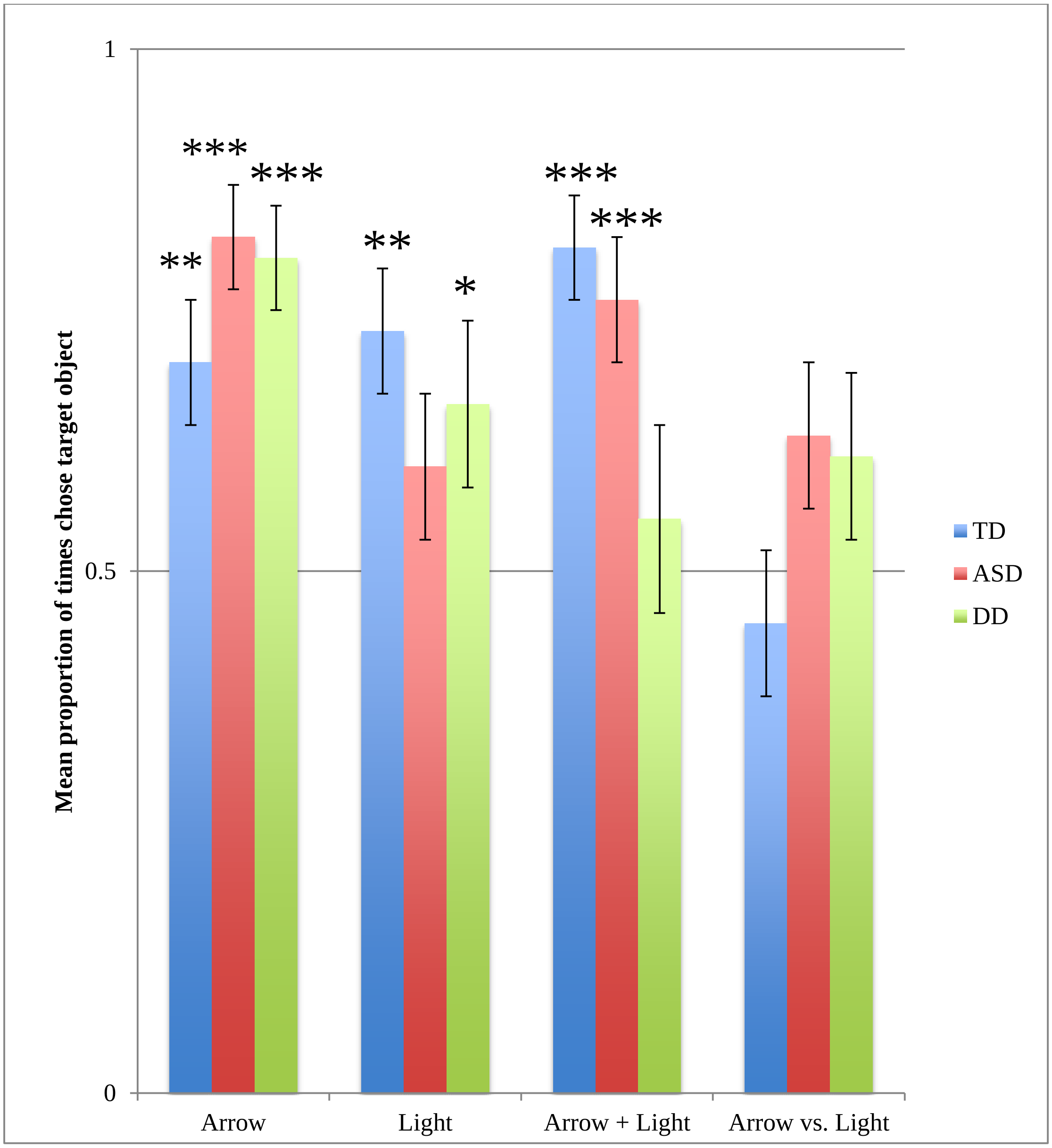

Figure 13: Mean proportion of times children chose the target object for three groups

*p <.05. **p <.01. ***p <.001.

Table 14:

Mean proportion of times (SD) children chose the target object for six groups

	TD		***ASD***		***DD***	
	Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Arrow vs. Light	.47	.43	.67	.61	.55	.67
	(.36)	(.23)	(.33)	(.46)	(.37)	(.39)
Arrow	.58	.86	.67	.92	.80	.79
	(.31)	(.31)**	(.33)	(.19)***	(.26)*	(.26)*
Light	.64	.86	.50	.66	.65	.67
	(.38)	(.31)**	(.37)	(.41)	(.34)	(.39)
Arrow + Light	.92	.68	.67	.82	.55	.54
	(.26)***	(.32)	(.33)	(.30)***	(.37)	(.45)

*p <.05 ** p <.01***p <.001

5.4.1. Arrow vs. Light

This baseline trial was included in order to establish if children rely on one type of associative cue more than the other for word learning. The TD and DD children were hypothesised to perform at chance, while the children with ASD were hypothesised to choose the object suggested by the arrow, as previous paradigms have found that these children attend to arrows in goal inference and reflective orienting paradigms (e.g. Baron-Cohen et al., 1995; Pruett, 2011; Rombough & Iarocci, 2012; Senju et al., 2004; Vlamings et al., 2005). As there was no 'correct' answer for this cue, the proportion of times children chose the object suggested by the arrow was arbitrarily chosen to be compared against chance. All three groups of children chose an object randomly both for the combined sample and when split by VMA (see Table 14). A 3 (Group) × 2 (VMA) Factorial ANCOVA found no effect of Group or VMA.

5.4.2 Arrow

One sample t-tests with a chance level of .50 were carried out, for both the combined and VMA-split groups. As the means indicated (TD = .70, *SD* = .33: ASD = .82, *SD* = .28: DD = .80, *SD* = .25), all three groups of children chose the target object above chance levels[9] (.50) (TD, $t(31) = 3.46$, $p = .002$, $d = .61$: ASD, $t(30) = 6.52$, p <

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[9] I acknowledge that the more stringent Bonferroni correction could have been applied for all analyses. Using this adjustment, the alpha value becomes .004 for the 3 group comparisons of trial type, .002 for the 6 group comparisons of trial type, .02 for the same vs. reversed position trials for 3 groups and .01 for the same vs. reversed position trials for 6 groups. This means that the DD children no longer chose the target object for the light and the DD low-VMA children no longer chose the target object for the arrow. The DD children no longer chose the same object for the reversed position trials, the TD low VMA children and DD high VMA children no longer chose the target object for the same position trials and the DD low VMA children no longer chose the target object for the reversed position trials. However, I did not do this following recent criticism against correcting for multiple t-tests on the grounds that this procedure inflates the risk of type 11 errors (e.g. Nakagagawa, 2004; Rothman, 1990) or is simply not necessary (Perneger, 1998). Note also that, even applying this correction, the vast majority of the significant comparisons

.001, *d* = 1.14: DD, *t*(21) = 5.51, *p* <.001, *d* =1.20). When subdivided by VMA, the TD-high VMA (*t*(13) = 4.37, *p* = .001, *d* = 1.16), ASD-high VMA (*t*(18) = 9.80, *p* <.001, *d* = 2.21), DD-low VMA (*t*(9) = 3.67, *p* = .005, *d* = 1.15) and DD-high VMA (*t*(11) = 3.92, *p* = .002, *d* = 1.12) all chose the object indicated by the arrow (see Table 14). A 3 (Group) × 2 (VMA) factorial ANCOVA found an interaction between Group and VMA (*F*(2) = 5.20, *p* = .008, ηp^2 = .13). To unpack this interaction, three independent samples t-tests were carried out, which revealed that the high VMA TD children (*t*(30) = -2.50, *p* = .018, *d* = -0.90) and high VMA children with ASD (*t*(29) = -2.46, *p* = .026, *d* = -0.93) chose the object suggested by the arrow more than their low VMA counterparts. However, there was no difference between the high and low VMA DD children.

5.4.3. Light

The one sample-t-tests showed that both the TD children (*M* = .73, *SD* = .36) and DD children (*M* = .66, *SD* = .36) chose the target object above a chance level (TD: *t*(31) = 3.70, *p* <.001, *d* = .64. DD: *t*(21) = 2.08, *p* = .050, *d* = .44), although the children with ASD chose randomly (see Table 14). When subdivided according to VMA, only the TD-high VMA children chose the target object (*t*(13) = 4.37, *p* = .001, *d* = 1.16) (see Table

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remain significant (6/7 for three groups and 6 groups, all comparisons for the 3 groups same position, 2/3 for the 3 groups reversed position, 4/6 for 6 groups same position and 5/6 for 6 groups reversed position).

14). Neither Group nor VMA had an effect on choosing the target object for the 3 (Group) × 2 (VMA) factorial ANCOVA.

5.4.4. Arrow + Light

One sample-t-tests showed that both TD children (*M* = .82, *SD* = .30, *t*(31) = 5.81, *p* <.001, *d* = 1.03) and children with ASD (*M* = .76, *SD* = .31, *t*(30) = 4.59, *p* <.001, *d* = .84) chose the target object for the arrow and light combined trials. When split by VMA, the target object was chosen above chance for the low VMA TD children (TD low-VMA: *t*(17) =6.87, *p* <.001, *d* = 1.62) and borderline above chance for the TD-high VMA cohort (*t*(13) = 2.11, *p* = .055, *d* = .56). The ASD-high VMA (*t*(18) = 4.61, *p* <.001, *d* = 1.07) children also chose the target object above chance for this cue (see Table 14). There was an effect of Ravens on the 3 (Group) × 2 (VMA) Factorial ANCOVA (*F*(1) = 7.46, *p* = .008, ηp^2 = .10). Observing the descriptive statistics indicated that children with a higher Raven's score did better than those with a lower Raven's score. There was also an interaction between Group × VMA (*F*(2) = 4.79, *p* = .011, ηp^2 = .12). Independent samples t-tests revealed that the *low* VMA TD children were more likely to choose the target object than the high VMA TD children (*t*(30) = 2.35, *p* = .026, *d* =.82).

5.4.5. Same position and reversed position trials

As with Study Three, to establish whether children form word-to-referent or word-to-spatial-location mappings, children's responses for the same and reversed position trials were also examined. As there was no 'correct' answer for the arrow vs. light trials, these were excluded from these analyses. One sample t-tests revealed that all three groups chose the target object for both the same (TD: *M* = .75, *SD* = .26, $t(31) = 5.46$, $p < .001$, *d* = .96. ASD: *M* = .79, *SD* = .22, $t(30) = 7.25$, $p < .001$, *d* = 1.32. DD: *M* = .68, *SD* = .32, $t(21) = 2.64$, $p = .015$, *d* = .56) and reversed position (TD: *M* = .75, *SD* = .28, $t(31) = 4.95$, $p < .001$, *d* = .89. ASD: *M* = .65, *SD* = .31, $t(30) = 2.79$, $p = .009$, *d* = .48. DD: *M* = .65, *SD* = .32, $t(21) = 2.19$, $p = .040$, *d* = .47) trials.

When separated into six groups, all of the groups except for the DD-low VMA children chose the target object for the same position trials (TD-low VMA: $t(17) = 2.87$, $p = .011$, *d* = .67. TD-high VMA: $t(13) = 5.64$, $p < .001$, *d* = 1.50. ASD-low VMA: $t(11) = 3.37$, $p = .006$, *d* = 1.00. ASD-high VMA: $t(18) = 6.78$, $p < .001$, *d* = 1.52. DD-high VMA: $t(11) = 2.71$, $p = .020$, *d* = .79). For the reversed position trials, both TD groups (TD-low VMA:, $t(17) = 3.21$, $p = .005$, *d* = .75. TD-high VMA: $t(13) = 3.96$, $p = .002$, *d* = 1.08), the ASD-high VMA children ($t(18) = 4.27$, $p < .001$, *d* = .96) and the DD-low VMA children ($t(9) = 2.50$, $p = .034$, *d* = .80) chose the target object, although the ASD low-VMA and DD-*high VMA* children did not (see Table 15).

A 3 (Group) × 2 (VMA) Factorial ANCOVA, with CA and NVMA entered as covariates, revealed no effects for the same position trials. However, for the reversed position trials, there was an effect of Raven's ($F(1) = 6.91$, $p = .011$, $\eta p^2 = .091$) and Group × VMA interaction ($F(2) = 3.68$, $p = .030$, $\eta p^2 = .096$). Observing the descriptive statistics indicates that children with a higher Raven's score were more likely to choose the target object than children with a lower Raven's score. Further, independent samples t-tests revealed that the high VMA children with ASD chose the target object more than the low VMA children with ASD ($t(29) = -3.02$, $p = .005$, $d = -1.11$) but there was no difference between the high and low VMA children in the other two groups.

Table 15:

Mean proportion of times (SD) children chose the target object for the same and reversed position trials for six groups

	TD		***ASD***		***DD***	
	Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Same	.68 (.27)**	.83 (.22)***	.75 (.22)**	.82 (.21)***	.63 (.37)	.72 (.28)*
Reversed	.74 (.32)**	.76 (.24)**	.47 (.26)	.77 (.28)***	.70 (.25)*	.61 (.37)

*p <.05 ** p <.01***p <.001.

5.4.6. Comparison of object position

A 2 (Object Position; Same vs. Reversed) × 3 (Group) × 2 (VMA) Mixed ANCOVA with CA and NVMA entered as covariates revealed no significant main or interaction effects. This suggests that children were not more likely to choose the target object in one type of trial compared with the other.

5.4.7. Correlations between object position, CA, VMA and NVMA

In order to see if word learning from associative cues was related to children's CA, VMA and NVMA, children were assigned a total proportion of correct responses for all trials combined, except for the arrow vs. light cue, as there were no 'correct' answers for these trials. Consistent with Study Three, as children may have differed in terms of their responses to the same and reversed position trials, this analysis was carried out for the same and reversed position trials separately. Thus, children were given a score out of 3, which was converted into a proportion for separate correlations for same and reversed position trials.

For the TD children, choosing the target object for the same position trials was positively correlated with CA ($r(31) = .36$, $p = .050$), VMA ($r(32) = .41$, $p = .019$) and Ravens ($r(31) = .46$, $p = .010$). For the children with ASD, choosing the target object for the reversed position trials was positively correlated with VMA ($r(31) = .43$, $p = .016$). For the DD children, Raven's score was positively correlated with the reversed position trials ($r(19) = .61$, $p = .005$).

5.5. Discussion

This study investigated whether TD children, children with ASD and DD children can use associative cues for word learning. It was hypothesised that the TD children would learn words from both arrows and lights, although the arrow would be a stronger word learning cue than the light for the children with ASD. As the DD children surprisingly had difficulties learning words from social cues in Study Three, it was anticipated that they might instead learn words from association. Alternatively, this cohort's problems with word learning may extend to associative cues, as well as social pragmatics. The results for each group will be discussed separately, starting with the findings for the TD children. I will then evaluate the effectiveness of each cue and provide some suggestions for future research.

Low VMA TD children only learnt words from the arrow + light, failing to learn words from either cue when they were presented separately. This finding suggests that providing the two cues simultaneously is a stronger indicator of which object is being named than showing each cue on its own. Low VMA TD children may require a clear associative cue (two signals together) in order to link a speaker's utterance to the association between the signifier and the signified.

This finding does not replicate previous studies with young TD children, which has found evidence of learning from just one associative cue. Specifically, Hollich (2000) found that children learnt words from an objects' perceptual salience (which conflicted with the speaker's eye gaze but did not conflict with any other associative indicator). Axelsson et al., (2012) discovered that children show word learning and retention from object illumination. Pellicano & Rhodes (2003) found that TD children attribute that a pictorial figure wants a sweet an arrow is positioned towards. These differences might be explained by differences in terms of the methodology of this paradigm compared with earlier studies. For example, Pellicano and Rhodes (2003) tested goal inference rather than word learning.

Another explanation for the failure of the TD low-VMA children to learn words from the arrow and light is that they were confused by the lack of social information provided by the speaker, who simply stared directly ahead into the camera. Unlike in Study Three, where the speaker actively gazed and/or pointed at the object, the speaker in this study did not provide any cues as to which of the two stimuli was being labelled. Young TD children might expect the speaker to be the one providing actions to suggest which object to choose. They may have been confused by the speaker's disconnection from the word learning situation and fixated on the speaker, expecting him to provide some cues as to which artefact was the target. Therefore, they may have been distracted when the arrow and light indicators occurred and failed to properly process them.

As expected, the high VMA TD children chose the target object when the arrow and light were presented separately. This suggests that, contrary to past research (e.g. Axelsson et al., 2012; Hollich, 2000; Pellicano & Rhodes, 2003), TD children actually need a *higher* VMA to learn words from associative cues. Supporting this proposal, word learning from the same position trials for the TD children was positively correlated with CA, VMA and Raven's score, suggesting that the more developed their cognitive abilities, the more likely they were to learn words from the arrow and light. However, surprisingly, the proportion of times the high VMA TD children formed word-object mappings when the arrow and light were combined only reached borderline significance

(p = .055). This unexpected finding would need to be replicated before any firm conclusions can be drawn; it is possible that this effect is simply due to a statistical anomaly and the fact that the *p* value is so nearly above chance levels supports this proposal.

Low VMA children with ASD did not learn words from any of the associative cues. This is a similar finding to the Low VMA TD children, who only learnt words when the arrow and light were combined. Taken together, these results suggest that children (both TD and ASD) needed a high VMA in order to learn words from association in this study. As previously mentioned, this conflicts with past studies which have suggested that TD children attend to association from infancy (e.g. Axelsson, 2012; Hollich, 2000). Perhaps this finding is due to high VMA children more frequently being exposed to arrows and lights as signs relative to low VMA children. For example, arrows are commonly seen as directional indicators on computer keyboards at school (Pellicano & Rhodes, 2003).

In Study Three, the children with ASD failed to learn words from the speaker's eye gaze and (direct) pointing when presented alone. This suggests that these children need a high VMA to learn words from *any* cue, social or associative. Past studies which have found that children with ASD infer goals from arrows (Baron-Cohen et al., 1997) and attend to arrows in reflective orienting paradigms (Senju et al., 2004) have tended to recruit older and more verbally able children with ASD as participants. For example, the children with ASD in Senju et al.'s, (2004) first study had a mean CA of nearly 11 and the children in their second study had a mean CA of nine. The children with ASD in Baron-Cohen et al., (1995) had a mean CA of eleven, a mean VMA of nearly five and a mean NVMA of seven. This means that it is has previously been unclear how children with ASD who were chronologically younger or had a younger VMA would respond.

Furthermore, previous studies have focused on goal inference and referential intent, rather than word learning from arrows. This study extends this past research by finding that high VMA but not low VMA children with ASD learn words when an arrow highlights attention towards a referent. It is possible that the low VMA children with ASD lacked the executive functioning skills needed to succeed at the task. Having a high VMA likely corresponds to better concentration, attention and working memory, all of which may have facilitated performance. For example, working memory affects children's ability to remember whereabouts the arrow was positioned. Future research within this area should carry out a measure of executive functioning abilities, in order to establish if this helps children with ASD succeed.

Even the high VMA children with ASD failed to learn words from the light cue unless it was presented alongside the arrow. As suggested by past research on TD children (Krehm et al., 2014; Woodward, 1998) this implies that some signs (arrows) are more influential than others (lights) for high VMA children with ASD. Interestingly, however, this finding does not extend to the high VMA TD children, who learnt words from both the arrow and light cue when they were presented separately.

One intriguing question is *why* it is that arrows but not lights facilitate word learning in high VMA children with ASD. One possible explanation is that arrows are commonly used to signal directional information. As previously discussed, children with ASD tend to be good at spatial navigation (Baron-Cohen, 2008; Jarrold et al., 2005; O'Riordan et al., 2001; Reser, 2011). Perhaps this facilitates children with ASD learning words from the arrow. Furthermore, it is possible that arrow signs might be more prevalent in special schools than mainstream schools, due to increased visual information and the use of interventions such as the Picture Exchange Communication System (PECS; Bondy & Frost, 2001).

However, children with ASD did not choose the object suggested by the arrow as the referent when it was in direct conflict with the light indicator. This is surprising, given that they formed word-object mappings from the arrow but not the light when presented alone. It is possible that the combination of the two cues together caused the children with ASD to experience sensory overload, becoming confused at the conflicting information and so perform at chance.

Both low and high VMA DD children learnt words from the arrow. Recall that the DD participants had difficulty learning words from the social cues in Study Three; they were delayed learning words from the speaker's eye gaze and neither group learnt words from the speaker's direct pointing. In contrast, this study shows that they learnt words earlier from the arrow in comparison to their TD and ASD counterparts, neither of whom learnt words from the arrow until they had a high VMA. Perhaps DD children find association an easier cue to form word-object mappings from than social pragmatics.

However, neither group of DD children learnt words from the light, suggesting that they do not form word-object mappings from all associative cues. This suggests that, like the high VMA children with ASD, arrows are especially important for the language acquisition of DD children. As previously mentioned, arrows have been found to help children with ASD learn words, possibly because they commonly provide directional information. As the low VMA TD children learnt words from neither the arrow nor light, the high VMA TD children learnt words from the light as well as the arrow but both DD groups only learnt words from the arrow, these results suggest that the high VMA children with ASD may have a preference for arrows not due to their ASD per se, but simply as a result of having any developmental disability.

Past studies regarding the effect of arrows on children with ASD have commonly failed to recruit a DD control group. One exception (Ames & Jarrold, 2007) modelled on Baron-Cohen et al., (1995) found that a cohort of children with moderate learning difficulties (MLD) behaved much like the TD controls, using both arrows and gaze cues to infer a character’s desire. The participants included within this study were relatively old, with the MLD group having a mean CA of 14 and a mean VMA of six. This matches the mean VMA of the high VMA DD children within this research, who formed word-object mappings from eye gaze in Study Three and the arrow within this study. Future research should aim to include DD children in paradigms of this kind, particularly DD children with a low VMA, in order to more fully explore whether arrows have a special significance for word learning in this population.

As noted within the introduction (section 5.2.), arrow signs are likely to have been frequently encountered and therefore highly familiar to the children. In contrast, the patch of red light, which fully covered the object, was probably quite novel for the participants. It is possible that children with ASD and children with DD perseverate and choose stimuli which they are accustomed to seeing, rather than stimuli they are unfamiliar with. Children with ASD have been shown to possess a preference for 'sameness' (e.g. Eisenmajer et al., 1998; Green et al., 2006; Kanner, 1943; Koegel & Koegel, 1995) and this characteristic might extend to DD children.

The DD children did not form word-object mappings when the arrow and light co-occurred. As children with DD often have sensory processing difficulties (Engel-Yeger, Hardal-Nasser & Gal, 2011; John & Mervis, 2010; Kogan et al., 2004) and slow processing speed (e.g. Burden et al., 2005; Miller et al., 2001; Mulder et al, 2011; Silverman, 2007), it is possible that the combination of stimuli for the arrow and light co-occurring trials was too much sensory information for the DD children to take in. The DD high-VMA children also performed at chance for the Eye Gaze and Pointing trials in Study Three, suggesting that this cohort may have difficulty understanding co-occurring cues in general.

Future research within this area could include measures of sensory processing and processing speed and establish if these are correlated with children's performance on these kinds of tasks. Further, the cues could be presented for longer than three seconds, giving the DD children more time to process them. If their word-object mapping ability improves in this context, this would suggest that inferior sensory processing and processing speed contributes to their poor performance.

Taken together, these findings suggest that TD children learn words from arrows and lights but children with ASD only learn words from arrows. However, both groups need a high VMA in order to utilise these cues. In contrast, both high and low VMA children with DD learn words from arrows but neither cohort learns words from lights. As well as investigating the four trial types (arrow vs. light, arrow, light, arrow + light), I explored the effect of spatial temporal positioning of the objects. Both groups of TD children chose the target object for both the same and reversed position trials, suggesting that they form word-to-object rather than word-to-location mappings. Both groups of children with ASD chose the target object for the same position trials, although only the ASD high-VMA children chose the target object for the reversed position trials, suggesting that children with ASD are delayed forming word-object mappings.

The DD high-VMA children chose the target object for the same position but not the reversed position trials. These results are all consistent with children's performance for Study Three (see Section 4.6). However, the DD-low VMA children did not choose the target object for the same position trials but *did* for the reversed position trials. This finding is perplexing, thus further investigation with a larger sample size is needed in order to establish if this surprising finding is replicated or simply represents a confounding variable, such as simple guesswork.

Taken together, these results suggest that arrows facilitate children's word-learning more than lights – 4/6 groups learnt words from the arrow but only 1/6 learnt words from the light. Past research has tended to focus on the effect of arrows (e.g. Baron-Cohen et al., 1995; Rombough & Iarocci, 2013; Senju et al., 2004; Vlamings et al., 2005). This means that any effects found might not be generalisable to other cues. Therefore, it is possible that there is something special about arrows *per se* and other associative cues do not have the same impact.

Alternatively, it is possible that the way the light cue was implemented in this study was a poor indicator of association for the children; this cue consisted of a patch of red light over the object, rather than the object itself lighting up. Axelsson et al., (2012) also included a patch of light (rather than whole object illumination) as their object illumination condition, although in their study the patch of light only occurred on a panel underneath the object and was bright white. In contrast, the light in this study was bright red and covered the entire object. These small methodological changes may have contributed to the difference in findings between their study and the present research.

Therefore, this study suggests that all high VMA groups and low VMA DD children learn words from when an arrow is positioned by the target object, which they interpret as a sign that the object is being labelled (Peirce, 1931; Saussure, 1983) (see Figure 11, within the introduction). However, only the high VMA TD children learn words from the object lighting up. The results for the low VMA TD children and children with ASD suggest that, contrary to past research, it is *high* not *low* VMA children who learn words from association. Furthermore, arrows are a more effective word learning indicator for children with ASD *and* children with DD than lights.

Saussure (1983) claimed that word learning is dyadic, between the signifier (e.g. an arrow) and signified (e.g. an object). Peirce (1931) argued that the relationship is actually triadic, as it also includes the interpreter. The interpreter within this study (i.e. the child) only picked out specific cues as being relevant, which sometimes differed between groups. Most of the children (the two exceptions being the TD and ASD low VMA subgroups) learnt words from the arrow but only the high VMA TD children learnt words from the light. Thus, this study shows that there is a triadic (not dyadic) relationship between the signifier, signified and, importantly, *interpreter* in order for word learning to take place from associative signs (see Figure 11). For the arrow cue, four groups of children perceived this as relevant to word learning, although for the light cue only one group of children perceived this as relevant.

As mentioned in the introduction (section 5.1), word learning from indicators such as arrows might not be purely associational; the children could have inferred that the cue must have been important for the speaker. Although it is important to remember that there is a potential confound of children inferring social pragmatic information from the associative cues, the signs within this study were likely to have been considered more associative than those within Study Three. Recall that in Study Three, the cues (eye gaze and or pointing) directly originated from the speaker himself, thus were probably considered more intentional than the cues within this study, which did not occur from the speaker. Indeed, if social pragmatics were inferred from the indicators within this study, it would be expected that the TD low VMA children would have learnt words from the arrow and light. Instead, as previously discussed, it is speculated that one reason why this cohort may not have learnt words is because they were preoccupied expecting the speaker to provide some social information.

These findings partially support past studies (Krehm, 2014; Woodward, 1998) which suggest that children are more likely to attend to some cues than others. The high VMA TD children learnt words from both the arrow and light, suggesting that they use these cues equally within their word learning - but only once they reach a higher VMA - and thus refuting Krehm et al., (2014) and Woodward (1998). However, the high VMA children with ASD and both DD groups only learnt words from the arrow, suggesting that they weigh these forms of associative cue differently within their word learning. Thus, some ‘dumb associative cues’ *are* stronger than others, for children with ASD and DD.

In summary, the results of this study suggest that arrows are more informative to the word learning of children with ASD and children with DD than lights. Future research should consider the role of other types of associative signs, such as object motion, perceptual salience and different types of object illumination (e.g. patches of light vs. the whole object lighting up). Furthermore, children with ASD *and* TD children do not learn words from association until they have a high VMA. In contrast, the DD children learnt words from arrows *earlier* than they learnt words from social cues in Study Three. This finding may have important implications for word learning interventions for DD children, suggesting that showing arrows might help them learn words at an earlier age than social cues.

Chapter Six: **Word learning from conflicting social (gaze and pointing) and associative (arrow and light) cues**

6.1. Introduction to the study

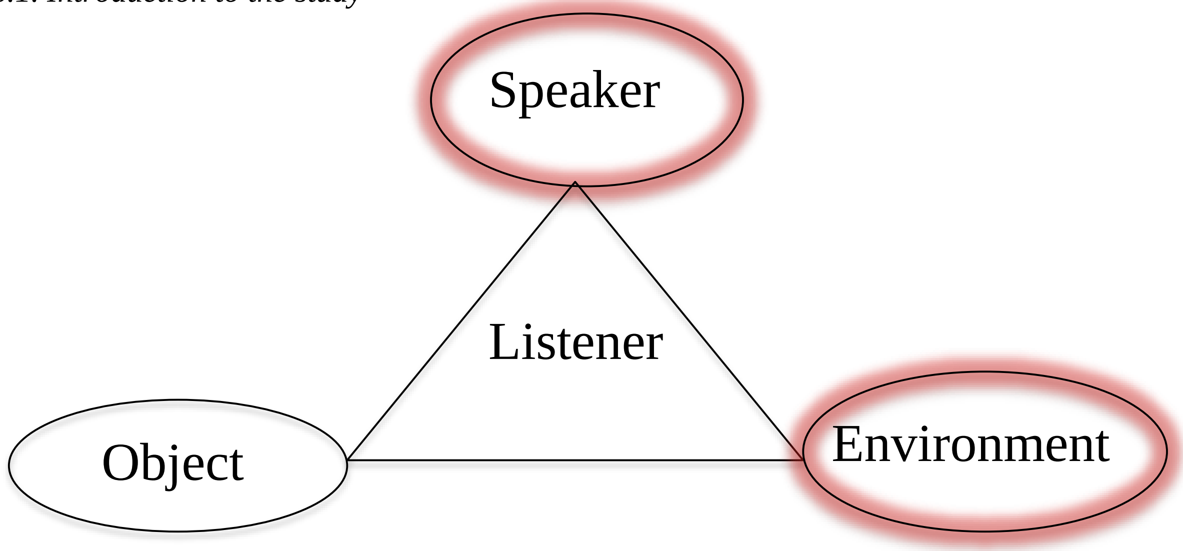

Figure 6.1: Visual interpretation of the speaker – object – environment interaction for word learning. This chapter will focus on both the 'speaker' and the 'environment' aspects of the triad.

The two previous studies have explored the influence of social cues (Study Three) and associative cues (Study Four) on children's word-learning. Although Studies Three and Four separately explored the effect of the speaker (Study Three) and the environment (Study Four) by presenting singular social (Study Three) and associative (Study Four) cues, they did not investigate whether children prioritise one type of cue (social or associative) over the other when the two are presented simultaneously. Thus, this study puts social cues and associative cues in direct competition with each other (i.e. the speaker's eye gaze or pointing occurs towards one object as an arrow is positioned towards the other object or it lights up).

Directly pitting social and associative cues together means that the mechanisms by which children learn words can be more clearly identified. Choosing the object suggested by gaze or pointing would suggest that word learning is primarily social; choosing the object suggested by the arrow or light would suggest that word learning is primarily associative. Performing at chance would either suggest that children learn words from both social and associative cues equally or that there was some failure with the paradigm. It is also possible that different effects are found between the high and low VMA children, between the three groups (TD, ASD, DD) and between the cues themselves. As has been discussed within the previous chapter, children sometimes weigh different types of indicators differently for word learning. For example, the high VMA children with ASD and both groups of DD children learnt words from the arrow but not the light. Therefore, it might be the case that children sometimes learn words from the social cue and sometimes learn words from the associative cue, which varies according to trial type.

Although this study puts social and associative cues in competition with each other, the emergentist coalition model stresses that social pragmatics and association do sometimes interlink together. A child might be more likely to pay attention to an object which is perceptually salient than an object which is perceptually boring, for example, and therefore more likely to notice if the speaker gazes at and points towards the perceptually salient object, giving it a novel label. Or the speaker themselves might infer that the child is interested in a particular object and so name that object for the child as they gaze and/or point towards it. Therefore, as previously discussed within Chapter One (General Introduction), children learn words from a wide variety of interconnected social, associative, cognitive and linguistic processes.

However, these cues sometimes contrast with each other. For example, the most perceptually salient object is not always the one that the speaker is gazing at or pointing towards, resulting in a conflict between association - or characteristics of the object (perceptual salience) - and social pragmatics - or characteristics of the speaker (gaze) (e.g. Hennon, 2003; Hollich et al., 2000; Parish-Morris et al., 2007). Or the speaker and child might be focused upon different novel objects (e.g. Baldwin, 1991; 1993; Baron-Cohen et al., 1995; Preissler & Carey, 2005). If the speaker labels the object of their own focus, the child has to disengage from the object they themselves are fixated on in order to make the correct word-object mapping. Another possibility is that a child hears a novel word while they are focused upon a novel object but it is uttered by a speaker who is disconnected from the word learning context, such as someone speaking on the telephone (Baldwin et al., 1996). Therefore, the child has to recognise that the speaker is not involved in the word learning scenario, thus the new word does not refer to the new object.

Past research (Baldwin, 1991; 1993; Baldwin et al., 1996; Hennon, 2003; Hollich, 2000; Parrish-Morris et al., 2007; Preissler & Carey, 2005) has suggested that in cases where associative processes contrast with social pragmatic information very young TD infants and children with ASD rely more on association; forming word-object mappings according to perceptual salience or the object of their own interest. However, older TD children (from about 18 months old) employ social pragmatics. This involves forming word-object mappings to the object the speaker is gazing or pointing at, even if it is perceptually boring and/or they themselves are interested in another object. TD children also fail to form word-object mappings if it is obvious that the speaker is uninvolved with the novel object, even if they say a novel word at the time that the child is looking at a novel object (Baldwin et al., 1996).

However, much of the previous research investigating children's word learning from conflicting social and associative information has only focused on one type of each cue. With respect to ASD, Baron-Cohen et al., (1997) and Preissler & Carey (2005) found that two-year-old TD infants form word-object mappings towards an object that the speaker is focused upon, even if this differs from the object of their own focus (see also Baldwin, 1991). However, VMA matched children with ASD learnt words for the object that they were fixated upon. This suggests that although TD children understand the referential intent of the speaker within their word-learning, children with ASD do not.

One disadvantage of these two studies (Baron-Cohen et al., 1997; Preissler & Carey, 2005) is that they only tested whether children use eye gaze (either in terms of social pragmatics, by forming word-object mappings towards the object of the speaker's focus, or in terms of association, by forming word-object mappings towards the object of their own focus) rather than directly pitting different types of social and associative cues together. Furthermore, as noted by Parrish-Morris et al., (2007), the earlier findings of Baron-Cohen et al., (1997) and Preissler and Carey (2005) might simply be due to children with ASD having a specific difficulty understanding eye gaze and might not extend to other cues. Parrish-Morris et al., (2007) investigated word learning for perceptually salient (e.g. a plastic wand filled with liquid and sparkly moons and stars) vs. perceptually boring (e.g. a white plastic bottle opener) objects, in a study modelled on Hollich's (2000) paradigm with TD children. Unlike TD children, children with ASD (who had a mean CA of 5 and mean VMA of 21-months-old) formed word-object mappings to the interesting object, even when the experimenter pointed or touched the boring object.

Similarly, Hennon (2003) contrasted an object's perceptual salience with a speaker's eye gaze cue. When a speaker gazed at and labelled a perceptually interesting object, three-year-old children with ASD formed word-object mappings to this artefact, rather than a plain-looking distractor. This is expected as, in this scenario, social pragmatics and association co-occur. However, when the speaker gazed at and labelled the 'boring' object, the children with ASD, like TD one-year-olds but not older TD children, still formed word-object mappings to the interesting artefact. This provides further support for children with ASD learning words from association, rather than referential intent, although whether children with ASD with more advanced receptive vocabulary would show the same pattern of performance is unclear.

Furthermore, although Parrish-Morris et al., (2007) and Hennon (2003) extended past research by directly pitting associative and social pragmatic indicators together, both studies only explored contrasting one type of associative cue (perceptual salience in both cases) with one type of social cue (pointing, touching or eye gaze). Therefore, it is unknown if children with ASD prioritise other forms of association within their word learning, when these conflict with social pragmatics. These include environmental cues such as arrows and lights, which occur *towards* the object, whereas perceptual salience is a characteristic *of* the object. Although past research within the ASD literature has explored the effect of arrows vs. eye gaze, this had tended to be in goal inference (e.g. Baron-Cohen et al., 1997) or reflective orienting (e.g. Senju et al., 2004), rather than word learning paradigms.

Reflective orienting paradigms typically involve children watching a cue (such as an arrow or gaze) occurring towards a specific part of a computer screen. This cue usually either predicts the location of a target (congruent) or the location of the target occurs in the opposite direction (incongruent). Length of time taken to orientate in the direction of the cue and how often children orientate in the direction of the cue is recorded. Goal inference paradigms typically involve showing children an image of a face with a cue (such as an arrow or gaze) positioned towards one of several objects (such as sweets) and asking children which one (e.g. sweet) the character wants or desires. Many of these have pitted arrows against a conflicting social cue, usually gaze, and have tended to find a preference for arrows in ASD and gaze in TD children (e.g. Baron-

Cohen et al., 1995; Rombough & Iarocci, 2013; Senju et al., 2004, although see Pellicano & Rhodes, 2003, who found that TD children interpret a character's goals according to arrows, as well as gaze).

In reflective orienting paradigms, TD adults (e.g. Senju & Hasegawa, 2001) and infants (e.g. Hood, Willen & Driver, 1998) have been found to look towards a target faster if it is preceded by a gaze cue, looking towards the direction of the gaze even if the target occurs in a different location. Most studies suggest that this shows an understanding of joint attention, as the same effect is not found, or not found as strongly, when other cues, such as arrows, are used (Friesen, Ristic & Kingstone, 2004; Kawai, 2011; Quadflieg, Mason & Macrae, 2004; Ristic, Wright & Kingstone, 2007; Senju et al., 2004; Vlamings et al., 2005, although see Eimer, 1997; Tipples, 2002). However, individuals with ASD have been found to orientate to both eye gaze *and* arrow stimuli (e.g. Senju et al., 2004; Sweetenham et al., 2003; Vlamings et al., 2005). This suggests that, for TD children, the social significance of gaze is important for their reflective orienting, implying that this is controlled by a process of referential intent. In contrast, children with ASD may not discriminate between gaze and other cues, suggesting that any perceptually salient indicator would have the same effect.

This study builds on past research by investigating conflicting eye gaze vs. arrows in the context of a word learning experiment and also including pointing and object illumination as contrasting indicators, in order to assess the influence of different types of speaker or environmental cues. It might be, for example, that if TD children learn words from gaze and children with ASD learn words from arrows when these conflict, as has been found in past studies, this effect is specific to these particular cues and does not occur with other indicators. Consistent with this possibility, the high VMA children with ASD learnt words from arrows but not lights in Study Four. This suggests that they differentially weight these two cues and thus emphasises the importance of the interpreter in using indicators for word learning (see Study Four for a more detailed explanation of the signifier, signified and interpreter). Alternatively, if TD children also learn words from pointing and children with ASD learn words from arrows, this provides stronger support that TD children's language acquisition is facilitated by social pragmatics but the word learning of children with ASD is facilitated by association.

6.2. Description of the present study

This study investigates word learning when social and associative cues conflict with each other; i.e. a social cue occurs towards one object at the same time as an associative cue occurs towards the other. The social and associative cues within this study were consistent with Studies Three and Study Four. As previously discussed within Study Four, the pointing and arrow are perceptually quite similar. Thus, children might be more likely to respond at chance for the pointing vs. arrow trials, compared with the other cue combinations, due to their similar appearance.

As with Studies Three and Four, children are shown a video of a speaker and two objects, with the speaker uttering a novel word to refer to one of the objects (e.g. *'there's* *a jeeter'*). In this video, for two trials the speaker gazes at one object as the same time as an arrow is positioned towards the other (gazing vs. arrow), for two trials the speaker gazes at one object at the same time as the other object lights up (gazing vs. light), for two trials, the speaker points at one object at the same time as an arrow is positioned towards the other (pointing vs. arrow) and for two trials the speaker points at one object at the same time as the other object lights up (pointing vs. light).

Replicating the earlier studies within this thesis, the children were divided into high and low VMA groups to test the delay vs. deviance hypothesis. For example, the low VMA children with ASD might be more likely to perform at chance than the high VMA children with ASD for all cues, as they previously chose randomly when the eye gaze and direct pointing (Study Three) and arrow and light (Study Four) were presented alone. Splitting the sample into high and low VMA subcategories also helps test the delay vs. deviance hypothesis for the same vs. reversed position trials, which were once again implemented in order to investigate the effect of spatio-temporal position on children's word learning. The low VMA children with ASD chose the target object randomly for the eye gaze and pointing in Study Three and the arrow and light in Study Four, which suggests that they do not show a preference for either social or associative information. Thus, it was predicted that they would form word-object mappings at chance for all trials, including same and reversed position.

The high VMA children with ASD learnt words from the social cues in Study Three but did not learn words from the light in Study Four, thus were hypothesised to learn words from the eye gaze and pointing when this conflicted with object illumination. However, due to their well-documented attention to arrows (e.g. Baron-Cohen, 1997; Rombough & Iarocci, 2013; Senju et al., 2004; Vlamings et al., 2005), they were expected to form word-object mappings from the arrow when this was pitted against eye gaze and pointing. As this group of children formed word-object mappings from both the same and reversed position trials in Studies Three and Four, they were predicted to perform consistently for the same and reversed position trials in this study.

Both TD groups were hypothesised to choose the object suggested by the social cue as they both learnt words from the eye gaze and pointing in Study Three. Although the high VMA TD children also learnt words from the arrow and light in Study Four, the fact that the TD children learnt words from the social cues at an earlier age suggests that these cues probably facilitate their word learning more than associative ones. Furthermore, past research suggests that they form word-object mappings from social pragmatics when this conflicts with associative information (e.g. Hollich, 2000; Houston-Price et al., 2006; Moore et al., 1999). Consistent with Studies Three and Four, both TD groups were hypothesised to form word-object mappings from both the same and reversed position trials.

Two different hypotheses are made for the DD children. As the high VMA DD children chose randomly for the eye gaze and pointing in Study Three and both groups chose randomly for the arrow + light in Study Four, DD children might have difficulty processing too many cues at once. Therefore, one prediction is that they may choose at chance for all trial types. Alternatively, both groups of DD children learnt words from the arrow in Study Four at an earlier age than the TD children and DD children. This suggests that the arrow could be a particularly salient cue for them. They might therefore be predicted to learn words from the arrow when this conflicts with eye gaze and pointing.

The low VMA DD children are predicted to choose at chance for the other two types of trial, as they did not learn words from the light in Study Four or the eye gaze and pointing in Study Three (note that this outcome is the same as for the first hypothesis, that the DD children would choose at chance for all trials and both the same and reversed position trials). As the high VMA DD children chose the object suggested by the eye gaze above chance, they were hypothesised to form word-object mappings from eye gaze when this conflicted with the light. They did not form word-object mappings from either the light or pointing. Therefore, like the TD children, they were predicted to perform at chance when these two cues conflict.

6.3. Method

6.3.1 Participants

Children were recruited from the same establishments as in the previous studies, with the same ethical permission granted. All children in the two clinical groups had been previously diagnosed with their disorder, as in studies Three and Four. Ninety children were recruited for this study, although one child was excluded for non-compliance. Thus, a total of 89 children took part in the study (TD, *N* = 33: ASD, *N* = 33: DD, *N* = 23). Sixty-two participants were male (19 TD, 28 ASD, 15 DD) and 27 were female (14 TD, 5 ASD, 8 DD) (see Table 16 for the participant demographic details).

Table 16:

Participant demographic details

	TD		***ASD***		***DD***	
	Low VMA N = 18 10 males	*High VMA N = 15 9 males*	*Low VMA N = 13 11 males*	*High VMA N = 20 17 males*	*Low VMA N = 13 9 males*	*High VMA N = 10 6 males*
Mean CA (SD)	3.48	5.08	9.28	10.19	7.82	9.41
	(.46)	(1.62)	(2.35)	(2.00)	(1.59)	(1.71)
Mean VMA (SD)	3.74	6.49	3.77	6.65	3.51	5.83
	(.53)	(1.98)	(.56)	(1.45)	(.50)	(1.31)
Mean Ravens score (SD)	9.88	17.50	15.25	20.00	9.73	16.30
	(2.15)	(7.93)	(7.84)	(8.50)	(3.85)	(8.93)
Mean CARS score (SD)	15.17	15.07	40.12	32.12	26.50	20.83
	(.58)	(.19)	(7.59)	(5.52)	(4.43)	(4.02)
Mean SCQ score (SD)	3.42	1.43	20.62	14.36	9.91	5.50
	(1.38)	(1.81)	(6.65)	(5.82)	(5.94)	(4.04)

The vast majority of participants took part in more than one of the video studies, with 64 children completing all three studies and a further 21 children completing two. Task order was counterbalanced. For each study, children were assigned a total score according to how many times they formed the correct word-object mapping. Which study children completed first was also recorded.

As there were three total scores (one for Study Three, one for Study Four and one for Study Five), three 3 (Group; TD, ASD, DD) × 3 (Order; Study 1, 2 or 3 first) between subjects ANOVA's were carried out, which found no order effects for any of the three groups for any of the three studies.

6.3.2. Design

A 3 (Group; TD, ASD, DD) × 4 (Trial Type; Eye Gaze vs. Arrow, Eye Gaze vs. Light, Pointing vs. Arrow, Pointing vs. Light) × 2 (Object Position; Same vs. Reversed) Mixed Factorial design was employed.

6.3.3. Cognitive tests and CARS and SCQ scales

The BPVS (Dunn et al., 1997) and Ravens (Raven, 2003) were administered as in the previous studies. For the majority of children, a parent or teacher completed the CARS (Schloper et al., 1988) (19 TD, 26 ASD, 15 DD) and the lifetime version of the SCQ (Rutter et al., 2003) (19 TD, 24 ASD, 17 DD) to confirm or rule out ASD.

Almost all of the children scored according to their diagnostic category on at least one of the questionnaires, with only one child (ASD) not scoring according to their diagnosis on either scale. However, as removing this child from the analyses led to almost identical results, and they had been officially diagnosed with ASD, this child was not excluded from the final sample.

6.3.4. Materials

This study used similar materials to those in Studies Three and Four, although a different speaker and objects appeared on the video. The scene (see Figure 14 for a sample eye gaze vs. arrow trial) showed a speaker seated at a table covered with a white tablecloth. The novel objects were later superimposed onto the video, using iMovie, with one novel object to the speaker's left and one novel object to the speaker's right.

A powerpoint presentation of the two objects side by side, with a white background, was then shown. For half of the trials, the objects appeared in the same spatial location as shown on the previous video, while for the remaining half of the trials, the position of the objects had reversed. The videos were edited and transfered onto a 1090×1080 laptop computer.

6.3.5. Procedure

The video (see Figure 14) followed the same format as that shown in Studies Three and Four. After three seconds, the speaker uttered '*There's a jeeter (mandoh, nez,* *pifo, teega, sas, koba, lorse)*', at the same time as a social cue occured towards one object and an associative cue occured towards the other.

For two trials, the speaker directed his eye gaze towards one object as an arrow was positioned towards the other, for two trials the speaker directed his eye gaze towards one object as the other object lit up, for two trials the speaker pointed towards one object as an arrow was positioned towards the other and for two trials the speaker pointed towards one object as the other object lit up. With the cues still present, the speaker uttered '*it's a jeeter!'*

Following this, the cues disappeared. As in studies Three and Four, four different videos were created, for counterbalancing purposes. Children then viewed the still image of the two objects, either in the same (half of the trials) or reversed (remaining half of the trials) spatial location and were asked to identify the target object (e.g '*show me a jeeter*'). Due to technical issues or non-compliance, four children (2 TD, 1 ASD, 1 DD) failed to complete one trial and one child (DD) failed to complete two trials.

Figure 14: Example image of an eye gaze vs. arrow trial

6.4. Results

For all analyses, each group was subdivided into 'high' and 'low' VMA to test the delay vs. deviance hypothesis. Children's CA and non-verbal mental age (NVMA; as measured by the Ravens) were entered as continuous covariates in all of the ANCOVA analyses in case these affected children's responses. Results for all four trial types are depicted in Figure 15 (combined; TD, ASD and DD) and Table 17 (VMA-split). As well as being depicted in Figure 15 and Table 17, the children's performance is presented one cue at a time within the text. No significant results were found for the same vs. reversed position trials and comparison of object position trials. This is likely due to performance being largely at chance for all four cues for all three groups of children. Therefore, these factors were not considered further.

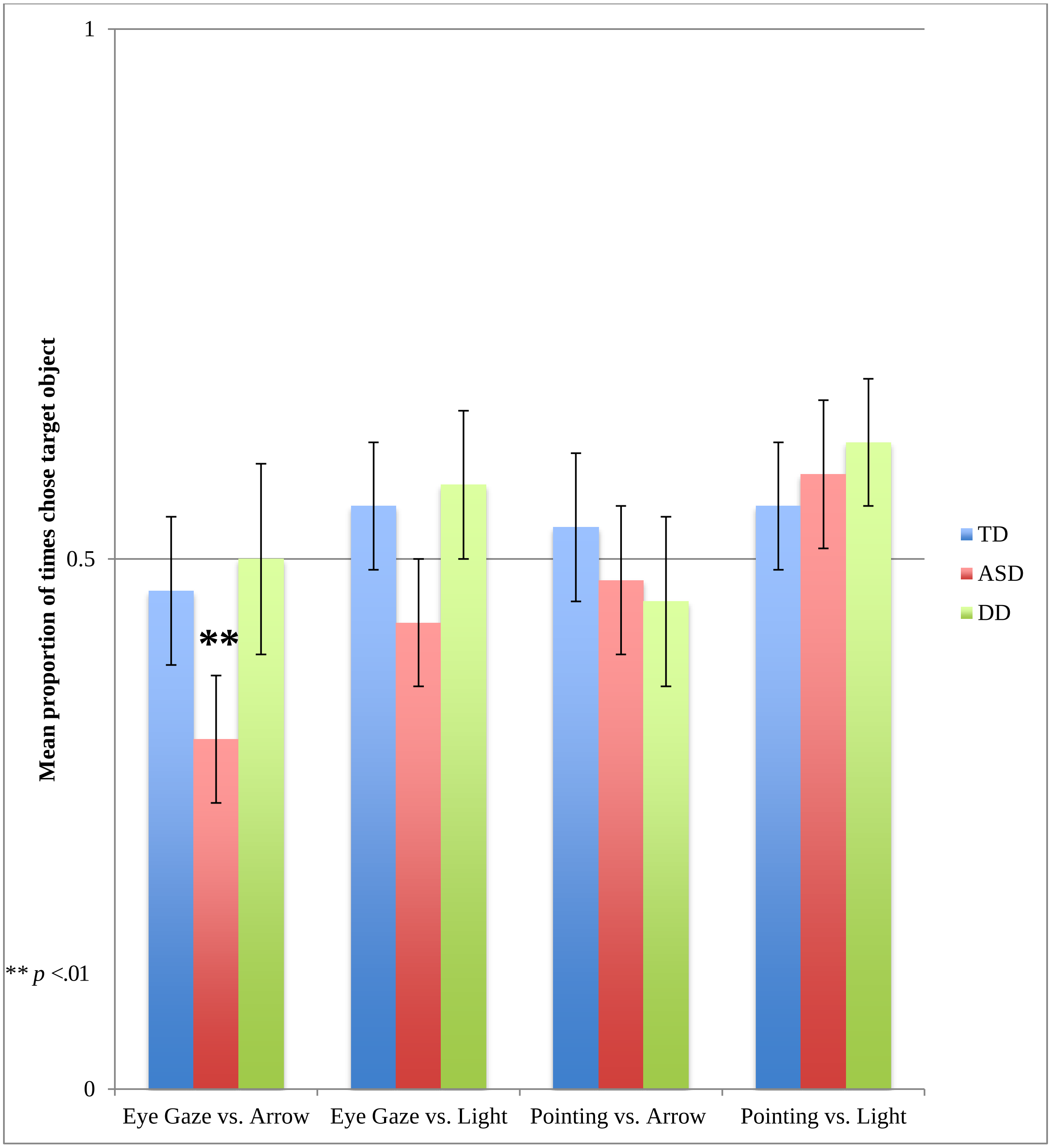

Figure 15: Mean proportion of times children chose the target object (suggested by social cue) for three groups

Table 17:

Mean proportion of times (SD) children chose the target object (suggested by social cue) for six groups

	TD		***ASD***		***DD***	
	Low VMA	*High VMA*	*Low VMA*	*High VMA*	*Low VMA*	*High VMA*
Eye Gaze vs. Arrow	.47 (.40)	.47 (.35)	.35 (.32)	.33 (.37)*	.42 (.40)	.60 (.46)
Eye Gaze vs. Light	.58 (.35)	.51 (.33)	.38 (.36)	.48 (.38)	.54 (.32)	.60 (.39)
Pointing vs. Arrow	.53 (.36)	.56 (.39)	.54 (.32)	.45 (.43)	.58 (.34)	.30 (.42)
Pointing vs. Light	.44 (.38)	.67 (.31)	.58 (.40)	.58 (.41)	.58 (.28)	.65 (.34)

*p <.05

6.4.1 Eye Gaze vs. Arrow

In order to explore any potential effects of VMA, one sample-t-tests with a chance level of .50 were conducted for both three groups (TD, ASD, DD) and when split by VMA (TD-low VMA, TD-high VMA, ASD-low VMA, ASD-high VMA, DD-low VMA, DD-high VMA). Although the TD (M = .47, SD = .37) and DD (M = .50, SD = .43) groups choose the target object at chance, the children with ASD chose the object indicated by the speaker's eye gaze (*M* = .33, *SD* = .35) less than chance (i.e. they chose the object suggested by the arrow), (*t*(32) = -2.77, *p* = .009, *d* = -.49). When subcategorised into six groups, the high-VMA children with ASD were below chance choosing the object suggested by the speaker's eye gaze (*M* = .33, *SD* = .37; *t*(19) = -2.10, *p* = .049, *d* = -.46). All other groups chose at chance between the two objects (see Table 17). A 3 (Group) × 2 (VMA) ANCOVA showed that there were no main effects or interactions.

6.4.2 Eye Gaze vs. Light

As suggested by the means for three groups (TD: *M* = .55, *SD* = .34. ASD: *M* = .44, *SD* = .37. DD: *M* = .57, *SD* = .35) and six groups (see Table 17), children chose randomly between the object suggested by the eye gaze and the object suggested by the light. A 3 (Group) × 2 (VMA) ANCOVA confirmed that there was no effect of Group or VMA or the covariates.

6.4.3. Pointing vs. Arrow

As the means for three groups (TD: *M* = .53, *SD* = .39. ASD: *M* = .48, *SD* = .38. DD: *M* = .46, *SD* = .40) and six groups (see Table 17) indicated, the TD, ASD and DD children all chose the object at chance. A 3 (Group) × 2 (VMA) ANCOVA revealed no effect of group or VMA or the covariates.

6.4.4. Pointing vs. Light

Again, all three groups of children performed at chance (TD: *M* = .55, *SD* = .36. ASD: *M* = .58, *SD* = .40. DD: *M* = .61, *SD* = .30), with no group differences. When subdivided into six groups, the TD-high VMA participants chose the object suggested by the speaker's pointing borderline more often than the object suggested by the light (*M* = .67, *SD* = .31, $t(14) = 2.09$, $p = .055$, $d = .55$), although all other groups showed chance performance (see Table 17). A 3 (Group) × 2 (VMA) ANCOVA showed no effect of Group, VMA or the covariates.

6.4.5. Correlations between object position, CA, VMA and NVMA

As with Studies Three and Four, children were assigned a total proportion of correct responses for all trials combined. Unlike Study Three (where the pointing incidental cue was omitted) and Study Four (where the arrow vs. light cue was omitted), all trials were included. As with the previous two studies, separate analyses were carried out for the same and reversed position trials, as children may have differed in their responses to these. Children were therefore given a score out of four, which was converted into a proportion for separate correlations for same and reversed position trials. The only significant correlation occurred for the low VMA children with ASD, where the proportion of times they chose the target object for the reversed position trials was positively correlated with VMA ($r(13) = .66$, $p = .014$). All other correlations were non-significant, probably due to the high rates of chance responding.

6.5. Discussion

This experimental paradigm extended the findings of Studies Three and Four by directly pitting social and associative cues against each other to explore if children weigh one type of cue more than the other for word learning. All three groups of children choose the target object at chance for all trials with two exceptions; the children with ASD (both as a whole group and the high-VMA cohort) choose the object suggested by the arrow when this conflicted with the speaker's eye gaze and the high-VMA TD children showed a trend towards choosing the object suggested by the speaker's pointing when this conflicted with the light. Although these significant differences were in the expected direction; i.e. choosing the object suggested by the social cue for the TD children and the object suggested by the arrow for the children with ASD, this provides weak evidence in support of the hypothesis as the findings only occurred for two out of the eight trial types.

Taken together with studies Three and Four, these findings suggest that children with ASD have delayed language acquisition in general, but eventually learn words from some social and associative indicators, as they were able to learn words from eye gaze (Study Three) and arrow (Study Four) cues. However, when social and associative cues conflict, children with ASD are generally unsure which cue to choose as the referent, hence perform at chance. The only exception to this occurred for the eye gaze vs. arrow trials, where the object suggested by the arrow was chosen more often than the object suggested by the eye gaze for both the high VMA children with ASD and when the whole

ASD cohort was included. This supports Baron-Cohen et al., (1995), who suggested that children with ASD ascertain information from arrows rather than eye gaze when these are pitted together.

As previously discussed within Study Four, arrows commonly provide directional information and children with ASD tend to be good at navigation (Baron-Cohen, 2008; Jarrold et al., 2005; O'Riordan et al., 2001; Reser, 2011). Although this fails to explain why the arrow was only chosen when it conflicted with eye gaze and not when it conflicted with pointing, children with ASD have been suggested to have particular difficulties using eye gaze to help them infer words (e.g. Baron-Cohen et al., 1997; Preissler & Carey, 2005). They have also been found to possess a particular interest in following arrows (e.g. Baron-Cohen et al., 1995; Rombough & Iarocci, 2013). Thus, the combination of these two cues together – arrows being easy for the high VMA children with ASD to ascertain information from and eye gaze being difficult – was the likely reason why the children with ASD only formed word-object mappings for this particular trial type.

Surprisingly, the TD children performed at chance for all trial types. However, for the TD high VMA participants, responses for the pointing vs. light trials showed a trend towards significance in favour of pointing. It is possible that the pointing cue was a particularly strong word learning indicator for the TD children (although this does not explain why they did not also choose the target object for the pointing vs. arrow cue). For instance, evidence (Lee et al., 1998; Paulus & Fikkert, 2012) suggests that pointing is a stronger social signal for TD children than eye gaze. TD children are able to infer a character's desire from pointing earlier than eye gaze (Lee et al., 1998) and 24-month-old infants and adults form word-object mappings from a character's pointing, rather than eye gaze, when these conflict (Paulus & Fikkert, 2012). This might have facilitated the TD high VMA children's trend towards forming word-object mappings from pointing but not for the eye gaze trials.

Other than this one exception, the random responding of the TD children for this study suggests one of two possibilities; it might be the case that TD children learn words from both social (Study Three) and associative (Study Four) cues equally and become confused about which indicator provides the relevant information when these cues are pitted against each other. Alternatively, perhaps there was something about this particular paradigm which caused or contributed to their random responding. Supporting this proposal, the results of this study conflict with much past research, which have found that TD children prioritise social pragmatics over association when the two conflict (e.g. Baldwin, 1991; 1993; Baron-Cohen et al., 1995; 1997; Hollich et al., 2000; Houston-Price et al., 2006; Moore et al., 1999; Parrish-Morris et al., 2007; Preissler & Carey, 2005).

Possible reasons for these conflicting findings include differences within the methodology of this study compared with past research. Firstly, as previously mentioned within the introduction to this study, some previous paradigms have focused on different types of cues to those presented in this study, particularly the associative indicators. For example, Baldwin (1991; 1993), Baron-Cohen et al., (1997) and Preissler and Carey

(2005) investigated whether children form word-object mappings according to the speaker's eye gaze, even when they themselves are focused upon a different object. Hence, this only explores how children use one type of cue (eye gaze) for word learning. Extending these studies, Hollich et al, (2000) contrasted the speaker's eye gaze with an object's perceptual salience and both Houston Price et al., (2006) and Moore et al., (1999) compared eye gaze with moving objects. These types of cues could be viewed as encompassing characteristics of the object itself. In contrast, the arrow and light were classed as environmental indicators as they occurred towards the object, rather than being a component of it.

Nevertheless, it is puzzling that the TD children did not form word-object mappings to the object suggested by the eye gaze, particularly when it contrasted with the arrow cue. However, some past studies have suggested that, contrary to other research, TD children orientate to arrows as well as eye gaze (e.g. Eimer, 1997; Ristic et al., 2002; Tipples, 2002) and use arrows to infer a character's desire and intention (Ames & Jarrold, 2007; Pellicano & Rhodes, 2003). Although contrasting pointing with an object lighting up has, to my knowledge, not been studied before, it has been found that two-year-old TD children form word-object mappings from both pointing and object illumination when the cues are presented separately but only maintained word-object mappings over time from object illumination (Axelsson et al., 2012).

The DD children did not show a preference for either the social or associative cues for any of the cue types and performed at chance for every trial. Although this could be interpreted as these children weighting social and associative cues equally during word learning, the DD children showed a deficit in word learning from many of the cues for Studies Three and Four and had difficulty forming word-object mappings for trial types where two cues were combined. Specifically, the high VMA DD group failed to learn words from the eye gaze and pointing cue in Study Three and neither DD group learnt words from the arrow + light cue in Study Four. Therefore, unlike the TD children and children with ASD, the chance performance of the DD children for all cues within this study could be explained not by a confusion about which cue is most important for word learning but, instead, by a general confusion with the task demands, finding it difficult to process two cues simultaneously.

If this is the case, then DD children struggle to form word-object mappings when *any* cues conflict; whether these be social, associative or both. As previously discussed within Studies Three and Four, this could perhaps be due to factors such as slow processing speed. It might have been more demanding for the DD children to process two cues together rather than just one within the timeframe of the videos. DD children have difficulty perceiving an abundance of sensory information (e.g. Burden et al., 2005; Engel et al., 2011; John & Mervis, 2010; Kogan et al., 2004; Miller et al., 2001; Mulder et al., 2011; Silverman, 2007), finding it harder to 'take in' two perceptually salient cues than just one.

Thus, the findings of this study suggest that, with only one clear exception and a further result which shows a trend towards significance, TD children, children with ASD and DD children do not discriminate between social and associative cues for word learning. Taken together with their earlier performance on Studies Three and Four, these findings suggest that DD children might find it difficult to choose between *any* two cues presented together, due to sensory processing impairments. In contrast, TD children and children with ASD may weigh social pragmatics and association as equally important for word learning. This supports the theory that social pragmatics and association, along with other factors such as cognitive and linguistic processes interlink to facilitate children’s language acquisition (e.g. Hirsh-Pasek & Golinkoff, 2006).

However, the setting of this study was quite artificial, with participants viewing the speaker, objects and cues upon a computer screen. Indeed, participants have been found to perform differently when the experimenter conflicts the social and associative cues in ‘real time’, with TD children learning words from social cues (e.g. Baldwin, 1991; 1993; Hollich, 2000; Houston-Price et al., 2006; Moore et al., 1999) and children with ASD learning words from association (Baron-Cohen et al., 1997; Hennon, 2003; Parrish-Morris et al., 2007; Preissler & Carey, 2005). Future work should aim to explore contrasting social and associative cues in a more ‘real world setting’, such as the experimenter him/herself looking at one object as another object simultaneously lights up. However, this criticism (the artificial setting) might also be made of Studies Three and Four, which used a similar methodology. Furthermore, there are some benefits of conducting the experiment in this way, such as ensuring that the scenario was standardised across participants. It might also be quite difficult in practice to conduct an experiment of this kind in ‘real time’.

Taken together, Studies Three to Five have extended the literature about the ability of TD children, children with ASD and DD children to learn words from social cues and the role of the speaker and the environment in children’s word learning. Relative to TD children, children with ASD are delayed learning words from social cues but learn words from arrows at the same developmental time point as their TD peers. Unexpectedly, the DD children also show word learning impairments, being delayed learning words from eye gaze and deviant learning words from direct pointing. However, they learn words from arrows earlier than TD children and children with ASD.

Importantly, these three studies suggest that not all cues are treated equally within children’s word learning, including the ‘same type’ of cue. DD children are delayed learning words from eye gaze but deviant learning words from direct pointing; high VMA children with ASD learn words from arrows but not lights; TD children show a trend towards significance for choosing the object suggesting by pointing when this conflicts with the light but not when this conflicts with arrows or for either of the trial types involving eye gaze. The next and final chapter is the General Discussion, which will summarise the results of all five studies within the thesis in relation to the speaker, object and environment triad and the emergentist coalition model.

Chapter Seven: **General Discussion**

7.1. General Findings

This thesis has investigated how TD children, children with ASD and children with DD learn words for novel objects. The five studies within this thesis test two main predictions which I draw loosely from the emergentist coalition model (e.g. Hirsh-Pasek & Golinkoff, 2006; Hollich, 2000) and extend these to include children with ASD; 1. A wide variety of cues interlink to facilitate children's language acquisition and 2. Children initially learn words from association, before later also using social pragmatics. The role of the object (shape bias and function bias), speaker (eye gaze and pointing) and environment (positioning an arrow towards an object and the object lighting up) in facilitating children's word learning were all explored. Furthermore, the word learning of children with both high and low VMA's from social cues (Study Three), associative cues (Study Four) and conflicting social and associative cues (Study Five) were examined.

Each study also identified the effect that children's receptive vocabulary skills have on their word learning, by subdividing the sample into 'low' and 'high' groups based on VMA. This allowed exploration of why children with ASD do not show the word learning abilities of their VMA matched TD and DD peers. They may eventually learn to show these skills (hence they are delayed) or might *never* acquire them (hence they are deviant). Furthermore, all five studies included both a TD and DD control group and the merits of doing so are discussed. Unexpectedly, the DD children showed word learning deficits; in some cases they were *outperformed* by the children with ASD. Some explanations for this surprising finding are given. This chapter will thus explore five key themes that run through the studies; word learning from the shape bias and function bias, word learning from social pragmatics vs. association, the delay vs. deviance hypothesis, use of control groups and the performance of the DD children. After exploration of these five themes, this chapter will conclude with the strengths and limitations of the thesis, suggestions for future research and final comments.

7.2. Word learning from the shape bias and function bias

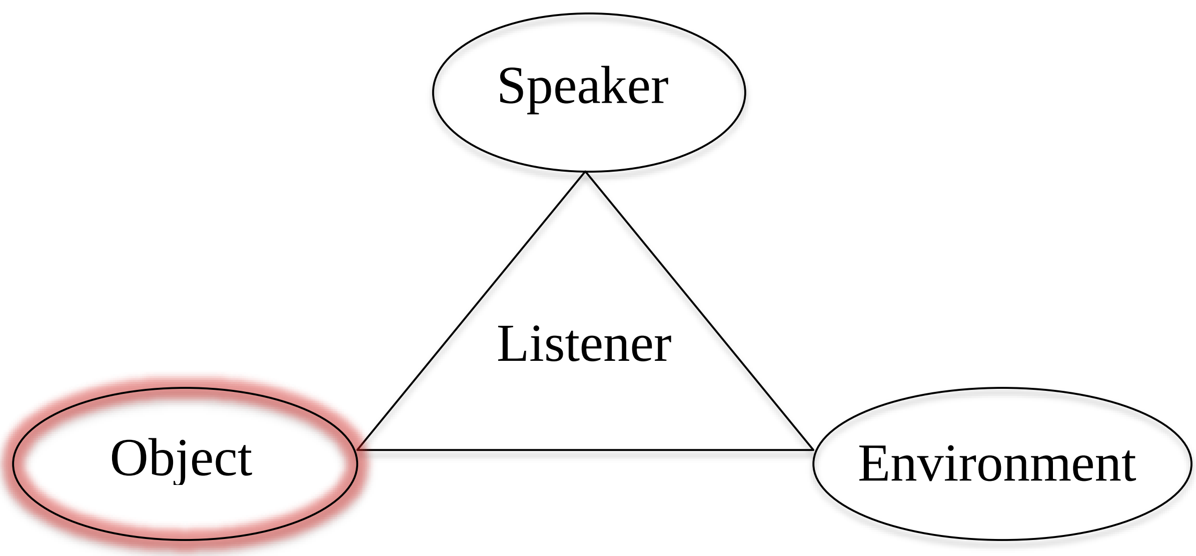

Figure 7.1: Visual interpretation of the speaker – object – environment interaction for word learning. This section will summarise the findings of Studies One and Two, which investigated the 'object' aspect of the triad.

Studies One and Two investigated how salient object characteristics influence the word learning of TD children, children with ASD and DD children, contrasting the *perceptual* characteristic of object shape (Study One) with the more *conceptual* characteristic of object function (Study Two). Replicating Tek et al., (2008), Study One investigated the shape bias in both a name (*'can you give me the other dax?'*) and no name (*'can you give me the other one?'*) condition. Due to their difficulties with referential intent, testing whether children with ASD select the shape match both when the object was explicitly labelled and when it was simply described allowed teasing apart the two hypotheses of whether the heuristic is controlled by the ALA (the shape bias is specific to naming) or the SAC account (the shape bias extends to non-naming scenarios).

This also helped investigate the controversy within the TD literature about whether the shape bias is specific to naming (e.g. Imai et al., 1994; Landau et al., 1988; Smith et al., 1996) or extends to non-naming contexts (e.g. Diesendruck & Bloom, 2003; Graham & Diesendruck, 2010). The TD children showed a shape bias, in both the name and no name condition. However, the children with ASD had a shape bias delay. Furthermore, the high VMA children with ASD and both groups of DD children only showed the heuristic in a naming context. These findings suggest that the shape bias is controlled by the SAC account for TD children but the ALA for both children with ASD and DD. Therefore, different processes might underlie shape bias understanding in typically and atypically developing children. Future research should aim to include a measure of referential intent, in order to establish if inferior referential intent skills contributed to the two clinical groups not showing the shape bias in the no-name condition.

Although an object's perceptual shape is generally a useful cue to help children rapidly generalise word-object mappings, there are occasions where same-shaped objects have different names (e.g. a violin and the container it's stored in) and where differently shaped objects have the same name (e.g. a beanbag chair and an armchair). Therefore, it is assumed that TD children use conceptual characteristics of objects, such as the function an artefact fulfils to help with naming (e.g. Diesendruck et al., 2003).

Within typical development, the shape bias develops earlier than the function bias, at around two-years-old (e.g. Landau et al., 1988). Unlike the shape of an object, the function it carries out is more conceptual and cannot be easily established from perceptual surface characteristics. Thus, the function bias develops later in TD children than the shape bias.

However, the literature provides conflicting evidence regarding the exact age the function bias emerges within typical development, with some studies claiming three-years-old (e.g. Diesendruck et al., 2003) and other studies claiming six (Merriman et al., 1992). Study Two within this thesis investigated whether the three groups of children prioritise shape or function as a cue for word learning when the two heuristics conflicted. As the three low VMA groups had a mean VMA of three-years-old and the three high VMA groups had a mean VMA of six-years-old, with the TD children having a similar CA, this study allowed a deeper exploration of whether the function bias develops at three or six in typical development. Study Two was also, to my knowledge, the first to investigate the function bias in children with ASD, and DD.

Unexpectedly, the children with ASD actually showed a function bias *earlier* than the TD children; possessing the heuristic with a low VMA. Equally surprisingly, they did not then maintain this skill over time as the high VMA group chose at chance between the shape and function match test object. The low VMA TD children selected the test object randomly, although the high VMA TD children showed a function bias. This refutes the findings of Diesendruck et al., (2003), on whom this study was based, that three-year-old children show a function bias, instead supporting Merriman et al., (1992). Neither the high nor low DD children showed a function bias.

Taken together, the results of Studies One and Two suggest that, while TD children focus on perceptual information within their early word learning (such as shape), children with ASD focus instead on conceptual information (such as function). Showing a shape bias followed by a function bias might be viewed as more adaptive for children's word learning than the other way around. Object shape is a more simplistic and easily obvious cue than its function; the shape of an object is immediately apparent to anyone with normal vision. As the same kinds of objects frequently possess the same shape, the shape bias is therefore a helpful and relatively simple heuristic for young children to show, which facilitates their early word learning.

In contrast, an object's function might not be immediately apparent. Children ascertain what an object is used for by three main mechanisms. Firstly, someone might explicitly describe the function of an object to a child. This was the procedure of Study Two, where the children were given a very detailed description and demonstration of the novel object, shape match and function match. However, in children's everyday life it is rare that the roles of objects are described in such depth. It seems a bit strange, for example, to explicitly explain '*this is a chair and its function is to allow me to sit down'*, while sitting down on an armchair.

Of course, a child who is curious to know what an object does might simply ask someone else what its function is, just as they might ask for its name. However, this requires the child him or herself to have relatively advanced linguistic and cognitive ability, being able to ask for the function of this object ('*what does this do*?') and then remember that this is the same function as other objects ('*chairs also involve someone sitting down upon them. This must be a chair'*).

Finally, the child may repeatedly observe someone using a specific object for a specific role and then, over time, remember this role in relation to other objects of the same kind (for example, after constantly having seen people sitting down on chairs, viewing someone sitting down upon a beanbag chair and realising it must be a chair even though it's a different shape to other chairs they've seen, as it serves the same function). However, this is arguably more complex and time consuming than showing a shape bias. It also might be more likely to lead to word-object mapping errors, as objects are sometimes not used for the function they were originally intended for. A large book might be used as a doorstop; a bottle might be used to store objects; a cup might be used to catch a large spider.

Thus, initially showing a shape bias facilitates children's early language learning. Later on in development, showing a shape bias by default but an increased awareness of object function allows children to further generalise object labels which do not share the same shape. This also prevents word-object mapping errors on the occasions where shape does not provide a good cue as to an object's name. This is exactly the pattern of performance that TD children show.

In contrast, showing a function bias early on in development could lead to confusion as the function of an object is rarely explicitly described and young children might not have the necessary vocabulary to ask what role an artefact fulfils. Not showing the shape bias until later means that young children fail to notice that objects with the same form have the same name and so many early word learning opportunities are missed. This is exactly the pattern of performance that children with ASD show.

Therefore, Studies One and Two investigated children's word learning from object characteristics. However, children also form word-object mappings according to numerous other cues, including social pragmatics, association, linguistic and cognitive processes. The first two of these – social pragmatics and association – and how these interlink were investigated in Studies Three to Five. These will be described within the next section.

7.3. Social Pragmatics vs. Association

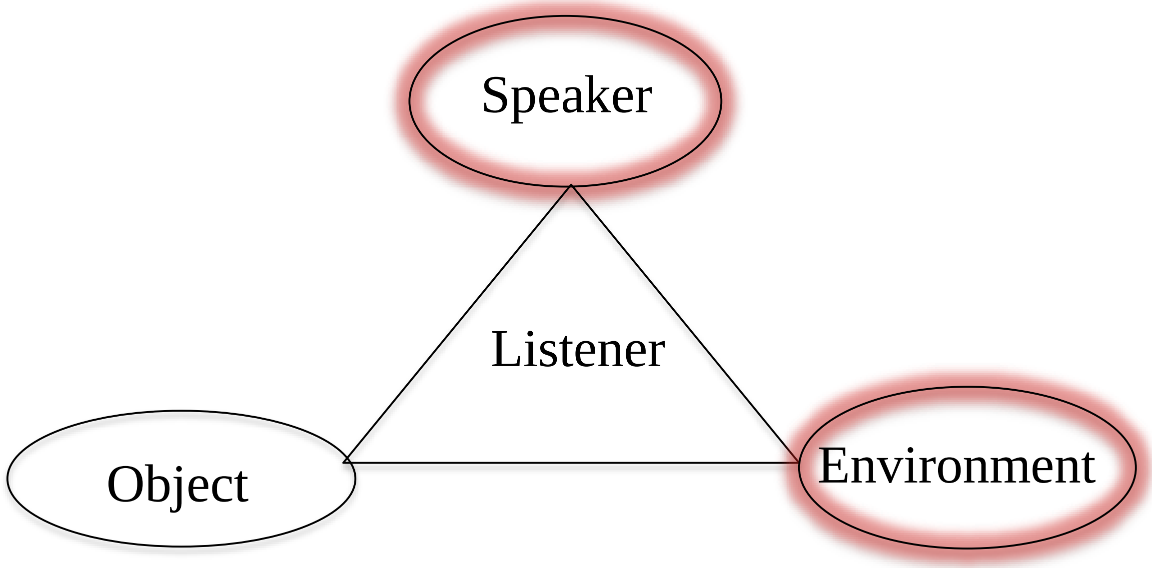

Figure 7.2: Visual interpretation of the speaker – object – environment interaction for word learning. This section will summarise the findings of Studies Three to Five, which investigated the 'speaker' (Study Three) and 'environment' (Study Four) aspect of the triad, as well as what happens when these conflict (Study Five).

As mentioned within the literature review, there has been much debate within both the TD and ASD child development literature regarding the processes underlying word learning. Some claim these processes are social (e.g. Baldwin, 1991; 1993; Baldwin & Moses, 1996; Bloom, 2000; Briganti & Cohen, 2011; Gliga & Csibra, 2009; Moore et al., 2009; Tomasello, 1999; Tomasello & Akhtar, 1995; Tomasello, Carpenter & Liszkowski, 2007). Others argue they are associative (e.g. Monaghan & Mattock, 2012; Saffron, Aslin & Newport, 1996; Samuelson & Smith, 1998; Smith, Jones & Landau, 1996; Smith

& Yu, 2008; Suanda, Mugwanya & Namy, 2014; Yu & Smith, 2007). Another group claims that *both* social and associative mechanisms facilitate word learning (see the emergentist coalition model, e.g. Golinkoff & Hirsh-Pasek, 2006; Hollich, 2000).

It was hoped that studying participants with ASD, who have difficulties with social pragmatics, would be helpful in order to fully tease apart whether social pragmatics, association or both underpin children's language acquisition. As briefly mentioned by Golinkoff and Hirsh-Pasek (2006) and discussed within the literature review, children with ASD experience the 'dampening' of one form of word-learning cue; social pragmatics. However, as discussed within Study Five, they are able to learn words from other types of linguistic, cognitive and associative information (e.g. Baron-Cohen et al., 1997; Hennon, 2003; Parrish-Morris et al., 2007; Preissler & Carey, 2005).

However, as discussed within Study Five, previous studies have tended to investigate a limited variety of cues. These include whether children form word-object mappings according to their own or another's eye gaze (e.g. Baldwin, 1991; 1993; Baron-Cohen et al., 1997; Preissler & Carey, 2005) or just contrasting one social cue (e.g. eye gaze or pointing) with one associative cue (e.g. perceptual salience or object movement) (e.g. Hollich, 2000; Hennon, 2003; Parrish-Morris et al., 2007; Moore et al., 2009). Furthermore, past research has sometimes recruited a narrow age range of participants (e.g. Hennon, 2003) and failed to recruit a DD control group.

Taken together Studies Three, Four and Five suggest that children with ASD are delayed (not deviant) forming word-object mappings from social cues. Although they originally experience a ‘dampening’ of social pragmatics, they eventually learn to use these cues, with a higher VMA than is usual. Concordant with past research (e.g. Baron-Cohen et al., 1997; Senju et al., 2004) high VMA children with ASD also learn words from directive cues (i.e. arrows), including when this contrasts with eye gaze. However, they do not learn words from the less directive cue of a patch of light illuminating the target object. This suggests that some cues are more important than others for word learning; they are not all weighted equally.

This also stresses the role of the interpreter (child) within word-learning (Saussure, 1983). Forming word-object mappings is not a passive, dyadic process between signifier (cue) and signified (object) but also includes whether the perceiver thinks the cue is relevant to word learning. Within Studies Three to Five, the relative influences of these factors varied according to a subtle interplay between the cue itself and the group that the child was a member of. For example, the high VMA children with ASD learnt words from arrows but not lights, suggesting that arrows are more relevant for the word learning of this group. Their low VMA counterparts learnt words from neither arrows nor lights, suggesting that they do not interpret either indicator as important for word learning. The high VMA TD children learnt words from arrows and lights, suggesting that they weighed the cues equally within word learning. Therefore, it is not only simply the cue itself that is important for word learning, but the child’s interpretation of it.

Studies Three and Four suggest that only high VMA children with ASD learn words from social *and* associative cues. In Study Five, both groups of children with ASD primarily chose at chance when the social and associative cues conflicted (the only exception being that the high VMA children with ASD chose the object suggested by the arrow for the arrow and light conflicting trials). The low VMA children with ASD did not show a baseline preference to begin with and the high VMA children with ASD seemingly did not know whether to prioritise social pragmatics or association when they contrasted with each other. The children with ASD were not alone; the TD and DD children also chose at chance for the conflicting cues trials.

At first glance, this high level of chance performance might seem to suggest that children use various different cues to facilitate language acquisition and that these interconnect with each other, as predicted by the emergentist coalition model (e.g. Golinkoff & Hirsh-Pasek, 2006). Random responding when social and associative cues conflict with each other may imply that children weigh these cues as equally important for word learning. However, the emergentist coalition model – and previous research – has also stated that TD children prioritise social cues over associative cues for word learning from as young as 24-months-old (e.g. Baldwin, 1991; 1993; Hollich, 2000; Moore et al., 2009). In contrast, children with ASD have formed word-object mappings from association rather than social cues (e.g. Baron-Cohen et al., 1995; Hennon, 2003; Parrish-Morris et al., 2007; Preissler & Carey, 2005).

These differences might be attributed to differences in terms of the paradigm used. It is a novel setting for the child to view a speaker and objects on a computer screen. Although all three groups of children primarily performed at chance for Study Five both the children with ASD *and* the DD children showed differences in their word learning relative to the TD children for Studies Three and Four. Specifically, the children with ASD were delayed learning words from eye gaze and pointing and failed to learn words from the light. The DD children were delayed learning words from eye gaze and deviant learning words from pointing. The concept of delay vs. deviance regarding word learning in children with ASD will be explored within the next section.

7.4. Delay vs. deviance hypotheses

The studies within this thesis all recruited participants with a broad range of receptive vocabulary skills. This wide variation in language ability was very useful in terms of investigating whether the word learning of children with ASD is delayed or deviant. Past research has tended to assume that children with ASD either succeed at a task or have a task deficit without considering that younger or older children might perform differently. For example, Baron-Cohen et al., (1997) only investigated word learning from the speaker's eye gaze in children with ASD with a VMA of two before concluding that children with ASD form word-object mappings to the object of their own interest, rather than the speaker's. It is possible that older children with ASD would react differently.

The five studies encompassed within this thesis support past research suggesting that some areas of language are delayed in ASD (e.g. Bartolucci et al., 1976; Eigsti & Bennetto, 2009; Mitchell et al., 2006) and other areas are deviant (e.g. Menyuk, 1978; Van Meter et al., 1997). Studies One and Three provide support for word learning delays in ASD; showing the shape bias in a naming context and word learning from social cues were all only mastered by children with a higher VMA[10]. Study One also provides support for word learning deviance in ASD, as these children did not show a shape bias in a non-naming context. Note, however, that it is possible that children with ASD eventually do so, with an even higher VMA, such as nine-years-old (see also footnote 1). Study Two found that children with ASD showed the function bias *earlier* than TD children, but then appeared to lose their functional understanding with a higher VMA.

The results of the ASD low VMA subgroup for Study Two were unexpected, and may well represent a deviance, just not in the predicted direction. Specifically, it was originally hypothesised that if children with ASD were deviant in one or more of the

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[10] Although it was also only the high VMA children with ASD who formed word-object mappings from the arrow in Study Four, note that the TD children did not form word-object mappings from the arrow either until they also had a high VMA. Therefore, this does not represent a delay compared with the TD children. Furthermore, as only the high VMA TD children chose the target object for the light, it cannot be determined whether this was delayed in ASD (children with an even higher VMA, such as nine-years-old, learn words from the light) or deviant (children with ASD fail to learn words from this cue, regardless of VMA).

paradigms this would mean that they failed to possess the skill, even with a higher VMA than TD children. However, '*deviant*' does not necessarily mean *never* acquiring an ability, but could simply refer to *differences* in terms of the developmental trajectory of this ability in children with ASD relative to TD children (Van Meter et al., 1997). Therefore, the results of Study Two suggest that children with ASD might actually show *advanced* function bias understanding relative to TD children.

Although sparse, there is some past research suggesting that children with ASD show some superiority in language relative to their TD (Norbury et al., 2010) and DD (Franken et al., 2010) peers. Specifically, Norbury et al., (2010) found that children with ASD are better than TD children at mapping phonological forms to novel referents and Franken et al., (2010) found that children with ASD learnt words within an ostensive context better than children with moderate learning difficulties. Indeed, it has been suggested that children with ASD may show 'islets of ability' (Kanner, 1944), excelling in certain areas, while having profound deficits in others. It is also the case that if individuals with ASD are found to have strengths within some areas, those working with these children can make use of these strengths to help children with ASD overcome their language weaknesses (Lin, 2014).

However, the function bias was not universal among children with ASD; the high-VMA individuals in this cohort appeared to have 'lost' the heuristic. Therefore, caution must be made before assuming that the function bias is a strength in children with ASD. As previously mentioned in Section 7.2, there are adaptive advantages for possessing a shape bias first and then possessing a function bias, as the TD children did. In addition to the high VMA children with ASD not possessing a function bias, the ASD cohort as a whole showed differences within their word learning (both delays and deviance) across the five studies within this thesis.

Therefore, taken together, these five studies suggest that children with ASD display word learning difficulties, primarily delays, in a wide range of contexts. There are various interpretations of this finding. Firstly, it might be the case that children with ASD need repeated trials and repetition to help them learn words, relative to TD children. Indeed, the participants with ASD in Tek et al., (2008), who *did* select the shape match test object in a name and no name condition, may have done so after repeated exposure to the objects (See Section 2.6). The shape bias has also been found to be present in TD infants as young as 17-months after repeated training (Ware & Booth, 2010).

Therefore, it may be the case that regularly repeating and emphasising words and making this explicitly obvious to children with ASD facilitates their word learning. Indeed, interventions targeted at children with ASD, such as applied behavioural analysis, or ABA (Lovaas, 1987) often do involve regular repetition. Another, not necessarily conflicting, hypothesis is that children with ASD are only able to learn words with a higher overall cognitive ability than TD children. As well as possessing a higher VMA, the high VMA children with ASD were likely to have also had greater resources at hand such as better concentration skills.

Finally, the high VMA children with ASD may have also had (although not in all cases) a higher CA than the low VMA cohort. More life experience and/or years of interventions (such as ABA and Picture Exchange Communication System, or PECS) might have facilitated word learning in the high VMA children with ASD relative to the low VMA participants. Future research should aim to investigate these factors in order to tease apart the reasons that children with ASD exhibit word learning delays and deviances.

Interestingly, it was not only the children with ASD who showed word learning delay and deviance with these tasks. Like the children with ASD, the DD children were delayed in word learning from eye gaze in Study Three. They were also deviant in many aspects of word learning relative to the TD children, specifically, showing the shape bias in a no name context, possessing a function bias and word learning from direct pointing. In some cases, they were even *later* to acquire these skills than the children with ASD. For example, the high VMA children with ASD formed word-object mappings from the speaker's direct pointing (suggesting a delay), although the high VMA DD children did not (suggesting a deviance or, at best, a severe delay).

This supports some past research, which has found that children with DD also struggle to learn words from social cues (Arens et al., 2005; Laing et al., 2002). It is possible that current research and interventions focus on children with ASD to the expense of children with other DD's, who are missing out on interventions that could help them with their word learning. Furthermore, as previously discussed within the study chapters, children with DD often have impaired cognitive processes (Burden et al., 2005; Engel et al., 2011; John & Mervis, 2010; Kogan et al., 2004; Miller et al., 2001; Mulder et al., 2011; Silverman, 2007), which may have affected their performance on the tasks. These results suggest that future research should focus on word learning in this population as well as children with ASD. This is further explored within the next section, which investigates the use of control groups in the ASD literature.

7.5. Use of control groups

Unlike the majority of studies within the ASD word learning literature (e.g. Akechi et al., 2011; 2013; Aldaqre et al., 2014; Allen et al., 2011; Baron-Cohen et al., 1997; Hartley & Allen, 2014; Luyster & Lord, 2009; Mayo & Eigsti, 2012; Norbury et al., 2010; Preissler & Carey, 2005; Tek et al., 2008), all five studies within this thesis used both TD and DD individuals as control groups. Past studies have often made inferences about children with ASD which might not actually be specific to the disorder as they were only compared against TD children. Even only comparing children with ASD with a DD control group (e.g. Franken et al., 2010) fails to identify whether TD children would, for some reason, act differently from DD children. Therefore, it is important to compare the three groups; the TD children to test normalcy and the DD children to test distinctiveness (Burack et al., 2004).

Several of the paradigms within this thesis had never or only rarely been investigated in DD children. The shape bias (Study One) had only been studied in children with language difficulties (Collison et al., 2014; Jones, 2003). Perhaps unsurprisingly given their speech impairments, these individuals failed to show the heuristic but it was unknown how children with other conditions would perform. To my knowledge, the function bias had never been explored before in either children with ASD or children with DD. There have been few studies on how DD children understand social pragmatics (exceptions include Arens et al., 2005; John & Mervis, 2010; Laing et al., 2002; Landry & Loveland, 1988; Loveland & Landry, 1986;) and even fewer on how they learn from association.

However, studying DD children can help explore whether any differences observed in children with ASD are truly specific to the disorder or also occur in children with other conditions, perhaps due to factors such as difficulties concentrating, slow processing speed or even different life experiences relative to TD children affecting language acquisition. Interestingly, across all of the five studies within this thesis, the only main results that can be attributed specifically to ASD were their delay in showing a shape bias in the name condition and the *low VMA* children with ASD showing a function bias. Therefore, the vast majority of results were not specific to ASD and, in some cases, the DD children actually performed *worse* than the children with ASD (see the following section). Therefore, this research highlights the importance of including a DD control group within ASD studies. Any results cannot be attributed to ASD *per se* unless they are compared with both TD and DD children.

One potential criticism of the DD participants within this thesis is there was a lot of heterogeneity within this group. This means that no conclusions can be made about how children with specific disorders would perform on the studies. Future work should aim to recruit whole cohorts of children with specific conditions, such as a group of children with Down Syndrome or a group of children with learning difficulties in order to establish if these effects are still found. It might be, for example, that high VMA children with Down Syndrome are able to show a function bias but high VMA children with learning difficulties like specific language impairment are not. This would then allow exploration of the factors that are likely to contribute to a function bias deficit; perhaps it is due to the extent of dialogue being too difficult for the cognitive abilities of children with learning difficulties but not for the children with Down Syndrome, VMA matched with the TD children.

7.6. Performance of the DD children

Unexpectedly, the children with ASD were not the only ones to exhibit word-learning difficulties; the DD children did too, in some cases even performing poorer than the children with ASD. Studies One, Two and Three in particular suggest word learning differences in DD children compared with TD children. Unlike TD children, both groups of DD children only showed the shape bias when the object was named. Neither group of DD children possessed the function bias. Only the high VMA DD children learnt words from the speaker's eye gaze and neither group learnt words from the speaker's pointing.

Study Four, however, found that DD children formed word-object mappings from the arrow *earlier* than their TD and ASD counterparts, although they failed to learn words from the light cue. The DD children also experienced difficulties with the same and reversed position trials in Studies Three and Four.

These findings are both unexpected and intriguing. It is well known that both children with ASD and children with DD have impairments with executive functioning skills (e.g. Danielsson, Henry, Messer & Ronnberg, 2012; Mackinlay, Charman & Karmiloff-Smith, 2006; Ozonoff, Pennington & Rogers, 1991; Pennington & Ozonoff, 1996; Semrud-Clikeman, Walkowiak, Wilkinson & Butcher, 2010; Vries & Geurts, 2012). This could have contributed to their poor performance. Regrettably this thesis did not include a measure of executive functioning, making it difficult to test this claim. This is something that could be implemented in further research.

Secondly, as mentioned within Chapter One, it might also be the case that the upbringing of both children with ASD and children with DD is very different from the upbringing of their TD peers (e.g. Karmiloff-Smith, 1992). TD children might be given more independence and more freedom to make language acquisition errors, for example, and in doing so this might actually help them learn more about the process of language (Karmiloff-Smith, 1992). Caregivers and teachers might be quicker to correct the language errors of children with ASD and DD for fear of them falling behind. However, by not being given the chance to make these common childhood word learning mistakes, the language acquisition of children with ASD and DD might actually become impaired (Karmiloff-Smith, 1992).

Similarly, with an increased concern for their children's safety, caregivers might not allow children with ASD and DD to explore the environment and objects as freely as TD children (e.g. Karmiloff-Smith, 1992; Karmiloff & Karmiloff-Smith, 2001), which might lead to a lack of understanding of object properties. The vast majority of participants with ASD and DD who took part in these paradigms attended specialist schools, where they may have been treated differently from the TD children who attended mainstream schools and day nurseries. Therefore, environmental influences might hinder word learning ability in both TD children and children with ASD and this should be factored into future research. Specifically, studies could establish if there are any potential differences between atypically developing children attending specialist and mainstream schools. One potential difficulty with doing this is that children attending mainstream schools might be, in general, less severely affected than those attending specialist schools. Therefore, baseline measures of ability would need to be taken into account and, if possible, equated.

Even given these explanations, it is puzzling that the DD participants performed *poorer* than the children with ASD for Studies Two and Three. It is possible that DD children are being overlooked in comparison to children with ASD, as numerous interventions are targeted at the latter population. These programs are specifically tailored to the unique needs of children with ASD but DD children may not receive such specialist support with word learning and socialisation skills, thus fall behind. Furthermore, the learning difficulties experienced by the DD sample may have hindered their abilities at the tasks.

7.7 Strengths of the thesis

This thesis has numerous strengths. As previously mentioned, the inclusion of both a TD and DD control group in every study allowed exploration of word learning in these two populations and being able to discern which effects were truly due to ASD per se. Furthermore, a large number of participants were recruited (a total of 214 children took part across the five studies), of varying CA and VMA. This allowed full exploration of the delay vs. deviance hypothesis, as it enabled the sample to be split into high and low VMA subcategories, with adequate numbers of participants in each group. Furthermore, children were recruited from a wide variety of settings; five mainstream schools, fourteen specialist schools, six mainstream day nurseries, two parental support groups and word of mouth across numerous locations within the North West of England. The large number of places where the children were tested means that the sample represents children from a wide variety of social classes and socioeconomic status.

The studies also included a relatively large number of female participants. Although the three groups were not matched for gender for any of the studies within this thesis, following Hartley and Allen (2014), two additional analyses were carried out for each of the paradigms, which established that gender did not affect participants' response for any study. Firstly, five ANOVA's of Gender by Responses found that children's Gender had no influence on the object they picked as the referent for any of the studies. Secondly, all analyses were rerun including only the male TD participants, which found no or minimal differences in the results.

To my knowledge, this thesis was the first to be loosely based upon the emergentist coalition model in relation to ASD. Focusing on the speaker, object and environment triad allowed exploration of the three main elements in children's word learning. As has been previously stated, the function bias had never been explored before in atypically developing populations. Unlike most of the past literature, Studies Three to Five encompassed same vs. reversed position trials, which helped tease apart whether children were forming word-to-object or word-to-location mappings.

It has often been assumed that if children choose the target object for word learning studies then this means that they have fully learnt the name of this object. In fact, it could be the case that they have simply mapped the word to a particular location in space. However, few previous studies have investigated the effect of spatio-temporal position on children's word learning. The low VMA children with ASD appeared to form word-to-location mappings, as only the high VMA children learnt words from the reversed position trials, although both groups learnt words from the same position trials. In contrast, both groups of TD children formed word-to-object mappings for both the same and reversed position trials.

This suggests that, unlike TD children, participants with ASD originally only map the name of objects to specific spatial locations. This could have major implications for the understanding of language acquisition in children with ASD. If they associate the word ‘brush’ only with the object they see upon their caregiver’s bedside table, this means that they then do not know this word when the brush moves to onto the bed. At the other extreme, when a cup moves to their caregiver’s bedside table, children with ASD risk mis-mapping this as a ‘brush’. Of course, over repeated occurences of seeing the brush and cup they will eventually learn these labels, but the process then becomes harder than for TD children. Previous research has neglected to explore this important issue.

7.8. Limitations of the thesis

Of course any thesis or series of studies has limitations. While the sample size is large for all studies within this research, including female participants and encompassing children of varied socioeconomic status, all of the participants obviously had to possess adequate receptive vocabulary understanding (two-years and over, as measured on the BPVS) and behaviour (the ability to sit and concentrate fully on the tasks) in order to participate in the study. Specifically, children had to be able to remember instructions and physically point towards or pick up objects. Indeed 53 children in total were excluded from the studies, some for the very reason that they lacked these skills, either due to inadequate cognitive abilities or behavioural difficulties. However, this means that the characteristics of the sample may not reflect the entire population of children with ASD and DD, some of whom are non-verbal below the two-year-age level, have more limited linguistic and/or cognitive abilities than could be tested here and/or or have severe behavioural problems, which impair their ability to concentrate on the task.

Splitting the sample according to the median VMA as measured by the BPVS allowed for an exploration of the delay vs. deviance hypothesis. However, the use of median splits has been criticised (e.g. MacCallum, 2002; McClelland et al., 2015), due to analysing continuous scores with a somewhat arbitrary cut off point, as though they were categorical. Whilst I acknowledge this criticism, subdividing the sample according to the median VMA replicates numerous past studies within the child development and ASD literature, which have split groups by the median VMA (e.g. Leekam et al., 1998; Slaughter, Dennis & Pritchard, 2002) or other types of median split (Charman, Ruffman & Clements, 2002; Fiore & Schooler, 2002; Lam, Bodfish & Piven, 2008).

For Study One, the median VMA split was further justified by looking at the correlations. The low VMA children did not show a shape bias in the name condition but the high VMA children did; as expected, there was a positive correlation between VMA and shape bias responses for the children with ASD in the name condition. For Study Two, although the correlational data was not consistent with the median split analysis, I also carried out a robust linear regression and scatterplots for this study, which confirmed the findings of the VMA split.[11]

A further potential weakness of the studies is that the CARS and SCQ scales did not always distinguish the children according to their clinical diagnoses, with 7 children with ASD in total not scoring within the ASD range on either scale and 2 children with DD scoring in the ASD range on both scales. For each of the five studies, a minority of children (Study 1 $N = 9$, Study 2 $N = 4$, Studies 3 – 5 $N = 1$) did not score according to their clinical diagnosis. A decision was made to keep these children in the sample based on their specialist diagnoses and to simply use the CARS and SCQ for additional information. The analyses for each study were also carried out excluding children who did not score according to their official diagnosis on both questionnaires, which found that this made little or minimal difference to the results.

Although measures like the CARS and SCQ can be helpful, they are subjective and ASD should only be diagnosed after a thorough clinical assessment and not simply on the basis of scores on a questionnaire (Gillberg 1990). Both of the scales are quite old (the CARS has been used since 1988 and the SCQ since 2003), therefore possibly outdated. Some of the children's parents and teachers did express concern with some of

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[11] Note that for Studies Three, Four and Five, the correlations were carried out using the total proportion of correct responses across all four trials, due to the low possible range of scores per cue (i.e. children could only score 0, .50 or 1). Therefore, it cannot be determined whether there were correlations between the cues which would be expected to correlate.

the language the questionnaires contained, such as the use of the word 'retarded' in the CARS. There is also some controversy regarding the current cut off scores for ASD on the CARS, with some claiming that children should be classed as on the autistic spectrum if they score 25 or 25.5 rather than 30 (Dickerson Mayers et al., 2012; Tachimori, Osada & Kurita, 2003) and others stating that the cut off point for ASD should be 27 for adults and adolescents (Mesibov, Schloper & Michal, 1989).

In the main, the children scored according to their diagnosis on the CARS and SCQ scales. Even in cases where they did not, as has been discussed, an observer's ratings of a child's behaviour on a questionnaire does not always provide an accurate indicator of their diagnosis. The fact that the analyses were conducted without including these children and found the same or similar results suggests that it was acceptable to keep them in the final sample.

In terms of the paradigms themselves, there were a few weaknesses within the stimuli shown to the children, particularly for Studies Two and Four. As mentioned within Study Two (the function bias study) some of the objects were more familiar to the children than others. Although this replicates Diesendruck et al., (2003) on whom the study was modelled and although the familiarity of the object set did not affect children's function bias responses, it would perhaps have been better to have made all objects novel. Furthermore, as previously discussed both within this Chapter and Study Four (the arrow and light study), the light cue might have been perceived as slightly odd as it consisted of a red patch over the object, rather than the actual object itself lighting up. Future research might want to investigate if children with ASD and DD still choose the target object at chance with different methodology, such as the whole object lighting up. As previously mentioned within Study 5, the setting for Studies Three – Five (watching a video) was also somewhat artificial, thus future research might want to explore children's word learning in more 'real world' contexts.

7.9. Suggestions for future research

One suggestion for future research would be to include measures of intention reading and executive functioning (especially memory and processing speed) for each study. Including a measure of intention reading for each study would allow one to see if each area of word learning is related to referential intent and if this differs for each group of children. For example, the shape bias would be expected to be related to a referential intent measure for the TD children (SAC account) but not the children with ASD or DD (ALA account). Including a processing speed scale would help identify if slow processing speed was affecting the performance of the DD children for the video studies.

For the three video studies, eye tracking could be used, to explore where the children are actually looking whilst watching the videos. This could provide helpful information, particularly for the eye gaze and pointing video. For example, for the gaze cue, eye tracking would help determine whether the low VMA children with ASD and DD fixate on the speaker's gaze towards the object but fail to form the correct word-object mapping or simply fail to notice the eye gaze at all.

For the pointing inconsistent cue, whether children actually look towards the speaker's face (looking off into the distance) and then towards the pointing at the object or look simply at the pointing towards the object could help disentangle children's mental processes as they are faced with this cue. This would explain whether children realise the speaker is looking elsewhere and are confused by this but then decide to choose the object suggested by the pointing or whether they simply fail to process that the speaker is looking elsewhere. Eye tracking would also help investigate any potential differences in looking patterns between the TD children and the children with ASD. For example, previous studies using a similar methodology have found that TD children look more towards the speaker's face while individuals with ASD look more at the background, objects and other non social stimuli (e.g. Jones, Carr & Klin, 2008; Klin, Lin, Gorrindo, Ramsey & Jones, 2009; Klin et al., 2002; Norbury et al., 2009; Riby & Hancock, 2009).

Future research could investigate whether children respond in the same way if the wording of the test question is changed, particularly for the shape bias study. Past research within the TD literature suggests that the way children are asked the test question in non-naming conditions of shape bias experiments can have an effect on the response they give. As mentioned in Chapter Two (Shape Bias), children are more likely to choose a shape match test object when it is emphasised that the objects are of the same kind, such as when they are asked to *'pick another object like this',* than when asked '*pick the object that goes together with this'* (Diesendruck & Bloom, 2003).

As stated within Chapter Three (Function Bias), following Diesendruck et al., (2003), the function bias paradigm contained a lot of dialogue, which may have caused children to lose concentration on the task. This was important in order to replicate Diesendruck et al., (2003) – had the wording been changed it could have been claimed that any differences between this paradigm in relation to Diesendruck et al., (2003) was due to this. However, future research should cut down on the extent of words the experimenter uses during the study, in order to see if this influences children's performance on the task.

It would also be a good idea to explore how children learn words in a more naturalistic environment than the laboratory studies here. While the methodology of the research is consistent with most similar studies of this kind with both TD children (e.g. Axelsson et al., 2012; Baldwin, 1991; Diesendruck et al., 2003; Doherty, Anderson & Howieson, 2009; Gliga & Csibra, 2009; Houston-Price et al., 2006; Lee et al., 1998; Merriman et al., 2003; Pellicano & Rhodes, 2003) and children with ASD (e.g. Baron-Cohen et al., 1995; 1997; Hartley & Allen, 2014; Hennon, 2003; Parish-Morris et al., 2007; Tek et al., 2008) it is important to remember that it is also useful to study how children acquire language in a more real world context. Future studies might like to make use of information from The Child Language Data Exchange System (CHILDES) (MacWhinney & Snow, 1985), which contains transcripts of children's language, which can be analysed.

7.10. Final Comments

In summary, this thesis investigated the language acquisition of TD children, children with ASD and DD children from word learning biases (specifically the shape bias and function bias), social cues (eye gaze and pointing) and associative cues (arrow and light). It therefore allowed an exploration of the emergentist coalition model, the delay vs. deviance account of ASD and the influence of the speaker, object and environment within word learning. A large number of children were recruited from each of the three groups and this thesis was the first to explore the function bias in children with ASD and other DD's.

Children with ASD are delayed showing a shape bias and word learning from eye gaze and deviant showing a function bias. Although, as expected, TD children show intact word learning from the shape bias and social cues, they need a VMA of six, rather than three, to show a function bias. Unexpectedly, the DD children exhibited word learning deficits, especially from social cues. Contrary to the assumption that TD children learn words from association and then utilise social cues (e.g. Hollich, 2000), both the high and low VMA TD children learnt words from social cues but only the high VMA TD children learn words from association. They also do not prioritise association when this conflicts with social cues.

Taken together, the five studies within this thesis show that language acquisition is impaired in both children with ASD *and* children with DD. This thesis highlights the importance of testing children with ASD who have a wide range of receptive vocabulary understanding. It also stresses the necessity of DD comparison groups within ASD research and the role of the object, speaker and environment in children's word learning. These findings suggest that children use various cues to facilitate their language acquisition and that atypically developing children (not just children with ASD) differ in the developmental time point at which word learning cues emerge in relation to TD children. Importantly, these studies reflect the need for research on children with ASD and DD to take on a developmental perspective. This is clearly shown between the subtle interaction between the dependent variables (facets of the stimuli and aspects of the cues shown to the child), the VMA of the child (as a proxy for developmental level) and group membership.

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