

**NEW WORD LEARNING IN YOUNG
CHILDREN WITH AUTISM SPECTRUM
DISORDER:**

**DO YOUNG CHILDREN WITH AUTISM SPECTRUM DISORDER
FAST MAP/LEARN MORE NEW WORDS THROUGH LIVE OR
VIDEO MODELLING; VIDEO MODELLING IN QUIET OR
BACKGROUND NOISE, WITH A SLOWED OR AN UNMODIFIED
SPEECH RATE, WITH AUDIOVISUAL SYNCHRONOUS OR
ASYNCHRONOUS SPEECH INPUT?**

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ABSTRACT

At least some children with Autism Spectrum Disorder (ASD) have sensory processing differences which are likely to impact on speech processing and early language development. There is limited research in this area with the population in this study, i.e., preschool children with ASD and minimal or no language. This study explores the effects of modified speech on fast mapping and learning new words using video modelling, based on evidence in ASD of particular difficulty processing speech in background noise, temporal speech processing and a potential multisensory integration deficit. A case series design with multiple measures was used to compare the impact of modified video modelling with control conditions on learning and fast mapping new words.

Video modelling had an overall positive impact on fast mapping and learning new words compared to non-taught control words, but was not superior to live modelling. Artificially slowing speech and background noise had minimal or no effect on taught vocabulary, although this does not preclude effects in natural environments. The atypical effects on fast mapping new words from asynchronous audiovisual presentation was consistent with a multisensory integration deficit in ASD, but the extent to which this supports theories of autism such as an extended multisensory temporal binding window requires further research. Methodological limitations indicate caution generalising findings.

There was wide variation in participant performance and profiles, including sensory processing. This suggests the need for detailed assessment of sensory processing alongside other abilities in order to tailor interventions supporting language development to each child's unique profile. Given evidence of deficits in attention and positive associations between video modelling and attention in this study and the literature, video modelling may be helpful alongside other strategies in supporting young children with ASD fast map or learn new words when they are struggling to do so by other means.

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AUTHOR'S DECLARATION

I declare that the work presented within this thesis is my own work and has not been previously submitted for any other degree or qualification.

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INTRODUCTION

The aims of this study are to explore influences on early vocabulary learning in non-verbal or minimally verbal children with Autism Spectrum Disorder (ASD) and to add to the literature on intervention strategies to support understanding and production of spoken words in this population. This study also considers the emerging evidence of sensory processing differences in ASD. It particularly focuses on adding to the evidence on; auditory and speech processing in children with ASD such as processing speech in background noise, temporal processing, and to the evidence of multisensory processing differences (Collignon et al., 2013; Mongillo et al., 2008; van der Smagt et al., 2007) such as an extended multisensory temporal binding window (Foss-Feig et al., 2010; Kwakye et al., 2010). This study also builds on evidence on the use of video modelling to teach vocabulary to children with ASD, exploring how sensory processing differences might contribute to the failure or success of this method.

Part 1 of this study expands on Baharav and Darling's (2008) case study, reporting increased vocabulary and social interaction after exposing a minimally verbal child with ASD to short sessions each day watching his parents singing or talking on video with an FM (Frequency Modulation) auditory trainer. In Baharav and Darling's (2008) study, the FM auditory trainer was set to transmit the parent's voice to the listener's headset at a comfortable, but louder level than the background noise, whilst watching the parent talking on video. Thus, both the visual (via video) and auditory (via the FM auditory trainer) aspects of the parent's voice were accentuated, which Baharav and Darling contend helped to sustain the child's attention and compensate for auditory-visual processing deficits in ASD. Part 1 compares live and video modelling and also explores the effects of modifying speech input on vocabulary learning to take account of possible sensory processing differences.

Part 2 builds on Part 1 by exploring how modified speech input in video modelling impacts on young children fast mapping vocabulary, i.e., learning to understand or to produce new words after minimal exposure. In addition to exploring the effects of background noise and slowed speech, Part 2 also looks at the impact of asynchronous and synchronous speech on vocabulary learning

and the implications for theories purporting an extended multisensory binding window in ASD.

Chapter 1: LITERATURE REVIEW

The first section of this chapter looks at language and communication in children with ASD. The second section explores how early vocabulary develops in these children compared to typically developing children, considering the evidence on potential influences. The third section goes on to examine sensory processing differences in children with ASD, including visual, auditory and multisensory differences and how these differences might impact on speech processing. The fourth section looks at intervention approaches to support early vocabulary development in children with ASD, with particular emphasis on strategies to ameliorate the effects of sensory processing differences, such as limiting background noise and slowing speech input. It includes the growing evidence on use of video modelling and why this might be a particularly useful intervention for some children with ASD. The final section summarises the evidence and rationale for this thesis.

1.1: LANGUAGE AND COMMUNICATION IN CHILDREN WITH ASD COMPARED TO TYPICAL DEVELOPMENT

1.1.1: Diagnosis and clinical characteristics of Autism Spectrum Disorder (ASD)

Diagnosis of ASD is currently made by expert clinicians with reference to either the 10th revision of the *International Classification of Disease (ICD-10)* classification of mental and behavioural disorders, clinical descriptions and diagnostic guidelines (World Health Organisation [WHO], 1992) - or the standardised criteria for diagnosis in the fifth edition of the *Diagnostic Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association [APA], 2013)*.

The two standardised diagnostic criteria in the most recent guidance of *DSM-5* are: (1) persistent difficulties in social communication and social interaction across multiple contexts and (2) restricted, repetitive patterns of behaviour, interests or activities. The second of the two diagnostic criteria must include two

of the following four factors: stereotyped or repetitive movements, use of objects or speech; insistence on sameness and routines or ritualistic verbal or non-verbal behaviour; highly restricted, fixated interests with abnormal intensity or focus; hyper or hypo-reactivity to sensory input or unusual sensory interests. In addition, diagnostic symptoms must be present in early development, have a significant clinical effect on current functioning and not be better accounted for by intellectual disability or global delay (APA, 2013, p. 50). Sensory processing difficulties are for the first time included as part of the diagnostic criteria for ASD. The *DSM-5* (2013) also advises that diagnosis should specify whether there is additional structural language impairment, reflecting the variation in language ability of this population.

Although the diagnostic criteria for ASD used in research have followed the *ICD-10* (WHO, 1992) or versions of the *Diagnostic Statistical Manual of Mental Disorders*, there have been revisions and updated guidance (APA, 2013, 2000), reflecting more recent research. In addition, there has been an increased general awareness of ASD (Elsabbagh et al., 2012), which may have changed or skewed who presents for diagnosis, e.g., an increased awareness of autism in girls. Most of the research cited in this chapter however reflects the diagnostic criteria for Autistic Disorder in the fourth edition of the *Diagnostic Statistical Manual of Mental Disorders – Text Revision (DSM-IV-TR)*; American Psychiatric Association [APA], 2000, p. 69-70), i.e., difficulties in communication, social interaction and restricted, repetitive and stereotyped patterns of behaviour, as the research base using *DSM-5* criteria was still limited at the time of writing.

The National Institute of Health and Care Excellence (NICE) guideline [CG128] on autism diagnosis in children and young people describes the gold standard in diagnosis of autism (NICE, 2011) although diagnostic practices and diagnostic tools used vary. Differences in diagnostic practice and the heterogeneity of individuals with a diagnosis of ASD or autism (Jones and Klin, 2009), may be confounding variables when comparing research findings for this population. In addition, although recommended diagnostic tools such as the *Autism Diagnostic Interview Revised* (LeCouteur et al., 2003b) and *Autism Diagnostic Observation Schedule* (Lord et al., 2002) distinguish between the

wider diagnostic label of ASD and the narrower diagnosis of autism, not all studies make this distinction when evaluating the evidence. Similarly, some studies distinguish between ASD, high functioning autism and Asperger's syndrome, whilst others do not. In *DSM-IV-TR* (APA, 2000, p. 70-71), Asperger's syndrome was defined as a qualitative impairment in social interaction with no clinically significant delay in language, cognitive development, self help skills, other adaptive behaviour or curiosity about the environment in childhood, as opposed to Autistic Disorder which did not specify age appropriate cognitive ability or language (APA, 2000). The *DSM-5* no longer includes Asperger's Syndrome as a separate category from Autistic Disorder in order to reflect the current evidence, but uses one diagnostic label of ASD (APA, 2013). For a review of the evidence that led to *DSM-5*, see Lord and Bishop (2015). Hence in the evidence cited in this chapter, differences in the diagnostic labels of the research participants may be a confounding variable when attempting to compare outcomes (Maenner et al., 2014; Volkmar and Partland, 2014).

1.1.2: Variation in language and communication abilities of children with ASD

Koegel et al. (2009) suggested that, based on available evidence, 10-25% of children with ASD never develop speech, whilst Hus et al. (2007) found that only 9% remain totally non-verbal. Norrelgen et al. (2014) found 15% of their sample of 165 children with ASD aged 4-6 years, were non-verbal and another 10% were minimally verbal. There is a wide variation in the language and communication abilities of children diagnosed with both autism and ASD (Hudry et al., 2010; Smith et al., 2007; Kjelgaard and Tager-Flusberg, 2001). This effects both verbal and non-verbal communication (Charman et al., 2003a). Luyster et al. (2007) found that structural language skills in children with ASD varied, particularly in relation to vocabulary, ranging from no spoken words to above average vocabulary. A range of evidence (Mitchell et al., 2006; Charman, 2004), suggests that despite the variation, language ability in the population of children with ASD as a whole, is often delayed and follows an atypical pattern of

development (Charman et al., 2003a). Mody and Belliveau (2013) note evidence in their literature review, from neuroimaging studies on individuals with ASD that suggests reduced use of left frontal lobe brain regions in language processing in favour of right hemisphere and posterior ventral temporal brain areas. Thus whilst acknowledging the heterogeneity of individuals with ASD, they suggest that language processing in ASD is not just quantitatively, but also qualitatively different from language processing in typical development.

A number of studies have attempted to explain the language variation in individuals with ASD. Key factors in the literature are non-verbal communication skills, cognitive ability and autism severity, although the relative importance attributed to each of these factors varies. Differences are likely to be at least partly explained by methodological variations such as differences in age and diagnoses of participants and variations in the assessment tools used.

With regard to non-verbal communication, Drew et al. (2007) found that the frequency and function of primarily non-verbal communication acts in preschool children with autism was associated with later spoken language ability as measured on the *Reynell Developmental Language Scales* (Reynell, 1985) and the *MacArthur Communicative Developmental Inventory* (Fenson et al., 1993). Use of social communication functions, comments and number of communicative initiations were better predictors of later language ability than requests and responses. They used the *Social Communication Assessment for Toddlers with Autism* (Drew et al., 2007), to longitudinally measure the form, function, role and complexity of communication acts in two samples of children with ASD. The first sample consisted of 17 children with childhood autism or atypical autism assessed at a mean age of 21 months and reassessed at 42 months. The children in this sample had a mean mental age of 16.4 months at the first assessment. The second sample consisted of 29 children with childhood autism assessed at a mean age of 25 months and reassessed at 37 months (mean mental age of 18.1 months on first assessment). Thus participant samples were relatively small and heterogeneous in terms of diagnoses and age.

Kjellmer et al. (2012) found that age and cognitive ability (based on detailed review of each child's clinical records and test results) explained about half of the variability in spoken expressive and receptive language skills in their study with a larger sample of 129 children aged 24-63 months with ASD. However it accounted for only about a fourth of the variability of non-verbal gestures and actions. Verbal and non-verbal outcomes were measured using four verbal subscales and one non-verbal subscale of the *MacArthur Communicative Development Inventory* (Fenson et al., 1993). This study also included a range of ASD diagnoses (78 diagnosed with autistic disorder, 32 with pervasive developmental disorder non-specified, 11 with ASD unspecified and 8 with Asperger Syndrome). In addition, it included analysis of autism severity based on the *Autistic Behaviour Checklist* (Krug et al., 1980), although this was not found to be a key influence.

In support of Kjellmer et al. (2012), Norrelgen et al. (2014) also found that cognitive ability, as measured on the *Wechsler Preschool and Primary Scale of Intelligence* (Wechsler, 2005) or the *Griffiths Developmental Scales* (Alin-Akerman and Nordberg, 1991), was the most important factor associated with development of expressive language in children with ASD. Norrelgen et al. (2014) based their findings on a longitudinal study of 165 children aged 4-6½ years with autistic syndrome, pervasive developmental disorder non-specified or Asperger Syndrome. The children's language was measured by parent interview, using the expressive communication scale of the *Vineland Adaptive Behaviour Scales* (Sparrow et al., 2005) to classify the children into non-verbal, minimally verbal or phrase speech. This study was important since unlike previous studies, it included non-verbal and minimally verbal children *at school age*.

Ellis Weismer and Kover (2015) also highlighted cognitive ability as a key factor influencing later language skills. This time language skills were measured using the *Preschool Language Scales-4* (Zimmerman et al., 2002), which assesses non-verbal and verbal spoken communication, and the *Peabody Picture Vocabulary Test-4* (Dunn and Dunn, 2007). However, unlike Kjellmer et al. (2012), they found that autism severity was a key influence. Ellis Weismer and Kover (2015) used longitudinal data from 129 children with ASD assessed at

2½ and 5½ years. Cognitive ability was assessed using the cognitive scale of the *Bayley Scales of Infant and Toddler Development-III* (Bayley, 2006) and autism severity by using calibrated scores on the *ADOS (Autism Diagnostic Observation Schedule)*; Lord et al., 2002).

In support of Norrelgen et al. (2014) and Kjellmer et al. (2012), Thurm et al. (2015) suggested that autism severity was not a key factor in language outcomes after cognitive ability had been accounted for. Thurm et al. (2015) measured expressive language and cognitive ability with the *Mullen Scales of Early Learning* (Mullen, 1995). The expressive language scale measures language skills from early non-verbal to verbal spoken communication. They studied 70 children with ASD, of whom 47 were minimally verbal. The children were first assessed between 1 and 5 years of age then re-evaluated at least a year later in their 5th year.

Thus overall, the evidence stresses the importance of cognitive ability in determining receptive and expressive language outcomes for children with ASD. Further evidence is required to clarify the importance of autism severity and non-verbal communication, but recent evidence suggests these factors should be considered. However, the above studies do not compare spoken with non-spoken verbal outcomes and comparison of the evidence is made difficult by the use of different language measures across studies (Hudry et al., 2014). Mody and Belliveau (2013) summarising behavioural research, argue that children with ASD overall tend to have reduced spoken language depending on cognitive ability, comprehension and attention, but the main difficulty is in social communication.

However, given that verbal communication is linked to better overall outcomes in ASD (Howlin et al., 2000; Gillberg, 1991) and better early expressive and receptive language is associated with increased language growth in the preschool years (Ellis Weismer and Kover, 2015), effective early intervention to enhance spoken language development is an important area of research. Evidence is emerging of the predictive potential of atypical early spoken word processing in children with ASD. Kuhl et al. (2013) found that ERPs (Event-Related Potentials, i.e., measured brain responses using EEG) of word

processing in children with ASD at 2 years, were strongly associated with later language comprehension, adaptive behaviour and cognitive ability at 4 and 6 years. Furthermore ERPs of word processing exceeded cognitive ability in their predictive power. This held true with different types of intensive intervention. However, the study did not include children receiving no intervention. Kuhl et al. (2013) recommend further research but suggest that the ERP measure of word processing might reflect the extent of the brain's ability to reorganise in response to social experience, where a lack of this ability limits learning.

Hence the evidence suggests that at least some children with ASD may process spoken language differently from typically developing children and early language skills are an important predictor of later outcomes. This highlights the need to better understand early language development in these children and what might be done to facilitate development.

1.2: VOCABULARY DEVELOPMENT IN YOUNG CHILDREN

1.2.1: Early vocabulary development in typically developing children

Hamilton et al. (2000) reported that typically developing children understand between 50 and 250 words at 18 months of age as measured on the *Oxford Communicative Development Inventory* (a UK standardised children's vocabulary checklist). In addition, Houston-Price et al. (2005) reported that even 18 month old children are able to learn words rapidly in the same way as preschool children. They found that 18 month old children were able to fast map words (associate an object with verbal label after minimal exposure) for either two moving images or two still images after just three repetitions. This was demonstrated by preferential looking towards the named object during the post trial test phase. The rate of learning for both still and moving images was the same. Munro et al. (2012) however found that although young children (mean age 33 months) could fast map and produce new words, retention was limited by encoding or establishing a memory trace rather than consolidation. The study found that when the children were exposed to six productions of a novel word and its referent, an unfamiliar toy, they accurately produced the word

when it was elicited immediately after modelling. However production accuracy was noticeably reduced when elicitation was cued one and five minutes later. Production accuracy on elicitation one to seven days later then stabilised. Munro et al. (2012) suggested that this time period of accuracy reduction indicated that poor retention of new word learning is more likely to be due to weak encoding than difficulties with consolidation. They also suggest that this may well be adaptive since gradual learning across contexts over time is more likely to enable the child to learn general patterns about the word.

Factors which influence word learning in typically developing children are said to be; attention (Samuelson and Smith, 1998), familiarity with the named object (Fennel, 2012) and the object's salience to the child (Houston-Price et al., 2005). Samuelson and Smith (1998) found that it was general attention and memory processes rather than knowledge of communicative intent that influenced word learning in their sample of forty eight children aged 18-28 months. Fennel (2012) found that familiarity with an object enhanced word learning in 14 month old infants, describing how object familiarity makes it easier for the child to make object word associations. Houston-Price et al. (2005) found that young children were able to fast map new words to object images after just three image-label repetitions when highly salient visual and auditory stimuli were used in their sample of sixty four children aged 18 months. Some studies suggest a preference for moving images in very young children's vocabulary learning (Werker et al., 1998). This is in contrast to the findings of Houston-Price et al. (2005) but as Houston-Price et al. (2005) suggest, might be accounted for by differences in participant age or object salience.

Contextual factors are also important to young children's vocabulary learning. Smith and Yu (2008) demonstrated that in typically developing children aged 12-14 months, learning new words depends not only on the attention, language and social limitations of the word learning context, but also on how well children are able to make sense of evidence from different and possibly ambiguous contexts. Bion et al. (2013) suggest that how well a child is able to choose the correct new object rather than a familiar one when they hear a new object name in an ambiguous context, improves between 18 and 30 months. They maintain

therefore that learning new words happens gradually over time and place and relies on the child making use of a range of cross-context, social, pragmatic and semantic cues. Ramirez-Esparza et al. (2014) found that use of 'parentese' or child directed speech (CDS) and one to one as opposed to group contexts, were both associated with increased vocabulary in young children. CDS is typically characterised by the adult speaking slower with a higher fundamental frequency, more pitch variations and repeated intonation patterns in addition to using long pauses and short sentences (Ma et al., 2011).

Thus for typically developing children, intrinsic factors in the child such as attention and cognitive ability, are important influences in early word learning. In addition, object familiarity and salience and the child's experiences in different contexts over time are also important influences.

1.2.2: Early vocabulary development in children with ASD

A range of studies have highlighted delayed vocabulary in preschool children with ASD, e.g., Luyster et al. (2008), Anderson et al. (2007) and Luyster et al. (2007). However, recent evidence has highlighted how the vocabulary development of children with ASD is not just delayed, but follows an atypical trajectory from the normal course of development. Patrick (2013) found that children with ASD younger than 6.5 years differed from typically developing children in their ability to map new words in response to gaze cues. Mapping in this instance referred to the child pointing to, touching or giving the named target object from a choice of three objects on request, after an experimenter had named the target object six times in one of four cued conditions. These conditions were: the experimenter looking at, pointing and looking at, touching, or manipulating the target object. However, children with ASD from 6.5-10 years did not differ from the typically developing children in any of the conditions. Furthermore, better outcomes were predicted by prior knowledge of nouns in typically developing children, whereas the same was true with knowledge of verbs in children with ASD. Patrick (2013) suggests that this may be because unlike typically developing children, children with ASD need to acquire a level of linguistic knowledge before they can make use of social cues in word learning.

Hudry et al.'s (2010) study of 152 children with autism and a wide range of language and cognitive abilities aged from 24-59 months, found that in contrast to typically developing children, receptive vocabulary was frequently more delayed than expressive vocabulary. Around 30% of the sample had expressive vocabulary nearing (but not in advance of) receptive vocabulary. The findings of Hudry et al. (2010) were robust in that they were based on a number of measures including direct assessment and parental report and individual assessment scores were highly associated across the different assessment tools. The effect was even more noticeable in children with a higher non-verbal ability, although the authors suggested that this may have been because it was difficult to measure the variation in children with lower non-verbal skills. The direct language assessment results were based on age equivalent rather than standardised scores due to floor effects for some participants on the *Preschool Language Scales-3* (Zimmerman et al., 1997). In addition, one of the parent report measures (*MacArthur Communicative Development Inventory-MCDI*; Fenson et al., 1993) relied on raw scores, whilst the other (*Vineland Adaptive Behaviour Scales- VABS*; Sparrow et al., 2005) used age equivalent scores. The lack of standardised scores potentially weakens the findings, although this is countered by the range of measures used. These findings of relatively advanced expressive compared to receptive language, however also support those of Luyster et al. (2008) in their study of 164 children with ASD at the younger age range of 18-33 months. They found that receptive language was relatively more impaired than expressive language on both standardised direct assessment using the *Mullen Scales of Early Learning-MSEL* (Mullen, 1995) and parent report on the *MCDI* (Fenson et al., 1993), although this did not translate to parent reported functional communication on the *VABS* (Sparrow et al., 2005).

A more recent study by Hudry et al. (2014) of fifty four preschool children at high risk of ASD, also found that there was a lower vocabulary comprehension advantage on the *MCDI* (Fenson et al., 2003) in 14 month old children with a high risk of ASD than for fifty low-risk controls. The children were each assessed at 7, 14, 24 and 36 months. This lower receptive advantage was only present at 24 months in those who later received a diagnosis of ASD or other

atypical outcome. However, there were few group differences between high risk infants and low risk controls on either direct language assessment measures on the *MSEL* (Mullen, 1995) or parent report of functional communication on the *VABS* (Sparrow, 2005), again using age equivalent scores. In contrast, a meta-analysis of 74 studies by Kwok et al. (2015) found no overall expressive advantage, but did find evidence of language delay. However, the authors conceded that there may be a subgroup of children with ASD who do have better expressive than receptive language.

It is possible that variations in measurement within and across studies such as direct assessment vs. parent report tools, might account for some findings of an atypical expressive vocabulary advantage. For instance, an extended phase of unmodified echolalia is frequently found in children with ASD (Roberts, 2014; Sterponi and Shankey, 2014). Echolalic speech may have confounded information from some parent reports, artificially boosting expressive scores. However, given the range of additional evidence reporting an expressive advantage based on direct assessment (Barbaro and Dissanayake, 2012; Volden et al., 2011; Ellis Weismer et al., 2010), it seems unlikely that this alone can account for the phenomenon. Hudry et al. (2014) recommend further investigation into the effects of atypical social and cognitive processes on the relative development of early receptive and expressive language skills.

Further evidence of atypical vocabulary development in children with ASD, is provided by Norbury et al. (2010). Whereas typically developing children learn new words by making use of social cues to integrate information on how words sound with their meaning, evidence from eye gaze data combined with word learning, suggested this was different for 6-8 year old children with ASD when matched by age, vocabulary and non-verbal ability to typically developing peers. Although the children with ASD could follow eye gaze cues the same as their peers, they were less sensitive to the social information from these cues, as demonstrated by decreased looking at the adult's face when gazing at the target object compared to typically developing peers. However, they were more successful at mapping phonological information to novel objects. Yet unlike their typically developing peers, the children with ASD did not maintain this advantage 4 weeks later.

Potential explanations for atypical vocabulary development in children with ASD have been explored in studies by Kuhl et al. (2005; 2013) looking at differences in ERP data related to word processing in typically developing children compared to children with ASD. Kuhl et al. (2005) argue that both the ability to discriminate speech and social interest in spoken language are crucial when children first learn language. This is evidenced by ERP data demonstrating that on a group level, children with ASD prefer non-speech analogue sounds to CDS (used as a social measure) and do not show expected mismatch negativity (MMN) in response to a change in syllable. MMN for auditory stimuli is a component of the ERP which is produced in response to an atypical sound within a sequence, in this case syllable change. Hence it is an indicator of basic auditory change detection. MMN is elicited automatically regardless of whether the child is paying attention. Interestingly, those children with ASD in the study by Kuhl et al. (2005) who did prefer CDS, also demonstrated similar MMN to typically developing children matched by chronological and mental age, supporting the link between social and linguistic processing in ASD.

Other studies highlight differences in P3, an ERP component linked with attention to key environmental stimuli, but typical MMN in high functioning children with autism (e.g., Ceponienne et al., 2003; Kemner et al., 1995). A further study by Kuhl et al. (2013) built on their previous 2005 study, but this time looked at word processing in twenty four 2 year old children with ASD compared with twenty two typically developing controls. They found that the children with ASD who had less severe social difficulties as measured by the *Autism Diagnostic Observation Schedule* (Lord et al., 2002), demonstrated similar ERP patterns in response to word processing to typically developing children, i.e., a left brain focal response, compared to a broader response across brain hemispheres for children with ASD with more severe social difficulties. However, the significant difference in ERP amplitude between known and unknown words in typically developing children was at the left temporal electrode site T3, whereas in children with ASD even with less severe social difficulties, it was at the left parietal electrode site, P3. Thus although the broader hemispheric response in children with ASD with less severe social difficulties was similar to very young typically developing children, there was still

a significant difference in ERP. Kuhl et al. (2013) highlight limitations of their study such as only including children receiving intensive treatments and small sample size. Nevertheless Kuhl et al. (2013) highlight how their findings provide an insight into how children with ASD process speech, warranting further research.

Kuhl et al. (2007) hypothesise that social interaction is essential for natural learning of spoken language and thus atypical social interaction characteristic of ASD is likely to have a negative impact on language learning (Mahdhaoui et al., 2011). The importance of social interaction in vocabulary learning might lie with the increased motivation to learn that social interaction provides, increasing arousal and attention to spoken language. Given that atypical social interaction is core to ASD, this process may not work in the same way for these children. Alternatively, social interaction might be important because of the nature of the relationship between auditory labels, objects and speaker intentions that the child encounters in natural language learning situations. However, again this might be affected by differences in attention in children with ASD. This is discussed in later in section 1.2.4.

In summary, the evidence suggests that early vocabulary learning follows an atypical rather than just delayed developmental trajectory in many children with ASD. ERP data provides further support for this assertion, highlighting differences in speech discrimination, attention and use of social and linguistic cues in the word learning context. The role of attention in early word learning will now be considered first in typically developing children, then in children with ASD.

1.2.3: The role of attention in early word learning in typical development

A range of evidence in the literature highlights the importance of both visual and auditory attention in early word learning. This evidence includes; reflexive and spontaneous orienting to eye gaze (Nation and Penny, 2008), joint attention (Yu and Smith, 2012), attention to social cues (Brooks and Meltzoff, 2008, 2005;

Mundy et al., 2007), and attention to objects and their associated word labels across contexts (Bion et al., 2013; Smith and Yu, 2008).

Changes in how attention is allocated in babies and infants can affect their early word learning. The ability to attend to the speaker's focus of attention is a critical skill in early word learning. From birth, typically developing babies attend more to faces than other stimuli (Farroni et al., 2005), with a preference for the eyes (Hunnius and Geuze, 2004).

Farroni et al. (2000) have demonstrated that babies as young as 4 months demonstrate a reflexive attention orienting response to shifts in eye gaze. The response is thought to be reflexive rather than voluntary attention because it occurs within a short time interval of 105 to 1000 ms and often even when the cue is non-predictive (Nation and Penny, 2008). This phenomenon has also been found in adults (e.g., Friesen et al., 2004) and 3-4 year old children (Ristic et al., 2002) as demonstrated in experiments using a Posner style spatial cueing task. These Posner type cueing tasks, when an individual is faster to press a button to identify a target in a location on a screen indicated by the direction of eye gaze, than a target in an alternative location not indicated by the eye gaze, demonstrate validity of reflexive attention orienting to eye gaze (Nation and Penny, 2008).

After 6 months of age, babies attend more broadly to the face (Oakes and Ellis, 2013) with more attention to the speaker's mouth than their eyes (e.g., Frank et al., 2012) particularly if the person speaks (Tenenbaum et al., 2013). This enables the baby to integrate sensory information about how words are produced. Then from around 12 months, they increase their attention to the eyes as well as the mouth, thus obtaining social-emotional and contextual information about what the speaker is saying (Lewkowicz and Hansen-Tift, 2012).

By around 10-12 months of age, typically developing children can spontaneously follow adult eye gaze to look at an object, although they can follow body turns prior to then (Brooks and Meltzoff, 2002, 2005; Hollich et al., 2000; Baldwin, 1993). There is a strong positive correlation between being able to follow eye gaze and subsequent vocabulary scores at 18 months of age

(Brooks and Meltzoff, 2005). Brooks and Meltzoff (2008) highlight the importance of visual attention to social cues when young children first learn words. They found that early gaze following and pointing predicted future language development. Briganti and Cohen (2011) found that 18 month old children could use social cues, e.g., pointing and head turning, to associate novel words with unfamiliar objects whereas 14 month old children could not yet use these social cues for word learning. However the 14 month old children could use the cues to inform which way to look. The authors therefore postulate that children's sensitivity to social cues changes with age. The ability to follow another person's gaze and orient to the exact object they are looking at, is critical in establishing joint attention (Frischen et al., 2007), which in turn is important in early word learning (Yu and Smith, 2012).

Joint attention occurs either as a result of the infant responding to the bids of other people or as a result of other people responding to initiations by the infant (Mundy et al., 2007). The classic definition of joint visual attention involves triadic gaze following. However Carpenter and Liebal (2011) argue that for joint attention to be shared attention, it requires more than alternating looks between a person and an object. It must also involve a shared look between the infant and the other person to acknowledge and comment on the shared interest. Hobson and Hobson (2011) also distinguish between joint attention and joint engagement where the latter refers to the ability to engage with the affective states of others rather than just sharing of perceptual states. Seemann (p.9, 2011) further highlights the idea of embodied attention in which the perceptual experiences of jointly engaged individuals are influenced by their actions, e.g., when a child's actions affect what the adult attends to.

Several studies have highlighted the importance of joint attention in early word learning in typically developing children. For instance, Yu and Smith (2012) highlighted the role of embodied visual attention in ambiguous natural contexts. They demonstrated that when 17-20 month old children played with novel objects with their parents, the way the children handled or looked at objects created brief time periods where one object was visually dominant in terms of size and lack of visual clutter. Head cameras worn by the parents showed that the target object was simultaneously visually dominant for the parent as they

also moved their heads towards the object the child was attending to. When parents reacted by also naming the objects at these times, there was an increased likelihood of the children learning the word. The authors suggest that the children supported their ability to learn to associate object names with the correct referent by reducing ambiguity, using their body, head, hands and eyes to create moments which parents could use to optimum effect to support word learning. Yu and Smith (2012) did not directly measure eye gaze and the sample comprised of a small number of parent-child pairs, but further support for the importance of minimal contextual ambiguity in word learning is provided by Pereira et al. (2014) in an experiment using head cameras on twelve 16-25 month old children. Their experiment comprised of a word learning assessment after an object play session. They found that object word learning was associated with minimal visual distractions in the child's visual field before, during and after hearing the object name.

In addition to visual attention, acoustic characteristics of speech are important in supporting auditory attention to word learning. Ma et al. (2011) found that child directed speech (CDS) facilitated word learning compared to adult directed speech, particularly in younger children. Thus CDS facilitated word learning better than adult directed speech in 21 month children, whereas 21 month old children with larger vocabularies and 27 month old children learnt words reliably with both adult directed and CDS. Graf Estes and Hurley (2013) found that the pitch variation component of CDS was particularly important in early word learning. They suggest that one possible explanation for this might be the role of prosodic variation in facilitating the quality of attention to spoken word labels, thus making it easier to associate the word with its referent.

In summary, a child's visual and auditory attention to spoken language and ability to direct and engage attention, making use of the relevant contextual and social cues, are powerful influences on early vocabulary learning in typical development.

1.2.4: The role of attention in early word learning of children with ASD

A range of evidence highlights the difficulty that children with ASD have with different aspects of attention such as; shifting attention, reflexive gaze following, joint and shared attention, atypical attention allocation and attention to child directed speech, compared to typically developing children. A narrative review of referential gaze and word mapping in ASD by Akechi and Kobayashi (2014) suggests that some individuals with ASD have difficulty mapping novel words to novel objects using eye gaze cues because they attend less to the speaker's face and some have difficulty because although they can follow the speaker's gaze, they do not appear to consider it an important referent. However, recent research suggests that some aspects of attention such as eye contact may not be a fixed deficit, but rather decline in babies who go on to get a diagnosis of ASD from normal levels in the first 2-6 months of life (Jones and Klin, 2013).

Children with ASD are reported to have particular difficulties with shifting and disengaging visual attention (e.g., Landry and Bryson, 2004), although some also have difficulties staying on task similar to those with ADHD (Hazen et al., 2014). Elsabbagh et al. (2013) found that early slower responses shifting and disengaging visual attention from a visual stimulus positioned centrally to one on the periphery, was associated with emerging autism in young children aged 14 months. One possible explanation for the difficulties that children with ASD have with shifting attention is low arousal and under sensitivity to sensory stimuli, leading to difficulty allocating attention resources (Schoen et al., 2009). Differences in shifting and disengaging attention are likely to impact on gaze following and joint attention and therefore object word association and use of social cues to learn word meanings.

Several studies suggest that older and high functioning children with ASD demonstrate reflexive orienting to gaze in the same way as those without ASD (e.g., Senju et al., 2004; Kylliainen et al., 2004 and Swettenham et al., 2003). However, these older high functioning children with ASD do have difficulties spontaneously following another person's gaze, although this may be a delay rather than an impairment (Leekam et al., 2000).

The evidence of impaired reflexive gaze following in younger children with ASD is more mixed. In contrast to Chawarska et al. (2003), Gillespie-Lynch et al. (2013) for instance, found that young children with ASD do have impaired reflexive gaze following. However, this is not evident in older or high functioning children with ASD (e.g., Pruett et al., 2011; De Jong et al., 2008; Swettenham et al., 2003). Gillespie-Lynch et al. (2013) compared twenty four children with ASD (aged 2.4 to 6.7 years) with forty two children without ASD, matched by either chronological or non-verbal mental age. Despite the evidence of atypical reflexive gaze following, word learning from gaze following cues was more likely to be associated with developmental level than ASD diagnosis. This suggests that the atypical reflexive gaze following was not solely a function of the ASD.

Evidence in the literature supporting difficulties with spontaneous gaze following in children with ASD includes; Patrick (2013); McDuffie et al. (2006); Preissler and Carey (2005) and Carpenter et al. (2002). Elsabbagh et al. (2012) found that babies aged 6-10 months who later went onto have a diagnosis of ASD, based on ERP evidence, were less sensitive to whether gaze was directed towards or away from them.

In contrast to evidence such as Preissler and Carey (2005), Norbury et al. (2010) found in their study of 6-8 year old children with ASD, that gaze following was not impaired, although there was reduced sensitivity to the social information from these cues compared to typically developing children. That is, although there was no significant difference between groups in spontaneous gaze following, the children with ASD looked less than the typically developing children at the adult face when gaze was socially informative and directed towards the target object. However, McGregor et al. (2013) found that in laboratory conditions, high functioning children with ASD (mean age 11 years 2 months) could monitor eye gaze and determine how reliable it was as a cue for word meaning as well as typically developing children, although lower language ability was associated with a reduction in mapping word meanings. Differences in findings regarding response to eye gaze might be explained by the age, cognitive or language ability of the participants. For instance, Luyster and Lord (2009) and McDuffie et al. (2006) found that gaze following was correlated with parent reported vocabulary scores on the *MacArthur CDI* (Fenson et al., 1993).

The findings of Norbury et al. (2010) broadly support those of Parish-Morris et al. (2007), who found that although young children with ASD (mean age 5.08 years) were able to use eye gaze to help learn new words, they found it difficult to use this information to infer meaning in more ambiguous situations. Norbury et al. (2010) suggest that children with ASD frequently learn new words through associative learning rather than by using eye gaze to infer meaning. Gliga et al. (2012) also measured eye gaze in the word learning of 3 year old children at high risk for ASD compared to low risk controls. In support of Norbury et al. (2010), they found that although the ability to follow eye gaze was essential to receptive word learning in the high risk children, eye gaze alone was not enough to enable the child to learn the words unless they could also infer meaning from the non-verbal cues.

As Nation and Penny (2008) highlight, the above studies do not answer the question as to whether impaired reflexive attention orienting in some way causes potential impairments with spontaneous gaze following. This is because most studies are with older and more able children with ASD and do not measure spontaneous gaze following in addition to reflexive gaze orienting (Nation and Penny, 2008). An exception is a study by Chawarska et al. (2003) who found that even where there was an impairment with the ability to spontaneously follow eye gaze, 2 year old children with autism had unimpaired reflexive visual attention orienting in a Posner style gaze cueing task. This suggests that impaired reflexive attention orienting does not necessarily underlie difficulties with spontaneous gaze following. However, other evidence contradicts the assumption of normal reflexive orienting to gaze in ASD. For instance, Senju et al. (2004) found a similar validity effect for the control condition using non-social arrow cues as for social eye gaze cues in children with autism, whereas reflexive orienting to targets was quicker for eye gaze than arrow cues in typically developing children.

Overall most evidence suggests that although there is typical reflexive attention orienting to eye gaze in children with ASD, this is not uniform and can be commonly found alongside a spontaneous gaze following impairment. In addition, reflexive gaze following is more likely to be impaired in younger or lower functioning children with autism. These findings have implications for

attention to word learning. Even where children with ASD do follow gaze cues in word learning contexts, they may still have difficulty inferring meaning. Further research is required to ascertain whether such attention difficulties can be attributed to a primary social deficit, a difference in saliency of social stimuli or primary difficulties with disengaging attention (Nation and Penny, 2008).

Joint and shared attention difficulties are core factors in the diagnosis of ASD in young children (Sigman and McGovern, 2005; Dawson et al., 2004; Charman, 2003; Leekam et al., 2000) and the ability to follow eye gaze is important in enabling joint attention. However, a systematic review by Korhonen et al. (2014) has found evidence of intact as well as impaired joint attention (defined as directing another person's visual attention or following their gaze to an object) in children with ASD at both an individual and group level, possibly explained by differences in context, task or participants.

Several studies of children with ASD show that joint attention difficulties are associated with problems in learning and fast mapping vocabulary (i.e., learning new words after minimal exposure). For instance, Priessler and Carey (2005) found that difficulty with fast mapping words was linked to the ability of the child with ASD to redirect their attention to the focus of the examiner. Walton and Ingersoll (2013) found that typically developing young children (mean age 23.53 months) can follow where another person is looking and fast map object names. However, the fourteen children with ASD (aged 38-97 months) in their study wrongly mapped novel words to what they, rather than the other person, were attending to. The study used three conditions: the adult labelling the object that the child was attending to; the adult labelling the object that they were attending to; and the adult using an orienting cue before labelling their own focus of attention. The language matched typically developing children fast mapped receptive words in all conditions, whereas the children with ASD wrongly mapped words to what they were attending to. However, they were able to correct their mistakes when they had an orienting cue. Yoder et al. (2014) found that responding to another person's bid for joint attention along with intentional communication and parent linguistic responsiveness, predicted language growth in eighty seven children with ASD and minimal language, aged 24-48

months at the start of the study. This was after cognitive ability and autism severity had been considered.

Difficulties with attention may affect both visual and auditory attention when young children with ASD learn new words. Wilson (2013) compared visual attention in live vs. video modelling of social communication behaviour in four children with autism aged 45-64 months. She found that attention to video modelling was greater than live modelling in three out of four participants, although positive visual attention did not always coincide with positive learning outcomes. This suggests that increased visual attention to video in itself is insufficient to support social communication learning.

In addition to differences in visual attention, there is evidence of differences in attention to auditory aspects of speech in children with ASD. Some studies have looked specifically at the impact of child directed speech (CDS) on attention to speech. So, for instance, Watson et al. (2012) found that children with ASD have reduced attention to CDS compared to typically developing children. Paul et al. (2007) demonstrated that preference for CDS in children aged 14-36 months with ASD was less than in age matched controls. Also, Kuhl et al. (2005) as noted earlier, demonstrated that children with ASD often prefer analogue non-speech sounds to CDS. However, there is limited evidence of responses by children with ASD to CDS vs. other forms of speech. Mahdhaoui et al. (2011) found no studies in their narrative review of the literature. Cassel et al. (2014) did a case study using retrospective home movie data from the first 18 months of life. They found that the child with ASD showed less response to both CDS and other speech forms than the typically developing child. However, there was a preference in the typically developing child for CDS up to one year. Furthermore, Paul et al. (2007) noted that time children with ASD spent orienting to CDS was positively correlated with receptive language.

Thus, although some evidence suggests that young children with ASD have less preference for CDS than typically developing young children, it is not yet clear whether this is specific for CDS or generalised across other speech forms. Further research on the effects of using different speech forms on attention to adult speech with children with ASD of different ages and abilities would help in

understanding the impact of using different speech forms on early vocabulary learning.

Children with ASD may also allocate visual attention differently and this may impact on word learning. Tenenbaum et al. (2014) explored the influence of different patterns of attention to faces and objects on early word learning in 2-5 year old children with autism, language matched typically developing children and language delayed children. They found that more attention to the woman's mouth was associated with increased scores on standardized language assessments in typically developing children and children with autism, but not in the children with language delay. This association varied with age and cognitive ability in typically developing children, but not with the children with autism. Furthermore, attention to the woman's mouth and eyes whilst she was saying the new words predicted faster word recognition in the children with autism. In support of Kuhl et al. (2013), the authors suggest that atypical social attention may be a key factor in children with autism and delayed language.

To conclude this section on attention, the evidence suggests that young or lower functioning children with autism are likely to have particular difficulties with a wide range of attention abilities in both the visual and auditory domains, affecting communication and word learning. These include; impaired reflexive attention to eye gaze or spontaneous gaze following, reduced joint attention, difficulties with attention allocation and shifting attention. Furthermore, research indicates that even when children with ASD are able to follow gaze accurately, they may have difficulty making use of social cues to support early word learning and effectively learn word meanings. However, research findings are not uniform. Further research is required with this population to understand why some children with ASD have these difficulties.

1.3: SENSORY PROCESSING

Dunn (1999) describes how in typical development, a child's nervous system evolves so that the child can modulate (i.e., facilitate or inhibit) their sensory responses to adapt to their environment. A hypothetical model proposed by

Dunn (1997) describes how neurological thresholds interact with behavioural responses. A neurological threshold is the amount of stimulation needed for a neural system to respond whereas the behavioural threshold is how the child acts in response to their neurological threshold (Dunn, 1991). Dunn (1999) describes four basic patterns of sensory processing according to whether the individual has a high or low neurological threshold and their subsequent behavioural response. These are low registration, sensation seeking, sensory sensitivity and sensation avoiding (Dunn, 1997, p. 23-25). Low registration occurs with a high neurological threshold and corresponding behaviour and tends to present as the child being uninterested or apathetic. Sensation seeking also occurs with a high neurological threshold, but this time the child's behaviour seeks to counteract this, presenting as active and continuously engaged. Sensory sensitivity occurs with a low neurological threshold and corresponding behaviour, with the child often presenting as distractible. Finally, sensation avoiding occurs with a low neurological threshold and counteracting behaviour, presenting as avoidant and resistant to change (Dunn, 1999, p. 33-37). These four patterns occur from babies to older adults (Dunn, 1997).

Children whose neurological thresholds are too high (under responsive) or too low (over responsive) may struggle with sensory modulation and demonstrate behaviour which is maladaptive in their everyday environment. Miller and Lane (2000) describe sensory modulation as the ability to regulate and organise responses to sensory input in a measured and functionally adaptive way. Effective sensory integration occurs only when children receive accurate reliable sensory information, process it and use the information to organise their behaviour adaptively.

Several studies have looked at the distribution and prevalence of atypical sensory responses across the population. Dunn (2001, 1999) describes how the sensory responses of children and adults in everyday life are normally distributed, thus approximately 2-4% of the population would be predicted to show a definite difference. Ahn et al. (2004) conducted a survey of all incoming kindergarten children in one U.S. school district (1,796 children), using the Short Sensory Profile (Dunn, 1999). They achieved a 39% response rate and found a prevalence rate of sensory processing disorder of 13.7% amongst respondents

but 5.3% of the total sample if non-respondents were assumed not to meet criteria. However the authors acknowledged that this study only used screening results and did not take into account how results might vary with age, the percentage of the population who also had disabilities (a factor associated with increased prevalence) and generalisation of the results may have been limited by population demographics. The following section goes on to look specifically at sensory processing in children with ASD.

1.3.1: Sensory processing differences in children with ASD

In recent years, increasing evidence of specific difficulties with the processing and integration of sensory information by individuals with ASD has emerged (Hazen et al., 2014). A range of studies have supported inclusion of sensory differences in the *DSM-5* (APA, 2013) diagnostic criteria for autism (Nieto del Rincón, 2008; Kern et al; 2007; Tomchek and Dunn, 2007). Most of the available evidence on atypical sensory processing is from studies using parental report tools, videotape analysis and accounts from adults with ASD. A range of assessment tools exist but at the time of this study, none (including the commonly used *Sensory Profile*; Dunn, 1999), had been standardised on children with ASD. From the available evidence, Hazen et al. (2014) conclude in their systematic review that the precise underlying neurological structures for such sensory differences remains unclear although connectivity between brain areas and impairments in the amygdala, cerebellum and hypothalamic-pituitary-adrenal axis have all been implicated.

Prevalence rates of atypical sensory processing in ASD in the literature vary from 69% (Baranek et al., 2006), 70% (Adamson et al., 2006) to 95% (Tomchek and Dunn, 2007). Interestingly, Lane et al. (2014) found that 37.5% of their sample of 228 children aged 2-10 years presenting for diagnosis had mainly typical sensory function, but explained this as a possible function of sampling. Hazen et al., (2014) suggest that differences in methodology, age and diagnosis of participants are all likely to have contributed to variation in prevalence rates. The reviews discussed below look at the prevalence of different sensory symptoms in ASD.

In their systematic review, Rogers and Ozonoff (2005) reviewed the evidence from 1960 onwards in forty eight empirical papers and twenty seven theoretical or conceptual papers on the range of sensory differences across modalities in the ASD population. They found that sensory symptoms were more noticeable and frequent in children with autism than in typically developing children. They also found very little support for hyper-arousal and failure of habituation, but more evidence of hypo-arousal. However, the review also found that there was a frequent lack of replication of these findings. The authors highlighted that changing standards over time made interpretation of the evidence difficult and concluded that there was a need for tighter methodological considerations in this area and specific research comparing different sensory modalities. Methodological differences might also account for some of the variation in findings of more recent studies (Tomchek et al., 2014).

In their meta-analysis, Ben-Sasson et al. (2009) found that sensory differences between groups of children with and without ASD were highest in the studies including children with ASD aged 6-9 years and when these children were compared to chronological rather than mental age matched or developmental disorder control groups. Hazen et al. (2014) conducted a systematic review and found a high rate of prevalence of atypical responses to sensory stimuli in the ASD population, supporting previous reviews. Although research findings vary, Hazen et al. (2014) found that there were increased rates of sensory symptoms in those with more severe forms of ASD and a low mental age. In addition, they found that unusual sensory responses appeared to reduce in later childhood, although it was not clear why. Hence, evidence as to the nature of sensory differences varies, although some themes are emerging (Tomchek et al., 2014). Evidence of difficulties with sensory modulation such as under responsiveness and sensory seeking behaviour, along with poor auditory filtering and difficulty with attention, emerges repeatedly from the literature as discussed below. Auditory filtering is defined as, 'ability to use and screen out sounds' (Tomchek et al., 2014, p. 1216) and will be the definition used throughout this text.

A range of studies and personal accounts from people with ASD have found evidence of difficulties with sensory modulation (e.g., Hazen et al., 2014; Tomchek and Dunn, 2007; Watling et al., 2001; Grandin, 1995). Sensory

modulation difficulties occur when responses to stimuli lead to functional impairment. Symptoms can include under responsiveness, over responsiveness and sensory seeking behaviour (Hazen et al., 2014). Ben-Sasson et al. (2009) conducted a meta-analysis of fourteen studies of the sensory modulation in children with ASD, categorized into three age groups. They found that the greatest differences between children with ASD and control groups in the studies were in under responsiveness followed by over responsiveness and sensory seeking behaviour. Overall, there is more evidence of sensory under responsiveness in the literature (e.g., Baranek et al., 2007; Ben-Sasson et al., 2007; Tomchek and Dunn, 2007; Adamson et al., 2006; Liss et al., 2006) than over responsiveness. However, Hazen et al. (2014) and Ben-Sasson et al. (2008) describe some contradictory findings.

Watling et al. (2001) found significant differences between children 3-6 years with and without autism on a range of individual *Sensory Profile* (Dunn, 1999) factors. The children with autism were more likely to be reported to demonstrate sensory seeking behaviour, low endurance/tone, be emotionally reactive, have oral sensitivity, demonstrate inattention/distractibility, and have poor sensory registration and fine motor perceptual sensory responses. Tomchek and Dunn (2007) compared 281 children aged 3-6 years with ASD with age matched typically developing children using the *Short Sensory Profile* (Dunn, 1999). They found the greatest differences between groups in the Under Responsive/Seeks Sensation, Auditory Filtering and Tactile Sensitivity sections, with 95% of children with ASD demonstrating sensory processing difficulties and significant difference on 92% of the items. Similarly, Adamson et al. (2006), found most sensory differences in children with ASD in sensation seeking, auditory filtering and under responsiveness. Comparisons with children with intellectual disability suggest that these differences cannot wholly be accounted for by cognitive ability, e.g., Joosten and Bundy (2010) found 5-18 year old children with ASD and intellectual disability differed from children with just intellectual disability on sensory sensitivity and sensory avoidant behaviour. This is further supported by the lack of association between non-verbal IQ and severity of sensory symptoms found by Lane et al. (2014).

Tomchek et al. (2014) analysed the responses from a large sample of 400 children on the *Short Sensory Profile* (Dunn, 1999). They found six factors which characterised children with ASD (most meeting the full criteria for autism), i.e., low energy/weak, tactile and movement sensitivity, taste or smell sensitivity, auditory and visual sensitivity, sensory seeking distractible behaviour and hypo-responsiveness (Tomchek et al., 2014, p.1214). Interestingly, Tomchek et al. (2014) also found that there was wide variation in reported behaviour in auditory and visual sections of the *Short Sensory Profile* even though auditory and visual sensitivity was a key characteristic of children with ASD. However, auditory filtering problems such as difficulty listening in noise, did appear as a more consistent difficulty. There is also some evidence that children with ASD cannot be differentiated from developmentally delayed children by their levels of auditory and visual sensitivity (e.g., Wiggins et al., 2009). The sensory seeking/distractibility factor included most items from the under responsiveness section of the *Short Sensory Profile* and one item on paying attention. Tomchek et al. (2014) compared their findings with mixed research evidence (e.g., Ben Sasson et al., 2007 and Joosten and Bundy, 2010) of the power of the sensory seeking factor from the *Sensory Profile* (Dunn, 1999) to differentiate children with ASD from other groups. The finding that hypo-responsiveness was a key differentiating factor was consistent with most of the evidence from the literature and has implications for failing to orient, attend and respond to typical stimuli levels.

Some researchers have examined the extent to which the particular sensory differences which characterise ASD are cross-modal and how they might relate to the core symptoms of ASD. Kern et al. (2006) examined the auditory, visual, oral and touch processing scales in the *Sensory Profile* (Dunn, 1999) for 104 participants aged 3-56 years and compared them to age matched controls. They found that individuals with autism had abnormal profiles significantly different from age and gender matched controls in all sensory modalities, apart from touch. Lower levels of sensory abnormality were found with increased age. In contrast to Lane et al. (2014), a follow-up study by Kern et al. (2007) demonstrated that sensory symptoms correlated with autism severity in

children, but not adults. Iarocci and McDonald (2006) found individuals with autism often show deficits in cross-modal sensory integration.

Thus in summary, there is now a large body of evidence describing sensory differences in individuals with ASD, but some variation in findings as to the nature of these differences. For instance, it is unclear which particular factors differentiate children with ASD from other populations and the extent to which any differences are cross-modal or implicated in individual sensory modalities. However, the research literature does now indicate that sensory differences in ASD in the visual, auditory and multisensory domains are common. Furthermore overall, the literature suggests that such differences are more common in younger children with ASD, those with a low mental age and ASD and those with more severe autism, although this is not a universal conclusion (Lane et al., 2014). Studies have particularly highlighted difficulties with sensory modulation including atypical sensory under responsiveness, sensory avoidant and sensory seeking behaviour, difficulty with auditory filtering, inattention and distractibility, along with some evidence of poor sensory registration.

Some studies have attempted to classify sensory processing differences by subtype, e.g., Ausderau et al. (2014) and Lane et al. (2014). The latter classified children with ASD by sensory subtype using clustering techniques of parent reported information on the *Short Sensory Profile* (Dunn, 1999) in 228 children aged 2-10 years. They identified four distinct subtypes (i.e., sensory adaptive, taste smell sensitive, postural inattentive, and generalised sensory difference) explained by sensory hyperactivity or and difficulties with multisensory processing. This chapter will go on to explore evidence of differences in the visual, auditory and multisensory modalities for individuals with ASD due to their relevance for spoken language, before going on to look at the particular implications such differences might have for speech processing.

1.3.2: Visual processing in ASD

The following section will focus on evidence of visual processing differences in individuals with ASD, particularly where visual processing of speech in word

learning might be implicated, such as; pattern recognition (e.g., Kaldy et al., 2011; Edgin and Pennington, 2005), face processing (e.g., Dawson et al., 2005) and attention (e.g., Amso et al., 2014). It will look at the evidence supporting visual processing differences and where findings conflict (Hazen et al., 2014).

There are reports of both hypo and hyper responses to visual stimuli (Bogdashina, 2003). Soulières et al. (2009) argue that visual processing mechanisms might play a stronger role in reasoning in individuals with autism, based on their results demonstrating greater occipital but less prefrontal cortex involvement compared to controls when solving Raven's Standard Progressive Matrices tasks. The review below will attempt to draw together some of these findings. Although many of the studies discussed included children, ages vary and there is some evidence that atypical visual processing along with other sensory differences, change with age (Kern et al., 2006).

Dakin and Frith (2005) reviewed the evidence on visual perception in ASD in their narrative review. They conclude that individuals with ASD frequently demonstrate superior local processing (fine detail) compared with either inferior global processing or the ability to ignore global (overall contextual) information. This has been demonstrated in a range of studies highlighting enhanced performance in hidden figure or visual search tasks in children with ASD, e.g., O'Riordan et al. (2001). Kaldy et al. (2011) found that toddlers aged 2 ½ years were more successful at finding a target than typically developing age matched controls. They suggest that this was because differences in visual discrimination made the target more salient for the children with ASD. A narrative review of studies from 1998 to 2013 by Kaldy et al., (2013) also concluded that individuals with ASD consistently do better on visual search tasks. Kaldy et al. (2013) suggest this advantage is better explained by attention rather than perception differences. However, evidence suggesting a motion processing deficit in ASD is less clearly attributed to local or global processing differences (Dakin and Frith, 2005), although Chen et al. (2012) suggest a local processing advantage.

Evidence of face processing difficulties have included difficulties with face recognition, discrimination (Behrmann et al., 2006a), processing of emotional affect (Gross, 2004) and differences in following eye gaze (e.g., Dalton et al.,

2005). So, are these face processing difficulties closely associated with a core diagnostic deficit of social interaction in ASD? Behrmann et al. (2006b) considered the evidence from neuroimaging and behavioural studies on visual perception in individuals with ASD in their narrative review and concluded that there are visual perceptual impairments in ASD which affect face processing that are independent of social abilities. Samson et al.'s (2012) meta-analysis of neuroimaging studies of face processing found both similarities and differences between those with and without autism. They propose that individuals with autism do not demonstrate under-activation of face processing areas, but do process faces differently from those who do not have autism. Hence, the evidence does not suggest a straight forward association between face processing difficulties and social interaction, but more research is needed to explore how these variables interact.

Amso et al. (2014) examined a potential filtering mechanism when orienting attention to faces by looking at the relative influence of bottom up attention influences vs. social influences on visual attention orienting. They used eye tracking measurements to compare the proportion of time fifteen 2-5 year old non-verbal to minimally verbal children with ASD, visually attended to faces in pictures of static scenes (social stimuli). Their responses were compared to typically developing children matched by age and gender. In addition, this data was compared with *Autism Diagnostic Observation Schedule (ADOS)*; Lord et al. 2002) and *Preschool Language Scale (4th ed.; PLS-4*; Zimmerman et al., 2009) scores in the children with ASD. They found that bottom-up attention to visual scene information had more influence on children with ASD than typically developing children. This effect occurred whether the social and scene stimuli were competing (non-face area most visually salient) or congruent (face most visually salient). The children with ASD also paid more attention to visually salient regions whether they contained faces or not. There was no difference in initial attention to faces between children with and without ASD, but the former did not sustain attention to faces. Finally, the greater the reliance of the children with ASD on bottom-up strategies, the greater their social deficit on the ADOS and the lower their receptive language score on the PLS-5. Although there were limitations in this study such as sample size and reliance on static images, the

authors interpreted these findings as evidence for a greater reliance on bottom-up attention strategies in ASD with additional evidence of a potential negative impact on language and social skills.

From the literature discussed, the evidence suggests that individuals with ASD may have superior local visual processing compared to global processing. In addition, the evidence suggests differences in how faces are processed and a preference for visual attention to detail. There have been attempts to explain these differences in visual processing with reference to evidence of emphasis on detail at the expense of the whole (Behrmann et al., 2006b) in line with Weak Central Coherence theory (Happé and Frith, 1996). Since faces are particularly dependent on processing the relationship between the constituent parts, such a local processing bias would be predicted to have a particular impact on processing faces. However, there is some evidence that in the case of faces, the local bias can be ameliorated by cueing attention (López et al., 2004), suggesting that the local bias is not fixed.

Two theories have been proposed on how a local processing bias might be linked to brain function which might also account for differences in visual perception, i.e., the Pathway Specific hypothesis and the Complexity Specific hypothesis (Bertone et al., 2005). The former theory states that deficits are linked to specific cortical modules. In contrast, the latter suggests that it is general integration functional processes, which are atypical (Groen et al., 2009, p. 742). Groen et al. (2009) describe how evidence that people with autism are more sensitive to stationary visual stimuli than to global motion, gave rise to the Pathway Specific theory. This difference, they suggest, highlights a deficit in the dorsal or visual motion processing stream, but not in the ventral or static processing stream (Blake et al., 2003; Milne et al., 2002; Spencer et al., 2000). Bertone et al. (2005) proposed the alternative Complexity Specific theory to account for evidence of ventral stream deficits in visual processing in addition to dorsal stream deficits.

A local visual processing bias might also be explained by enhanced visual perception ability, allowing increased attention to detail, but not at the expense of global processing. For instance, Mottron et al. (2006) proposed the Enhanced

Perceptual Functioning (EPF) model to explain the apparent strengths that individuals with autism have for tasks such as embedded figure detection, visual search and discrimination. This model describes locally biased visual and auditory perception along with enhanced perceptual function in tasks such as low level discrimination. Thus, this model might explain some of the sensory differences reported in ASD.

There are both similarities and differences of this model to Weak Central Coherence theory. Both predict superior local processing, but whereas Weak Central Coherence theory sees this as a result of a global processing deficit, the EPF model sees superior local processing as a result of stronger perceptual engagement. In support of the EPF model, Samson et al. (2012) conducted a meta-analysis of functional imaging studies looking at visual processing of individuals with autism and found they displayed less activity in the frontal cortex than those without autism, but more activity in the posterior brain regions known to support visual processing. Furthermore differences between groups with and without autism varied in the spatial distribution of brain activity across the visual processing tasks. These findings support predictions from the EPF model that there would be more activity in the visual regions of the brain and might explain enhanced performance for visual tasks related to pattern detection, matching and object manipulation in individuals with autism compared to those without autism.

However, Kaldy et al. (2013) suggest that local visual processing advantages might be better explained by atypical attention. They highlight deficits in ASD for attention alerting, orienting and executive control of attention networks. See Keehn et al. (2013) for a narrative review of the evidence. Kaldy et al. (2013) suggest that attention disengagement difficulties (part of the attention orienting system) cascade into other systems leading to a local processing bias and attention to detail.

The findings in support of either impaired global processing or enhanced local processing theory remain mixed, but recent evidence has suggested that global processing may not be impaired but simply not be the default mode. Koldewyn et al. (2013) conducted an experiment comparing forty five typically developing

children aged 5-12 years with forty five children with ASD matched on non-verbal IQ, completing a free choice task selecting local or global properties of shape/letter stimuli and a similar task with instructions to report on the global properties. They found that when the children with ASD were given instructions to specifically attend to global properties, global processing was unimpaired. They suggest that these findings support a hypothesis of a disinclination to use global processing rather than a global processing impairment. Thus, the findings support theories of local processing as a default preference (Happé and Frith, 2006). Further evidence is required to confirm this hypothesis with different ages and abilities.

From the evidence discussed, it appears that individuals with autism attend to and/or perceive and process visual information in a different way, highlighting use of local processing. This also has implications for multisensory processing. Why this is the case remains open to debate, but recent evidence suggests that a global processing impairment alone cannot account for this bias. In summary theories predict that either poor global processing, enhanced perception of local detail or a default towards local processing account for differences in visual processing. It is currently unclear which of these theories offers the better explanation and may vary with different ages and autism phenotypes.

This tendency for individuals with ASD to favour local processing has important implications for social communication and word learning. Hellendoorn et al. (2014) highlight the potential implications of atypical visual processing in ASD. They found that atypical visual processing in children between 3 and 7 years, correlated with social functioning. Children with ASD often look more at mouths than eyes (Klin et al., 2003) potentially missing social information. Amso et al.'s (2014) findings of reliance on bottom-up attention orienting would also negatively feed into such a process. This is supported by their evidence of reliance on bottom up strategies correlating with lower language scores and higher social deficit.

1.3.3: Auditory processing in ASD

The American Speech-Language-Hearing Association (ASHA, 2005a, p.2) defines auditory processing as involving a range of skills such as localization and lateralization, auditory discrimination, auditory pattern recognition, temporal aspects of sound processing, auditory filtering in background noise. There are a range of studies to support higher than expected co-occurrence of ASD and auditory processing difficulties (Dawes et al., 2008; Nieto del Rincón, 2008). This section will begin by examining what is meant by auditory processing difficulty. It will then look at evidence of atypical auditory processing in ASD.

Auditory processing difficulties might involve a deficit in one or more of the skills described by ASHA, although there remains debate as to what might constitute a disorder (Dawes and Bishop, 2009). An increasing body of research looks at how auditory processing difficulties co-occur with other disorders. Auditory processing difficulties have been reported in relation to attention, reading or language difficulties as well as in ASD (Ferguson et al., 2011; Dawes and Bishop, 2009). Studies have often reported difficulties in controlling for the influence of attention when testing for auditory processing difficulties, although they have not necessarily seen attention as integral. It should be noted that Moore et al. (2010) found intrinsic auditory attention (as indicated by variable auditory processing test composite scores), was a better predictor of caregiver reported listening abilities in children than measures such as temporal and spectral resolution.

Personal accounts from people with autism have highlighted difficulties in the auditory domain, e.g.,

Quotation omitted (28 words) but is available in hard copy from the University of Sheffield Library.

Dawes et al. (2008) reported that there is an over representation of ASD and ASD symptoms in children referred for auditory processing testing. The debate as to the specificity of a definition of auditory processing disorder is particularly relevant to ASD when considering whether difficulty with auditory processing

tasks is due to top-down influences or is a result of low level impairments. For instance, the question arises as to whether poor auditory performance should be called an auditory processing disorder if it is caused by poor attention or do the auditory processing difficulties result in reduced attention (Dawes and Jones, 2009)? In addition, how are auditory processing and attention difficulties linked to language difficulties in ASD?

The literature on auditory perceptual difficulties in children with ASD, describes enhanced but also impaired auditory perception (Dawes and Jones, 2009). A literature review using bibliographical research on auditory perception and ASD in evoked potential and neuroimaging studies by Nieto del Rincón (2008), describes a range of auditory differences in autism. The review concludes that there is ERP evidence in people with autism of altered processing of; auditory information and auditory attention, sound identification and related decision making (Nieto del Rincón, 2009, p. 72). In addition, a range of studies concur with the findings of Bhatara et al. (2013), suggesting generally intact frequency discrimination but deficient temporal processing (evidenced by gap detection thresholds). However, some studies report enhanced frequency discrimination whilst Bhatara et al. (2013) also found impaired high frequency discrimination in those with auditory hypersensitivity. The evidence on auditory processing differences in ASD will now be discussed.

1.3.3.1: The effects of stimulus complexity

A narrative literature review by Samson et al. (2006) suggests intact or superior pure tone processing in ASD, but deficits processing complex spectral or temporal auditory stimuli, e.g., speech perception in noise (Alcántara et al., 2004). Auditory temporal processing refers to the processes responsible for perceiving sounds across time, whereas auditory spectral processing refers to the processes responsible for resolving and perceiving sounds across frequency. The review by Samson et al. (2006) also suggests a reduced capacity for attending selectively to complex sounds and environmental sound with a range of sound sources (e.g., Teder-Salejarvi et al., 2005). Lepistö (2008) suggests that enhanced frequency discrimination might partly explain

auditory hypersensitivity reported in autism and complicate the task of attending to relevant acoustic information. Ashburner et al. (2008) expand on the conclusions of Samson et al. (2006) further by citing converging evidence of difficulties in individuals with ASD in processing complex sensory stimuli (i.e., sounds which are fast, changing or unpredictable) with relative strengths in processing simple sensory stimuli (static, repetitive, predictable). Ashburner et al. (2008) suggest that the effects of this are a propensity to seek out predictable repetitive sensory input in preference to complex sensory input which may be overwhelming.

In addition to the findings from Samson et al. (2006), Haesen et al. (2011) in their narrative literature review described a range of behavioural and electrophysiological studies and concluded that individuals with ASD can usually identify and discriminate simple acoustic features such as pure tones and these abilities may even be enhanced. In contrast to Samson et al. (2006), Haesen et al. (2011) also found that processing was usually intact for complex tones and speech sounds. Examples of studies showing an advantage for simple pure tone processing are; Bonnel et al. (2010), Jones et al. (2009) and Čeponienė et al. (2003), although other research has suggested a deficit in processing pure tones, e.g., Oram Cardy et al. (2005); Tecchio et al., 2003. Examples of studies showing enhanced or intact processing of complex tones are; Bonnel et al. (2010), Gomot et al. (2008), Lepistö et al. (2005) and Čeponienė et al. (2003). Overall, there is more support for atypical processing of complex than pure tones (Jones et al., 2009).

1.3.3.2: Frequency and pitch processing

There is some evidence of enhanced frequency discrimination (Jones et al., 2009) and enhanced musical pitch discrimination (Heaton et al., 2008b) in ASD. Jones et al. (2009) found enhanced frequency discrimination was present in 20% of their sample of seventy one adolescents with ASD. However, there were no differences at group level between those with ASD and a group of IQ and age matched controls on frequency and intensity discrimination. This exceptional frequency discrimination was not linked to auditory sensory

behaviours, i.e., 'behaviours in response to auditory sensory input' (Jones et al., 2009, p.2). Examples of these behaviours included individuals blocking out sound by humming or putting their hands over their ears. The idea of a specific phenotype with enhanced skills and enhanced frequency processing is supported by Heaton et al. (2008b). They found that although enhanced pitch discrimination was not characteristic of participants as a whole, a subgroup of adolescents aged 11 years 6 months to 19 years with autism had scores from 4-5 standard deviations above the mean for pitch discrimination and memory. The task involved the participants deciding the musical distance between the target tone and a standard tone using a visual scale. Their findings held true independently of intelligence, musical training or experience. Heaton et al. (2008a) also found a link between enhanced pitch processing and lower vocabulary scores and looked at this within the context of early changes in auditory specialisation in infants. These studies suggesting specific autism phenotypes have implications for the interpretation of conflicting findings within and across studies in the literature.

In contrast to Jones et al. (2009), Bhatara et al. (2013) found no differences in frequency discrimination at group level between 10-14 year old participants with high-functioning ASD and controls. However, as frequency increased, the threshold for discrimination increased at a faster rate in the group with ASD than for typically developing participants, suggesting a particular impairment in discriminating high frequencies in ASD with potential implications for high frequency speech consonant perception. Boets et al. (2014) have suggested that frequency discrimination above 4 kHz relies mainly on a tonotopic 'place mechanism' from the tonotopic organisation of the basilar membrane. However, lower frequency discrimination is resolved mainly by a 'temporal phase locking mechanism', i.e., temporal neural firing pattern in response to frequency (Boets et al., 2014). Bhatara et al. (2013) also found that participants with ASD and auditory hyper-sensitivity were impaired in frequency discrimination relative to non-sensitive typically developing and ASD participants. The findings of Bhatara et al. (2013) have been supported by evidence of impaired frequency discrimination in adolescents with ASD (Boets et al., 2014). This study found that impaired frequency discrimination was particularly evident where more

complex global processing was required due to a varying reference stimulus. Boets et al. (2014) query whether previous findings of enhanced perceptual skills might be explained by cognitive abilities.

Thus, differences in frequency discrimination in ASD, appears to vary according to particular subgroups rather than being evident in all individuals with ASD. Recent evidence calls into question previous suggestions of enhanced frequency discrimination in ASD. Further research is required to ascertain the nature of frequency discrimination differences.

1.3.3.3: Stimulus intensity and loudness

Discrimination and perception of sound intensity (e.g., Jones et al. 2009) and duration (e.g., Lepistö et al., 2006) have also sometimes been found to be atypical in individuals with ASD, but again findings are inconsistent. However, variations in participants and task might explain some of these outcomes (Haesen et al., 2011).

Khalfa et al. (2004) found enhanced loudness perception of pure tone intensity in 9-17 year old individuals with autism compared with typically developing controls. This contrasts to Jones et al. (2009), who found no difference in intensity discrimination between individuals with ASD (mean age 15.5 years) and matched controls. However Jones et al. (2009) did find that those participants with ASD, who were worst at auditory intensity discrimination, reported more atypical auditory sensory behaviours such as putting their hands over their ears in response to everyday sounds. Bruneau et al. (2003), found that children with ASD aged 4-8 years had an underactive electrophysiological response to sound intensity compared with controls, as measured by auditory evoked response potentials. Furthermore, cortical responses were asymmetric in the children with ASD, but not in the controls.

1.3.3.4: Temporal processing

Haesen et al. (2011) describe evidence suggesting a possible temporal processing deficit in ASD. However, evidence for atypical temporal discrimination is mixed. Jones et al. (2009) found no difference in duration discrimination between adolescents with ASD and controls. In addition, those with good duration discrimination had more wide ranging auditory sensory behaviours. Lepistö et al. (2006) however found that children with Asperger's Syndrome had decreased mismatch negativity (MMN) for duration changes compared to controls. Bhatara et al. (2013) found higher gap detection thresholds in children with ASD. Boets et al. (2014) also found some evidence suggestive of inferior temporal processing in 12-19 year olds with high functioning ASD, based on gap in noise detection tests. In the test, participants were required to detect varying length silent intervals in a white noise context. However, the difference from control outcomes was not significant. Thus overall, whilst some evidence suggests inferior temporal processing in ASD, this is not conclusive.

1.3.3.5: Age related changes in auditory processing

Any evaluation of the evidence on auditory processing difficulties in ASD must also take account of whether auditory processing skills change with age. It has been found that auditory perceptual skills improve with age in typically developing children from 6-10 years, except for fine temporal processing which is relatively stable over the age range (Dawes and Bishop, 2009).

However, most studies have been done on children over 8 years or on adults. Lepistö (2008) found that children with Asperger's syndrome had difficulty with sound discrimination and involuntary orientation to sound changes but not the early stages of sound processing, whereas adults with Asperger's Syndrome had enhanced processing of temporal changes. Further evidence of age-related changes which may result from brain maturation is provided by Bonnel et al. (2008), who found that increasing spectral and/or temporal complexity does not necessarily have a detrimental effect on autistic teenagers' ability to

discriminate acoustic stimuli as it might with younger children. Russo et al.'s (2009) study of auditory cortical processing deficits in background noise in 7-13 year old children with ASD, partly supports a developmental delay hypothesis, but reduced evoked response potential (ERP) amplitudes in the children with ASD meant that this hypothesis could not fully account for the results.

1.3.3.6: Explanations for differences in auditory processing in ASD

So what might account for the reported differences in auditory processing in some individuals with ASD? Russo et al. (2009) discuss a range of differences in auditory cortical processing in children with ASD compared to typically developing children such as; abnormal connectivity affecting the auditory pathway with decreased neural synchrony, increased neural intra-connectivity and activity at neuronal synapses, or reduced language experience in ASD preventing normal development of the auditory cortex. Gepner (2008) suggests that individuals with autism might have hyper or hypo neural electrical synchronization with functional under or over connectivity between neuronal regions and pathways. Hyper synchronisation of neural electrical charges refers to over synchronisation of neural firing whereas hypo neural synchronisation refers to under synchronisation. Differences in neural synchrony have implications for within sensory modality processing speed and temporal binding of sensory information across modalities. Heaton et al. (2008a) present evidence which argues against an across domain theory for all individuals with ASD, i.e., evidence of a dissociation between enhanced pitch processing skills and enhanced performance of visual processing in block design tests. Others (e.g., Haesen et al., 2011) have argued for a right brain dominance leading to atypical auditory processing in ASD, although this has been contested by Boets et al. (2014).

A range of theoretical explanations have also been put forward to account for the evidence of atypical auditory processing. Theories used to account for atypical visual processing highlighting local processing strengths in ASD as described earlier, have also been applied to auditory processing, e.g., Weak Central Coherence (Happé and Frith, 2006), the Complexity Specific model

(Groen et al., 2009) and the Enhanced Perceptual Functioning model (Mottron et al., 2006; Samson et al., 2006). Differences in spectral vs. temporal processing lend support to a Complexity Specific theory of auditory processing in ASD since frequency discrimination is primarily processed locally due to tonotopic cortical organisation whereas temporal processing and aspects of pitch discrimination are based on complex neural networks. However, Dawes and Bishop (2009), cite evidence that does not fit with these theories, e.g., enhanced musical affect - a global processing strength (Heaton et al., 1999) and impaired frequency discrimination - primarily a local processing deficit (Tecchio et al., 2003). The latter evidence would also refute an enhanced spectral processing theory.

Recent suggestions of a global processing disinclination rather than a visual processing deficit, may also be relevant to auditory processing. A narrative review of the literature by Haesen et al. (2011) suggests that superior local processing in ASD is not affected by the complexity of the stimulus and that there is insufficient evidence for a universal global processing deficit. As noted earlier, they postulate that a right brain hemisphere dominance (with greater specialisation for spectral processing) over the left hemisphere (with greater specialisation for temporal processing) might explain the atypical patterns of auditory processing frequently seen in individuals with ASD. Studies are cited in evidence such as Lepistö et al. (2005) who describe enhanced MMN to pitch changes but reduced MMN to duration changes indicating possible impairment of temporal discrimination. The narrative review of magnetoencephalography (MEG) studies by Roberts et al. (2008) also supports this theory. However, evidence from Boets et al. (2014) questions the theory of dominant right, but inferior left hemisphere auditory processing.

Haesen et al. (2011) highlight variation in the literature as to what is considered local and what is considered global. Therefore they suggest it is better to think of local to global processing as a continuum from e.g., individual frequency discrimination at one end, to perception of sentences in background noise at the other. Furthermore, Marco et al. (2011) suggest that auditory processing impairments may be affected by top down factors such as limited attention inhibiting early processing. Boets et al. (2014) question a right auditory cortex

processing superiority in ASD in their study of twenty one 12-19 year olds with ASD and normal IQ compared to age matched controls. This is based on evidence of right hemisphere impairment with frequency discrimination and evidence only suggestive of left hemisphere temporal difficulty with gap in noise tests. They highlight limited evidence of superior frequency discrimination of pure tones. Boets et al. (2014) suggest that top down factors such as memory or weak central coherence might explain apparent superior frequency processing in some individuals.

To summarise, the evidence suggests a range of auditory processing differences in children with ASD, although the nature of such differences is likely to vary with age and ASD phenotype. There is some evidence of enhanced or intact local processing of frequency and simple sounds associated with a global processing disinclination and difficulty processing complex spectral or temporal sounds as in speech, mediated by difficulties with top down influences such as attention. However, the evidence is not conclusive and the Complexity Specific model has been disputed. As in visual processing, a range of theoretical explanations such as Weak Central Coherence and Enhanced Perceptual Functioning, have been put forward to account for these differences. Thus the question arises on the extent to which atypical sensory processing in ASD is domain specific to auditory or visual processing difficulties or whether at least some children with ASD might have cross domain multisensory processing difficulties as discussed in the following section.

1.3.4: Multisensory processing in children with ASD

Multisensory integration is critical for the adaptive responses needed to make sense of the constant bombardment of stimuli in everyday life and is an important factor in functional speech processing, particularly under noisy conditions. Collignon et al. (2013) reviewed the evidence in the literature on multisensory integration in individuals with ASD and conducted a study comparing individuals aged 14-31 years with and without autism, looking at whether an auditory cue synchronised with a target colour change benefited performance on a visual search task. They found that only the individuals

without autism benefited from the auditory cue although the individuals with autism were better than those without autism when no auditory cue was present. Thus, they suggest that reduced multisensory integration is not limited to complex multisensory stimuli as suggested previously by Mongillo et al. (2008) and van der Smagt et al. (2007), but is also present for low level stimuli. The findings potentially demonstrate difficulties with integrating local information into complex percepts between sensory modalities as predicted by a Complexity Specific hypothesis (Bertone et al., 2003, 2005) and consistent with the Weak Central Coherence model (Happé and Frith, 2006). Collignon et al. (2012) suggest that their findings may be linked to evidence suggesting neural under-connectivity (e.g., Courchesne et al, 2007) or an extended multisensory temporal binding window in individuals with ASD (Foss-Feig et al., 2010; Kwakye et al., 2010). Brock et al. (2002) proposed a temporal binding deficit theory of autism whereby weak central coherence arises from reduced synchrony and integration of specialised neural networks. An extended multisensory binding window refers to the short time period in which multisensory stimuli are bound together to create a percept. Foss-Feig et al. (2010) found that children with ASD report a flash-bleep illusion (where a single visual flash is paired with several auditory beeps, resulting in the perceptual illusion of two or more flashes in typical individuals) over an extended time range of stimulus-onset asynchronies in children with ASD compared to typically developing children.

Support for an extended multisensory temporal binding window is also provided by Kwakye et al. (2010). They found there was no difference in performance on visual temporal order judgement tasks between children with ASD and typically developing children. They did however find higher thresholds for auditory temporal order judgement and multisensory tasks in children with ASD than in typically developing children. The study used participants with IQs over 70 and a mean age of 12.21 years. The visual task required the participants to report whether the first circle seen on a screen was above or below a target in a series of random presentations. The auditory task involved reporting which ear heard a click first and the multisensory task reporting the first circle seen where a beep was always presented simultaneously with the first circle and with variable

(0-500ms) delay with the second circle. The results found by Kwakye et al. (2010) supported the evidence of Foss-Feig et al. (2010) suggesting wider temporal windows for multisensory integration in children with ASD. Thus, there is growing evidence to support an extended multisensory binding window as a potential theoretical explanation of sensory differences in ASD. This is explored further in relation to multisensory processing of speech in section 1.4.4.

In summary, in addition to modality specific deficits in sensory processing in ASD, there is increasing evidence of multisensory processing differences, specifically in making use of temporal cues to integrate sensory information across modalities. The next section will explore specifically how young children typically process speech prior to looking at speech processing in ASD, with particular reference to the evidence on the impact of sensory processing differences.

1.4: SPEECH PROCESSING

Processing of words and sentences is a complex process requiring accurate auditory perception and potentially effective use of visual cues and global processing. As seen already, these are aspects of sensory processing where children with ASD are likely to experience difficulty.

Infant's early speech perception abilities are important for later language development. Tsao et al. (2004) found that babies' ability to discriminate speech sounds as evidenced in vowel discrimination tasks at 6 months, predicted later language abilities of word comprehension and production and also phrase comprehension at 2 years. They argue for the importance of speech perception skills in identifying words in running speech for infants. However, they also acknowledge that speech perception and later language processing abilities might rely more on cognitive skills, attention, auditory or general sensory abilities than phonetic abilities in themselves. Thus, speech processing in babies and children is a complex task involving both bottom up and top down processing influences.

This section on speech processing will now look in detail at frequently reported auditory processing difficulties said to affect speech and language in young children with ASD, i.e., speech perception in noise, temporal and pitch processing and multisensory processing of speech. It will also consider the impact of top down processes such as attention on speech processing. In addition, it will examine the evidence on these different aspects of speech processing in both typical development and children with ASD. Finally, it will look at how evidence of atypical speech processing in ASD might impact on early vocabulary development.

1.4.1: Speech perception and auditory processing in noise in ASD

Difficulties with speech perception in background noise are one of the most frequently reported manifestations of auditory processing difficulties (e.g., Bamiou et al., 2006; Bamiou et al., 2001). Auditory filtering in this context refers to the ability of the individual to make use of some sounds whilst screening out irrelevant sounds (Dunn, 1999). As discussed in section 1.3.1, a range of parent report studies highlight auditory processing in noise as a particular difficulty in children with ASD, e.g., Lane et al. (2014); Tomcheck and Dunn (2007). Difficulties with auditory processing in noise found in individuals with ASD (Ashburner et al., 2008), are likely to impact on the perception of speech in noisy environments.

Lagace et al. (2010) give a detailed analysis of the factors underlying auditory speech perception in noise. They describe how when speech is degraded (e.g., when masked by background noise), both auditory and language based mechanisms might compensate. With regard to language, a sentence might serve to give contextual and semantic clues through top down processing. With regard to auditory mechanisms, Cameron and Dillon (2008) discuss bottom up cues such as the importance of being able to attend selectively to sound streams distinct from other sounds, where the sound stream can be based on source location, intensity or the spectral/temporal complexity of the sound. The perceptual anchorage effect (Ahissar, 2007) is also reported to make a contribution to the perception of speech in noise. This effect is said to occur

when over time, the listener's speech perception in degraded conditions is aided by the formation of an internal stable referent stimulus. The target speech is then evaluated against this referent. Such an effect is demonstrated when it appears to get easier to listen in a noisy background over time. Due to the contribution of both auditory and language mechanisms, Lagace et al. (2010) postulate that both children with language and auditory deficits are likely to present with problems with speech recognition in noise. The effects of background noise on speech perception are wide ranging. This has implications for children with ASD, where there is a higher than usual rate of both language and auditory deficits.

However, when considering the evidence, it is important to bear in mind that speech processing in noise changes with age. Babies and children require enhanced signal to noise ratios to detect stimuli compared to adults (Hall et al., 2004). Most studies of children with ASD have used children over 8 years, but there is a need for further research on how speech perception in noise changes at different ages, particularly in preschool children. Furthermore, it is sometimes difficult to make comparisons across studies due to the different types of background noise and signal to noise ratios employed.

Several studies supporting predictions for children with ASD derived from Lagace et al. (2010), have highlighted difficulties with processing speech in background noise in individuals with ASD using controlled experimental conditions (e.g., Schafer et al., 2013; Russo et al., 2009; Alcántara et al., 2004), whilst others have highlighted auditory filtering (as defined earlier in this section) difficulties based on parental report, e.g., Ashburner et al. (2008) or personal account (e.g., Grandin, 1995). However, as Alcántara et al. (2004) point out, real life background noise coming from multiple sound sources with reverberation and echo, is likely to have even greater impact than experimental speech in noise tasks. O'Connor (2012) also points out that extracting meaning from speech in background noise requires the individual to discriminate acoustic cues relevant to the speaker of pitch, timing and location and also make use of top-down cues of attention, language and memory. This highlights the complexity of the task for individuals with ASD given the evidence of difficulties with making use of both top down and bottom up cues. For instance, individuals

with ASD have difficulty using top down cues such as attention, memory and language (e.g., Anderson and Kraus, 2010). They also have difficulty using bottom up cues such as non-speech sound location in noise (e.g., Teder-Salejarvi et al., 2005) and increased difficulty making use of temporal dips in noise to identify words (Alcántara et al., 2004; Groen et al., 2009).

Alcántara et al. (2004) measured speech perception in noise in 11 adults with High Functioning Autism (HFA) or Asperger's Syndrome (AS). They found that speech perception in noise was worse for adults with HFA/AS than for controls in a range of noise conditions such as single talker speech and noise with spectral and/or temporal dips. However, it was only statistically significant in complex background noise with temporal dips. The speech perception thresholds were 2-4 dB higher for the HFA/AS group in the temporally modulated background noise. Temporal dips are dips in the background noise which occur when the signal to noise ratio (SNR) is higher as in for instance, brief pauses in competing voices, allowing the listener glimpses of the target speech (Alcántara et al., 2004). The authors suggest that individuals with HFA/AS may not have made use of the temporal dips to work out what was being said because of atypical peripheral auditory processing (temporal resolution or frequency selectivity difficulties) or problems with top down processing such as use of contextual or syntactic clues to fill in the gaps. However, use of sentences by Alcántara et al. (2004) may have precluded any purely bottom up explanations for their findings (Alcántara et al., 2012). Groen et al. (2009), in a study described below, reduced the potential influence of top down influences by using semantically similar words.

The background noise stimuli in the study by Alcántara et al. (2004) were selected so as to be similar to natural speech with varying lengths of temporal dips, thus giving ecological validity. However, the variation in temporal dips duration potentially confounded interpretation of the outcomes (Groen et al., 2009). Groen et al. (2009) attempted to remedy this by using controlled versions of pink noise, i.e., white noise where the acoustic energy is divided equally across frequency bands of the human auditory system, masking for natural sounds (Groen et al., 2009, p. 744). In addition to pink noise, the study also used; amplitude-modulated pink noise, i.e., temporal masking dips every 10

seconds; moving ripple, i.e., complex spectral and temporal ripple effects resulting in noise that is particularly hard to distinguish from speech; and amplitude-modulated moving ripple, i.e., ripple noise with temporal dips as in the modulated pink noise (Groen et al., 2009, p. 745). These were selected so as to vary the neural demand in the presence of both spectral dips (spectral regions allowing the target to stand out) and temporal dips (brief time periods where the target can stand out). Groen et al. (2009) used these different types of background noise in order to differentiate between simple low level auditory perceptual tasks and complex low level perceptual tasks, given the limited evidence of the latter. Their experiment with adolescents with high functioning autism and matched controls in a perception task using 2 syllable words (complex low-level stimuli) in various types of background noise, found that those with autism were worse at integrating auditory information in temporal dips in pink background noise. This finding supports a Complexity Specific hypothesis. However, the results were similar for both groups for temporal dips in ripple noise, the ripple noise countering the benefits of the temporal dips for controls. Thus, Groen et al.'s results support those of Alcántara et al. (2004) in finding difficulty using temporal dips to aid speech perception in individuals with ASD relative to controls.

Overall, the evidence predicts that high functioning older children with ASD at least, are likely to have significant difficulty in making use of temporal dips to aid speech perception in background noise, although the spectral-temporal complexity of the background noise may reduce the difference between those with ASD and controls. Hence, at least some children with ASD are likely therefore to have particular difficulty processing speech in everyday settings with background noise. Alcántara et al., (2012) suggest that this difficulty might be explained by a temporal processing deficit in picking out 'temporal envelope' sound cues based on their finding of reduced detection of amplitude modulation over time.

ERP (Event-Related Brain Potential) evidence from Russo et al. (2009a) supporting a study by Whitehouse and Bishop (2008), found an auditory cortical processing speech deficit in white noise (a heterogeneous mix of sound waves over a wide range of frequencies often used to mask speech) in verbal

children with ASD. In addition, their results suggested that for children with ASD, processing speech in quiet is the same as processing speech in noise for typically developing children. However, the children with ASD were diagnosed by expert clinicians and evidence would have been strengthened by use of the *Autism Diagnostic Observation Schedule [ADOS]* (Lord et al., 2002) or *Autism Diagnostic Interview-Revised [ADI-R]* (LeCouteur et al., 2003b). Furthermore, a low level video soundtrack was played in the non-test ear to encourage compliance, which while not thought to affect responses for children without ASD, may have had an effect on children with ASD. Russo et al. (2009b) also found evidence of deficient brainstem auditory processing in children with ASD, using brainstem evoked responses to speech syllables. The children with ASD demonstrated a lower level of neural synchrony (timing) and phase locking (frequency encoding) compared to controls in quiet and background noise. These deficits may have implications for children with ASD when processing the cues which distinguish between vowels and consonants and also the cues indicating speaker identity and intention. The children with ASD also had reduced speech evoked responses in background noise compared to controls. These findings are important because brainstem responses are passive and would not have been influenced by cognitive ability or attention. The study has important implications for language development since neural resilience to background noise was strongly associated with better core language and language comprehension abilities. Ashburner et al. (2008) found that evidence of poor auditory filtering difficulties (i.e., ability to attend to and process relevant sounds but ignore irrelevant sounds) and sensory under responsiveness on parent report tools, correlated with academic under performance, accounting for 47% of academic variance in twenty eight children with ASD compared to gender and age matched controls.

Overall the evidence suggests that children with ASD may have particular difficulty processing speech in complex ecologically valid background noise which is likely to impact on language development. The evidence suggests that this is above and beyond any difficulty experienced by typically developing children. However, higher cognitive ability enabling greater use of top down influences may reduce the negative effects of background noise. The ability to

cope with background noise is associated with better language in individuals with ASD. Difficulties with speech perception in background noise may present as distractibility and may lead to difficulties with selective attention to speech as the child only has the choice of being potentially overwhelmed or blocking out all sound. Newman et al. (2013) highlight the need for further research in young children with ASD and the extent that they are able to make use of visual speech cues, citing the importance of such findings for day-care settings and intervention strategies.

1.4.2: Temporal processing of speech in ASD

Auditory temporal processing of speech includes the ability to rapidly process sequences of speech sounds at the rate of normal speech. The focus in this section will be on temporal processing and its role in speech perception and vocabulary learning pertinent to the current study. Both a generalised temporal processing deficit and auditory cortical deficits in temporal speech processing have been implicated in studies.

With regard to auditory cortical deficits, Lepistö et al. (2005) found that the MMN (mismatch negativity) of event related potentials (ERPs) to deviant vowel durations in a sequence was reduced in children with autism compared to controls, although the significant group difference was in the non-speech rather than speech condition. Gepner et al. (2005) also found a deficit in speech phoneme categorisation as measured by tasks requiring children to identify /ma/ (MA), /na/ (NA) and blended MNA phonemes, normalised when phoneme presentation was slowed down twice. The authors suggest that this might be because children with autism have difficulties processing rapid speech flow and thus postulate an auditory temporal integration deficit. Such auditory temporal processing deficits might affect the language development of children with ASD as temporal cues play an important role in perceiving speech (Shannon et al., 1995).

With regard to a more general temporal processing deficit, Tardif et al. (2007) found evidence of a temporal processing deficit of multisensory events when

comparing twelve children with ASD aged 7 years 3 months to 14 years 2 months with controls matched on verbal and non-verbal mental age. Gepner and Feron (2009) suggest that individuals with autism have a temporal-spatial processing disorder that involves abnormal perception and integration of rapid and transient events including speech, but more research is required.

1.4.3: Pitch processing and speech in ASD

Pitch processing includes the ability to process different frequencies and spectral components of speech sounds, affecting discrimination of speech sounds and interpretation of prosody.

A range of evidence suggests enhanced or at least preserved pitch processing in ASD compared to controls (e.g., Haesen et al., 2011; Heaton et al., 2008b; Lepistö et al., 2008; Whitehouse and Bishop, 2008; Bonnel et al., 2003; Heaton, 2003). However, this is not universal (Boets et al., 2014).

The evidence of an advantage for pitch processing is highlighted since some studies have questioned whether the advantage in pitch processing might be at the expense of vocabulary learning (Jarvinen-Pasley and Heaton, 2007). However, there is also evidence that enhanced pitch processing does not always correlate negatively with language skills (e.g., Heaton et al., 2008a). Eigsti and Fein (2013) demonstrated that in individuals with ASD aged 8-21 years with average cognitive ability, heightened pitch perception was correlated with decreased early word learning, but it was not associated with their current language abilities.

Hence, there is some evidence for enhanced or preserved pitch processing, although not universally. There is also some evidence suggesting a possible deficit in the rapid temporal processing necessary for speech in ASD. However, the extent to which speech processing difficulties in ASD arise from top down influences such as differences in attention allocation, memory and weak central coherence, or arise from bottom up influences such as an auditory temporal processing deficit, or are part of a wider multisensory processing deficit, remains debatable.

1.4.4: Multisensory processing of speech

1.4.4.1: Multisensory integration in speech perception in children with ASD

As noted earlier, an emerging body of literature suggests difficulty with multisensory integration in ASD. Multisensory integration of speech cues enables the listener to identify words combining visual and auditory cues, but also to combine cues to give information about social communication such as feelings or speaker intention. Therefore any such deficit has a far reaching impact on word learning and language. Multisensory processing is particularly important when the speech signal is degraded or in early development. Successful early communication is dependent on synchronising visual (face, lip, body movements) and auditory cues (voice) to interpret meaning (Calvert et al., 1998). Stevenson et al. (2014a) give a detailed account of the effects of a multisensory integration deficit on the speech of children with ASD. They conclude that deficits in multisensory binding may have cascading effects on both speech perception and processing social information.

However, evidence from the literature on the abilities of children with ASD to integrate multisensory information in speech perception tasks has been inconsistent. Methodological differences may account for some inconsistency in study outcomes, but are unlikely to account for all of the evidence supporting a deficit in multisensory integration.

Guiraud et al. (2012) found evidence of difficulties with audiovisual speech integration using the McGurk effect in 9 month old infants at high risk of autism compared to no difficulties in those at low risk. This is a well researched phenomenon that illustrates how most listeners automatically combine visual cues from the speaker's face to form speech percepts (MacDonald and McGurk, 1978). This effect is demonstrated when an individual automatically combines different visual (e.g., lips saying 'ga') and auditory (hearing 'ba') information, to report hearing a new combined percept, 'da'.

De Gelder et al. (1991) also found that older children with autism (mean age 10.8 years) had a lower susceptibility to the McGurk effect with reduced

influence of visual cues, but appropriate lip reading and auditory speech processing. This lower susceptibility was supported by Mongillo et al. (2008) and Irwin et al. (2011), but not by Woynaroski et al. (2013) or Iarocci et al. (2010). In contrast to the latter two studies, Smith and Bennetto (2007) found from their research requiring multisensory integration in background noise, individuals with high functioning autism (mean age 15.8 years) may indeed have difficulties with auditory and visual speech integration. This discrepancy in findings may be due to methodological differences and differences in experimental stimuli. The participants in the study by Smith and Bennetto (2007) also had a higher mean age than in other studies and the experiment used whole words rather than CV syllables. Factors such as participant age and cognitive ability, task stimuli characteristics and instruction differences are likely to have accounted for at least some variation in susceptibility to the McGurk effect in children with ASD (Woynaroski et al., 2013). This has implications for interpretation of studies suggesting a multisensory integration deficit affecting speech processing in ASD. As noted earlier for instance, cognitive ability or age for instance, may reduce the impact of any deficit.

1.4.4.2: Evidence on the relative weighting of auditory vs. visual cues on speech perception in children with ASD compared to typically developing children

There have been mixed results in the literature regarding the relative weighting of auditory vs. visual cues in speech perception in children with ASD compared to typically developing controls. However, despite suggestions of some strengths in visual processing in children with ASD, a range of studies (e.g., Mongillo et al., 2008; Massaro and Bosseler, 2006; De Gelder et al., 1991) have suggested less influence of visual than auditory cues on speech perception in children with ASD compared to typical developing individuals, although age of participants may influence this (Tremblay et al., 2007). In contrast, Kwakye et al. (2010) found a deficit in auditory but not visual temporal judgement tasks in participants with ASD compared to typically developing controls.

Williams et al. (2004) found that children with ASD (mean age 9 years) were likely to be less consistent in their use of visual information in speech perception tasks than typically developing children. Iarocci et al. (2010) also found a visual deficit. They compared children and adolescents with autism (mean age 10.7 years) with mental age-matched typically developing peers, looking at bimodal and unimodal perception of speech sounds. A computer task was used where only the mouth area of the face was shown and children had to say what they heard or saw when presented with consonant-vowel sounds in, a unimodal auditory condition, a unimodal visual condition, and a bimodal condition. In support of Williams et al. (2004), they found that in the children with ASD, there was less visual and more auditory influence on bimodal speech perception, compared to typically developing children. This was mainly due to significantly worse performance with just the visual cues from lip reading. The authors conclude that children with autism may not benefit as much as typically developing children from visual cues in speech perception. This finding is also interesting given Tenenbaum et al.'s (2014) finding that attention to the woman's mouth and eyes whilst she was saying the new words predicted faster word recognition in children with autism. It highlights the importance of visual speech cues in at least some contexts in ASD. Difficulty with lip reading may increase attention allocation to the mouth, possibly at the expense of the eyes in some situations, further reducing access to social cues.

Careful measurement of the amount and quality of visual attention to task stimuli and faces, in addition to detail on age and abilities of participants, might shed light on the apparently reduced use of visual cues in subjects with ASD. Using an eye tracking methodology, Irwin et al. (2011) found that even when children with ASD were fixated on the speaker's face, they were less influenced by the visual cues in audiovisual tasks than typically developing children. As noted earlier, limited use of visual cues has particular implications in background noise where additional visual cues are important to enhance the speech signal (Johnson et al., 1994).

Some evidence supports the importance of age in auditory vs. visual cue weighting in typical development. Hillock (2010) suggests that a visual deficit

may be a function of how unisensory cues are weighted in terms of how auditory vs. visual stimuli are encoded in the maturing nervous system and a preference in processing of auditory signals in infants and young children (Sloutsky and Robinson, 2008; Robinson and Sloutsky, 2004). Hillock (2010) found that typically developing 10 and 11 year olds were as good as adults at detecting audiovisual synchrony when the visual stimulus was first, but there were significant differences at stimulus onset asynchronies when the auditory stimulus was first. Robinson and Sloutsky (2004) describe how 4 year olds are more consistent in using auditory cues to locate a target, whereas adults are more consistent using visual cues.

The evidence suggests that individuals with ASD may have particular difficulties making use of visual cues in speech perception, but these difficulties alone seem unlikely to account for the deficits found in multisensory integration of speech (Foxy et al., 2013). Further research is needed on the weighting of the effects of auditory vs. visual cues in multisensory speech perception at different ages and stages of development in ASD (Woynaroski et al., 2013; Hillock, 2010).

1.4.4.3: Maturation changes in multisensory processing of speech in typical development and ASD

There is a limited evidence base on how multisensory processing of speech changes with age in both typical development and ASD. In particular, there is a paucity of evidence on changes in multisensory processing of speech in early childhood.

With regard to typical development, Hillock (2010) discusses the extent to which maturation of unisensory skills might affect the developmental trajectory of multisensory integration abilities in childhood. There is also debate on the extent to which multisensory integration abilities are present from birth. Overall, the evidence suggests that infants can detect some amodal features such as synchrony and tempo very early on, but that detection of more complex temporal cues develops as infants mature (Hillock, 2010; Lewkowicz, 2000).

Any disruption in synchronisation is likely to affect development of early communication skills and continue to affect pragmatics even if language develops.

Change with age in how children combine auditory and visual cues in typical development, has been demonstrated using the McGurk effect. Several studies report the McGurk effect in typically developing infants (Burnham and Dodd, 2004; Desjardins and Werker, 2004), but it may not be consistent under eight years (Hillock, 2010; Tremblay et al., 2007).

Tremblay et al. (2007) maintain that maturational changes in attention may also impact on multisensory vs. unisensory perception of speech in typical development. The evidence of maturational changes in multisensory perception of speech are important as they suggest that multisensory integration of speech cues are not fully developed in younger children, thus they may rely more on unisensory auditory cues (Tremblay et al., 2007) and require quieter conditions to develop accurate speech percepts. Similarly, consistent auditory and visual cues in speech models may be especially important in early childhood to increase experience in development of unified percepts. Equally, any deficit in multisensory integration of speech cues has potentially far reaching consequences.

With regard to children with ASD, Foxe et al. (2013) demonstrated that in a sample of eighty four children with high functioning ASD, there were severe deficits in multisensory integration impacting on speech (identifying words in pink background noise) in children from 5-12 years, but no such deficits in children between 13-15 years. In addition, Taylor et al. (2010) demonstrated improvement of multisensory integration (increased susceptibility to the McGurk effect) with age. Auditory only performance remained static, similar to typically developing peers, whereas visual only performance improved in both the ASD and typically developing control group, but remained worse in children with ASD.

The findings of Foxe et al. (2013) have important implications for intervention due to their ecological validity compared to less realistic experiments in quiet conditions. There are only two other studies which have looked at multisensory

integration of speech in background noise, i.e., Irwin et al., (2011) and Smith and Bennetto (2007). Foxe et al.'s (2013) findings are consistent with the latter but not the former. However, Foxe et al. (2013) point out differences in stimuli, i.e., identifying words within sentences in the study by Smith and Bennetto (2007), vs. phoneme recognition used by Irwin et al. (2011) and monosyllabic word identification by Foxe et al. (2013). They also highlight the lack of eye gaze measurements by Smith and Bennetto (2007), although found in their own study that reduced visual fixation could not explain the results.

1.4.4.4: Evidence for an extended multisensory temporal binding window impacting on speech perception in ASD

As discussed in the section on multisensory processing of non-speech stimuli, Stevenson et al. (2014b), Foss-Feig et al. (2010) and Kwakye et al. (2010) have suggested that children with ASD have a wider temporal window for multisensory integration than those without ASD. Stevenson et al. (2014b) found that compared to typically developing children, high functioning children aged 6-18 years with ASD showed a speech specific deficit (evidenced using the McGurk effect) in multisensory temporal processing which was strongly correlated with the width of the temporal binding window in low level multisensory temporal processing tasks. Further evidence for an extended multisensory binding window impacting on speech perception is provided by Woynaroski et al. (2013). They compared 8-17 year old children with ASD with age, sex and IQ matched controls on speech perception tasks using consonant-vowel syllables across different auditory and or visual conditions. The conditions were; auditory, visual, matched and mismatched audiovisual conditions. The children with ASD reported a visual influence on heard speech in the mismatched condition over a wider window than the typically developing controls. Correlation analysis also suggested an association between multisensory speech perception, communicative abilities and responses to sensory stimuli in the children with ASD.

Hillock-Dunn and Wallace (2012) and Hillock et al. (2011) show that far from being a static construct, the multisensory temporal binding window changes

with age and task complexity even in typical development. Hillock-Dunn and Wallace (2012) found a decrease in window size with age in their study of typically developing individuals aged 6 to 23 years using simple audiovisual stimuli. In addition, they found that differences between children and adults persisted into adolescence. With particular relevance to this thesis, Lewkowicz and Flom (2013) found that the audiovisual temporal binding window continues to narrow from 4-6 years of age, but is still wider at 6 years than in adults. There is a lack of evidence on age related changes in the multisensory binding window in ASD.

1.4.4.5: Summary of multisensory processing of speech in ASD

Overall, most evidence suggests that children with ASD can demonstrate multisensory processing of speech particularly in adolescence, but that both unimodal and multisensory integration may be impaired compared to typically developing children, particularly in relation to the size of the multisensory temporal binding window. In addition, the question remains as to whether the differences in multisensory processing found in the various studies on children with ASD were due to attention or perception differences or both. However, Soto-Faraco et al. (2004) argue that the evidence supports the view that multisensory integration of speech stimuli as exemplified in the McGurk effect, is an automatic process that occurs before selective attention is allocated.

The evidence discussed primarily suggests a visual rather than auditory deficit in multisensory processing of speech. This is in contrast to previous evidence of auditory processing speech difficulties in ASD (e.g., Kuhl et al., 2005). However, much of the evidence pertains to older and more cognitively able children. There is little evidence on the extent to which multisensory differences or visual deficits in speech processing in ASD are present in those with a broader cognitive profile or in younger children with ASD. Furthermore, there is a need for more research to explore differences in multisensory temporal binding comparing the auditory vs. visual weighting and when the order of presentation of visual vs. auditory stimulus changes.

1.4.4.6: The impact of multisensory processing differences in ASD on speech, language and communication development

Differences in unimodal processing and multisensory integration of speech have implications for how language and communication develops in children with ASD. Stevenson et al. (2014a) and Bahrick and Todd (2012) look at the evidence on multisensory processing in ASD compared to typical development and postulate how differences in multisensory processing might underlie reported atypical development in ASD including speech, language and communication. Bahrick and Todd (2012) describe how attention skills such as social orienting and attention to social events which are impaired in autism, depend on successful multisensory integration in early development. They highlight evidence of a heightened attention to detail in both visual and auditory processing relative to global processing in ASD. This is reflected in adequate low level perceptual processing, but increasing perceptual processing impairment as stimulus complexity increases. They suggest that atypical timing differences in the development of some early amodal (i.e., across modality) skills may have amplified effects across development favouring the above profile. Furthermore, they suggest that an inter-sensory processing disturbance might cause the documented evidence in ASD of difficulties in early attention processes and social communication.

In typical development, the ability to organise and selectively attend to some stimuli and ignore others is present by the age of six months (Bahrick, 2010). It is suggested that intersensory redundancy and amodal properties of stimuli are crucial for such development. Redundant amodal information from the different senses such as rhythm, synchrony, tempo and intensity, is evident in most events across the dimensions of time, space or intensity. This amodal information shapes selective attention, e.g., when the rhythm, synchrony and tempo of someone's face, gesture and voice match, the listener is more likely to selectively attend to the unified percept of the person speaking than other stimuli. As such, amodal features also serve to prevent inappropriate sensory associations and consequent inaccurate event perceptions and concept formation. Bahrick and Todd (2012) point to a range of studies supporting a priority for detection and attention to amodal information in the first few months

of life in typically developing babies. For instance, they highlight detection of face-voice synchrony (Lewkowicz et al., 2010), detection of spectral information related to mouth shape and specific speech sounds (Kuhl et al., 1991) and detection of emotion rather than face or voice identification, e.g., Flom and Bahrick (2007). In addition, initial detection of amodal information such as temporal synchrony, can act as a gatekeeper prior to perceptual processing of modal properties. As social events contain a high level of inter-sensory redundancy emphasizing amodal properties, such events are more likely to promote attention to faces, gestures and voices, thus increasing social interest over non-social events (Bahrick and Todd, 2012). Bahrick et al. (2010) argue that intersensory facilitation of perception and attention is most noticeable in difficult tasks and therefore may continue into adulthood in some contexts. They demonstrated that 5 month old infants were able to discriminate tempo changes of moderate difficulty in both unimodal and bimodal contexts, but were only able to discriminate high difficulty tempo changes in bimodal contexts similar to younger 3 month old infants.

Amodal processing prevents weak central coherence, where detail is favoured over global meaning. Weak central coherence is commonly found in ASD (Happé and Frith, 2006; Mottron et al., 2006). Poor amodal processing is likely to disrupt audiovisual synchrony, in turn limiting opportunities for learning accurate word-object associations and decreasing prioritisation of attention to social events and emotions. Attention bias resulting from reduced amodal processing could therefore affect both early language and communication development and later learning, particularly in contexts of competing stimuli or high processing load.

1.4.5: The role of attention in speech processing in ASD

Marco et al. (2011)'s narrative review, highlights the complexity of the effects of attention on speech processing in ASD. Attention to speech involves orienting to and selectively attending to what is said, shifting attention between different aspects of speech (within or across modalities) and then maintaining attention for sufficient time to process and integrate the relevant incoming sensory

information. Deficits or differences in all these aspects of attention have been found in individuals with ASD (Patten and Watson (2011)).

Irwin (2007) cites evidence from ERP (Event-Related Brain Potential) studies which show that verbal children with ASD are less attentive to speech than controls and have poorer speech discrimination skills. Further evidence is cited from functional neuroimaging techniques such as MEG (magnetoencephalography) and fMRI (functional magnetic resonance imaging) studies.

As discussed in section 1.2.4., although not universal, a range of evidence has highlighted difficulties in ASD with orienting attention to speech (Kuhl et al., 2005; Lepistö et al., 2005; Čeponienė et al., 2003), shifting attention (Hazen et al., 2014; Marco et al, 2011) and selective attention (Marco et al., 2011; Teder-Salejarvi et al., 2005), which are likely to impact on speech processing. Murray et al. (2008) highlight how children with ASD may map new words to incorrect meanings due to their difficulties with gaze following, linking joint attention difficulties to reduced vocabulary development. Joint attention requires the child to orient, shift and sustain attention and therefore deficits in these aspects of attention (Patten and Watson, 2011) in visual or auditory modalities would indeed be predicted to impact on speech processing and early word learning.

Dawes and Bishop (2009) suggest that auditory perceptual abnormalities in ASD may be attributable to a speech-specific, post sensory impairment related to attention orienting. In addition, Whitehouse and Bishop (2008) suggest from the findings of their study of ERPs in fifteen children aged 7-14 years with high functioning autism, that difficulties with speech processing were attributable to top down attention influences on basic sensory processing. However, Whitehouse and Bishop (2008) highlight that their findings do not exclude the involvement of sensory encoding problems such as those found by Lepistö et al. (2005) and Čeponienė et al. (2003). They found that ensuring active auditory attention (i.e., cueing) appeared to normalise speech processing in the children with ASD, despite difficulties with involuntary attention to speech compared to non speech sounds when not cued. This finding was supported by Dunn et al.

(2008) who found that decreased MMN to simple stimuli, became normal when attention was directed.

Differences in ages and abilities of participants and research methods are all likely to have contributed to the variation in findings on attention to speech, but overall the evidence suggests that difficulties with both auditory and visual attention in ASD likely to impact on speech processing are wide ranging with particular difficulties with orienting attention, spontaneous gaze following, shifting attention, joint and shared attention.

1.4.6: Summary of sensory processing differences in relation to speech processing and early vocabulary learning in children with ASD

The majority of the evidence supports a Complexity Specific theory of the sensory processing difficulties in ASD across both visual and auditory domains. Examples of dissociation argue against a cross domain hypothesis as an explanation for all individuals with autism. Recent evidence suggests that sensory processing differences might vary across specific phenotypes. Some of the discrepancies in the evidence might be accounted for by the possibility of different subgroups within ASD. However, this area of research is also beset with methodological limitations and difficulties, necessitating caution when making comparisons between studies and interpreting evidence across the literature.

For auditory processing, there is evidence in some individuals with ASD of relatively intact or enhanced spectral processing compared to inferior temporal processing. However more recently, this has been contested. Some evidence suggests that enhanced pitch processing may be associated with delayed vocabulary in ASD.

Complexity Specific theories predict that children with ASD will be better at processing simple low level stimuli (e.g., pure tone discrimination) rather than complex stimuli (e.g., perception of simple words in complex background noise). There are many confounding variables relating to definitions and diagnosis of both auditory processing difficulties and ASD as well as a range of

methodological issues in the studies available. Further research is suggested in a number of areas (Dawes and Bishop, 2009; Foss-Feig et al., 2010; Moore et al., 2010). In addition, evidence of atypical visual attention, use of visual cues and processing of faces might impact downstream on multisensory processing of speech.

There is recent evidence of a multisensory integration deficit and extended multisensory temporal binding window in ASD (Woynaroski et al., 2013; Foss-Feig et al., 2010). This evidence is consistent with theories of ASD highlighting a global processing disinclination and weak central coherence. Bahrnick and Todd's (2012) discussion on the importance of amodal features in speech perception are promising lines of further research. An extended multisensory binding window may have implications for social communication difficulties, resulting from repeated experience of asynchronous verbal and non-verbal stimuli over time and possible interventions. However, there is a need for further evidence on speech perception in non-social compared to social tasks, changes in response to tasks with age, the effects on language and on comparison of the amount and type of visual attention during multisensory tasks in individuals with ASD vs. typically developing children.

In conclusion, the literature suggests that at least some children with ASD have particular difficulties attending to and processing speech associated with; enhanced pitch but inferior temporal processing, problems with speech perception in background noise and difficulties integrating multisensory perceptual information. In addition to lower level deficits in speech processing, the importance of top down influences such as motivation, memory and attention in speech perception and early word learning are important. The evidence as to which factors are primary is currently inconclusive. However, evidence suggesting an extended multisensory binding window in some children with ASD impacting on speech processing, is consistent with theories of ASD such as Weak Central Coherence. This has implications for early vocabulary learning, but requires further research, particularly in younger children with ASD.

From evidence discussed, it is predicted that successful intervention approaches for early word learning in ASD need to increase attention, reduce competing stimuli such as background noise or visual distractions, decrease adult speech rate, link social and high interest non-social stimuli and enable repeated learning of highly synchronous multisensory stimuli with overall reduced processing demands from competing stimuli. The next section considers these factors, looking at the current evidence for intervention to support speech processing and early word learning in ASD. There is a particular emphasis on video based interventions as used in this study and the extent to which they address these considerations in early word learning for children with ASD.

1.5: INTERVENTION

A number of reviews have attempted to evaluate the evidence on interventions to ameliorate the core difficulties of ASD, including language and communication. However, there have been a range of methodological limitations in the studies reviewed as highlighted in section 1.5.1. Section 1.5.2 discusses sensory processing interventions and their importance for adaptive responses to learning, building on sections 1.4.1- 1.4.6 which looked at the impact of sensory differences on speech processing. This reflects the growing interest in this domain and recent addition of sensory differences to the diagnostic criteria for ASD (APA, 2013). Section 1.5.3 looks specifically at management of auditory processing difficulties and section 1.5.4 describes intervention studies which highlight the importance of joint attention in language learning. Finally, section 1.5.5 looks in detail at the evidence on use of video modelling, as this is the intervention method used in the current study.

1.5.1: Intervention approaches to develop early language skills in children with ASD

Rogers and Vismara (2008) did a systematic review on evidence for treatments to improve developmental functioning, reduce symptom severity and non-

adaptive behaviour in young children with autism since 1998. They recommended the need for more randomised controlled trials. In their review, no treatments met the criteria for probably efficacious, and only three studies met the criteria for possibly efficacious. Whilst they conclude that early intervention is beneficial, the long term effects on social functioning are unknown. Although some of these studies targeted joint attention and use of visual supports, no studies targeted sensory processing directly.

Howlin et al. (2009) did a systematic review of eleven Early Intensive Behavioural Intervention studies for children with autism and echoed the need for more rigorous methodology in intervention studies. They found that at group level, Early Intensive Behavioural Interventions resulted in improved IQ, but that there was considerable variation amongst individuals and methodological weaknesses in the studies. Weaknesses included lack of adequate control groups and limited information on; baseline data and follow up, duration and intensity of the intervention, a detailed range of assessment measures, clearly defined diagnostic criteria and family functioning. Furthermore, although most of the interventions were reported to be based on a behavioural programme developed by Lovaas et al. (1981), there was considerable variation in how the interventions were implemented. In addition, measures of IQ varied between and within studies with reported scores varying between raw scores, age equivalents and standardised scores. Finally, as the authors point out, there is no reason why improvement in IQ per se leads to better outcomes in terms of core autism symptoms such as communication or sensory processing differences. They advocate further research to compare evidenced interventions based on social communication as well as behavioural interventions.

With particular relevance to the current study, Tager-Flusberg and Kasari (2013) highlight the limited evidence base for effective interventions to improve language and communication in school age minimally verbal children with ASD. Furthermore, Maglione et al. (2012) conducted a systematic review of non-medical interventions for children with ASD and also found limited evidence for effective interventions to support preverbal and minimally verbal children with autism, identifying this area as a research priority. This review included studies

to address core ASD impairments including language and adaptive behaviour but not sensory processing.

With regard to interventions specifically targeting language and communication, Kasari et al. (2005) argue there is no evidence for a single approach to develop language and communication skills suitable for all children with ASD. Age, cognitive skills, language abilities and frequency and intensity of intervention will all effect outcomes. In addition, numerous researchers have pointed out the methodological limitations in much of the research to date.

Approaches to develop language and communication in children with ASD vary between those aiming to improve communication by enhancing the quality of the parent-child interaction, those based on behaviourist principles, those based on educational interventions and approaches using a combination. There is however a general consensus on the importance of involving caregivers, generalisation into functional contexts and the amount of time the child is exposed to interventions. Crowe and Salt (2015) describe the current 2013 NICE guidance [CG170] on management and support for children with ASD which recommends psychosocial interventions to increase joint attention and reciprocal communication, although again the evidence base was limited.

One study looking at parent-mediated communication interventions in 2-4 year old children with autism vs. treatment as usual (Green et al., 2010) used a large scale randomised control trial to evaluate the intervention approach in the *Preschool Autism Communication Trial (PACT)*. It found no group effect on social-communication scores of the *ADOS* (Lord et al., 2002) but positive effects on parental report of their child's language and communication and on direct observation of parent-child interaction. Parent report was based on use of the *MCDI* (Fenson et al., 1993) and the *Symbolic Behavior Scales Developmental Profile* caregiver questionnaire (Wetherby and Prizant, 2002). Effects were strong for parent-child synchrony and child-initiations to parent and still positive but less strong for shared attention, defined as, 'episodes in which the parent and child shared attention focus' (p.1422, Green et al.). Although the results on the primary outcome of the *ADOS* score meant the *PACT* intervention could not be recommended as an intervention in preference to

treatment as usual, the methodological rigour of the study has raised the standard for treatment intervention research for this population in the future. However, the study also highlights the difficulties of measuring change in young children with autism.

Spence and Thurm (2010) questioned whether the lack of positive published trials for interventions in children with autism is due to poor efficacy, lack of sensitive outcomes or the heterogeneity of autism, or a combination of these factors. They highlight the importance of separating out treatment factors such as parent vs. therapist, home vs. clinic, individual vs. group, time vs. intensity and discrete trial vs. play or relationship based. Lack of available rigorous and sensitive outcome measures, lack of stability in autism diagnosis in very young children and the high degree of heterogeneity of autism, are also emphasised as limiting factors in interpretation of research findings even in well designed studies.

Howlin et al. (2009) recommend that future research on interventions for children with ASD should include more randomised control trials, but recognise that the heterogeneity of the population and difficulties in obtaining adequate primary outcome measures means that case control comparison studies will still be needed. They suggest as a minimum such studies should include baseline data, age at treatment onset, length, intensity and exact follow up time of interventions for both treatment subjects and controls, use of standardised assessments, diagnostic instruments as recommended by NICE (Baird et al., 2011) and measures of family functioning.

Some studies have looked in particular at which factors are associated with better vocabulary growth. For instance, Smith et al. (2007) found that in thirty five children with autism aged 20-60 months, the number of words used, verbal imitation, pretend play and amount of gesture used to initiate joint attention, were all factors associated with fast growth in expressive vocabulary over time, whereas the least vocabulary growth was associated with significant developmental delay and autism severity. All the children received an average of 15-20 hours a week of intervention comprising of structured teaching, speech and language therapy, occupational therapy or individualised preschool

services. There is general agreement that autism severity and cognitive ability often influence later language skills but the exact relationship is debated as discussed in section 1.1.2. Interestingly, in the study by Smith et al. (2007), cognitive scores on the *Mullen Scales of Early Learning* (Mullen, 1995) did not predict language development until 6 months after the start of the study, questioning the reliability of early measures of cognition in predicting language development. In addition, there were limitations in the study such as, variations in types of intervention, small sample size, and a potential measurement error arising from the use of different versions of the *MacArthur Communicative Developmental Inventory* (Fenson et al., 1993) with different children.

Ellis Weismer and Kover (2015) also found that maternal education and response to joint attention were significant factors in those children with high or low language scores by the final visit in a longitudinal study of the children aged 2.5-5.5 years, although did not predict the rate of language growth. To increase confidence in outcome measures, Tager-Flusberg et al. (2009) recommend that measures of expressive language in children with ASD should come from a combination of sources such as natural language samples, parent reported information and standardised measures.

1.5.2: Management of sensory processing difficulties

Given the differences in sensory processing in ASD highlighted previously (section 1.3), this section will begin by looking at the evidence for supporting such differences across modalities and then focus on the evidence for supporting auditory processing as multisensory and auditory processing are particularly salient for this study in terms of vocabulary learning. See section 1.4.6 for a discussion of the relationship between sensory processing differences, speech processing and early vocabulary learning in ASD. Each sub-section will look at the wider evidence in addition to that pertaining specifically to individuals with ASD.

Recent research has looked at the effectiveness of different interventions for sensory processing difficulties in varying groups of children including children

with ASD such as; sensory integration, sensory diet and environmental adaptation. Sensory integration intervention (Ayres, 1972) involves enabling the child to be actively engaged in meaningful, individualised sensory-motor activities that offer just the right amount of challenge. This is so that their nervous system improves modulation, organisation and integration of sensory information to produce an appropriate adaptive response, enabling readiness to learn. Sensory diets involve a schedule of sensory activities throughout the day in order that the child's sensory needs are met appropriately, whereas environmental adaptation includes modifications to the environment which take account of the child's sensory needs such as hypo or hyper responsiveness (Hazen et al., 2014). Interventions and environmental adaptations targeting adaptive responses as described above are likely to benefit learning including language and communication.

Miller et al. (2007) found in their randomised control trial that sensory integration was more effective than no intervention or play based activity intervention in ameliorating some of the difficulties that children with sensory modulation disorder experienced. Parham et al. (2007) attempted to assess the validity of research into sensory integration outcomes in 34 studies, looking in particular at treatment fidelity. They found that the validity of sensory integration outcomes studies was weakened by poor fidelity to therapeutic processes, making it difficult to come to any conclusions regarding the effectiveness of sensory integration therapy.

There are methodological issues in much of the research on sensory processing interventions, although some are attempting to remedy this. Pfeiffer et al. (2011) conducted a pilot study to identify a model for use of randomised control trials to examine outcomes of a sensory integration treatment programme compared to a fine motor treatment programme in thirty seven 6-12 year old children with ASD. Pfeiffer et al. (2011) found that while there were positive changes in goal attainments for both treatment groups, these were only significant in the sensory integration group. However, the study included both children with autism and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) creating a relatively diverse participant group, and the

intervention period was relatively short (three sessions a week over six weeks). These factors urge caution in generalisation of the findings, despite the use of randomised control trials.

Lang et al. (2012) conducted a systematic review of 25 intervention studies using sensory integration therapy in children with ASD, but found only three studies which suggested that sensory integration therapy was effective and fourteen suggesting no benefits. However, again they note that many of the studies including those reporting positive results had serious methodological issues. Hence sensory integration therapy was not recommended outside of well controlled research. However, the review by Lang et al. (2012) has been criticised in terms of inclusion criteria and interpretation bias by Case-Smith and Schaaf (2012). Schaaf et al. (2014) conducted a controlled but small scale randomised trial on the use of sensory integration therapy in seventeen children aged 4-8 years with ASD compared to fifteen children with ASD in the 'usual care' group. The researchers found significantly better Goal Attainment Scores and better scores on measures of parental assistance for self help in the intervention group. Diagnosis of all children was based on standardised diagnostic tools. Verbal and non-verbal IQ, autism severity, hours receiving occupational therapy intervention and concurrent use of pharmacological treatments were also described for each intervention group.

Hazen et al. (2014) conducted a systematic review of a range of studies on sensory intervention in ASD and found that sensory integration therapy, sensory diet and environmental modification appear to be the best treatments available at the current time. However, they recommend more research into these treatments to support their efficacy. Case-Smith et al. (2014) systematically reviewed 5 studies of sensory integration and 14 of sensory based intervention and found positive effects from two small randomised control trials and three other studies of sensory integration, but few positive outcomes for studies of classroom sensory strategies such as use of weighted vests or therapy balls to influence arousal, although there were issues with targeting sensory processing difficulties and following treatment protocol in the latter interventions.

1.5.3: Management of auditory processing difficulties

To date, there is limited evidence of effective intervention for auditory processing difficulties generally, further complicated by the difficulties defining what constitutes an auditory processing disorder (Moore et al., 2013). Most evidence on management is low level such as expert reports or case/observational/retrospective studies with controls. There is a lack of evidence using randomised control trials (Sharma et al., 2012; British Society of Audiology, 2011). The evidence for intervention forms three main categories, i.e., modifying the listening environment, auditory training and compensatory strategies. Philips (1995) concludes that structured organisation of sensory pathways may vary between individuals, and have some plasticity, even in adulthood. Thus there arises the possibility of improving auditory processing, which arguably might ameliorate the affects of the autism. However as discussed earlier, the evidence base is limited in the general population, even more so for the ASD population.

Paul (2008) highlights the difficulties of reviewing evidence on the efficacy of treating of auditory processing difficulties due to the unreliable and varying diagnostic variables of participants. Paul (2008) further suggests that there is little evidence that intensive listening exercises have any effect beyond children getting better at doing the exercises. Such exercises usually include intensive listening to synthesised sound in order to detect increasingly small differences in duration, pitch and order, increase location of sounds, combine sounds from two ears, or discriminate sounds in background noise. Fey et al. (2011) evaluated peer-reviewed research on the efficacy of training and interventions in children with auditory processing difficulties in their systematic review and concluded that the evidence for treatment was weak, although their findings have been criticised by Bellis et al. (2012) due to exclusion of some relevant studies and problems with the inclusion criteria for others. Although training may improve auditory discrimination, this does not seem to be generalised to language or literacy (Agnew et al. 2004). At the current stage of evidence therefore, it would seem that the focus of intervention for auditory processing difficulties should be on improving attention to speech and direct training of

language skills rather than focussing on non-verbal auditory processing. However, as Dawes and Bishop (2009) conclude, more research is needed on intervention in children with auditory processing difficulties, in particular combining neurophysiological and behavioural measures.

Rather than attempting to directly treat the auditory processing deficit, some studies have looked at indirect measures to reduce the impact of any such difficulties. These include, environmental modification (e.g., sitting the child at the front in the classroom, using of visual cues, short instructions, chunking and pacing of instructions or modifying room acoustics) or speech signal enhancement (e.g., the teacher using a directional microphone). The following sections will focus on the impact of ameliorating the impact of background noise and effects of slowing the rate of speech presentation, due to their relevance to this study and children with ASD.

With regard to children with ASD, a narrative review of the evidence to date, suggests that auditory deficits in ASD are highly modulated by stimuli meaning and are because of top down influences rather than an underlying difficulty with detecting or discriminating auditory features (Dawes and Bishop, 2009, p.454). However Dawes and Bishop (2009) recommend further research to confirm or refute this hypothesis. They suggest that such top down influences will mean that it is unlikely that the listening problems in children with ASD will be helped by the environmental adaptations recommended by Bamiou et al. (2006). However, some researchers are attempting to evaluate environmental adaptations for children with ASD, as described below.

1.5.3.1: Ameliorating the impact of background noise on speech processing for children with auditory processing difficulty

Lemos et al. (2009) did a systematic review on the use of Frequency Modulation (FM) systems to treat auditory processing difficulty and found only low level evidence to support their use. A personal FM system operates on particular frequencies and has a transmitter microphone used by the speaker and a receiver worn by the listener. It serves to enhance the speaker's voice in

relation to background noise. More recently, some studies which included control groups, have supported the use of FM systems. For instance, Hanschmann et al. (2010) found that all children regardless of their result on the *Oldenberg Sentence in Noise Test*, made improvements in speech intelligibility using an FM system, but there was little difference in the improvements between experimental groups and controls without auditory processing difficulty. Johnston et al. (2009) did a small study of ten children with auditory processing difficulty and poor speech perception fitted with personal FM systems for daily use over 5 months in noisy classrooms. They found speech perception improvements in noise as well as academic and psychosocial benefits and after prolonged use, improved unaided speech perception in noise. This was true for all the children, even though two of the ten did not have specific difficulties with auditory figure-ground. However, the study did have some limitations. It did not look at the effects of maturation by including a control group with auditory processing difficulty not using an FM device, although maturation effects might have been expected to be minimal over the short time period. In addition, academic performance was based on parent rather than teacher rating. A systematic review of 19 studies using FM systems as an intervention for auditory processing disorder, found only a low level evidence base to support their use (Lemos et al., 2009). However a more recent randomised control trial by Sharma et al. (2012) found positive outcomes for the use of FM systems as an intervention in auditory processing disorder

Hence, it is not possible to fully confirm the possibility that FM systems are an effective intervention for auditory processing difficulties. However, recent evidence suggests that this is a promising method of intervention. Further research is needed.

1.5.3.2: Ameliorating the impact of background noise in ASD

As discussed earlier in section 1.4.1., Alcántara et al. (2004) found that high functioning adolescents with ASD require speech to be 2-3.5 dB louder than their typically developing peers to enable a similar level of comprehension in

background noise. Alcántara et al. used 5 different noise conditions (single talker, speech shaped noise, speech shaped noise with temporal dips, speech shaped noise with both temporal and spectral dips). They found that the most difficult conditions were the complex background noise conditions including temporal dips.

Teder-Salejarvi et al. (2005) suggest that children with ASD may benefit from an acoustically simplified environment, e.g., teacher voice amplification and beneficial classroom acoustics. They suggest that there is a need to (1) increase salience of instructions and minimise competing input, (2) increase predictability, (3) present information at a reduced pace. However, their suggestions are based on ERP findings with adults.

In support of Teder-Salejarvi et al. (2005), Schafer et al. (2013) found that use of an FM system enhancing signal to noise ratio, significantly improved the recognition of speech in noise to normal levels in children with a diagnosis of ASD and/or Attention Deficit Hyperactivity Disorder (ADHD). This is important given the lower recognition of speech in noise without an FM trainer in experimental groups compared to typically developing controls. They studied eleven children, seven with ASD (aged 9-11 years) and ADHD and four with ADHD and compared them to eleven age and gender matched peers. The positive effect of using an FM system for children with ASD is also supported by Rance et al. (2014) in their study of 20 children, who found that FM listening devices could improve speech perception in noise, assist social interaction and increase educational outcomes. Baharav and Darling (2008) also found beneficial effects on word learning using an FM system with a 5 year old child with ASD.

Thus, reducing background noise is predicted to have a positive effect on speech recognition in children with ASD. However, the evidence base for young children with ASD in this area is limited. The present study aims to increase the evidence available in this population. Use of modified or unmodified audiovisual media has the potential to adapt presentation of vocabulary modelling to take account of the specific needs of children with ASD, albeit with a cost in terms of

social context. Use of video modelling as a tool to support language learning is explored in section 1.5.5.

1.5.3.3: The effects of slowing speech on typically developing children and children with language impairment

Studies such as Tallal et al. (1996) have highlighted beneficial effects of slowing down speech and amplifying fast transitional speech in children with language impairments, although there have been difficulties replicating their results. Similar to a smaller randomised control trial (RCT) by Cohen et al. (2005), Gillam et al. (2008) found in their RCT of 6-9 year old children with language impairments, that the *Fast ForWord-Language*® programme (Scientific Learning Corporation, 1997) did not improve general language skills more than academic enrichment, computer assisted language intervention or individualised speech and language therapy. The children were randomly assigned to the conditions and all received 1 hour 40 minutes of intervention 5 days a week over 6 weeks. These findings were supported by a systematic meta-analysis of the evidence on treatment outcomes for *Fast ForWord*® (Strong et al., 2011). The *Fast ForWord-Language*® programme uses modified speech based on a presumed underlying temporal processing deficit (Tallal et al., 1996). Furthermore, Uchanski et al. (2002), although not directly comparable to Tallal et al.'s (1996) study, found no benefits for intelligibility of words or syllable discrimination from either slowing down speech by 50% or envelope amplification with or without slowed speech, in both hearing impaired and typically developing children.

A range of studies however suggest that slowed speech may benefit offline language processing (i.e., response required after sentence is heard) particularly for complex items, but hinder automatic online processing in typically developing children. Montgomery (2004) compared language impaired children (6 years 4 months to 10 years 5 months) and typically developing children (6 years 3 months to 7 years 10 months) matched on receptive syntax and found that slowing speech by 25% of the normal rate aided sentence comprehension in the language impaired children so that it was comparable to

the typically developing children, but there was no association between sentence comprehension and phonological working memory (measured by a non-word repetition test) for either rate in any group. Thus Montgomery argued that slowing the speech rate can support language comprehension. Love et al. (2009) looked at the effects of a slowed speech rate (slowed to 66% of the normal rate) on offline processing using a sentence picture matching task and online automatic processing using a cross-modal picture priming task. They found that whereas slowed speech benefitted offline processing of pronouns, it had a negative effect on online automatic processing of pronouns and reflexives. Haake et al. (2014) found that in typically developing Swedish speaking children aged 5 years to 6 years 1 month, a fast speech rate (60% faster than the speaker's normal rate) negatively affected off-line processing as measured by TROG-2 scores whereas a slowed speech rate (160% of the speaker's normal rate) increased scores generally, but only for individual children with a higher working memory capacity (as measured by a sentence processing and recall test). Speech rates were selected so as to have an effect without sounding unnatural. Haake et al. (2014) also found that for these children, a slow speech rate was particularly helpful for the more difficult items. This finding supports the findings of Love et al. (2009), but appears to contradict those of Montgomery (2004). This apparent contradiction might have been because Montgomery (2004) measured phonological working memory whereas Haake et al. (2014) measured working memory capacity.

Thus overall, the research suggests that slowing speech may benefit offline processing in typically developing children when language mastery is not fully acquired and where there is a good working memory capacity, but hinder online unconscious processing. Previous research has also highlighted benefits of slowed speech for children with language impairment, but there have been difficulties replicating these findings. In terms of practical implications, digitally slowed or speeded up speech may not be the same as an adult naturally changing their speech rate to support understanding, although it does enable tighter control of experimental variables.

1.5.3.4: The effects of slowing speech in ASD

Tardiff et al. (2007) found significant benefits in imitation for children with autism from slowing down facial expressions and vocal sounds. They found that 7-13 year old children with autism, especially those with more severe autism, were more likely to imitate facial expressions and associated vocal sounds (such as 'yeh' for the expression of joy) when these were slowed down naturally and then artificially, to last twice as long. Similarly, Laine et al. (2008) cited in Gepner and Feron (2009), found that slowing down both the visual and auditory aspects of spoken single or double sentences, increased verbal understanding, particularly in low functioning children with autism. Laine et al. (2011) also found positive benefits for imitation of facial and body movements in children with severe autism aged 6 to 17 years when movements were slowed from two to four and five seconds, but not in the wider group of children with autism as a whole.

Thus there is some limited evidence that slowing down speech may be beneficial for language comprehension in some children with ASD, especially for those with severe ASD. However, to the researcher's knowledge, all the relevant studies include a visual as well as an auditory component to the slowed speech, so it is not possible to separate out visual and auditory effects. In addition, studies of typically developing children suggest that working memory capacity may be an important factor in determining the benefits of slowed speech on offline processing as required in the current study. More research is needed looking at the effects of slowed speech in relation to working memory and the impact of the visual and auditory components of slowed speech. In addition, there is a lack of evidence on the effects of slowed speech in young children with ASD.

1.5.4: Supporting attention in children with ASD

Some studies have looked at the effects of supporting attention on language given the difficulties in attention in ASD discussed earlier. Wang et al. (2007) found that when children with ASD were explicitly instructed to attend to facial

expression and tone of voice, there was increased activity in the medial pre-frontal cortex. Activity in this area is important for understanding the intentions of others. However explicit instructions did not result in enhanced task performance in irony detection, although this might have been limited by the nature of the task (see sections 1.2.4 and 1.4.4 for evidence of the benefits of cueing attention).

The importance of joint attention is further emphasised by Gulsrud et al. (2007). They found that children with autism (aged 33-54 months) receiving a joint attention intervention as defined below as opposed to a symbolic play intervention, were more likely to acknowledge a novel auditory or visual probe stimulus and improve in the proportion of time engaged in shared attention. In the joint attention condition, the children were taught to engage in 'joint attention acts', e.g., pointing and showing, and supported to share attention between the adults and objects using eye contact (p. 538, Gulsrud et al., 2007). Key factors in the success of the joint attention intervention might have been due to improved shifting of attention, the effects of increased focus on people and objects, and the positive effects of violating routines on shared attention. Video modelling is one intervention frequently used with children who have ASD, which has the potential to have an intrinsic effect on attention.

1.5.5: Use of video modelling interventions to support language and communication for children with ASD

Video modelling involves the child viewing a video of someone engaging in the desired behaviour and then imitating the behaviour (Charlop-Christy and Freeman, 2000, p.537). Overall, the literature suggests that live rather than screen or video based modelling is more effective in promoting learning in young typically developing children, e.g., Varner (2014); Anderson and Pempek (2005), Kuhl et al. (2003) and also Richert et al.'s (2011) narrative review of children's screen media learning. Kuhl et al. (2007) hypothesise that language learning is heavily influenced by social interaction, which is necessarily limited when children learn language from video. However, given that social interaction abilities are atypical by definition in individuals with ASD, it is possible that

children with ASD may not benefit from social interaction in language learning in the same way as typically developing children. A wide range of studies have looked at outcomes from video learning in general in children with ASD and also at the impact specifically on communication.

Studies of children with ASD (e.g., Kagohara, 2010; Nikopoulos et al., 2009; Nikopoulos and Keenan, 2004; Simpson et al., 2004; Nikopoulos and Keenan, 2003;) and systematic reviews (e.g., Shukla-Mehta et al., 2010; Rayner et al., 2009; Bellini and Akullian, 2007; Delano, 2007), have mostly supported the effectiveness of video modelling in supporting learning generally in children with ASD, albeit with certain caveats such as the need for further specification of participants or contextual details and for consistent reporting to enable comparison and clear conclusions to be drawn. The reviews highlight variations between studies such as whether video modelling was the only intervention, the type and amount of video modelling, the extent of the time delay after modelling, participant and learning task differences and whether prompts and reinforcements were used. Plavnick et al. (2014) also point to the differential effects of video modelling depending on the environmental context and behaviour it is attempting to elicit. Nevertheless, Shukla-Mehta et al. (2010) highlight three of the four studies in their review where video modelling was the main intervention providing evidence of learning, generalising and or maintaining social and communication skills.

The meta-analysis by Rayner et al. (2009) of five reviews on video modelling including twenty five studies measuring the impact of video based intervention on social communication, found that video modelling interventions can be effective in teaching a range of social and communication skills, although only one study (Wert and Neisworth, 2003) included early vocabulary learning as in this thesis and this was in the context of spontaneous naming rather than labelling.

The review by Shukla-Mehta et al. (2010), describes several studies where video modelling was used specifically to enhance language and communication in children. Outcomes were mostly positive, but involved case studies or very small samples and sometimes combined video modelling with other

interventions. Shukla-Mehta recommend further research with specific criteria associated with positive outcomes, i.e., (1) the use of prompts or reinforcements, (2) evaluation of the child's attention, imitation, visual processing, understanding, matching and spatial abilities, in order to decide the video content and length, (3) children able to attend to the video for at least one minute, with the camera focus close up to the target cues and responses, (4) video clips between 3 and 5 minutes watched twice a day (Shukla-Mehta et al., 2010, p. 32-33).

More recently, Charlop et al. (2010) found that video modelling was associated with positive effects on language and other forms of social expression in three children with ASD aged 11 years 9 months, 8 years 5 months and 7 years 1 month. Schefflen et al. (2012) also found video modelling effective in developing play skills in four children with ASD aged 37-69 months with a range of play, cognitive and language abilities. In addition, there was an increase in the complexity and frequency of language after video modelling for some of the children. Shepley et al. (2014) found video modelling effective in teaching four verbs over five trials per target to three children with social communication difficulties aged 3-5 years. They used a progressive time delay procedure, i.e., incremental or decremental 0-4 second delays in providing the target word dependant on the child's response. Furthermore, two children generalised learning when video modelling was combined with the teacher specifically modelling expanding and generalising the targets.

Some studies as recommended by Delano (2007) have also directly compared the impact of video modelling with live modelling on learning in children with ASD. They found that learning from video modelling is as effective (Gena et al., 2005) or more effective (Charlop-Christy et al., 2000) than live modelling. Wilson (2013) examined the efficacy of video modelling compared to live modelling on social communication skills in a classroom setting in four children with ASD aged 3 years 9 months to 5 years 4 months and found a range of outcomes across individual children's profiles. Three out of four children benefitted from video modelling, although there was no change for one of the children. Wilson (2013) also highlighted the importance of reduced visual attention for some children. Comparing live and video modelling, Watson et al.

(2012) found that although children aged 29-42 months with ASD paid less attention to live modelling than language matched controls, potentially reducing learning opportunities, there was no more sustained visual attention to video than live presentation. Sustained visual attention was defined as the proportion of time spent looking at the target stimuli when the child looked for at least two consecutive seconds. Their study had a somewhat larger sample than many of the other studies, comprising of twenty two children with ASD and fifteen language age matched controls. Cardon and Azuma (2012) found that children with ASD preferred video to live presentation of a puppet show when comparing nine children with ASD aged 2-5 years with typically developing children. However, although both children with ASD and typically developing children attended to the video presentation for longer than the live presentation, visual attention was shorter in both conditions for the children with ASD.

The meta-analysis by Wang et al. (2011) of single-case research studies compared peer-mediated versus video modelling of social skills in children with ASD. They found both methods significantly and equally effective with participant age also significantly affecting outcomes, younger children appearing to benefit more. However the analysis only reviewed five studies on video modelling with four studies using participants in the 4-6 year age range and one in the 9-15 year age range. In addition, the authors point to a number of limitations of the studies in relation to interpreting the effect size in single case studies. The studies did not look at the categories of dependant variables, setting or cognitive ability which may have influenced the results. They suggest developing different standards for measuring the effect size according to the research design, intervention goal and type of participant. However the authors conclude that social skills interventions, including video modelling should be introduced as soon as possible.

There is also some evidence looking at the use of screen based interventions generally to facilitate early vocabulary learning in children with autism. Ramdoss et al. (2011) systematically reviewed ten screen based interventions used to teach communication to children with ASD based on software packages (e.g., Massaro and Bosseler, 2006; Bosseler and Massaro, 2003) rather than video modelling alone. They did not consider such interventions to be a research

based approach but highlighted some positive evidence requiring further research. Only one, Moore and Calvert (2000) targeted vocabulary learning, finding increased receptive vocabulary after a software programme intervention in comparison to live modelling. They found that where fourteen children with autism aged 3-6 years were randomly assigned to either computer or behavioural learning conditions, the former were more attentive, more motivated and retained more nouns in a delayed recall test. However, there were methodological limitations in the small sample size and lack of norm-referenced measures to describe the subjects. Bosseler and Massaro (2003) expand on the multimodal processing framework for vocabulary intervention by using a software programme to teach nine children aged 7-12 years with autism new words. This was done by reinforcing paired pictures of objects and a computer animated face saying the object words. Although the sample was small, all the children showed an increase in vocabulary linked to the training, generalised use to the items outside of the training sessions and retained their learning after 30 days. However use of the vocabulary in spontaneous speech was not evaluated.

Researchers have also looked at key factors about the video learning context or within the child which might impact on successful outcomes when considering the use of video modelling in supporting learning for children with ASD. Corbett and Abdullah (2005) highlight specific beneficial characteristics of video learning for children with ASD such as; a restricted field of focus, repetitive presentation and association of video with recreation increasing motivation, which need to be considered alongside strengths in children with autism such as selective attention and visual learning. They also highlight the reduced demands on social attention and interaction that video places compared with most live modelling contexts. This might be a key factor given the potential difficulties that many children with ASD have with social learning, affecting future abilities including language (Kuhl et al., 2013). Charlop et al. (2010) suggest that video modelling may be effective because it increases motivation, builds on visual strengths and focuses attention on relevant cues, reducing any difficulties arising from problems attending to multiple stimuli. Shukla-Mehta et al. (2010) highlight the importance of assessing children's abilities in key areas (such as

attention, visual processing, imitation and comprehension as in the current study), prior to considering video modelling, so that video content and length can be tailored to the child's strengths and needs.

There is some evidence in the literature that learning from screen media depends, at least in part on exposure (Crawley et al., 1999), but other variables also contribute such as how the children relate to the onscreen character (Richert et al., 2011; Calvert et al., 2007). Interestingly, in a study by Yu and Smith (2012) highlighting the role of joint visual attention, the number of times the parents named the objects to typically developing 1 year old children was negatively correlated with word learning, suggesting that frequency of word presentation in itself does not promote word learning.

The current study attempts to add to the literature on sensory differences and use of video modelling in children with ASD, in particular expanding on a study by Baharav and Darling (2008). They describe a case report with a minimally verbal child with ASD of 5 years 8 months exposed to 2 video sessions a day watching her parents with a Frequency Modulation (FM) trainer auditory trainer say new vocabulary. Thus the child was exposed to enhanced visual input via the video and enhanced audio input via the FM trainer. Results indicated substantial gains in word production, social orienting and increased eye contact. There were more gains in comprehension than expression. However, this study did not control for practise effects vs. the importance of the FM trainer and information is not provided on the exact nature of the background noise and signal to noise of the speaker. The current study compares video and live modelling and also uses video to explore some of the sensory processing differences evidenced in the literature, i.e., the effects of background noise, speech rate and asynchrony on early word learning. It particularly focuses on young children with ASD to meet a gap in the literature.

1.6: SUMMARY OF THE LITERATURE AND RATIONALE

The evidence reported at the beginning of this chapter highlights atypical vocabulary learning and that at least some individuals with ASD demonstrate

marked sensory differences likely to impact on speech, language and communication. However in contrast to recent studies based on the *DSM-5* (APA, 2013), the diagnostic criteria in the *DSM-IV-TR* (APA, 2000) used for many earlier studies did not include sensory differences. Thus, some caution is required when comparing earlier and later evidence on the impact of sensory differences in ASD. In addition, the heterogeneity of the population of individuals with ASD and variation in diagnostic practice, need to be considered when comparing research outcomes across the literature.

The extent to which sensory differences are unimodal or result from differences in multisensory integration and the extent of the influence of attention and top down factors, remains debatable. More research is also needed on how auditory, visual and multisensory differences change with age and if or how these impact on the core language and communication impairments reported in ASD.

The evidence for intervention approaches to support early language development in ASD is inconclusive although there is some emerging evidence of important factors for consideration. It is beyond the scope of this thesis to look in depth at the wider aspects of social communication in ASD, although its crucial importance is acknowledged.

There is a paucity of evidence for efficacy of treatment approaches for auditory processing difficulties and for auditory processing difficulties in ASD in particular, but most evidence is centred on environmental modifications to reduce the effect of auditory processing difficulties, such as reducing background noise or slowing speech presentation. Recent reviews of video modelling interventions with children with ASD also suggest promising outcomes for communication, but further research is needed, particularly in relation to vocabulary learning in young children. This study takes into account recommendations by Shukla-Mehta et al. (2010) described earlier, which are associated with positive outcomes from video modelling.

The current study seeks to add to the evidence on intervention supporting early vocabulary learning in ASD, in particular building on reported positive outcomes from video modelling and the evidence of sensory and speech processing

difficulties in this population. It particularly looks at the under researched population of young children with ASD and minimal language, to meet a gap in the literature. Part 1 of this research examines video modelling as an intervention technique utilising reported strengths such as visual learning and a preference for repetition associated with ASD. It compares this to live modelling and modified video input designed to compensate for possible auditory/sensory processing deficits. Part 2 looks at fast mapping vocabulary and the effect of modified video input. It also explores multisensory influences by looking at the impact of a potential extended multisensory binding window on vocabulary learning, comparing the effects of asynchronous vs. synchronous speech. Hence this study seeks to add to our understanding of factors which might contribute to atypical word learning in young children with ASD.

Chapter 2: RESEARCH RATIONALE, AIMS AND METHOD

2.1: RESEARCH AIMS AND RATIONALE

The evidence to date on vocabulary learning in Autism Spectrum Disorder (ASD) suggests that at least some children with ASD may have auditory and or speech processing differences, which impact on their early language development. These differences may be unimodal or multisensory.

As outlined in the introduction, this thesis examines the impact of video modelling on early word learning. Video modelling potentially compensates for possible auditory/sensory processing deficits whilst utilizing reported strengths such as visual learning and a preference for repetition associated with ASD.

Part 1 of this study also seeks to investigate which specific factors may be important in enabling young children with ASD to learn new words. There is evidence that some children with ASD demonstrate differences from typically developing children in processing speech in relation to speech rate (e.g., Gepner et al., 2005) and that they have particular difficulties with figure ground speech perception (e.g., Schafer et al., 2013; Alcántara et al., 2004). This study aims to consider the impact of any such differences. It looks at whether differences in the presentation of spoken object names such as slowing speech or adding background noise, make a difference to the early word learning of six young children with ASD and minimal spoken language over a four week intervention period.

Part 2 of this study focuses on which factors are important for young children with ASD when fast mapping vocabulary, i.e., learning to understand or produce new words after minimal exposure. It considers the impact of video modelling in different speech conditions (unmodified, slowed or with background noise) on fast mapping new words in eight young children with ASD and minimal vocabulary. Specifically, it aims to look at whether there is any difference in fast mapping between video modelling with the modified speech and non-modified speech video conditions. Part 2 therefore seeks to build on evidence from the

results in Part 1 on specific audiovisual factors to consider when supporting language and communication development for children with ASD.

Part 2 also explores the impact of asynchronous audiovisual presentation vs. simultaneous audiovisual presentation on fast mapping vocabulary. This is to consider emerging evidence on whether individuals with ASD may have an extended multisensory binding window (the time frame within which different sensory information is integrated) as suggested by a range of emerging literature, e.g., Woynaroski et al. (2013), Foss-Feig et al. (2010) and Kwakye et al. (2010). Bebko et al. (2006) found that young typically developing children (aged 2-4 years) showed significant preferential looking for synchronous stimuli for non-linguistic, simple linguistic and complex linguistic stimuli. For children with ASD, this was only the case for non-linguistic stimuli. This may be because children with ASD do not detect or are slow to detect the asynchrony or that they have atypical expectations about speech in linguistic stimuli. An extended multisensory temporal binding window in children with ASD has a potentially negative impact on vocabulary learning.

In summary, this study aims to add to the evidence on factors to consider when supporting the language and communication development of children with ASD with particular reference to video modelling, an area with a limited evidence base and emerging interest.

2.2: STUDY DESIGN AND RATIONALE

Both Part 1 and Part 2 of this study used a case series design. This design was selected for the following reasons:

(1) The difficulty in controlling for inter-variability in the participants created the necessity for intra-subject comparison across conditions.

(2) There was limited information on exact diagnostic criteria of participants in this study. The *International Classification of Diseases (10th edition; ICD-10)* classification of mental and behavioural disorders (World Health Organisation [WHO], 1992) and the *Diagnostic and Statistical Manual of Mental Disorders*

(4th edition; *DSM-IV*; American Psychiatric Association [APA], 2000) diagnostic criteria for ASD are; qualitative impairments in (A) communication, (B) social interaction and (C) restricted, repetitive, and stereotyped patterns of behaviour, with onset before 3 years. Recently, the *Diagnostic and Statistical Manual of Mental Disorders* (5th edition; *DSM-5*; American Psychiatric Association [APA], 2013) has updated these criteria to take account of current evidence. The new diagnostic criteria, where symptoms must be present in early development are; (A) persistent deficits in social communication and interaction and (B) restricted, repetitive patterns of behaviour, interests or activities. The latter must include at least two of the following: (1) atypical response to sensory input, (2) stereotyped or repetitive movements, use of objects or speech, (3) insistence on sameness, or (4) highly restricted, fixated interests that are abnormal in intensity or focus (APA, 2013, p. 50). Hence, although there is broad agreement on diagnostic criteria and participants were diagnosed prior to the update, there is potential for confound. The limits of this study meant that information on the diagnostic profile was only gathered on parental reported symptoms, although all children had already been given a diagnosis based on the full diagnostic criteria for observed and reported symptoms.

(3) The *National Autism Plan for Children* (LeCouteur et al., 2003a) and the NICE (National Institute for Health and Care Excellence) *Clinical Guidance 128* (2011) on diagnosis of autism describes the gold standard in diagnosis, although in reality, diagnostic practices vary. Both this and the heterogeneity of individuals with a diagnosis of ASD (McPartland et al., 2012; Lombroso et al., 2009) are likely to be significant confounding variables when attempting to make cross subject comparisons.

(4) Wang et al. (2011) list a number of reasons why single case studies are frequently chosen for research design in children with ASD. Relatively low prevalence of ASD makes random assignment to groups difficult. In addition, there are ethical considerations of assigning children to the control group.

(5) Case studies are low cost and result in greater in depth information from participants than is possible in larger case studies. Cakiroglu (2012) highlights the advantages of single case study designs in special education, i.e., being

able to conduct investigations with relatively low incidence populations such as autism, being able to measure individual performance and take account of ethical considerations as highlighted above by Wang et al. (2011). He also notes that single case study design is particularly useful for helping to understand the performance of individuals under specific conditions as in this study, where the effect of more than one independent variable on a dependant variable (vocabulary learning) is measured.

(6) The advantages of case study designs for educational interventions are described by Horner et al. (2005) as: a clear analysis of the relationship between specific interventions and outcomes; a practical way of measuring repeated applications of an intervention so both process and product of change can be measured; a means of testing the validity of theories of behaviour change; and a cost effective way of adding to the body of evidence to inform large scale analysis. This study did not apply all the intervention conditions to all the participants, but randomly assigned two conditions per subject. This was considered ethically appropriate since there is no current conclusive evidence which points to a clear advantage of using any one of the intervention conditions. Critical reviews of the evidence have not found any one intervention for children with autism that can be considered to have a strong evidence-based recommendation for use (Reichow et al., 2008). The recent *NICE Clinical Guidance 170* on management and intervention for children and young people with autism (NICE, 2013) recommends considering intervention for the core aspects of autism including, techniques to expand interactive play, communication and social routines, modelling and video interaction feedback. This intervention focused on the child watching vocabulary modelling within a play routine.

However, case studies can lead to type I (false positive) and type II (false negative) errors caused by the data direction trend regardless of the intervention. Detailed participant data and case series design with random allocation to intervention conditions were used to control for error as far as possible. External validity and generalization of the findings are also possible problems in single subject research. Cakiroglu (2012) suggests one way of reducing this problem is through replication. In this study, each intervention

condition was conducted with two different participants. Furthermore, the dependant variable (i.e., vocabulary learning) was measured through both assessment and questionnaire in Part 1. The second part of this study (see Part 2) also looks at the effects of the intervention conditions using clips from the same modified videos on immediate word learning (fast mapping) with a different set of participants and in an educational setting as opposed to a home setting.

The independent variable of manipulated video modelling was selected as an ecologically valid means of intervention that would be a cost-effective and relatively easy method of intervention to implement.

2.3: ASSESSMENTS AND SCREENING TOOLS USED IN PARTICIPANT SELECTION

The following checklists and assessments were used to support participant selection in both Part 1 and Part 2.

(1) *The Oxford Communicative Development Inventory (OCDI; Hamilton et al., 2000)*

This assessment is a standardised vocabulary checklist for children and is a UK adaptation of the *MacArthur Communicative Development Inventory* (Fenson et al., 1993). The checklist contains 416 standard words used by children aged 1.0 to 2.1 years old, which parents or caregivers report on for both understanding and expression. The words were obtained from a sample of 669 British children. The checklist is recommended for children within the above age range or older children with developmental delays. It takes from 20-30 minutes on average for parents to complete. The *OCDI* was selected as a screening tool to ensure the children in the study met the inclusion criteria of 20 spoken words or less, as it provides a standardised list of developmentally appropriate vocabulary suitable for the ages and developmental level of the participants. However, since this was a reported measure, it is possible that there may have been under or over report of the child's actual vocabulary. Additional assessment of the intervention

and control vocabulary was carried out using an informal photo lotto assessment. This is described in section 2.5.12 of this chapter.

(2) The 3Di Autism Diagnostic Assessment; shortened version (Skuse et al., 2004)

This assessment was used to confirm the diagnosis of ASD for each participant. It is standardised for individuals aged 2.4-21.1 years (Santosh et al., 2009). The assessment consists of a semi-structured parent interview format of 53 questions on the child's language and non-verbal communication, social relationships, play and friendships, restricted interests and unusual preoccupations and onset of autistic symptoms. Responses are inputted into a computerised algorithm to give scores for each of the sections and whether these meet the minimum for clinical significance for a diagnosis of ASD.

The assessment is reported to have good reliability, validity, sensitivity and specificity comparable to other gold standard diagnostic assessments (Skuse et al., 2004), although as noted earlier, a review of the current evidence base in the NICE *Clinical Guidance 128 (NICE, 2011)*, found the evidence level for all diagnostic tool accuracy overall to be very low. The practical limitations of this study did not allow for further observational diagnostic assessment using standardised tools. It is recognised that autism diagnosis cannot be made on parental/carer report alone, but it was felt that as all the children had already been given a diagnosis of ASD by an experienced autism team which included observational assessment and parental/carer report, the use of a standardised parent/carer report tool in addition to the autism team assessment, was sufficient to confirm the diagnosis within the practical limitations of this study.

The following screening tools and assessments were used to support participant selection in Part 1 only.

(1) Bayley-III Scales of Infant Development Screening Test: Cognitive subtest (Bayley, 2006)

This test is a norm referenced play based screening test for children aged 1-42 months. The cognitive scales take approximately 10-15 minutes to administer. It is designed to screen young children to ascertain if more detailed assessment is required. Cut scores (standardised categories of expected scores) for different age groups are given.

It is recognised that this test is not standardised for the age group of the children in this study or for children with autism and could only give an approximate indication of cognitive ability. However, it was considered the best alternative available to screen for a minimal cognitive ability to meet the inclusion criteria, given the lack of suitable cognitive assessments for this population that the researcher had permissions to administer. The selection of this test also took account of the benefits of a quick toy based assessment that children with possibly very short attention spans, would be able to tolerate and complete.

(2) *The Preschool Language Scale-UK: 4th Edition [PLS-4-UK]* (Zimmerman et al., 2009)

This assessment was used to assess auditory comprehension and expressive communication. This assessment is designed identify young children from birth to 6 years 5 months old with a language disorder or delay. It is made up of two subscales, one for auditory comprehension and one for expressive communication (Zimmerman et al., 2009, p.2).

Each subscale was administered from item (1) until the ceiling of 5 consecutive zero scores. This enabled assessment of early listening and preverbal skills such as discriminating sounds and early vocalisations. Relevant early listening skills assessed were; reacting to sound, locating sound and speech, turning to name and responding appropriately to routine phrases. Positive scores on these items provided a control for hearing and listening skills. Items were scored using a combination of spontaneous or elicited behaviours or parental report as defined by the assessment procedure.

2.4: PARTICIPANT PROFILE ASSESSMENTS AND RATIONALE

The assessment below was used in both Part 1 and Part 2 to provide additional participant information on the children's sensory profile, play skills and speech processing abilities to support interpretation of the results.

(1) The *Sensory Profile* (Dunn, 1999)

This assessment provides standardized scores across different sensory modalities based on the answers to 125 questions reported by the caregiver. It is standardised for children from 3-10 years. Raw scores are compared to cut scores, that is, standardised score categories of: Typical Performance at or above 1 standard deviation (SD) below mean; Probable Difference at or above 2 SD below the mean but lower than 1 SD below the mean; or Definite Difference lower than 2 SD below the mean for each section on the *Sensory Profile* (Dunn, p. 31). This is to determine if the child's sensory processing abilities are in the expected range or atypical for their age.

The information from this profile was gathered to inform interpretation of the intervention outcomes for each participant.

The following assessments were used in Part 1 only to provide additional participant information on the children's sensory profile, play skills and speech processing abilities to support interpretation of the results.

(1) The *Auditory Skills Assessment (ASA; Geffner & Goldman, 2010)*

This assessment is a criterion-referenced screening tool for children aged 3 years 6 months to 6 years 11 months. It is designed to identify children at risk of an auditory skills deficit and takes 5-15 minutes per child to administer (Geffner and Goldman, 2010, p.1). The assessment gives cut scores, a performance descriptor and a percentile rank for each age group. Only the Speech Discrimination domain (subtests: Speech Discrimination in Noise and Mimicry) of this assessment was used as this was the only domain valid for the age

range of the participants included in the study. The temporal tasks in ASA were beyond the age range or linguistic capacity of the study participants.

The Speech Discrimination in Noise subsection measures the child's ability to distinguish words in background conversational noise at an SNR (Signal to Noise Ratio) of +6 dB. After the initial practice items, the child is required to point to the correct picture from a choice of four with two distracter items and one phonologically similar item varying by the medial vowel, initial or final consonant. The test taps listening and selective attention (auditory figure-ground perception) in addition to auditory discrimination (Geffner & Goldman, 2010, p.3-4).

The Mimicry subsection measures the child's ability to hear and repeat a nonsense word that follows conventional English sound patterns. The test consists of ten pre-recorded words ranging from one to four syllables. It makes demands on attention, listening, speech discrimination and working memory (Geffner & Goldman, 2010, p. 4).

The assessment was presented using the administration CD played on a Lenco digital audio portable stereo CD player. The speakers were sited approximately 45 cm from the child and the volume adjusted to a comfortable level as recommended in the test instructions. All participants received the word discrimination trials of the assessment. Only those participants who passed the word discrimination trials proceeded with the assessment, as specified in the test instructions.

This assessment was used to gain additional information on auditory discrimination to compliment that on discrimination of non speech sounds obtained as part of the Auditory Comprehension section of the *PLS-4* in Part 1. The ASA is one of the few assessments of auditory skills available for children in the age ranges of the study. Although its use is disadvantaged by the confounding effects of an American accent on speech perception in noise, a suitable English alternative was not available at the time of the study.

(2) The *Early Repetition Battery (ERB) Preschool Repetition Test (Seeff-Gabriel, et al., 2008)*

This test was administered to all the children in Part 1. It requires the child to repeat 18 words and 18 non-words. Unlike the *ASA*, the *ERB* is standardised on children with UK English pronunciation (Seeff-Gabriel et al., 2008, p.58). The test was selected as a measure of phonological processing and memory and speech production.

This test was used to provide further information on those children with good speech repetition skills (echolalic abilities) but limited or no understanding or use of spoken words (as identified on other assessments). This is a pattern found more often in the children with ASD than in typically developing children of the same age (e.g., van Santen et al., 2013). However, the test does not give information on the nature of the child's echolalia, e.g., whether it is interactive (Sterponi and Shankey, 2014) or a result of lack of inhibition and poor filtering of background sounds (Grossi et al., 2012).

(3) The *Symbolic Play Test (Lowe & Costello, 1988)*

The Symbolic Play Test is a non-verbal structured test of play. The test is designed to measure early concept formation and symbolization through presenting the child with four sets of miniature toys and observing their response (Lowe and Costello, 1988, p. 1). Standardised age equivalent scores up to 36 months are provided. Although standardised on children 12-36 months, a number of studies such as Herrera et al. (2008), Stanley and Konstantareas (2007) and Gould (1986), have compared the age equivalent scores with scores on other assessments for older children with autism or other developmental delays.

This test was used as an additional measure of non-verbal cognitive aspects of symbolic play to provide a broader context to intervention results. It was selected as a quick and simple test to assess the non-verbal ability for children with a limited attention span. Furthermore as it is entirely non-verbal with no verbal instructions or need for verbal responses, verbal ability will not act as a

confounding variable on the scores. The test was administered to all the children who completed the pilot and went on to the intervention stage of Part 1.

2.5: METHODOLOGY FOR PART 1

2.5.1: Hypotheses for Part 1

(1) Young children with ASD and delayed spoken vocabulary will learn more new words through a video modelling intervention in quiet than through a video modelling intervention in background noise.

(2) Young children with ASD and delayed spoken vocabulary will learn more new words through a video modelling intervention with a slowed speech rate than through a video modelling intervention with an unmodified speech rate.

(3) Young children with ASD and delayed spoken vocabulary will learn more new words through a video modelling intervention than a live vocabulary modelling intervention.

2.5.2: Principle objective for Part 1

To add to the evidence base on the effects of video modelling, slowed speech and background noise on young children with ASD learning new vocabulary.

2.5.3: Study design for Part 1 intervention

2.5.3.1: Outline of study design

The study used a case series design with multiple baselines. Each participant was randomly allocated to a pair of intervention conditions from a choice of; AD, BD and CD until each pair of conditions had been allocated to two participants. The intervention conditions were,

A = vocabulary modelling by parents without video, speech at normal rate in quiet,

B = video of vocabulary modelling, speech at a normal rate in background noise,

C = video of vocabulary modelling, speech at a slow rate in quiet,

D = video of vocabulary modelling, speech at a normal rate in quiet.

The effect on vocabulary learning on 4 taught and 6 control words was then compared for each participant across conditions. A parent/carer questionnaire was repeated at four data collection points, i.e., baseline, pre-intervention, post-intervention and after a follow up period with no intervention. An informal picture-based assessment of taught and control vocabulary was carried out at three data collection points, i.e., at baseline, after a period of non-intervention and post intervention. Baseline sensory, play, language and cognitive assessments were also used to inform the results. These assessments provided both qualitative and quantitative information. The assessment findings were used to support interpretation of the results by comparing the results of these assessments with the outcomes of the intervention.

Part 1 consisted of a pilot and intervention stage with a rolling programme until six families had completed both stages of Part 1 of the research. It was necessary to recruit ten children for the pilot in order to obtain the requisite number of participants for the main intervention (six children).

The Part 1 pilot consisted of an initial home visit to obtain consent, administer baseline assessments of early cognitive and communication skills and explain the pilot video procedure. Parents/carers were asked to play a daily 5 minute video of an actor saying the names of two toys for 2 weeks to assess suitability for participation in the research.

Part 1 main intervention consisted of a further 3 home visits to conduct further assessments of play, listening skills and sensory processing, explain and model the intervention and conduct pre and post intervention vocabulary assessments.

The intervention consisted of children having four words modelled systematically live by parents or on video daily over a four week period. Families were randomly allocated to two of the four conditions for the

intervention and assigned to intervention conditions involving (A) a live vocabulary modelling condition, (B) playing videos to the children of vocabulary modelling modified to include background noise or, (C) videos of vocabulary modelling modified for rate or finally (D) unmodified videos. Families were asked to randomly vary the order of the two intervention conditions by not looking at the label of the DVD they selected first, so that the effects of changes in attention linked to the order of the intervention had minimal influence on the results.

2.5.3.2: Study design controls

The methodology in Part 1 met the primary quality indicators outlined by Reichow et al. (2008), i.e.,

(1) A full description of participant characteristics was provided, including standardized scores where relevant. Sufficient information was given about the participants, the intervention, equipment, setting, baselines and outcome measures to enable replication.

(2) Experimental control was provided by measuring vocabulary development using informal assessment and parent/carer questionnaire at three different points in time, including prior to and after a period of no intervention and after the intervention. A parent questionnaire provided a fourth data collection point. In addition, a parent/carer diary was used as a measure of fidelity. The diary recorded when intervention took place, how long for and observations of the child's response. Close observational data would have given additional fine detailed evidence on participant responses. However, due to the nature of the assessment and intervention schedule and limitations posed by the home locations selected for ecological validity, direct or video observation was not practical within the current study.

(3) Each family completed a follow up questionnaire after a final period of no intervention, so the effects of maturation could be considered when measuring

vocabulary change. The questionnaire also acted as a measure of maintenance and generalization.

(4) The study was considered to have good social validity due to the potential benefits of increasing spoken vocabulary vs. relatively little disruption to family routines and time and because the intervention was carried out by families in the home context, giving potential for immediate functional benefits to the child.

Further measures taken to control for the difficulties inherent in case study designs described in section 2.2 were:

(1) Participants were allocated to treatment conditions on a random basis to avoid the effects of bias on treatment outcomes. In addition, families were asked to administer the two intervention conditions for their child in random order each day to minimize any confounding effects of varying visual and auditory attention to the vocabulary modelling conditions.

(2) Change in vocabulary was measured using procedures standardised across participants. Any change in words used for intervention was compared to changes in matched non-intervention control words.

(3) The case series design gave pilot results for six individuals with the main intervention extending the study to look at the effects of the independent variable in different contexts. This allowed for discussion of the results beyond a single case.

2.5.4: Summary of data collection order for Part 1

Below is a summary of the chronological order of data collection. Further details are provided in subsequent sections.

- **Invitation sent to all families on local ASD data base whose children appeared to meet the study inclusion criteria.** Home visit arranged by telephone for families who contacted and gave consent.
- **First home visit. The study was further explained and informed consent to proceed obtained.** It was confirmed that participants met

the inclusion criteria. Baseline assessments were conducted. A pilot DVD of an actor naming toys was given to the families to trial over 2 weeks to check the child was able to tolerate headphones and watching a similar video to the intervention video.

- **Second home visit. Informed consent to proceed to main intervention obtained.** Diary and verbal feedback on pilot obtained. Further baseline assessments undertaken including assessment of potential taught and control vocabulary and a parent vocabulary questionnaire, where consent given. Control vocabulary and taught vocabulary for Part 1 main intervention were agreed.
- **Third home visit after 4 week period of no intervention.** Vocabulary reassessed and repeat completion of baseline questionnaire by parents. Outstanding baseline assessments completed. Families were randomly allocated to early word learning intervention conditions comparing video modelling vs. live modelling, video modelling in quiet vs. noise and video modelling at normal vs. slowed speech rate. Part 1 main intervention videos and intervention instructions were given to families to implement twice daily, 5-7 times a week.
- **Fourth home visit after 4 week intervention period.** Control and taught vocabulary was reassessed. Parents updated the OCDI and vocabulary questionnaire. Diaries were collected.
- **Follow up parent questionnaire sent after 6 weeks** to assess retention of any words learnt or new word learning.

2.5.5: Assessment materials for Part 1

2.5.5.1: Participant selection assessments

The following assessments were used to support participants meeting the inclusion criteria for selection to Part 1. See section 2.3 for a full description and rationale for use.

- (1) *Bayley-III Scales of Infant Development Screening Test: Cognitive subtest.*
- (2) *Oxford Communicative Development Inventory (OCDI).*
- (3) *The 3Di Autism Diagnostic Assessment; shortened version (Skuse, et al., 2004).*

2.5.5.2: Participant profile assessments

These following assessments were used to provide additional participant profile information. See section 2.4 for a detailed description and rationale.

- (1) *Auditory Skills Assessment (ASA).*
- (2) *Early Repetition Battery (ERB) Preschool Repetition Test.*
- (3) *Symbolic Play Test.*
- (4) *Sensory Profile.*

2.5.6: Part 1 participants

All children on the local ASD databases with a diagnosis of ASD given by an experienced clinician within the timescale of the study and who met the inclusion criteria (see section 2.5.9) were sent an information leaflet inviting them to participate in the study. Six of the ten children who opted into the study and met the inclusion criteria were recruited and completed both stages of the study (see section 2.5.8 for further information on recruitment selection). Three females and seven males were originally recruited with a gender ratio of five males to one female in the six participants who completed all Part 1 of the study. The mean age of the six participants was 61.6 months with an age span from 48 months to 70 months. Ethical approval for the study was obtained through IRAS (Integrated Research Application System) since the participants were recruited from an NHS data base and the study was monitored by local NHS trusts. Part 1 of the study was subject to proportionate review and was

approved by the National Research Ethics Service Committee East Midlands – Nottingham 1.

2.5.7: Recruitment to Part 1

Families who contacted the researcher received a telephone call within 2 weeks to check that their children met criteria for inclusion in the study and explain the information sheet. If agreed, a home visit was planned. Recruitment ceased when 6 children had completed both stages of the study. All families completed consent forms for the pilot and main intervention. The parent/carer information sheet and consent forms were discussed to ensure that informed consent was obtained. There were clear opt out procedures at all stages.

2.5.8: Part 1 sample size

Ten children were recruited for the pilot to allow for participants who were either unsuitable or did not wish to proceed to the main intervention for Part 1.

Thirty families initially contacted the researcher in response to the information leaflet. Of these, ten children met the inclusion criteria and were recruited to pilot stage of Part 1. Two of the ten families did not proceed after the pilot, as the children would not tolerate headphones for sufficient time to participate in the main intervention stage. Two families were recruited to the main intervention, but did not complete this stage. This was because one family did not continue to completion and one child was discounted as they no longer met the inclusion criteria below.

2.5.9: Inclusion criteria for Part 1

The inclusion criteria were; children aged between 3 years 6 months and 5 years 11 months with significantly reduced vocabulary for their age, English as the home language, no hearing impairment or uncorrected visual impairment

and a formal diagnosis of ASD given by experienced clinicians. Local diagnosis of ASD for the participants was made by an experienced multidisciplinary team of clinicians using a combination of observation, parental/carer interview and child assessment. Formal ASD diagnostic tools are used by the team in making some but not all diagnoses. This is consistent with the guidance on ASD diagnosis by NICE (2011). NICE recommends the use of a semi-structured interview and observation in diagnosis, but does not recommend any specific tool. It was found that the evidence of diagnostic tool accuracy is very low and the clinical benefits of using ASD specific diagnostic tools remain unclear (NICE, 2011). However, in order to control for consistency of diagnosis in this study, one of the gold standard diagnostic tools described by NICE, the *3Di Autism Diagnostic Assessment* was administered to confirm the diagnosis for each participant.

The invitation to join the study stated that participants should not have a hearing impairment and should have normal vision with or without corrective aids. Only children who met the criteria for vision and hearing were invited on the study and this was further checked on the initial telephone call to parents/carers. Parents/carers were also asked to confirm that the language spoken at home was English and their child did not have an upper respiratory tract or ear infection prior to starting the study. In addition, it was ascertained from parents that the children were likely to be able to attend (i.e., present as engaged by signs of looking and listening) to the TV or computer screen for at least 5 minutes.

Parents/carers of all children invited to join the study reported that their child showed below average vocabulary for their age (less than twenty spoken words used with communicative intent) and demonstrated understanding of at least 3 single words. They did not understand or say at least 4 of the taught words and 6 of the matched control vocabulary prior to intervention, based on parental/carer report and informal assessment prior to the pilot.

Confirmation of the inclusion criteria for vocabulary and measurement of the range of language levels of participants was obtained by administration of the *PLS-4* and *OCDI*, on the first visit. All the children scored at the 1st percentile

(standard score 55) for both the Auditory Comprehension scale and the Expressive Communication scale of the *PLS-4*.

Inclusion for the main intervention in Part 1 required compliance at the pilot stage and further informed consent from the parents/carers.

2.5.10: Part 1 baseline information on participant vocabulary, cognitive and Sensory Profiles

Table 2.1 gives baseline information on each participant's abilities. Vocabulary raw scores were derived from parental completion of the *OCDI*. Receptive vocabulary varied between 3 and 312 words, with 5/6 participants understanding between 3 and 23 words. Due to the spread of scores, a mean receptive vocabulary count across participants was not calculated. Expressive vocabulary varied between 0 and 13 spoken words with a mean vocabulary across participants of 5 words.

An estimation of each participant's level of cognitive functioning was made using the *Bayley-III Scales of Infant Development Screening Test; Cognitive subtest*, quoting the associated raw score and age level for young children without ASD. All the participants who completed both stages of the study scored competent at the 18-24 months, 24-30 months or 30-36 months score category.

Raw scores derived from parent/carer reported information on the relevant sections of the *Sensory Profile*, were reported as standard categories of definite or probable difference as appropriate. Where the score for auditory, visual, multisensory, touch or inattention/distractibility is not reported, this is because it fell into the standard category of typical performance for the child's age.

Table 2.1: Participant baseline vocabulary, cognitive and sensory profiles (auditory, visual, touch, inattention/distractibility sections)

Participant number	Age at start of data collection	<i>OCDI:</i> Receptive vocabulary	<i>OCDI:</i> Expressive spoken vocabulary	<i>Bayley-III Screening</i> Test raw scores/ competence level on cognitive subtests	<i>Sensory Profile</i> Section Scores indicating definite (D) or probable (P) difference for age
1	5yr 1m	2	2	24/ 18-24m	Auditory(D), Touch(D), Multisensory(D), Inattention/Distractibility(D).
2	4yr 9m	311	13	29/ 30-36m	Auditory(D), Multisensory(D) Inattention/Distractibility(D).
3	5yr 7m	20	3	27/ 24-30m	Auditory(D), Visual(D) Touch(D), Multisensory(D) Inattention/Distractibility(D).
4	5yr 2 m	7	4	27/ 24-30m	Auditory(P), Visual(P), Multisensory(D) Inattention/Distractibility(P).
5	4yr 0m	0	0	21/ 18-24m	Auditory(D), Visual(D) Touch(D), Multisensory(D) Inattention/Distractibility(D).
6	5yr 6m	1	4	21/ 18-24 m	Auditory(D) Multisensory(D) Inattention/Distractibility(D).

Key: D = Definite difference for age, P = Probable difference for age

2.5.11: Part 1 intervention materials

The following section outlines how the pilot vocabulary and the taught and control vocabulary for the main intervention were selected. It also describes in detail how the intervention videos were produced and modified and how the intervention was carried out. The final section describes the pre and post intervention outcome measures used.

2.5.11.1: Part 1 pilot toy vocabulary

The words 'kite' and 'coil' were selected as pilot vocabulary. These were the names of two high interest visually motivating toys likely to provide optimum engagement with the video in the pilot. These words met the criteria for one syllable consonant-vowel-consonant words used throughout the study. The words were selected to be meaningful to the children, but unlikely to be in their vocabulary. These words were used across all participants.

2.5.11.2: Part 1 intervention toy vocabulary

Four target words for the intervention were selected from seven high interest toy names from the *OCDI* and one from the *Preschoolers Vocabulary Checklist* (Marvin et al., 1994). The target words were 'cat', 'duck', 'top', 'dog', 'cars', 'ball', 'pig' and 'cup'. All the toys used for the vocabulary intervention were of a similar size from 8-12 inches at their maximum width or length. The animals were soft toys except for the dog which was a plastic. The cup and ball were plastic and the spinning top metal. All the toys were brightly coloured or had a colour contrast to stand out against the background in the video. Toys were selected for their safety, potential interest and appeal to young children. The latter was considered of primary importance in order to engage the children and parents/carers and potentially increase face validity. Phonological, perceptual and frequency properties of the words were considered as detailed below, although limited by the practical considerations of the study and available evidence for the population of children in the study.

Four words that the children could not name or understand at the pre-intervention assessment were selected for intervention for each child from the list. Selection was also based on parent/carer judgment of toys that children would find the most motivating. Two reserve words were selected as alternatives to use if parents/carers reported that the child had learnt some of the target words prior to the start of the study.

Functional selection criteria of the vocabulary necessarily limited phonological selection criteria. The following conditions were imposed to minimize variation; (1) each word should consist of one syllable, (2) each word should be of consonant-vowel-consonant (CVC) structure, (3) each word should begin with a plosive and end with a different final consonant. Some words ending in the same consonant might have changed the difficulty level, hence all words selected ended in a different consonant. It was not possible to further limit criteria for the final consonant due to difficulties of finding words that the child would be interested in.

The vocabulary selected contained words at a range of perceptual difficulty levels based on the findings of Fallon et al. (2000), who ranked child (aged 5-11years) and adult average accuracy identifying spoken CVC nouns in multi-talker babble background noise. The average rank according to Fallon et al. (2000) of words in this study were; 'ball' (40), 'pig' (25.5), 'dog' (18), 'duck' (17.88), and 'cat' (9.75). 'Cars', 'cup', and 'top' were not in the Fallon et al. (2000) list. It was not possible to fully control for potential levels of perceptual difficulty within the practical limits of this study which necessitated high interest toy name vocabulary to engage the child. In addition, the aforementioned ranks were based on an average age range above that of this study and based on typically developing children rather than children with ASD, so relevance may have been limited. Nevertheless, unknown words were randomly allocated to participants to minimise any confounding effects of perceptual difficulty.

In addition to perceptual difficulty, the frequency of the selected vocabulary was also considered. The words in the *MacArthur Communicative Development Inventory (CDI)*, infant form (Fenson et al., 1994) are selected from word frequency counts of a wide cohort of children in the USA from 11-16 months, and although there are some frequency norm comparisons with British children aged 12-25 months, the construction of the *Oxford Communicative Development Inventory (OCDI)* does not involve standardised evaluation of individual word frequencies (Hamilton et al., 2000). At the time of writing, UK standardised frequency counts for communicative development inventories were not yet available. Furthermore, although the *MacArthur CDI* has been

used with children with autism evidencing delay and atypical patterns in language development as well as similarities to typical development (Charman et al., 2003), the extent to which frequencies of individual words might differ for children with autism in the UK in the age group of this study, is not known. Therefore, although the target words were selected from those found most frequently in young preschool children, standardised information of children's word frequency applicable to the population in this study was not available.

Frequency of word use by parents is thought to be a factor influencing early word learning in young children, particularly when derived from child directed speech (CDS). Young children learn to say parental higher frequency words within categories earlier and understand higher frequency nouns sooner (Goodman et al., 2008). The *CHILDES Parental Corpus* (Li and Shirai, 2000) derived from the *CHILDES* data base (MacWhinney, 2000) consisting of a representative sample of typical speech children are exposed to including CDS, was used to check parent frequency of each of the target words from 24,000 word types and 2.6 million word tokens. The following range of frequencies were found; dog (1,529), ball (1,124), top (1061), cat (1026), cup (851), duck (609), pig (405), cars (396), although the data included parental talk to school age as well as young children. 'Kite' and 'coil' were only included as plurals in the Parental Corpus and were at very low frequencies. Words were randomly allocated to participants from those toy names not understood or named, to attempt to mitigate confounding effects of frequency.

The functional criteria for selection of the four words for each child were (1) child not able to name or identify the toy names in pictures on the informal vocabulary assessment and parental/carer report, (2) accessibility and safety to enable parents to present the toys in the non-video group and (3) high interest level based on informal previous presentation to preschool children with ASD not part of this study cohort and parental report for the individual child. Motivation and interest in the toys were considered a priority to encourage the children to participate in the first instance, given that difficulties with attention are common in this subject group (e.g., Leekam et al., 2000).

2.5.11.3: Video production for Part 1

A simultaneous continuous video and audio recording was made of an actor speaking the toy names (taught vocabulary) on to a MiniDV tape using a Canon XM2 video camcorder. The camera was set to capture full frames at 25 frames/second.

A two minutes thirty second video was made for each toy. During the video, the actor played with the toy and repeated the name of the toy six times. Six repetitions were chosen to maximise learning opportunities, but enable natural repetition within the time limitations of a short attention span common among young children with ASD. The actor was seated in a quiet laboratory room. Appropriate lighting ensured uniform illumination across the actor's face. The camera was positioned to film at the actor's eye level, with the actor's face and the toy clearly visible.

A separate audio recording was made on a Marantz Solid State Recorder (PMD670) with a Sennheiser MD425 microphone. The microphone was placed approximately 50 cm from speaker's mouth, but at a height that meant it was out of the camera frame. The audio recording was sampled at 44.1 KHz, with 32 bit resolution.

The video recordings for each toy were filmed to ensure consistent timing, lighting and sound levels.

Videos were edited in iMovie '11 (version 9.0.4). The separately recorded audio signal was aligned with each video segment, using an alignment point marked at the beginning of each recording. This alignment point was marked by the actor who clapped to create a simultaneous visual and audio event. The audio recorded on the camera was then removed from the final video and replaced with the separately recorded audio.

For the pilot, a 5 minute video was written onto a DVD. This DVD was the same for all participants. It consisted of two 2 minute 30 second videos of the actor playing with the toys (the 'coil' and the 'kite'). Each word ('kite' or 'coil') was repeated six times in each video at a normal rate and presented in quiet conditions without any modification.

For the main intervention in Part 1, videos of allocated taught vocabulary (toy names) were paired to make one five minute video and written onto a DVD depending on the random allocation to the different conditions and toy selection, e.g., 'cars' and 'ball' with background noise.

Each DVD began with a video recording of the actor singing a song: 'Time for toys' to the tune of Frere Jacques and an introductory phrase, 'Hello, I've got some toys', to focus the child's attention. The actor then held up the first toy up near their face and repeated its name twice, preceding the first instance with the verbal cue, 'It's a...'. They then played with the toy for 20 seconds to maximise visual attention to the toy. The play was followed by the phrase, 'Look + name of the toy'. The sequence was repeated with each toy to obtain 6 toy name repeats during each two and half minute video clip. The end of each video clip was signalled by the actor saying 'Bye, bye' and waving.

An example transcript for each DVD is shown below.

Time for toys' – sung (repeated x6).

'Hello, I've got some toys' – spoken.

Toy bag shown.

'It's a duck – duck. Look, duck' – spoken. 20 seconds play (repeated x1).

'It's a cat – cat. Look, cat' – spoken. 20 seconds play (repeated x1).

'Bye bye' with wave to signal end.

2.5.11.4: Part 1 video modification

Videos for Part 1 main intervention conditions were modified as described below.

Words presented in background noise. The video clip with added background noise was produced by marking the repetition of the target word in the signal and then extracting the relevant segment. The audio signal was then

mixed with multi-talker babble at a Signal to Noise Ratio (SNR) of +6 dB. The multi-talker babble was taken from the Medical Research Council Institute of Hearing Research *BKB (Bamford-Kowal-Bench) Sentence Test* CD (2014). The noise was processed with a 350 ms amplitude ramp to proceed and succeed the marked segment to ensure gradual onset and offset of the noise. The background noise was presented at approximately -44 dBA to ensure safe noise exposure (Fallon et al, 2000).

This type of background noise and SNR was selected to reflect the noise level often found in classroom settings and therefore increase ecological validity of the findings of this study.

The SNR of +6 dB selected was based on reported SNRs often found in classrooms, although recent evidence from UK preschool settings was not available. Picard and Bradley (2001) compared the SNR for teacher's voice levels against classroom noise. They estimated that the SNR varies from +3 dB in kindergarten to nearly +7 dB in university classrooms. Manlove et al. (2001) reported a range of studies giving SNRs in classrooms from -3 to +12 dB in infant and toddler classrooms and -7 to +5 dB in elementary classrooms. Crandell and Smaldino (2000) also report SNRs in classrooms ranging from -7 to +5 dB, although all the studies cited were prior to 1990. ASHA recommends classroom SNRs should be at least +15 dB (American Speech-Language-Hearing Association, 2005b). However, Bradley and Sato (2008) found that +15 dB was an inadequate classroom SNR for six year old children when comparing results of average scores on speech intelligibility tests.

Typically developing five to seven year old children are reported to understand 89% monosyllabic words at a distance of 6 feet with a SNR of +6 dB (Crandell and Bess 1986, cited in Crandell and Smaldino, 2000). A SNR of +6 dB was also reported to show the greatest difference in speech perception in noise between clinical and non-clinical populations for children aged 3;6 to 6;11 years age in clinical trials of the *Auditory Skills Assessment* (Geffner & Goldman, 2010).

Words presented at a slowed speech rate. The slowed speech video clip was created by modifying the video as follows.

First, the target word was marked in the audio signal and the video and extracted as described in the previous section. The video and audio signals were then slowed so that auditory and visual presentation was 75% of the normal rate. This rate was selected as being the slowest rate likely to make an impact (based on available evidence) that also did not distort the visual and audio data so the word remained recognisable. Love et al. (2009) found that slowing speech to 75% of the normal rate had a beneficial effect on conscious off line processing of pronouns but not on unconscious online processing of reflexives in typically developing children. Tardiff et al. (2007) found significantly enhanced facial-vocal recognition in half/quarter rate (slow/very slow) conditions compared to normal rate conditions. In addition, a study of twenty two children diagnosed with ASD aged 4.5 to 16 years directed by Gepner and Massion (2002), cited in Gepner & Tardif (2006), found that a deficit in children with ASD in phoneme categorisation perception (compared to typically developing children) was not present when speech was slowed down twice.

The video was slowed adjusting the speed setting in the iMovie '11 software (Apple Inc., 2010). The audio was separately processed using the STRAIGHT vocoder (Kawahara, 2001). The signal was decomposed into its source and filter components using STRAIGHT and a temporal scaling factor was applied to the signal to make the slowed signal last 25% longer than the original. The slowed audio was then aligned with the slowed video clip to create the slowed sample. Each clip was checked to ensure the appropriate synchronization of lip movement and speech was maintained.

2.5.11.5: Pre and post intervention assessment measures for Part 1

(1) The *OCDI* was selected as a parent/carer reported measure of each child's receptive and combined receptive and expressive vocabulary pre and post intervention. See previous section 2.3 for a description of this checklist. It has

been used to measure vocabulary in children with ASD in a number of studies (Bopp and Mirenda, 2011; Charman et al., 2003a).

(2) Informal Parent Questionnaires were used as baseline, pre and post intervention and follow up measures (see Appendix). The questionnaires were devised by the researcher and piloted on a small group of parents to ensure clarity, although no amendments were suggested. The questionnaires consisted of three questions as to whether the child could identify, name or repeat the experimental words. The questionnaires were used to track the child's ability to identify, name and repeat the four target words. In addition, parents/carers were asked about any new words that their child had learnt and any recent factors that might have helped or made it difficult for their child to communicate.

(3) Informal Photo Vocabulary Assessments were constructed by the researcher to provide direct pre and post intervention assessment of the experimental taught vocabulary and matched control vocabulary.

The experimental vocabulary assessment consisted of A4 photo lotto boards based on the eight experimental toy names including the four taught words selected.

Two further A4 photo lotto boards of six matched object names were used as control vocabulary for the before and after picture assessment of taught words. The control vocabulary, similar to the experimental taught words, was selected from early noun vocabulary lists such as the *OCDI* or *Lincoln Toddler CDI* (Meints and Fletcher, 2001). The six control words were selected from the following; 'cot', 'coat', 'doll', 'bird', 'pool', 'dog', 'duck', 'pen', 'bed', 'keys', 'cows', 'park', 'toes'. 'Dog' and 'duck' were only used as control words if they were not included in the taught vocabulary. The control vocabulary photos for the picture assessments were obtained from '*Picture This: Version 3.0*' photo library, whereas the taught vocabulary assessments used photos of the toys used in the intervention.

The six control words were matched on word length, syllable structure and consonant vowel structure for each child. The initial consonants in the control words were matched to the taught words as far as possible depending on available words that the child did not know.

It was not possible to match all the control and taught vocabulary by rank order of difficulty as described by Fallon et al. (2000). This was because some object names selected for interest level that were used in this study were not included in the list by Fallon et al. (2000). However, the control words were matched with the taught vocabulary on phonological structure and similar potential level of difficulty overall.

Table 2.2 compares the experimental and control vocabulary for phonological structure and also parent frequency of use from the *CHILDES Parental Corpus* (Li and Shirai, 2000) derived from the *CHILDES* data base (MacWhinney, 2000).

Table 2.2: Taught vocabulary with control words matched by syllable structure and initial consonants with parent frequency counts from a sample of 2.6 million word tokens

Taught vocabulary	Matched control words by initial consonant and syllable structure. Final consonants matched where possible.
Pig (405)	<i>Pen</i> (370), Park (372), Pool (149)
Cars (396)	<i>Cows</i> (185), Keys (160)
Ball (1,124)	<i>Bed</i> (1,767), Bird (730)
Top (1,061)	<i>Toes</i> (101)
Cat (1,026)	<i>Coat</i> (484), <i>Cot*</i> (53),
Dog (1,529)	<i>Duck</i> (609), Doll (329)
Cup (851)	<i>Cot*</i> (53), <i>Coat</i> (484)
Duck (609)	<i>Dog</i> (1,529), Doll (329)

Key: Control words in italics were the first choice matched by final consonant where possible. Subsequent words were used if the first choice was already in the child's vocabulary. Number in brackets = parent frequency count from the *CHILDES Parental Corpus* (Li and Shirai, 2000) derived from the *CHILDES* data base (MacWhinney, 2000).

Footnote: *The apparent low frequency of 'cot' might be explained by the corpus base including American English data where 'crib' (frequency = 58) might be used for the same meaning.

Table 2.2 highlights that both the control and target vocabulary had a wide range of word frequencies based on the parent frequency corpus. Whereas some target and control words were fairly similar in terms of word frequency, e.g., 'pig' and 'pen', others were quite different, for example, 'top' and 'toes'. However, since the parental frequency data also contained parent talk with school age children (up to 7; 5 years, although most were under 4 years), it may not have accurately reflected pre-intervention exposure to the words for the children in this study. In addition, it is possible that the children's diagnosis of ASD had an effect on parental vocabulary in the light of any specific child interests or interaction styles of the child related to the diagnosis.

The expressive vocabulary assessment procedure consisted of the researcher showing the child photos of each of the toys and matched objects and using the lead in phrase, 'What's that?'. Graded cues were used if necessary to elicit a response, i.e., (1) pause cue up to 5 seconds (2) question repetition and (3) 'It's a...'. The lotto games were then used to assess receptive vocabulary. The child was asked to point to or give each of the named pictures. The child or researcher then matched the photo to the board as reinforcement.

2.5.12: Description of Part 1 intervention procedure

The pilot stage lasted approximately 3-5 weeks per family from the first telephone contact. The main intervention stage lasted approximately 8-10 weeks per family, except for one family where the child was ill at the start of the main intervention causing postponement of the intervention. However, once started, the intervention and assessment followed the same time span as for the other participants. All families gave their child opportunity to watch the pilot video for 2 weeks and main intervention video for 4 weeks, but practical family considerations and child motivation meant that the amount of exposure varied. A short questionnaire to monitor changes in vocabulary was given to parents/carers to complete prior to the intervention, immediately after the intervention and after 6 weeks to assess maintenance of any treatment effects. Parents/carers were also asked to keep a diary of treatment fidelity including comments on the child's responses, frequency and length of intervention administered. All parents/carers completed the diaries for the occasions when the interventions were administered. Some parents/carers chose to give more detailed entries than others, so for comparative purposes, this served as a measure of how many times the interventions were implemented. However, the additional qualitative information such as information on the child's attention, provided by some parents was used to further inform the outcomes.

Families recruited to main intervention stage of Part 1 were randomly allocated to two of the conditions below, i.e., AD, BD, or CD, until each pair of conditions

had been allocated to two participants. The study compared the effects for each participant across the conditions:

A = vocabulary modelling by parents/carers without video, speech normal rate and in quiet,

B = video of vocabulary modelling speech at a normal rate in background noise,

C = video of vocabulary modelling speech at a slow rate in quiet,

D = video of vocabulary modelling speech at normal rate in quiet.

The effects on vocabulary learning on taught and matched non-taught control words (see section 2.5.11.5) were then compared for each participant across conditions, with an initial period of no intervention and with a post treatment phase of no intervention.

2.5.12.1: Part 1 pilot stage

Visit 1:

Families who responded to the initial invitation received a home visit to explain the project and obtain consent for the pilot stage.

A *3Di* assessment was completed to confirm the diagnosis of ASD for all children. Children had to score positively on the *3Di* to be included in the study.

The *Bayley-III Screening Test* was administered along with the *PLS-4* as baseline measures of cognitive ability and early communication skills respectively. All children included in the study obtained a raw score of at least 21 (competency level for typical children 18-24 months) on the cognitive subtests of the *Bayley-III*.

Parents/carers were given a 5 minute pilot video on a DVD of an actor playing with and naming 'kite' and 'coil' 6 times each. Families were asked to play the video to their child whilst the child was wearing

headphones (Sennheiser 515) with the parent present, daily for 2 weeks. All six children watched the videos between six and thirteen occasions. Unless the child was ill or unavailable as recorded in the diaries, the child was given opportunity to watch the video each day. On a few occasions, the children elected themselves not to watch the videos, thus accounting for the variation in exposure.

Written health and safety guidance on use of headphones with a TV or computer were explained and given to each family. Health and safety issues, i.e., care with leads and volume control, were also explained. The headphones selected did not have a volume limiting control as this would have distorted the sound quality of the videos. Therefore the need for parents/carers to closely control the volume on the TV or computer was stressed. Parents/carers were instructed to sit with the child on all occasions when playing the video through headphones and to stop playing the video if the child showed any signs of distress. All reported that they did this. They were instructed that in this eventuality they could try later. However, if the child showed repeated signs of distress, the family were instructed to stop playing the video and contact the researcher.

Parents/carers were asked to note their child's responses to the pilot video along with intervention session dates and reasons for any missed sessions in a diary. This was to ensure against any adverse effects indicating that progression to main intervention stage of Part 1 was not recommended. Parents/carers were given the *OCDI* to complete prior to the next visit.

Approximately two weeks after the initial visit, parents/carers received a follow up phone call to check progress and arrange the next visit if they wished to continue.

2.5.12.2: Part 1 main intervention stage

Visit 2:

The second home visit occurred within approximately 2-3 weeks. The pilot video and diary were collected. If the child had tolerated the headphones and video, the main intervention stage of this study was explained to the parents/carers. They then made a final decision regarding moving to the next stage or not. A second stage consent form was completed by those families who wished to continue and consent discussed as before.

An informal picture based Vocabulary Assessment (see section 2.5.11.5) was also administered.

Parents/carers were asked to select four toys and two reserve toys (to allow for unforeseen learning prior to the start of the study) from the list of eight for the video intervention. Six object names matched on word length, syllable structure and consonant vowel structure were used as control vocabulary. All the words selected for intervention or for control vocabulary were not, at the time of the assessment, in the child's receptive or expressive vocabulary or both, based on the *OCDI*, the picture based vocabulary assessment and parental questionnaire. See section 2.5.11.5 for a description of the questionnaire used in pre- and post-intervention measures.

The *ERB* and *ASA* were attempted and administered to those children able to attend and complete the assessments. Only one child was able to complete these two assessments to obtain a score. The *Symbolic Play Test* was also administered to all children. The *Sensory Profile* was left for all parents to complete on the following visit.

Families were randomly allocated to two conditions, i.e., AD, BD or CD.

Visit 3:

Families received a third home visit after approximately 4 weeks. The *Sensory Profile* was collected.

The informal photo lotto Vocabulary Assessment was repeated to provide multiple baselines at three time points so the rate of vocabulary learning during no intervention, pre-intervention and post intervention could be compared. Parents/carers were also asked to complete again the informal baseline questionnaire on their child's vocabulary.

Two 5 minute edited DVDs were given to families except where one of allocated conditions was live modelling (condition A). These families received one 5 minute DVD. Families were given instructions to play each video on the computer or TV (varying the order of play where possible) to the child wearing headphones, with the parent present twice daily (5-7 times a week) for 4 weeks. All reported in their diaries how often and when they had achieved this. Due to unavoidable factors such as illness, tiredness or interest, there was some variation in how often and how long the children were exposed to the intervention. However, all watched the videos on between 14 and 18 occasions and the diaries suggested that exposure to the two conditions for each child was approximately equal due to the random presentation.

Families allocated to condition A, received written instructions (see Appendix) and demonstration on modelling the vocabulary in the same manner and for the same time period as in condition D. The toy from the video clip for the toy name was lent to the family for the duration of the intervention. The script given was the same as in video conditions (see section 2.11.5.3).

Families were instructed to record in their diary any comments on their child's responses including attempts at naming the toy, either during the intervention or after the intervention. Families were also instructed to reinforce any spontaneous use of taught or control vocabulary outside of the intervention sessions using natural comment, recording in their diary how often this occurred. This was in addition to a record of treatment sessions in their diary, used as a measure of treatment fidelity.

Visit 4:

Families received a fourth home visit after the 4 week intervention period.

The *OCDI*, the informal parent questionnaire and the Vocabulary Assessment described in section 2.5.11.5 were re-administered.

Families received a repeat follow up informal questionnaire (see section 2.5.11.5) by post after a period of approximately 6 weeks with no intervention to ascertain if any vocabulary learning had been retained.

2.6: PART 2

2.6.1: Hypotheses for Part 2

(1) Young children with Autism Spectrum Disorder and delayed spoken vocabulary will fast map more new words through video modelling in quiet than through video modelling in background noise.

(2) Young children with Autism Spectrum Disorder and delayed spoken vocabulary will fast map more new words through video modelling with a slowed speech rate than with an unmodified speech rate.

(3) Young children with Autism Spectrum Disorder and delayed spoken vocabulary will fast map a similar number of new words when they are presented with simultaneous audiovisual speech input as when they are presented with an asynchronous audiovisual speech input.

2.6.2: Principle objective for Part 2

To add to the evidence base on the effects of slowed speech, background noise and asynchronous audiovisual speech compared to unmodified speech on how young children with Autism Spectrum Disorder (ASD) fast map new vocabulary after minimal exposure to video modelling.

2.6.3: Study design for Part 2

2.6.3.1: Outline of study design

Part 2 of the study also used a case series design with participants randomly allocated to a pair of the intervention conditions below (i.e., AD, BD or CD) until each pair of conditions had been allocated at least twice. The conditions were:

A = video of vocabulary modelling, speech at a normal rate in quiet with audio-visual asynchrony (auditory speech component delayed onset by 450ms after the visual speech component),

B = video of vocabulary modelling, synchronous speech at a normal rate in background noise,

C = video of vocabulary modelling, synchronous speech at a slow rate in quiet,

D = video of vocabulary modelling, synchronous speech at a normal rate in quiet.

The effect on vocabulary learning on 4 intervention and 4 control words was then compared for each participant across the two conditions.

Difficulties with controlling confounding variables in the participant group means that this study is limited in the extent to which it can answer questions for children with ASD as a whole. However, baseline testing sought to describe the subjects in sufficient depth to enable replication of the findings. A parent/carer questionnaire was used to ascertain if the children knew any of the intervention or control vocabulary prior to the intervention. An informal picture based assessment of taught and control vocabulary was carried out immediately before and after the intervention.

The study proceeded as a rolling programme aiming to recruit twelve children during the data collection period. However, it was only possible to recruit eight children who met the participant inclusion criteria within the allocated time.

Briefly, Part 2 of this study proceeded as follows. Firstly, a summary of the study and an invitation to find out more information was sent to local schools and parent groups. School/settings who gave consent were asked to send out a Participant Information sheet and reply slip to families of all children who met the inclusion criteria. A home visit was arranged where further information was requested. The purpose of this visit was to obtain consent and administer parent baseline questionnaire assessments on sensory processing, vocabulary and confirmation of ASD diagnosis. This was followed by a school visit where further information on vocabulary was obtained from school staff by means of a vocabulary checklist prior to the intervention session. All questionnaires except the ASD diagnostic questionnaire, were posted to school staff or parents/carers as relevant prior to final interview completion with the researcher. The informal vocabulary assessment of the control and intervention vocabulary was repeated.

On the basis of the vocabulary checklist completed by school staff and confirmed by an informal assessment, four object words that the child could not name were selected for intervention along with four matched control words also not in the child's expressive vocabulary. The intervention consisted of the children having four words modelled systematically on a video played on an iPad in a quiet room at school. Children were randomly allocated to two of the four conditions for the intervention in the following presentation pairs: AD, BD and CD. The four intervention words were presented in random order to minimise any effects of varying auditory/visual attention to the vocabulary modelling associated with order of presentation.

2.6.3.2: Study design controls

In Part 2, the measures taken to control for difficulties inherent in case study designs described in section 2.2 were as described below.

(1) Subjects were allocated to intervention conditions on a random basis to avoid the effects of bias on intervention outcomes. In addition, the vocabulary was randomly allocated to two of the intervention conditions.

(2) The vocabulary allocated to the two intervention conditions for each child was presented in random order to minimise any confounding effects of varying visual or auditory attention or other variables that may have been associated with order of presentation.

(3) Additional control was provided by asking parents/carers to complete an informal vocabulary questionnaire to ascertain which if any of the intervention and control words the child could understand or name before the intervention.

(4) Experimental control was provided by assessing matched vocabulary in addition to the intervention vocabulary using an informal vocabulary assessment before and after intervention.

(5) School staff were also asked to complete the *OCDI* prior to intervention as an additional measure of overall vocabulary including the intervention and control words.

(6) Change in vocabulary was measured using procedures standardised across participants.

(7) Participants, equipment and settings are described in detail to allow replication with similar individuals.

The methodology in Part 2 met many of the primary quality indicators outlined by Reichow et al. (2008). The study was considered to have good social validity due to the potential benefits of increasing spoken vocabulary vs. relatively little disruption to school routines and time and also because the intervention was carried out in the school context, giving potential for immediate functional benefits to the child.

2.6.4: Assessment materials for Part 2

2.6.4.1: Participant selection assessments

The following assessments were used to support participants meeting the inclusion criteria for selection to Part 2. See section 2.3 for a full description and rationale for use.

(1) *Oxford Communicative Development Inventory (OCDI)*.

(2) *The 3Di Autism Diagnostic Assessment; shortened version*.

2.6.4.2: Participant profile assessment

The *Sensory Profile* was also used to provide additional participant profile information. See section 2.4 for a detailed description and rationale.

2.6.5: Part 2 participants

The study aimed to recruit up to twelve children. Ten families expressed an interest and data was collected from eight children who met the inclusion criteria. Two of the ten families did not continue with the study as the initial telephone calls to the families indicated that their child's vocabulary levels were above that of the inclusion criteria for the study. The gender ratio of the participants recruited was six males to two females. The mean age of participants was 72 months with an age span of 52-107 months.

Ethical approval for recruitment of participants and completion of the study was obtained through the Department of Human Communication Sciences Research Ethics Review Panel within the University of Sheffield.

2.6.6: Recruitment to Part 2

Senior management representatives of local schools with populations likely to meet the participant inclusion criteria were sent an information sheet about the study with a reply slip and phone contact details to express an interest and request further information. The same information was also sent to coordinators of local parent groups of children with ASD. Four schools requested further information and of these, three schools reported that they had children who met the inclusion criteria and opted into the study. Two parent group coordinators also circulated information about the study to parents, but no expressions of interest were received from this source.

The study was explained to school senior management representatives who contacted the researcher and it was ascertained that the school had children who met the inclusion criteria. Where agreed, a follow up meeting was arranged to seek informed consent for the school to participate in the study. On obtaining consent, the senior management representative sent out an information sheet about the study to parents/carers with children who met the inclusion criteria with a reply slip to return to the school or researcher if they wished their child to participate in the study.

Parents/carers who responded to the invitation in the information sheet were contacted by the researcher by telephone within two weeks. The study was explained and opportunities given to answer questions. For those parents/carers who expressed interest in continuing, a consent form to look at was sent in the post and a home visit arranged. The parents/carers were given a contact number to ring if they subsequently decided that they did not want to be visited. At the home visit, the consent form and information sheet was explained and opportunity to answer any further questions about the study was given in order that informed consent was obtained in writing for those who wished to proceed. A clear opt out procedure at all stages of the study was explained. All children for whom informed consent form was obtained and who fitted the inclusion criteria were recruited to the project.

2.6.7: Inclusion criteria for Part 2

The inclusion criteria were; children aged between 4 years and 8 years 11 months with significantly reduced vocabulary for their age (i.e., less than 20 spoken words used with communicative intent as reported by school staff), English as the home language, no hearing impairment or uncorrected visual impairment and a formal diagnosis of ASD given by experienced clinicians. Local diagnosis of ASD for the participants was made by an experienced multidisciplinary team of clinicians using a combination of observation, parental interview and child assessment. Formal ASD diagnostic tools were used in some but not all local diagnoses. This is consistent with the *CG128* guidance on ASD diagnosis (NICE, 2011). See section 2.5.9 for further explanation. As in Part 1, in order to control for consistency of diagnosis in this study, one of the gold standard diagnostic tools described by NICE, the *3Di Autism Diagnostic Assessment* was administered to confirm the diagnosis for each participant. In addition, all the children in the study were at least at P level 3 for maths based on teacher report to ensure a minimum cognitive ability across participants.

The invitation to join the study stated that participants should not have a hearing impairment and should have normal vision with or without corrective aids. Only children who met the criteria for vision and hearing were invited to join the study and this was further checked on the initial telephone call to parents and with school staff on the school visit. Parents/carers were also asked to confirm that the language spoken at home was English. School staff were asked to confirm that participant children did not have an upper respiratory tract or ear infection immediately prior to the start of data collection and intervention. In addition it was ascertained from both parents/carers and school staff that the children would be likely to attend (as evidenced by behaviours such as looking and listening) to the iPad screen for the duration of the intervention.

Parents/carers of all the children invited to join the study reported that their child showed below average vocabulary for their age (less than twenty spoken words used with communicative intent for seven of the participants and less than fifty for one). Thus, although indicating a discrepancy between parental/carer and teacher report of vocabulary size in one instance, all the children were reported

to have less than fifty spoken words used with communicative intent by both parents/carers and school staff. Parents/carers also completed a short questionnaire indicating that their child could not understand or name at least four of the ten intervention words and four matched control words.

Confirmation of the inclusion criteria was obtained by completion of the *OCDI* by school staff prior to the start of baseline data collection and administration of an informal photo lotto assessment of the intervention and control vocabulary immediately prior to the intervention.

2.6.8: Part 2 baseline information on participant vocabulary and *Sensory Profiles*

Table 3.3 gives baseline information on each participant's abilities. Vocabulary raw scores were derived from school staff completion of the *OCDI*. Receptive vocabulary varied between 0 and 221 words with 4/8 participants understanding between 16 and 50 words. Due to the spread of scores, a mean receptive vocabulary was not calculated. Expressive vocabulary on this teacher reported vocabulary assessment varied between 0 and 19 words with a mean vocabulary across participants of 6.75 words.

Raw scores (derived from parental/carer reported information on the relevant sections of the *Sensory Profile*) were reported as standard categories of definite or probable difference as appropriate. Where the score for auditory, visual, multisensory, touch or inattention/distractibility is not reported, this is because it fell into the standard category of typical performance for the child's age.

Table 2.3: Participant baseline vocabulary and sensory profiles (auditory, visual, touch, inattention/distractibility sections)

Participant number	Age at start of data collection	OCDI receptive vocabulary raw score	OCDI spoken vocabulary raw score	Sensory Profile Section Scores indicating definite (D) or probable (P) difference for age
1	8yr 1m	40	0	Auditory(D), Visual(D), Multisensory(D), Touch(D), Inattention/Distractibility(D)
2	4yr 4m	16	16	Auditory(P), Multisensory (D)
3	6yr 3m	0	0	Auditory(D), Multisensory(D), Touch(D), Inattention/Distractibility(D)
4	8yr 11m	16	9	Auditory(D), Visual(D), Inattention/Distractibility(P)
5	6yr 2m	221	1	Auditory(D), Inattention/Distractibility(D)
6	4yr 5 m	47	19	Multisensory(P) Touch(P)
7	7yr 11m	148	9	Auditory(D), Multisensory(D), Inattention/Distractibility(D)
8	5yr 1m	0	0	Auditory(D), Touch(D), Multisensory(D), Inattention/Distractibility(D)

Key: D = Definite difference for age, P = Probable difference for age

The following section outlines the sequence of data collection events and how the control and intervention vocabulary were selected. It also describes in detail how the intervention videos were produced and modified and how the

intervention was carried out. The final section describes the pre and post intervention outcomes measures used.

2.6.9: Part 2 intervention materials

The materials listed in the following sections were used for intervention.

2.6.9.1: Selection of intervention toy vocabulary

Four target words for the intervention conditions were selected from the names of ten high interest toy names. These were, 'cat', 'duck', 'top', 'dog', 'cars', 'ball', 'kite', 'coil', 'pig' and 'cup'. All the toys used for the vocabulary intervention videos were of a similar size from 8-12 inches at their maximum width or length. All the toys were brightly coloured or had a colour contrast to stand out against the background in the video. Toys were selected for their potential interest and appeal to young children. Four words that the child could not name or could not identify based on data from the parental/carer questionnaire, the OCDI and a pre-intervention informal lotto assessment, were selected for intervention for each child from the list.

As in Part 1, functional selection criteria of the vocabulary necessarily limited phonological selection criteria. The following conditions were imposed to minimize variation, (1) each word should consist of one syllable (2) each word should be of consonant-vowel-consonant (CVC) structure (3) each word should begin with a plosive and end with a different final consonant. Some words ending in the same consonant might have changed the difficulty level, hence all words selected ended in a different consonant. It was not possible to further limit criteria for the final consonant due to the difficulties of finding words that the child would be interested in. See section 2.5.11.5 for a discussion of perceptual difficulty and frequency of the vocabulary.

2.6.9.2: Video production and modification

The video clips from Part 1 of an actor naming a toy whilst simultaneously playing with the toy were used to extract video clips for use in the intervention in Part 2. A short video of each of the actor speaking the ten toy names only ('cat', 'duck', 'top', 'dog', 'cars', 'ball', 'pig', 'cup', kite and 'coil') was extracted from each of the original experimental conditions. Four toy names were used for each child, determined by the baseline assessments. The original experimental conditions from Part 1 also used in Part 2 are listed below.

(B) Video of vocabulary modelling, synchronous speech at a normal rate in background noise,

(C) Video of vocabulary modelling, synchronous speech at a slow rate in quiet,

(D) Video of vocabulary modelling, synchronous speech at a normal rate in quiet.

See Part 1 (2.11.5.3 and 2.11.5.4) for a description of how the original videos were produced and modified with an explanation for the underlying rationale. Videos were selected to ensure a clear view of the actor's face saying each word and a clear view of the toy.

In addition, a video of the actor saying each of the intervention words was produced for a new condition, (A) video of vocabulary modelling, speech at a normal rate in quiet with audio-visual asynchrony (auditory speech component delayed onset by 450ms after the visual speech component).

The asynchronous video was created as follows. First, as for the slowed condition, the repetition of each target word was marked in the audio signal and the video. These segments were then extracted. The beginning and end of the extracted audio was marked in each video in the *iMovie '11* software programme on an Apple computer. The audio was then edited in a sound waveform editor, *Audacity* (Mazzoni and Dannenberg, 2000) to include a silent

interval at the beginning of the file of the appropriate length. This longer sound file was saved. The audio file was then put back into the video at the previously marked starting point. This then resulted in the audio being asynchronous with the speech signal delayed. Each video segment was written to an iPad video format using the *iMovie '11* export function.

Each video was transferred from the Apple computer used to create the original videos via a memory stick to a Dropbox store on the iPad, then uploaded to obtain 6 identical repeats of the target word per labelled album in the iPad photo app. Each album was labelled with the relevant vocabulary word and intervention condition to facilitate ease of access for random presentation during the intervention. The six repeats of the target word lasted approximately 15-20 seconds for each condition.

The rationale for the video modifications in conditions B and C is discussed in Part 1 of this chapter. With regard to the video modification of condition A, a stimulus onset asynchrony of 450 ms (visual stimuli leading) was selected to ensure sufficient size and direction of asynchrony predicted to have an effect in typically developing children, albeit from a limited evidence base. The rationale for the size and direction of asynchrony selected for condition A is as follows.

In infants, the temporal binding window for speech is around 666 ms, but narrows after the first few months of life (Lewkowicz, 2010). The evidence for developmental changes in the temporal binding window is limited. However, Hillock (2010) found that the temporal binding window for speech is around 350 ms for adults and children without ASD, based on the McGurk illusion. A stimulus onset asynchrony of 450 ms was selected so as to be wider than the expected time frame where temporal binding would occur in typically developing children over 4 years and thus potentially impact on vocabulary learning.

Evidence as to the impact of auditory vs. a visual lead in asynchronous speech is also limited. Donahue (2012) found that adults with ASD were worse at detecting asynchrony (i.e., susceptible to the McGurk illusion) if there was an auditory lead and adults without ASD if there was a visual lead. However, Irwin et al. (2011) found that children (5-15 years) both with and without ASD, were

worse at detecting asynchronous speech with a 250 ms visual lead. Overall in typical development, evidence suggests the temporal binding window is initially wider to the right (visual lead) and contracts later in development, particularly for non-speech stimuli (Hillock, 2010). Therefore this experiment used a visual lead to ensure maximum opportunity for temporal binding as in typical development other than a potential effect from the size of the asynchronous condition compared to the synchronous condition.

2.6.9.3: Pre and post intervention assessment measures for Part 2

(1) Informal Parent Questionnaires were used as a baseline measures to ascertain which of the experimental taught words or control words the child knew prior to intervention (see Appendix). The questionnaires were devised by the researcher and piloted on a small group of parents to ensure clarity, although no amendments were suggested. The questionnaires consisted of three questions as to whether the child could identify, name or repeat the experimental taught words or control words prior to the intervention. It was necessary for the child to not be able to name or not to be able to understand at least four of the taught words and at least four of the control words for inclusion in the study. See previous section on inclusion criteria.

(2) Informal Photo Vocabulary Assessments were constructed by the researcher to provide direct pre and post intervention assessment of the experimental taught vocabulary and matched control vocabulary.

The taught and control vocabulary assessment consisted of A4 photo lotto boards based on the ten experimental toy names and matched control vocabulary for the before and after picture assessment. Words were selected based on the parent questionnaire for the four experimental taught and matched control words, then confirmed by the vocabulary assessment. The vocabulary assessments were of the same type as those used in Part 1 (see section 2.5.11.5).

The following table compares the experimental and matched control vocabulary used in Part 2 for phonological structure. See Table 2.2 for a comparison of word frequency and section 2.5.11.5 for discussion of frequency effects. Where possible, control vocabulary was matched to experimental vocabulary by initial consonant, selecting the word in italics as a preference, depending on the words known by the child (see Table 2.4).

The expressive vocabulary assessment procedure consisted of the researcher showing the child photos of each of the toys and matched objects and using the lead in phrase, 'What's that?'. Graded cues were used if necessary to elicit a response, i.e., (1) pause cue up to 5 seconds (2) question repetition and (3) 'It's a...!'. The lotto games were then used to assess receptive vocabulary. The child was asked to point to or give each of the named pictures. The receptive assessment had 2 repetitions per word to minimise attention effects. The child or researcher then matched the photo to the board as reinforcement.

Table 2.4: Taught vocabulary with control words matched by syllable structure and initial consonants

Taught vocabulary	Matched control words by initial consonant and syllable structure. Final consonants matched where possible.
Pig	<i>Park</i> , Pool
Cars	Cows, Keys
Ball	<i>Bed</i> , Bird
Top	<i>Toes</i>
Cat	<i>Coat</i> , Cot, Cows
Dog	<i>Duck</i> , Doll
Cup	Cot, Cows
Duck	<i>Dog</i> , Doll
Kite	Cot, Cup
Coil	Keys, Cot

Key: Words in italics were the first choice matched by initial consonant where possible. Subsequent words were used if the first choice was already in the child's vocabulary

2.6.10: Description of Part 2 intervention procedure

The following section describes the intervention used in Part 2, beginning with a summary of events.

2.6.10.1: Summary of event chronology in Part 2

Home visit with parents/carers:

1: The informal vocabulary questionnaire and *Sensory Profile* were completed verbally with parents/carers.

2: The *3Di* parent/carer interview was administered to confirm diagnosis.

3: The visit took approximately one hour per family.

School data collection with child and school staff:

1: A copy of the *OCDI* was sent to school for completion by an adult who knew the child well before or during the researcher visit. This took about 10-15 minutes per child prior to the session.

2: The staff member accompanying the child for intervention was asked to highlight any wellbeing, behaviour or sensory preference issues which might affect the child's ability to participate safely in the study (10-15 minutes). The researcher checked with the staff member regarding any signs of anxiety or potential exclusion criteria such as upper respiratory tract infection affecting hearing.

3: The staff member remained accessible throughout data collection and confirmed the assessment outcomes. The child sat opposite the researcher at a table in a quiet room with minimal distractions. The researcher used a sound meter as described previously to monitor any extraneous noise. The assessment and intervention session took approximately 20- 30 minutes per child.

4: If necessary to focus attention, a 'First, Then' verbal/visual cue was used at the outset to support task completion, concluding with a preferred activity as determined by a staff member who knew the child well.

5: Each child was presented with a baseline vocabulary assessment of the 10 intervention toy names from which four words the child could not name were selected. Four words matched on phonological similarity from the *OCDI* were then presented (for use as a before and after control measure). The informal vocabulary assessment consisted of a photo lotto to assess comprehension and

expression and took approximately 5-10 minutes to administer on each occasion. After each set of four pictures were presented, the child was asked to (a) name the picture, (b) point to the picture from a choice of four.

6: Four videos were presented to the child on an iPad placed on the table directly in front of the child. Each video lasted approximately 15-20 seconds and consisted of 6 repetitions of the target word.

7: The vocabulary assessment was repeated immediately after the intervention to assess fast mapping skills post intervention of the intervention vocabulary, and any change in the four control vocabulary items.

2.5.10.2: Part 2 intervention

Prior to the school visit, staff were requested to provide a quiet room with no extraneous background noise, a table and three chairs and a member of staff who knew the child to accompany them during the intervention and assessment procedure. The researcher ensured these conditions were met prior to the baseline assessment and intervention and set up a sound meter (Precision Gold Mini Sound Level Meter NO5CC) centrally placed immediately behind the child to control for any extraneous noise during the video presentations. The sound meter was set to measure background noise between 10 and 30 dB, general sound level weighting using the maximum hold position to obtain maximum background sound levels recorded prior to, after and between video clip presentation. In all cases, the background noise was minimal and remained at less than 40 dB. Theoretically, it is possible that there was a higher background noise level during the individual video clip presentations since it was not possible to measure background noise at these points due to the confound of noise from the videos. However, this was unlikely since the checks were consistent and no extra noise was evidenced by the researcher.

All the children for whom data was collected were able to sit and attend to the videos on the iPad for the duration of the intervention. A 'First work, then choose' visual and/or verbal cue was used as necessary to support attention to

the baseline assessment. Participants were also shown the assessment lotto and iPad at the outset so they were aware what the work tasks involved. All the children were able to attend to the assessment and intervention tasks with minimal prompts after the initial cues.

An informal baseline photo lotto vocabulary assessment was carried out before the intervention to confirm intervention and control words the child did not know. Four words that the child did not know were selected for intervention and randomly assigned to two of the intervention conditions. Four matched phonologically similar words were selected as control vocabulary as described in section 2.6.9.3.

The vocabulary intervention was then carried out in a quiet room with a familiar staff member present using an iPad showing four videos of an actor naming the intervention vocabulary. The four videos, each assigned to one of the interventions conditions, were presented to the child in random order. Each video had six identical repetitions by the actor of a target word that the child could not name or could not understand, whilst simultaneously showing the toy.

The informal vocabulary photo lotto assessment was repeated to ascertain the effects if any of the intervention in each of the two conditions on the targeted vocabulary compared to the non-intervention control vocabulary. Section 2.6.9.3 describes in detail the measures used as baseline and post intervention measures.

Chapter 3: RESULTS FOR PART 1

3.1: RESEARCH QUESTIONS ADDRESSED AND DISCUSSED IN THIS CHAPTER

In this chapter, individual case profiles are described and evidence of children's vocabulary learning before and after intervention from a live or video vocabulary modelling intervention, is presented. Vocabulary learning measured by parent/carer report and informal picture based assessments is compared across conditions. Intervention outcomes are considered in relation to case profiles and factors inherent in the research design. Outcomes for each participant are analysed to answer each of the research questions below and key group data trends explored.

1: Do young children with Autism Spectrum Disorder (ASD) and delayed spoken vocabulary learn more new words through video modelling than live vocabulary modelling by parents?

2: Do young children with Autism Spectrum Disorder (ASD) and delayed spoken vocabulary learn more new words through video modelling in quiet than through video modelling in background noise?

3: Do young children with Autism Spectrum Disorder (ASD) and delayed spoken vocabulary learn more new words through video modelling with a slowed speech rate than through video modelling with an unmodified speech rate?

3.2: FACTORS INFLUENCING DATA ANALYSIS

Descriptive analysis was used to analyse the data due to the small sample size (N = 6) and small number of words presented to each child; two words for each of two conditions per child compared to a control sample of six matched words.

The large potential for error would not allow for meaningful inferential statistical analyses. Therefore qualitative analysis and discussion was used for each case to answer the research questions posed. In addition, data trends were analysed.

The practical limitations of the study meant that one of the participants could *understand* all of the control words at the outset and a further participant could understand one of the control words at the outset, but none of the participants could *name* any of the control words at the outset. In addition, one participant could understand all four of the taught words at the outset and one participant could understand three out of four of the taught words at the outset. However, none could name the taught vocabulary. Therefore all results were compared for naming and relevant results compared for understanding.

All of the participants had short breaks during the intervention periods of one to four days due to illness or holidays, but this was anticipated and managed by parents/carers reporting in their diaries and resuming the intervention immediately afterwards. All completed both Stage 2 interventions on 14-18 occasions based on information from parental diaries and verbal report, with intervention condition order randomly distributed throughout.

3.3: VALIDITY AND RELIABILITY OF BASELINE AND OUTCOME MEASURES

3.3.1: Validity

Face validity of the outcome measures was supported by parents/carers reporting on the actual vocabulary they had used during the intervention. Also, the informal vocabulary assessment used photos of the same toys that were used in the intervention, reducing symbolic representation demands. Furthermore, piloting of the questionnaire helped to ensure that the questions were clear and a valid measure of the parent/carer's opinion.

Due to the nature of the case study data and limitations such as small sample size and subject variation, internal validity was tested through triangulation of

data collected through multiple methods. Golafshani (2003) suggests that triangulation may use several methods of data collection or analysis, according to the research criteria. In this case, both parent questionnaire and informal assessment of vocabulary were compared as in Figures 3.1 and 3.2.

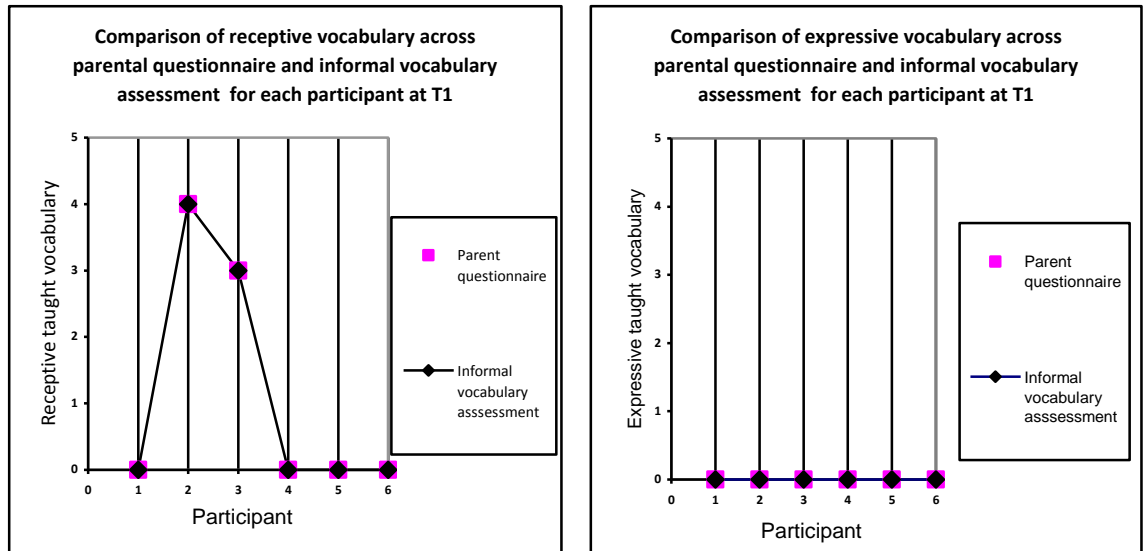


Figure 3.1: Comparison of receptive and expressive vocabulary across measures at T1

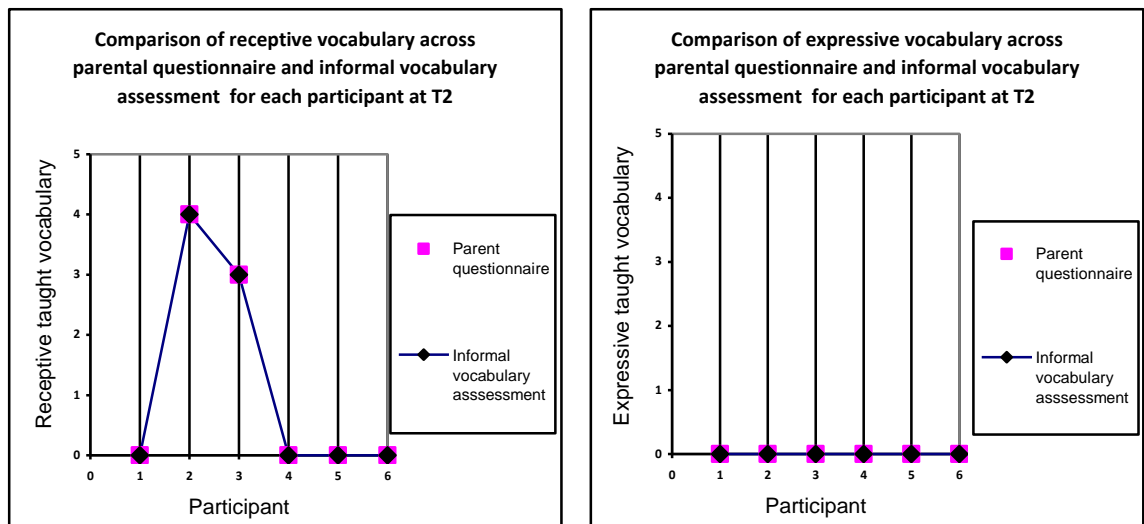


Figure 3.2: Comparison of receptive and expressive vocabulary across measures at T2

Figures 3.1 and 3.2 show 100% consistency across measures at T1 and T2, lending support to the internal validity of the measures used to assess vocabulary prior to intervention.

The nature of the research meant that measures of vocabulary standardised for the participant population were unavailable to inform a criterion related validity test of the outcome measures. However, replies to the parent/carer questionnaire at T1 were consistent with parent/carer report in *the Oxford Communicative Development Inventory (OCDI; Hamilton et al., 2000)*, a checklist standardised on younger children, but also recommended for children with delayed language and frequently used in research with children with ASD (Charman et al., 2003a, Bruckner et al., 2007). Consistency across these baseline measures was expected, since both measures were carried out on the same occasion with opportunities to clarify with the researcher if required. Further qualitative and quantitative information on each participant's language skills was obtained through the use of a standardised assessment, the *Preschool Language Scale UK: 4th Edition* (Zimmerman et al., 2009). This data was used to support interpretation of the results.

The consistency of the outcome measures were also compared in the Figure 3.3 below at T3.

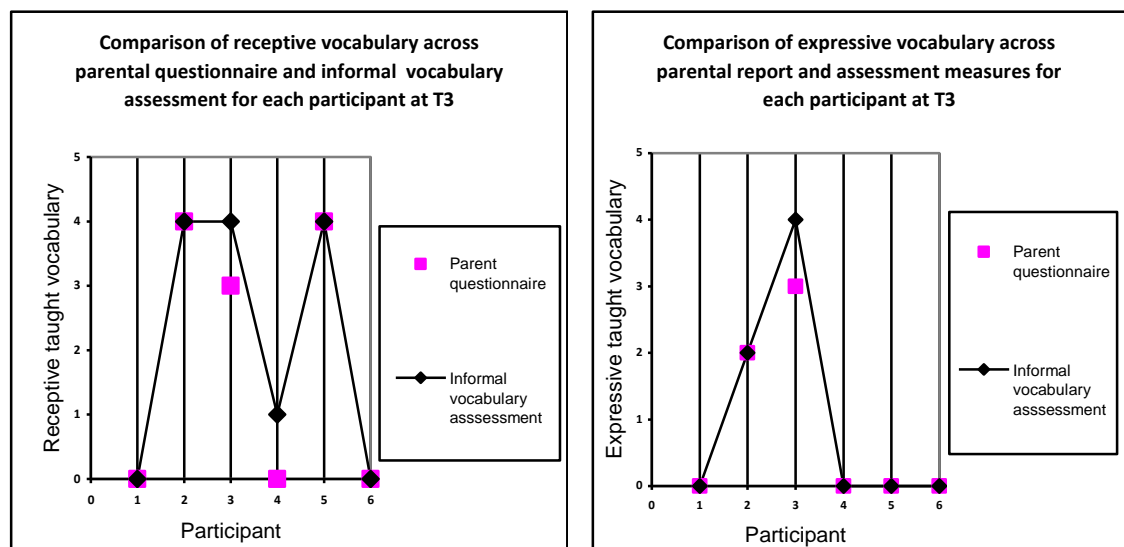


Figure 3.3: Comparison of receptive and expressive vocabulary across measures at T3

Figure 3.3 demonstrates that there was less consistency across measures at T3, due to under reporting of vocabulary by one word in Participants 3 and 4 on the parent/carer questionnaire compared to the vocabulary assessment. This may have been a feature of the parent/carer questionnaire construction, although as each questionnaire was administered face to face with opportunity for discussion and clarification, other explanations are more likely. More likely explanations are that the children responded differently to a structured picture based assessment than naturalistic observations by parents/carers, that difficulties such as sensory modulation and attention increased the likelihood of inconsistency of responses across contexts or that intrinsic or extrinsic differences in motivation impacted on responses, particularly for new learning which may not yet have been fully established. Such influences therefore need to be considered when interpreting the findings detailed in the rest of this chapter.

External validity of the outcomes of this study was compromised by the variation in participant characteristics and the individual intervention contexts of the participants' homes. To decrease confounding effects, participants were randomly assigned to experimental conditions and parents instructed to present the intervention conditions in random order with specific presentation instructions. Parents/carers were also asked to keep a diary to record their child's responses and any factor which might have influenced outcomes. These measures sought to increase the likelihood that the intervention outcomes were valid outcomes of the experimental intervention conditions rather than experimental confound, but were limited in terms of effect on generalisation of the outcomes.

3.3.2: Reliability

With regard to external reliability, the repetition of the informal vocabulary assessment and parent/carer questionnaire at T1 and T2 in Figures 3.1 and 3.2 demonstrated no change in baseline measures with either the parent/carer questionnaire or the informal vocabulary assessment, suggesting good test-retest reliability. The test-retest interval of four weeks reduced some potential

for test learning, but gave rise to the potential of some change in participants over time confounding the results. In addition, the reliability of the findings of this study was limited by potential bias arising from the researcher carrying out the data collection in addition to reporting and analysing the results. Reliability would have been improved by an additional person blind to the experimental conditions completing the outcome measures. Video of the informal vocabulary assessment would have enabled the outcomes to be rated by external observers and inter-rater reliability calculated.

3.3.3: Summary of reliability and validity

To summarise, there was good internal validity in terms of face validity and good consistency across outcome measures compared to excellent consistency of baseline measures. There was good evidence of test-retest reliability, although evidence of overall external reliability was reduced by the lack of inter-rater reliability measurement. Therefore, there are limitations with reliability and validity in terms of generalisation of the findings to larger populations or contexts. As such, findings of this study are explorative, requiring further research to confirm or refute the outcomes.

Case study data is omitted from 3.4 to the end of 3.9, but is available in hard copy from the University of Sheffield library.

Chapter 4: RESULTS FOR PART 2

4.1: RESEARCH QUESTIONS ADDRESSED AND DISCUSSED IN THIS CHAPTER

This chapter builds on outcomes of the previous chapter to further explore the effects of video modelling on children's vocabulary learning. In particular, it looks at the effects if any, of a school based video modelling intervention on fast mapping vocabulary, i.e., showing understanding or producing new words after minimal exposure. This was to explore whether any effects of video modelling in the different experimental conditions evident in Part 1 were also apparent after minimal exposure to words or whether effects were only evident after the cumulative exposure in Part 1. The methodology of Part 2 also enabled further experimental controls.

Fast mapping outcomes measured by an informal picture based assessment immediately before and after intervention are compared across two of four randomly assigned experimental conditions, i.e., unmodified speech, speech in background noise, slowed speech and asynchronous audiovisual speech. Intervention outcomes are considered in relation to case profiles with particular reference to sensory differences as measured by the Sensory Profile (Dunn, 1999). Outcomes for each participant (child) are analysed to answer each of the following research questions and key group data trends explored.

1: Do young children with Autism Spectrum Disorder (ASD) and delayed spoken vocabulary fast map more new words through video modelling in quiet than through video modelling in background noise?

2: Do young children with Autism Spectrum Disorder (ASD) and delayed spoken vocabulary fast map more new words through video modelling with a slowed speech rate than through a video modelling with an unmodified speech rate?

3: Do young children with Autism Spectrum Disorder (ASD) and delayed spoken vocabulary fast map more new words through video modelling with simultaneous audiovisual speech input than through video modelling with asynchronous audiovisual speech input?

4.2: FACTORS INFLUENCING DATA ANALYSIS

Descriptive analysis was used to analyse the data due to the small sample size (N = 8) and small number of words presented to each participant; 2 words for each of 2 conditions per participant compared to a control sample of 4 matched words. The large potential for error would not allow for meaningful inferential statistical analysis. Therefore qualitative analysis and discussion was used for each case to answer the research questions posed.

Recruitment limitations within the available time for the study meant that one of the eight participants (12.5%) could *understand* all of the control words on the informal vocabulary assessment at the outset and a further participant could understand one of the control words at the outset, but none of the participants could *name* any of the control words at the outset. In addition, three of the eight participants (37.5%) could understand one of the four of the taught words at the outset based on the informal vocabulary assessment. However, none could name the taught vocabulary. Therefore all results were compared for naming and relevant results compared for understanding. All the participants were able to sit and attend to the videos on the iPad with only occasional prompts. All

participants were motivated to watch the video demonstrating compliance to complete the picture assessments using a ‘First lotto, then iPad’ visual/verbal cue.

4.3: VALIDITY AND RELIABILITY OF BASELINE AND OUTCOME MEASURES: PARENT QUESTIONNAIRE VS. INFORMAL VOCABULARY ASSESSMENT AT T1

Face validity of the outcome measures was checked in a similar manner to Part 1 (see section 3.3.1 for a rationale). The parent questionnaire constructed for Part 2 was piloted and the same photo vocabulary assessment was used as for Part 1, but with photos relevant to the vocabulary selected for participants in Part 2. Due to the nature and limitations of Part 2 such as small sample size and participant variation, internal validity of baseline vocabulary was checked through triangulation of data collected through multiple methods. Parents/carers completed a short vocabulary questionnaire prior to the intervention, which was compared to the informal vocabulary assessment results at T1 in the Figure 4.1 below.

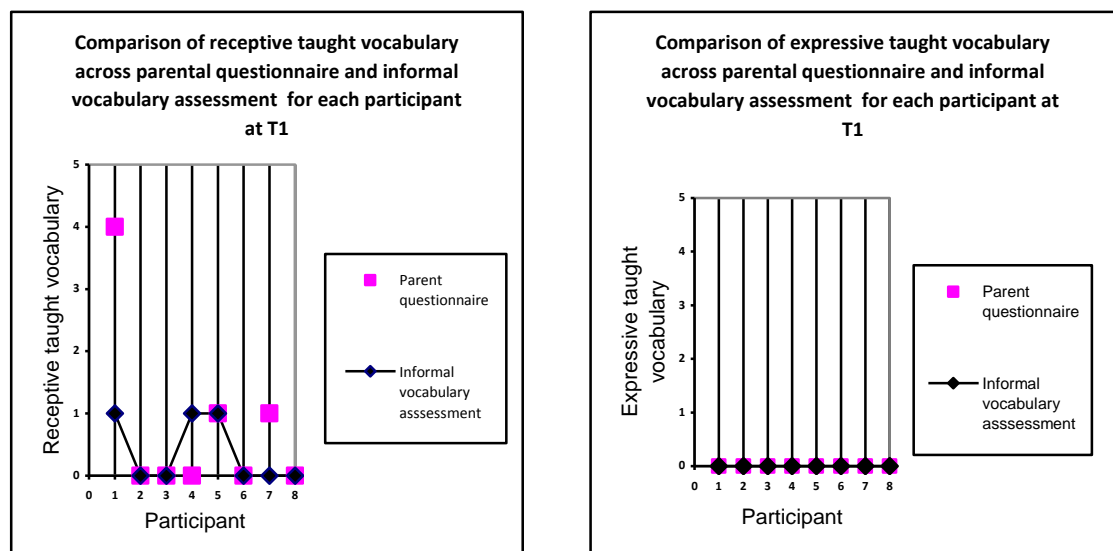


Figure 4.1: Comparison of receptive and expressive taught vocabulary across measures at T1

Results across baseline measures were consistent for all participants for expressive taught/control vocabulary, for five out eight participants (62.5%) for receptive taught vocabulary and seven out of eight (87.5%) participants for receptive control vocabulary (not shown on chart). Participant 1 was reported by parents/carers to understand all the taught vocabulary at the outset, but on the informal vocabulary assessment, only understood 1 out of 4 words. Similarly, Participant 5 was reported to understand 3 control words at the outset, but only identified one on the informal vocabulary assessment. In contrast, Participant 4 was reported to understand none of the taught words at the outset, but was able to identify 1 word on the informal vocabulary assessment and Participant 7 could understand no words on the informal vocabulary assessment, but one taught word according to parent/carer report. However, the results on the *OCDI* (*Oxford Communicative Development Inventory*: Hamilton et al., 2000) completed by a member of school staff who knew the child on the date of data collection, were consistent with informal vocabulary assessment results for all participants for taught and control vocabulary. There was only one instance of parents/carers reporting an overall expressive vocabulary count different from the *OCDI*, although this did not impact on experimental vocabulary. Therefore, overall, most baseline measure findings were consistent. Variation may have been accounted for by time or context differences in baseline data collection. Consistency was greater for expressive vocabulary.

To summarise, there was internal face validity for baseline and outcome measures and consistency across baseline measures for receptive vocabulary for most participants. However, baseline measure consistency was excellent for all participants for expressive vocabulary. Practical limitations meant that there was no evidence of experimental inter-rater reliability, although vocabulary assessment outcomes were confirmed by education staff present. Therefore, overall the findings of this study will be explorative in nature, requiring further research to confirm or refute the outcomes and generalise the findings to larger populations or contexts.

Case study data from 4.4 to the end of 4.8 is omitted, but is available in hard copy from the University of Sheffield Library.

Chapter 5: DISCUSSION

A growing body of research suggests that sensory differences in children with ASD are an important consideration when planning intervention programmes. There is also increasing evidence on how difficulties with attention negatively affect word learning in this population. The current study explored how individual sensory differences and associated attention difficulties might impact on fast mapping or learning early vocabulary in young children with ASD. It also explored how video modelling vs. live modelling or modified presentation of the video modelling influenced outcomes, given these potential sensory differences.

This chapter discusses the outcomes and emerging themes from a word learning video modelling intervention in Part 1 and fast mapping video modelling intervention in Part 2 and then considers these findings within the context of the literature. It concludes by looking at the implications of the study in terms of current theory and practical considerations for early word learning and intervention in young children with ASD. However, the conclusions and implications discussed must remain tentative until confirmed by further research, due to the small number of participants and limited number of words compared across conditions in an explorative study such as this.

5.1: KEY OUTCOMES

The outcomes related to the research questions in Part 1 and 2 are discussed jointly to clarify overlapping and contradictory findings between the word learning and fast mapping outcomes. The outcomes from the research questions for young children with ASD at a group level in this study were as follows.

1: Consistent with most of the evidence for children with ASD, video modelling had an overall positive impact on both fast mapping and learning new words compared to non-taught control vocabulary. This was true for participants with and without speech sound difficulties. However, there was insufficient evidence

to support a significant difference between live and video modelling on outcomes for word learning.

2: Despite wide ranging evidence of auditory processing difficulties in ASD, this study found that background noise during video modelling may have had a negative influence on fast mapping or learning new words, but the impact was limited in the young minimally verbal children in this study.

3: Compared to unmodified speech, artificially slowing the audiovisual speech rate in video modelling conferred only a minor advantage for word learning in one individual and none for fast mapping new words. This is within the context of a limited evidence base of the benefits of slowed speech on word learning in young children with ASD.

4: Audiovisual asynchronous presentation of speech in video modelling resulted in an expressive advantage but receptive disadvantage for fast mapping new words in three out of four participants. An atypical response to asynchronous audiovisual speech is consistent with evidence from the literature suggesting multisensory integration difficulties in children with ASD.

Each research question will now be addressed in detail.

5.1.1: The impact of video modelling on early word learning in children with ASD

When comparing live modelling directly to video modelling in Part 1, neither condition had an effect on receptive vocabulary in the two allocated participants. There was however, an increase in expressive vocabulary in the video condition for one of the two participants. However, as discussed in the results chapter, the video modelling advantage for that participant needs to be considered within the context of; an overall vocabulary spurt, the effects of an improvement in speech and a higher cognitive ability than the other participant.

When comparing the results across conditions in Part 1, the evidence comparing taught vs. untaught vocabulary learning suggested that video

modelling did contribute to vocabulary learning for most participants. There was increased expressive or receptive vocabulary learning in response to the video modelling condition (D) in four of the six participants, but only one participant demonstrated an increase in non-taught control vocabulary. Overall, there was insufficient evidence to support a hypothesis that young children with autism and delayed spoken vocabulary learn more new words through video modelling than live modelling or vice versa. However, there was a clear effect of video modelling on taught vocabulary learning across the conditions compared to non-taught control vocabulary.

In Part 2, video modelling resulted in fast mapping some taught vocabulary in all participants compared to no change in control vocabulary. However the number of words learnt after video modelling and whether participants learnt receptive or expressive vocabulary varied.

Hence, both Part 1 and Part 2 of this study produced evidence that video modelling was effective in supporting word learning and fast mapping of vocabulary compared to non-taught control vocabulary. In Part 2, although video modelling was positively associated with fast mapping vocabulary, this only required associative learning, a relative strength in children with ASD. There is however also evidence of difficulty fast mapping words in ASD (Walton and Ingersoll, 2013; Priessler and Carey, 2005). Evidence of associative learning in ASD is provided by Norbury et al. (2010) in their study of word learning and eye movement data. They suggested that children with ASD often learn new words through associating the phonological form with the referent rather than integrating semantic and phonological information to consolidate understanding. Hence measuring fast mapping rather than word learning may have enhanced Part 2 outcomes. In addition the slightly older age range of participants in Part 2 may have benefited outcomes at group level, although other individual participant differences are also likely to have interacted with the effects of age.

The positive effect of video modelling on taught vocabulary learning across conditions over time affecting both receptive and expressive vocabulary in Part 1 compared to non-taught control vocabulary, suggests that the impact of video

modelling went beyond initial associative learning in at least some participants. Video modelling may have had a positive impact and increased attention to the actor naming the words and to the word referents, minimising any negative effects from difficulty following eye gaze. However, it is not known whether the use of video also helped the children infer meaning from the actor's non-verbal cues. Gliga et al. (2012) highlight the importance of being able to infer meaning from these clues as well as following eye gaze in order to understand word meaning.

Overall, the results of this study support the generally positive findings in literature on the effectiveness of video modelling on developing language and communication skills in children with ASD e.g., Shepley et al. (2014); Schefflen et al. (2012); Charlop et al. (2010); Shukla-Mehta et al. (2010); Rayner et al. (2009). However as noted earlier, there was insufficient evidence to support the superiority of video modelling over live modelling in vocabulary learning. This supports the findings of Moore and Calvert (2000), although they compared a software programme including sensory reinforcement which specifically attempted to teach the words vs. live vocabulary teaching rather than simply modelling the vocabulary on video as in the current study. The results of the current study also concur with Wang et al.'s (2011) meta-analysis of single case studies of video modelling. They found video modelling and peer mediated social skills interventions to be equally effective. Wilson (2013) also found a range of social communication outcomes across individual profiles in a study comparing live vs. video modelling in four preschool children with ASD.

The results of the current study support the literature on the positive effects of video modelling on language and communication generally (Shukla-Mehta et al., 2010) and vocabulary learning in particular (e.g., Shepley et al., 2014; Wert and Neisworth, 2003). However, there are a number of variations between studies on video modelling interventions in ASD likely to affect outcomes, making it difficult to directly compare the results from the current study to the literature. These variations include; whether video modelling was the only intervention, the type and amount of video modelling, the extent of the time delay after modelling, participant and learning task differences and whether

prompts and reinforcements were used. However, all the studies as in this study, included a period of video exposure to the desired behaviour and opportunity to demonstrate learning after exposure.

The literature suggests that video modelling can be at least as effective as live modelling in promoting language and communication for some young minimally verbal children with ASD, whereas in typically developing children, most of the literature supports preferential outcomes for live modelling (e.g., Anderson and Pempek, 2005; Kuhl et al., 2003). The outcomes of this study support video modelling, but also support the benefits of face to face learning of vocabulary as in typically developing young children (e.g., Varner, 2014). Evidence of difficulties with generalisation caution against over reliance on screen based learning depending on the child's age and video content (Calderon, 2015). However the outcomes of this study are consistent with predictions from the benefits of video learning for children with ASD cited by Corbett and Abdullah (2005), potentially compensating for reported difficulties with attention (Charlop et al., 2010) and social learning (Kuhl et al., 2013) in ASD. Yet, the question remains as to why video modelling was more successful in supporting some children to learn vocabulary than others.

To answer this question, it is important to look in greater depth at the case study profiles and the vocabulary learning or fast mapping context. The variation in outcomes between participants with different ability profiles in this study agrees with the literature suggesting the importance of the interaction between the learning task and specific individual ability profiles, in determining learning outcomes from screen based learning in children generally (Richert et al., 2011) and from video modelling in children with ASD in particular (e.g., Shukla Mehta et al. (2010).

What common themes emerged from the individual profiles in this study that might have influenced video modelling outcomes? Richert et al. (2011) suggest a range of factors which might impinge on learning from screen based interventions in typically developing children. These include the child's social relationship with the onscreen character, developing perceptual skills and

symbolic understanding. However, as the participants in the current study all had documented evidence of atypical rather than delayed perceptual and social development and below average symbolic understanding associated with their diagnosis of ASD, the impact of such factors are likely to be different from those influencing outcomes in typically developing children. Analysis of the results suggested that differences in sensory profiles, imitation skills, attention/distractibility, motivation and cognitive abilities may all have been significant. This concurs with Shukla Mehta et al. (2010) who recommend an evaluation of attention, visual processing, language understanding, imitation and spatial ability when using video modelling with children with ASD. For instance, Shukla-Mehta et al. (2010) suggest that children need to have a minimum attention span to benefit from video modelling. See section 5.2 of this chapter for further discussion on how the individual abilities of the children potentially affected word learning outcomes in the current study.

The sensory profile data indicated a high level of atypical sensory processing across all participants, although individual profiles varied. Participants in both Part 1 and Part 2 met the inclusion criteria of significantly delayed spoken language and minimal cognitive levels, but there was some variation in cognitive ability, speech imitation ability and baseline vocabulary. Although Rayner et al. (2009) concluded that current evidence cannot say which children will or will not benefit from video based intervention, language skills and visual processing are likely to be significant influences (Delano, 2007). McCoy and Hermansen (2007) also highlight the role of imitation and attention, although as also noted by Rayner et al. (2009), data on these abilities is not consistently reported in the literature on video modelling and as such it is not possible to arrive at definitive conclusions about how these abilities might impact on the success of video modelling. The current study attempted to add to the evidence base on the importance of individual ability profiles through detailed case study pre-intervention assessments, although due to the small sample size and variation amongst participants, further research is required. Since visual and auditory processing, attention and imitation skills are particularly important in video modelling, evidence from the case profiles was used to shed further light on the overall positive outcomes from video modelling.

There was less evidence of atypical visual processing amongst participants than in other modalities. Only two out of six participants in Part 1 and two out of eight in Part 2 were reported to demonstrate atypical visual processing. This may have been a function of parent report as opposed to more objective measures or of whether the questions in the Sensory Profile were able to adequately capture atypical visual processing such as a local processing preference suggested by the literature (e.g., Koldewyn et al., 2013). Alternatively if visual processing was relatively intact, this may have increased the likelihood of word learning given a possible association between poor visual processing and social functioning (Hellendoorn et al., 2014) and word processing and social learning in ASD (Kuhl et al., 2013). However, this may not relate to video modelling and other evidence has suggested less influence of visual than auditory cues on speech perception compared to typically developing children (e.g., Irwin et al., 2011).

Regardless of the relative influence of visual processing on word learning, it is likely that most of the children in the current study would at least have been able to transfer learning from one 2D image (the screen) to another (the picture test) as found by Zack et al. (2009) and Scofield et al. (2007) in typically developing children aged 15 months and two to three years respectively. Furthermore, Richert et al. (2011) suggest that young children can learn from symbolic screen information before they have fully developed 3D symbolic understanding if they see the screen as live, e.g., by looking at it through a window. Given the low levels of cognitive ability and symbolic understanding of participants, it is possible that some children did not yet view the on screen objects as symbolic representations of real objects, a process that appears in typically developing infants at around 15 months of age (Pierroutsakos and Troseth, 2003). This might account for some positive picture test results but also for documented difficulties with generalisation in Part 1. Even where generalisation was reported, it is unclear from some of the parent questionnaires how functional this was, e.g., were the children generalising to 3D representations and across a range of people and contexts?

Despite relatively typical visual processing in most participants, there was widespread evidence of atypical auditory processing which is likely to have influenced the results. This is also discussed in the later section on sensory processing (5.2.1). A potentially negative impact of atypical auditory processing might have been mitigated by the role adults played in cueing auditory and visual attention to the words and toys both on and off screen. This is particularly important given the widespread evidence of difficulties with attention across modalities including joint and shared attention, in children with ASD in this study and generally, along with evidence of beneficial effects of cueing (Wilson, 2013; Shukla-Mehta et al., 2010; Whitehouse and Bishop, 2008).

Richert et al. (2011) conclude that typically developing children under 2 years rarely learn from screen models without an adult highlighting the importance of the words, although may this not be the case for older children. In the current study, the actor in the video highlighted the words by her actions and communication style. Studies such as Richert et al. (2010) and Krcmar et al. (2007) highlight the importance of joint reference through live interaction in the word learning of typically developing children under 2 years in addition to the benefits of an adult drawing attention to the words and their referents on the screen. However, O'Doherty et al. (2011) suggest that it is the presence of participatory or observed reciprocal social interaction that is important in typically developing toddler word learning, whether this is live or on video. Given the known difficulties with joint and shared attention in children with ASD (e.g., Akechi and Kobayashi, 2014; Sigman and McGovern, 2005; Dawson et al., 2004), the use of cues by the researcher in this study to support attention to the actor and objects on the screen, may have had a significant positive effect on outcomes. Such cues are likely to have increased attention to the spoken words and their referents, as found by Walton and Ingersoll (2013). Yoder et al. (2014) also highlight the importance of response to joint attention (as evidenced by looking in response to an adult directive such as a point) on word learning in ASD.

Further support for the influence of attention on word learning outcomes from video modelling is provided by the parent/carer diaries in Part 1. There were

indications from some parent/carer diaries that time visually attending to the screen may have impacted on results, although this was not objectively measured due to limitations of the home context. However, frequency of intervention sessions did not reflect outcomes. The two children who learnt no vocabulary were exposed to intervention sessions on 14 and 18 occasions respectively from an overall range of 14-18 sessions. However, although the children were exposed to a similar frequency of intervention sessions, variations in attention/distractibility and motivation are likely to have functionally reduced this exposure. There is evidence in the literature that although learning from screen media depends at least in part on exposure (Crawley et al., 1999) other variables contribute such as how the children relate to the onscreen character (e.g., Richert et al., 2011; Calvert et al., 2007) and joint attention. Yu and Smith (2012) examined embodied joint attention (as reflected by changes in body movements) in typically developing toddler's word learning. They found that the number of times the parents named objects was negatively correlated with word learning, suggesting that frequency of word presentation in itself does not necessarily promote word learning in typically developing children at least. This was also the case in the current study as exemplified by the lack of correlation between frequency of exposure to modelling and word learning (although the study design meant evidence was limited).

With regard to impact of the onscreen presenter, as the actor was not someone the children knew or necessarily identified with, this could have reduced engagement, although atypical attention and social skills may also have reduced any benefits from knowing the actor. However, the actor did speak directly to the children, which Richert et al. (2011) highlight as an advantageous factor in word learning from screen media in typically developing children. Some evidence also suggests benefits from child directed speech (CDS) for children with ASD (e.g., Cassel et al., 2014; Cohen et al., 2013) although other evidence contradicts this (e.g., Watson et al., 2012; Paul et al., 2007). However, only Cassel et al. (2014) and Cohen et al. (2013) compared CDS with other speech forms. Also, the Cassel et al. (2014) research was a case study with two children aged up to 18 months (one who later developed autism and one who

did not), whilst Cohen et al. (2013) had a relatively small sample size (N=14 who later developed ASD and N =14 who did not) and focussed on infants up to 12 months of age. In addition, both looked at infant responsiveness rather than word learning. Therefore, the evidence on the benefits of CDS compared to other speech forms on word learning for children with ASD is limited. The evidence is more robust in supporting less auditory attention to CDS and other speech forms for children with ASD compared to typically developing children.

With regard to the effects of imitation ability on video modelling outcomes, case study data indicated varying imitation abilities amongst participants. For instance in Part 1, two participants demonstrated an increased naming vocabulary and two different participants demonstrated increased repetition but not spontaneous naming. In Part 2, more participants (five out of eight) learnt to fast map taught expressive vocabulary. Lindsay et al. (2013) highlighted imitation as an important prerequisite skill for video based interventions, but one which is frequently limited in children with autism (Hamilton et al., 2007). Although the review by Lindsay et al. (2013) covered a range of imitation skills, it is likely that some of their findings are relevant to this study. For instance, they highlighted the benefits of cueing to specifically elicit imitation and use of toys with sensory effects for children with autism as in the current study, but also the increased difficulty of delayed imitation as necessitated in the Part 1 assessment compared to the shorter time period between intervention and assessment in Part 2. Specific assessment of imitation prior to intervention would aid interpretation of the findings of the benefits of video modelling in the current study.

In addition to individual participant characteristics and abilities, specific aspects of the video learning context are likely to have influenced the impact of video modelling on early word learning and fast mapping. As most of the children demonstrated more focussed and sustained attention to video modelling when watching the TV/computer or looking at the iPad than in live learning contexts generally (based on parent report or observation), this is likely to have reduced the negative effect of external distractions. Difficulties with visual attention in young children with ASD are often reported in the literature (e.g., Wilson, 2013)

along with a preference for video compared to live presentation (e.g., Cardon and Azuma, 2012). In addition, the repetitive nature of the video presentations enhanced predictability. Diagnosis of ASD in the *DSM-5* includes difficulties coping with change and preference for routine (American Psychiatric Association, 2013). Learning is more likely when the anxiety associated with unpredictability is decreased. See Gomot and Wicker (2012) for a discussion on the difficulties individuals with ASD have with processing unpredictable events. Finally, video often has positive associations with recreation for children with ASD, increasing motivation. All these characteristics are likely to have increased learning opportunities, building on strengths in children with ASD such as selective attention and visual learning along with reduced demands on social attention and interaction (Corbett and Abdullah, 2005).

Thus the benefits of video modelling for the children in this study might be explained by specific aspects of the video modelling context combined with atypical but varying developmental profiles. Key factors emerging as particularly important in the success of video modelling from this study and from the literature are attention and motivation (Corbett and Abdullah, 2005). These will be discussed in detail in a later section on emerging data trends.

5.1.2: The limited impact of background noise on fast mapping and early word learning

In Part 1, there was tentative evidence of some benefit of the quiet condition as opposed to the background noise condition for taught vocabulary learning. In Part 2, both participants allocated to quiet vs. background noise conditions were able to fast map some of the taught vocabulary after intervention compared to no change in the control vocabulary. There was however, insufficient evidence to support an advantage of either condition on fast mapping.

Therefore, although there was some tentative evidence of the benefit of quiet vs. noisy conditions in early word learning across participants in Part 1, the negative impact of background noise in both Part 1 and Part 2 was minimal.

The lack of impact of background noise on fast mapping vocabulary was in contrast to evidence of difficulties with background noise from personal accounts (e.g., Grandin, 1995) and most of the research highlighting particular difficulties processing speech in noise for individuals with ASD (e.g., Foxe et al., 2013; Alcántara et al., 2012; Schafer et al., 2013; Groen et al., 2009; Russo et al., 2009b; Alcántara et al. 2004). The difference might at least partly be explained by ceiling effects, small sample size and varying cognitive, language, attention abilities of participants across conditions at baseline. Equally, the difference might be accounted for by variation in sensory processing abilities, task differences (e.g., identifying words in noise vs. fast mapping) or variations in types of background noise used in this compared to other studies. The current study used multi-talker babble for ecological validity at an SNR of +6dB as this SNR has been reported to show the greatest difference between clinical and non-clinical populations for speech perception in noise in young children (Geffner & Goldman, 2010). This SNR is thus potentially more likely to demonstrate any atypical responses for the participants in the current study. However, as Alcántara et al. (2004) highlight, real life background noise coming from multiple sound sources with effects of reverberation and echo, is likely to have even greater impact than artificially produced speech in multi-talker babble. O'Connor (2012) points out that extracting meaning from speech in background noise in natural contexts requires the individual to discriminate acoustic cues relevant to the speaker of pitch, timing and location and also to make use of top-down influences such as attention, language and memory. It may well be that use of video modelling in this study enabled an increased use of both bottom up cues and top down influences, limiting the negative impact of background noise. Given that most participants demonstrated auditory processing difficulties on the Sensory Profile data (in support of Tomchek et al., 2014; Tomchek and Dunn, 2007), predicting worse performance in noise, this is a plausible explanation.

5.1.3: The effects of slowed speech on fast mapping and learning new words

In Part 1, there was no change in taught expressive vocabulary after either the slowed condition or unmodified video modelling in either participant, coinciding with no change in control vocabulary. However, there was reported evidence of additional non-taught expressive vocabulary learning from the videos for one participant. In addition, there was a positive effect on repetition ability in the unmodified condition for one participant and in the slowed condition for the other. Again in Part 2, both participants allocated to the slowed vs. unmodified conditions were able to fast map some of the taught vocabulary after the video modelling interventions compared to no change in the control vocabulary. As described in chapter 4, there was a small advantage for fast mapping the expressive vocabulary in the slowed condition for one participant, but overall insufficient evidence to support the hypothesis that young children with ASD fast map more new words in slowed speech than in unmodified speech presentation in video modelling.

Thus overall, artificially slowing the rate of speech conferred only a minor advantage for one individual on fast mapping in Part 2 and none for word learning in Part 1, compared to unmodified speech. This is in contrast to predictions made from some research suggesting benefits from slowed speech in children with autism (Gepner and Feron, 2009; Tardif et al., 2007). However the current study slowed the actor's speech to 75% of the normal rate in order to retain intelligibility, whereas Tardif et al. (2007) slowed down vocal sounds to 50% and 25% of the normal rate. Thus, as there were differences in ages and abilities of participants and the extent of slowing speech in this study compared to previous studies, more research is needed to assist with interpretation of the findings. Further research would also help to confirm or refute a possible rapid temporal speech processing deficit postulated by Mayer and Heaton (2014), based on their research with high functioning adults with ASD. Furthermore, it may be that naturally slow speech using pauses rather than artificially slowed speech, does more to support speech processing by allowing time to

compensate for a general processing speed deficit reported in some children with ASD (Travers et al., 2014).

Boets et al. (2014) have queried previous evidence suggesting a temporal processing deficit in ASD, based on their study using gap-in-noise and slow amplitude modulation detection testing in adolescents. Although there was some evidence of poorer gap-in-noise detection compared to typically developing adolescents, the evidence was not significant (in contrast to Bhatara et al., 2013) and there was no evidence of slow amplitude modulation detection group differences. Thus, the findings of the current study along with that of Boets et al. (2014) call into question theories of a temporal processing deficit in for all individuals with ASD.

5.1.4: The differential influence of asynchronous speech on fast mapping words

In Part 2, as in the previous conditions, video modelling in both asynchronous and simultaneous conditions produced at least some evidence of fast mapping compared to no change in control vocabulary for all participants.

Interestingly, given the prediction that participants would not experience an advantage when fast mapping new words in either condition, three out of four participants fast mapped more expressive words in the asynchronous condition than the simultaneous condition, although there were only two words per condition. This therefore differed from the original prediction of no difference in impact from the asynchronous condition in children with ASD due to an extended multisensory temporal binding window (Woynaroski et al., 2013; Foss-Feig et al., 2010). However, receptive fast mapping of vocabulary did not show a similar asynchronous advantage. Instead the simultaneous condition gave the advantage overall. These findings suggest atypical multisensory processing in the young children with ASD in this study as described by Stevenson et al. (2014a), but cannot refute or confirm a theory of an extended multisensory binding window in ASD since there were no typically developing controls and evidence of changes in window size and shape for typical development in the

literature remains limited as discussed below. In addition, most relevant studies in the literature have been conducted with older children with ASD and have focussed on asynchrony detection with no studies looking at the effect of asynchrony on fast mapping. Furthermore, multisensory binding window widths are calculated differently in infants (preferential looking) compared to children (group scores for simultaneous judgement) compared to adults (individual stimulus judgment thresholds), potentially confounding comparisons. Finally, the results in the current study need to be interpreted with considerable caution due to the variations between participants on baseline assessments, the small sample size and limited potential effect sizes of only four new words per participant.

The current study used a 450 ms stimulus onset asynchrony with a visual lead, predicting that this stimulus onset interval would not affect multisensory binding of speech in young children with ASD resulting in no difference between synchronous and asynchronous speech conditions on fast mapping vocabulary, but this was not the case. However, the prediction was based on a limited evidence base on the nature of the multisensory binding window in typical development and ASD. It is possible considering the evidence below, that differing ages of the participants in the current study impacted on outcomes, although there was no obvious pattern suggesting an age effect with the youngest and oldest participants demonstrating similar outcomes.

In typical development, Lewkowicz (2010) reported a window size of around 666 ms with an auditory lead in infants, but the size is unknown for a visual lead (Lewkowicz and Flom, 2013). In adults, this narrows to around 60-200 ms for an auditory lead and 180-240 ms for a visual lead (Lewkowicz and Flom, 2013). Looking at when the multisensory binding window might start to narrow in typically developing early childhood, Lewkowicz and Flom (2013) found that whereas 4 year olds could detect auditory lead speech asynchrony with a 666ms difference, 5 year olds could also detect 500ms and 6 year olds, 366ms. Visual lead asynchrony detection times were not included but most evidence suggests a relatively symmetrical window at birth, with decreasing symmetry in childhood.

With regard to children with ASD, in contrast to Taylor et al. (2010) whose findings show less difference with age (7-8 years compared to adolescence), Stevenson et al. (2014c) reported increased susceptibility in children with ASD to the McGurk illusion compared to typically developing children aged 13-18 years, but not in younger children aged 6-12 years. These studies highlight changes in multisensory binding with age in ASD, but not in which direction. Irwin et al. (2011) found that children aged 5-15 years with and without ASD did better at detecting asynchronous speech with a 550 ms than 250 ms window whether there was an auditory or visual lead, but both groups did worse with a visual lead with the 250 ms asynchrony. However, there were differences in tasks and inclusion criteria (e.g., age, language ability and diagnostic criteria) between Irwin et al. (2011) and the current study. Further research using different stimulus onset asynchronies comparing participants with and without ASD at different ages is required to shed further light.

The results therefore cannot confirm or refute an extended multisensory temporal binding window in ASD. It is possible however that the results are indicative of atypical multisensory processing and integration of audiovisual speech (Foxy et al., 2013; Taylor et al., 2010; Smith and Benetto, 2007). The asynchronous disadvantage for receptive fast mapping in some participants might be predicted if as Irwin et al. (2011) suggest, asynchronous audiovisual detection is similar in ASD and typical development in children. The advantage in the asynchronous condition for expressive vocabulary may have been because the participants relied primarily on auditory speech cues to support delayed imitation of the target word when presented with a picture cue, which was in some way beneficial in the asynchronous condition. Delayed imitation of speech is often a relative strength in ASD compared to use of non-echoed speech (van Santen et al., 2013). This explanation is consistent with evidence of difficulty with multisensory processing of speech and reduced use of visual cues in speech perception in ASD (e.g., Stevenson et al., 2014c; Iarocci et al., 2010; Williams et al. 2004; De Gelder et al., 1991) and younger children (Ross et al, 2011; Tremblay et al., 2007; Hockley and Polka, 1994). Irwin et al. (2011) found reduced use of visual cues in multisensory speech processing in 5-15 year old children with ASD compared to typically developing children in the McGurk

effect and for both those with and without ASD in asynchronous speech with a 250 ms window, although not a 550 ms window. Overall, the evidence suggests that use of visual cues in multisensory speech processing varies with age, task complexity, i.e., more difficulty evident in tasks such as those demonstrating the McGurk effect and speech processing in background noise (Irwin et al., 2011), and with the size and order of stimulus onset asynchrony in asynchronous conditions.

In summary, although the changes in receptive vocabulary were in line with what might be predicted in typical development and the positive influence of asynchronous speech on expressive vocabulary fast mapping was greater than expected, it is unclear whether different parameters would have markedly altered the results. More research is required to examine the construct of an extended multisensory temporal binding window and the influence of unisensory vs. multisensory cues on language learning children in children with ASD compared to typically developing of different ages and abilities. Current findings provide some intriguing results requiring further research to understand their significance, but provide some limited support for atypical multisensory processing of speech in ASD. Sections 5.2.1 and 5.2.2 discuss further evidence of multisensory processing differences in ASD found in the current study and the implications for vocabulary learning.

5.2: DATA TRENDS

In addition to answering the original research questions, there were some emerging trends from the data in both Part 1 and Part 2 which warrant further discussion. These were:

1: The high prevalence of sensory differences amongst participants and emerging profile themes such as difficulty with sensory modulation, multisensory processing, attention and auditory filtering, largely consistent with the evidence base.

2: The potential impact of different sensory profile patterns and individual ability profiles on fast mapping or learning new vocabulary in young children with ASD, within the context of a limited evidence base for this population.

3: The impact of cognitive ability in vocabulary learning outcomes consistent with evidence of the influence of cognitive ability, but within the context of mixed evidence in the literature of the influence of cognitive ability compared to other variables such as autism severity.

4: An association between taught vocabulary learning in Part 1 and increase in non-taught vocabulary outside of the intervention context for some individuals. This either suggested an extended learning effect possibly due to enhanced attention to speech related to video modelling, or meant that something other than the intervention such as intrinsic factors to the child (e.g., cognitive ability or improvements in the child's speech sound system), were influencing outcomes.

5: Reported or observed evidence of attention/distractibility and motivation potentially having an effect on learning or fast mapping new words from video modelling consistent with predictions from the literature.

6: Generalisation of learning after video modelling across contexts and time was inconsistent amongst participants. This is however consistent with evidence of the impact of individual differences in cognitive and other abilities as discussed in the case studies and in the literature.

7: Wide variation of individual ability profiles impacting on outcomes.

5.2.1: Prevalence of sensory differences

The *Sensory Profiles* of all the participants in Part 1 demonstrated a range of definite or probable differences in sensory processing, based on parent reported information. The profile patterns were mixed, but there were some emerging group trends as described in chapter 3, in particular

inattention/distractibility, atypical sensory modulation, sensory seeking behaviour and in the auditory and multisensory modalities. This was similar in Part 2. In addition, evidence of sensory modulation difficulty and sensory seeking behaviour was associated with inattention/distractibility in most participants. Thus, difficulty with attention linked to other sensory difficulties was a consistent theme.

This high rate of prevalence of sensory differences amongst participants is consistent with the findings of Ben-Sasson et al. (2009) indicating peak rates of sensory disturbance at 6-9 years. However, the participants in the current study ranged from 3;6 to 8;11 years and high rates of sensory difference were found from aged 4 to 8 years, suggesting a high rate of prevalence may also be evident in a wider age range, including younger children. This is supported by findings from the literature review by Tomchek et al. (2014) who found higher rates of sensory symptoms in those with more severe forms of ASD and a low mental and chronological age, similar to some of the participants in this study. The findings of a high rate of atypical sensory processing are also consistent with a range of studies across different ages (Hazen et al., 2014; O'Donnell et al., 2012; Lane et al., 2010; Ben-Sasson et al., 2007; Leekam et al., 2007; Tomchek and Dunn, 2007; Baranek et al., 2006; Kern et al., 2006; Rogers and Ozonoff, 2005; Watling et al., 2001, observational video data (e.g., Baranek, 1999) and first person accounts (e.g., Minshew and Hobson, 2008; Jones et al., 2003).

The variability in atypical *Sensory Profile* trends found in both Part 1 and Part 2 is also evident in the literature, although this variation might in part be associated with the varying age, severity of autism symptoms and cognitive ability of the participants (Hazen et al., 2014; Ben-Sasson et al., 2009; Baranek et al., 2006).

The profiles of the current study were particularly similar to Tomchek and Dunn's (2007) study of two hundred and eighty one 3-6 year old children with ASD in terms of the differences found in sensory modulation, auditory and tactile processing, inattention/distractibility and sensory seeking behaviour; with

their study confirming previous evidence in the literature (Tomchek et al., 2014, Hazen et al., 2014). Reported atypical multisensory processing but not hypo-responsivity in this study, was most likely a reflection of the categories in the long version of the *Sensory Profile* used in this study rather than the *Short Sensory Profile* used by Tomchek and Dunn (2007). Furthermore, although there was strong evidence of atypical auditory processing in participants in the current study and some evidence of atypical visual processing, there was no evidence of sensory sensitivity in the participants in Part 2 and only for two participants in Part 1. This finding was at odds with that from the factor analysis of four hundred 3-6 year olds with ASD by Tomchek et al. (2014) but again this may have at least partly been explained by differences in parent report tools and participant characteristics. In addition, Tomchek et al. (2014) in their narrative review, found wide variation amongst studies. The two children who did have definite differences in sensory sensitivity in the current study also had the lowest spoken vocabulary scores on the *OCDI*, yet another participant who also had a low baseline expressive score on the *OCDI* did not demonstrate atypical sensory sensitivity. However, this participant was of similar cognitive ability to one of the two participants with sensory sensitivity but not the other. Such dissociations indicate that there was no specific reason to account for the lack of sensory sensitivity found in the current study other than overall individual variation.

The findings from this study of a high level of atypical auditory processing are highly consistent with a range of evidence in the literature from both reported (Tomchek et al., 2014; Tomchek and Dunn, 2007) and experimental findings, e.g., Haesen et al., 2011; Russo et al., 2009; Samson et al., 2006; Lepistö et al., 2005; Alcántara et al., 2004). However, as many experimental studies have been done with older and more able children, there is a need for more evidence to confirm the findings for younger or less able children.

The current study suggested evidence of atypical sensory processing across modalities and difficulties with sensory integration, but there was less evidence of atypical visual responses. Whilst the findings of atypical cross modal sensory

processing, sensory modulation and sensory integration difficulties are consistent with most of the literature (e.g., Lane et al., 2014; Kern et al., 2006; Iarocci and McDonald, 2006), limited evidence from parent report of atypical visual processing at group level compared to other modalities, contradicts the literature (See reviews by Hazen et al., 2014; Tomchek et al., 2014). However, Alcántara et al. (2012) reported in their study of 248 children with ASD that use of the sensory item on the *Autism Diagnostic Interview - Revised* (LeCouteur et al., 2003b) indicated more frequent reports of positive visual but negative auditory sensory symptoms along with rare cross modal features, confirming variability. In addition, two out of six participants in Part 1 and two out of eight participants in Part 2 did demonstrate a definite difference in visual processing and there was evidence of atypical modulation of visual input, indicating typical visual processing was a group rather than individual finding. Differences at group level between the current study and other findings may have again been a function of measurement, since this study used the long version of the *Sensory Profile* whereas most studies use the short version which conflates auditory/visual sensitivity as one category containing only 3 items on visual processing. Furthermore, Tomchek et al. (2014) found wide variability within the auditory and visual sensitivity factor, but more consistent evidence of poor auditory filtering. Other explanations might be that the *Sensory Profile* taps different aspects of visual processing from some experimental evidence (for instance Samson et al.'s 2012 meta-analysis of neuroimaging studies of face processing) or because some of the children in this study differed by age, ability or phenotype (Kern et al., 2006). In addition, as this study did not measure eye gaze or more detailed aspects of visual processing, it is equally possible that atypical visual processing was present in participants, but simply not highlighted by parent report. Thus, comparisons of the findings from this study with evidence from the literature on visual processing must be tentative, although cross modal and sensory integration difficulties in ASD are well supported.

The question arises as to what extent might the rate of sensory differences found have been explained by the low cognitive ability of some of the participants? Wiggins et al. (2009) found that children with ASD did not differ from those with developmental delay in terms of under responsiveness, low

energy, movement preoccupation, auditory sensitivity and visual sensitivity. Also, as in the current study, there was wide variation in auditory and visual sensitivity although auditory filtering difficulties were common. However, in line with results from Part 1 where there was no clear association between cognitive ability and sensory profiles, Joosten and Bundy (2010) also found that there was no clear association between cognitive ability and sensory profile data when comparing children with ASD and an intellectual disability and children with just an intellectual disability. The lack of association between sensory profiles and cognitive ability is also supported by the findings of Lane et al. (2014). Together, these findings suggest that sensory differences cannot wholly be accounted for by cognitive ability or vice versa. Nevertheless, this assertion must be exercised with caution for the current study, since assessment of cognitive ability was not standardised for the age and diagnosis of participants.

Overall the high rate of atypical sensory profiles and variability found in the current study are consistent with the literature, although visual processing differences were less than expected. However, although there is now widespread agreement of the high frequency of atypical sensory processing in ASD for older children and adults, the evidence base in younger and less able children is still limited. Furthermore, as both this study and other studies report data differently or use different versions of the *Sensory Profile*, further epidemiological and neurophysiological evidence using consistent methodology is required to confirm any hypotheses of specific sensory profiles which might be expected for different age groups and abilities of children with ASD.

5.2.2: Association between sensory differences and vocabulary outcomes

There was some evidence from this study that sensory differences may have had an effect on intervention outcomes, but no clear association. As described in chapters 3 and 4, the most likely factor to have impacted on outcomes was attention, although sensory differences in a wide range of modalities was also a negative influence. Other common sensory differences such as atypical sensory modulation and sensory seeking behaviour, may have impacted on attention,

although were not obviously linked to outcomes themselves. Overall, most children benefitted from video modelling across conditions despite the high level of sensory differences, unless four or more sensory modalities were affected including auditory and multisensory processing. This suggests that a high level of wide ranging sensory differences is more likely to impact negatively on vocabulary learning from video modelling than where less sensory modalities are affected. Further research is required to support or refute the impact of sensory differences on video modelling. To the researcher's knowledge no studies have directly compared the range of differences across sensory modalities with word learning outcomes from a video modelling intervention

In Part 1, the results suggested that sensory differences may have impacted on vocabulary learning, but the nature of the impact varied. Attention difficulties presented as the strongest influence overall taking into account parental diary information and *Sensory Profile* data. There was also an association between high levels of sensory modulation difficulty and inattention/distractibility, but the association between sensory seeking behaviour and inattention was less clear.

In Part 2, there was also evidence of fast mapping in response to video modelling intervention across conditions for all participants despite a high level of sensory difference. There was however only limited association between sensory profile patterns overall and intervention outcomes, although some group trends emerged. Firstly, most participants had definite or probable differences in auditory and multisensory processing and sensory modulation affecting emotional responses. Thus these sensory differences did not appear to significantly impede fast mapping overall in response to video modelling, although there was no comparison data available in this study including children with ASD who had minimal sensory differences. However again, although participants were able to benefit from video modelling despite having a number of sensory modalities affected, those with four or more modalities demonstrating a definite difference including auditory and multisensory processing, did not learn to fast map any taught expressive vocabulary after video modelling. Secondly, all but one participant fast mapped receptive taught vocabulary, although even this participant did demonstrate an increase in expressive

vocabulary. Interestingly this participant also had the least sensory differences across modalities. However, there was some evidence of inconsistency in vocabulary use and the case profile suggested a tendency towards echolalia without corresponding understanding, which may also have contributed to the lack of receptive taught vocabulary improvement. Thirdly, individual case profiles highlighted the role factors such as the increased visual and auditory attention to vocabulary modelling associated with the video may have played in fast mapping outcomes given the high levels of sensory differences and reported difficulties with attention outside of video modelling.

In summary, this study suggests that sensory differences may have contributed to, but did not impede vocabulary learning from video modelling unless there were differences across a wide range of sensory modalities including auditory and multisensory modalities, when vocabulary learning or expressive fast mapping was less likely to occur. This finding is consistent with evidence in the literature of the negative impact of atypical multisensory processing on speech perception in children with ASD (Foxy et al., 2013; Irwin et al., 2011; Smith and Benneto, 2007). Furthermore, attention difficulties presented as a key factor likely to have influenced outcomes. Understanding the extent of this influence would be supported by objective measurement of attention during vocabulary learning or fast mapping in addition to observational or reported evidence. The suggested influence of attention/distractibility on outcomes in the current study concurs with the literature highlighting the importance of attention in early vocabulary learning in ASD (e.g., Whitehouse and Bishop, 2008; Dawes and Bishop, 2009). Tenenbaum et al. (2014) recommend that the relative influence of attention difficulties vs. atypical multisensory integration requires further research.

To the researcher's knowledge, no study has directly compared information from sensory profiles with fast mapping or early vocabulary learning from video modelling. However, there is a range of literature which examines the effect of unimodal or cross modal sensory differences on speech perception and word learning. For instance, Haesen et al.'s (2011) review highlights auditory

processing differences which might impact directly on word learning or downstream on multisensory processing and similarly, for visual processing (Amso et al., 2014). Walton and Ingersoll (2013), Luyster and Lord (2009) and McDuffie et al. (2006) and Parrish-Morris et al. (2007) all found that gaze ability affected early word learning in children with ASD. Norbury et al. (2010) found that deficits in multisensory integration of social, semantic and phonological information reduced the ability of children with ASD to make effective use of social contextual clues when learning new words. Foxe et al. (2013) found that high functioning children with ASD aged 5-12 years have severe difficulties with multisensory integration of speech in background noise when required to identify audio visual presentations of words compared to auditory only or visual only presentations in noise

Overall, the evidence from the literature suggests that sensory differences may act as a barrier to word learning in natural contexts without additional intervention and support, resulting in limited vocabulary or learning by atypical routes. Evidence on effective interventions to promote early language and communication in children with ASD is limited and likely to depend on individual differences (Kasari et al., 2005) but there is agreement on some important positive influences in improving areas of difficulty such as parent-child synchrony and shared attention (Green et al., 2010). Although the current study highlights positive benefits of video modelling for word learning by potentially ameliorating some effects of atypical sensory processing, arguably Green et al.'s (2010) use of video to increase parental awareness of their own interactive style during live modelling, compliments rather than contradicts the benefits of video modelling vocabulary. Improvement in parent-child synchrony as a result of awareness training is likely to consolidate early word learning and facilitate generalisation of words learnt. The current study highlighted difficulties with generalising learning from video modelling for some individuals.

The varying vocabulary learning outcomes of the current study add to the existing literature on sensory differences and their potential impact on vocabulary learning. Study outcomes highlight the potential interaction between heterogeneous sensory and language profiles in ASD, although there was

limited evidence of associations between specific profiles and vocabulary learning. The results of this study argue against any one approach to language intervention, but highlight the importance of considering sensory profiles in determining intervention approaches. However, the frequent evidence of multisensory, auditory filtering and attention/distractibility difficulties found in this study, suggests that an intervention such as video modelling that reduces the negative impact of such differences, is likely to be beneficial for at least some children with ASD.

5.2.3: The impact of cognitive ability on taught vocabulary learning

As cognitive ability was only assessed in Part 1, this section does not refer to the fast mapping outcomes in Part 2. Three out of four of the children (75%) in Part 1 who demonstrated an increase in taught vocabulary, also exceeded the minimum cognitive ability range of 18-24 months on the *Bayley-III Scales of Infant and Toddler Development Screening Test: Cognitive subtest* (Bayley, 2006), corroborated by scores on the *Symbolic Play Test* (Lowe and Costello, 1988). In addition, of the two children who did not learn any vocabulary, both only reached the minimal inclusion criteria of 18-24 months on the aforementioned *Bayley III Scales*. There was also only a minimal association between baseline vocabulary and taught word learning post intervention, suggesting this was not a confounding variable. Therefore the results suggest that cognitive ability is likely to be an important consideration when planning the use of a video modelling intervention. However, the measures of cognitive ability used in the current study were not standardised and only gave limited information as to which aspects of cognition might be important. The results are consistent with evidence such as Kjellmer et al. (2012) who found that expressive and receptive language ability in children with autism is mainly related to cognitive ability and Norrelgen et al. (2014) who found that the most important determinant of expressive language of 4-6 year old children with ASD was cognitive ability. Similarly, Ellis Weismer and Kover (2015) found cognitive ability predicted expressive language in preschool children but in contrast to Thurm et al. (2015), found autism severity predicted expressive and receptive

language. Kuhl et al. (2013) have also highlighted the predictive power of differences in word processing from ERP data superseding cognitive ability. Hence, there is a need to explore the importance of cognitive ability further using standardised cognitive testing. Evidence from Thurm et al. (2015) on the impact of autism severity on expressive and receptive language, suggests that it is also important to incorporate a measure of autism severity.

5.2.4: Association between taught vocabulary learning in Part 1 and overall vocabulary learning

Two out of the six participants in Part 1 had vocabulary learning spurts coinciding with the intervention. In the results chapter, the question was posed as to whether the video modelling intervention was in some way linked to this significant increase in vocabulary? Did the vocabulary spurt influence the outcomes such that these children were at a point of readiness to learn new words regardless of the intervention? Alternatively, did the intervention in some way help to precipitate the increase in overall vocabulary, perhaps by increasing interest and attention to vocabulary modelling generally? Interestingly, both these participants exceeded the minimum cognitive inclusion criteria and also had a speech sound difficulty, which was reported to have improved over the course of the intervention. It is not possible from the evidence available to say that the video modelling intervention caused a reduction in the speech sound difficulties, but the high level of interest in the video modelling may have increased attention to speech, which in turn may have supported listening and imitation. This may have been particularly helpful given the reported difficulty with attention, sensory modulation, auditory and multisensory processing for both participants.

Of the two participants who had vocabulary spurts, the participant allocated to the live vs. video modelling condition learnt to say both taught words from the video modelling along with a small increase of both expressive and receptive non-taught words. There was also an increase in expressive vocabulary reported by parents at follow up. The other participant increased his overall

receptive and expressive vocabulary significantly, although interestingly his expressive vocabulary of 19 signs remained constant. He also learnt to understand and name both taught words from the quiet video modelling and background noise video modelling conditions. Thus video modelling was associated with both spoken and receptive vocabulary improvements. As highlighted in the case profiles, a number of interacting variables may have contributed to the improvements, but these results suggest that children with a speech sound difficulties and ASD can benefit from video modelling. This is important given the range of difficulties such children face in developing spoken language.

A further participant learnt additional non-taught vocabulary that was repeated more often in the videos than the taught vocabulary words, suggesting that for at least one participant, frequency of repetition was an important factor. All the children were exposed to the taught vocabulary a similar number of times, but outcomes varied. This suggests that frequency of exposure might have combined with other variables such as sensory or cognitive differences to affect outcomes for this participant. However, see Yu and Smith (2012) for evidence suggesting that frequency of exposure in itself does not necessarily influence early word learning in children.

Hence learning of additional non-taught vocabulary in the three participants discussed is likely to have been influenced by a range of factors depending on each of their unique profiles. Video modelling may have played a role in facilitating overall vocabulary learning in some children by increasing attention to speech modelling or alternatively intrinsic factors within the child may have increased vocabulary learning regardless of the mode of intervention. Further research is required to explore this in more detail.

5.2.5: The role of attention and motivation in successful word learning from video modelling

The findings from both Part 1 and Part 2 suggest that attention/distractibility and motivation were important factors influencing outcomes, although this

suggestion would be strengthened by further objective evidence such as eye gaze or EEG data. The findings are consistent with studies highlighting the importance of top down attention processes in word learning for children with ASD, e.g., Whitehouse and Bishop (2008). Dawes and Bishop (2009) suggest that auditory perceptual abnormalities in ASD may be attributable to a speech-specific, post sensory impairment associated with attention orienting. In addition, the narrative review of neurophysiologic research by Marco et al. (2011) suggests that auditory processing deficits in ASD are attributable to factors such as limited auditory attention as much as impairments of auditory encoding or discrimination.

The overall findings from the current study are consistent with evidence from the literature describing components of attention which are important in children's early word learning such as; interest and motivation (Mineo et al., 2009), joint attention, i.e., the ability to look where someone else is looking or direct another person's attention to something (Korhonen et al., 2014), attention to relevant social cues such as gaze following and pointing (Brooks and Meltzoff, 2008; Mundy et al., 2007; Brooks and Meltzoff, 2005) and attending to and making the correct association between objects and simultaneous word labels across contexts (Bion et al., 2013; Smith and Yu, 2008).

So why did the video modelling result in increased motivation and attention to vocabulary modelling for most participants? In addition to limiting sensory modulation demands, the repetitive structure of the video and restricted attention focus, may have helped to accentuate the link between the spoken word and its referent. Furthermore, the reduced social demands during video modelling may have lowered anxiety and the overall processing load, contributing to the successful outcomes. The following sections will discuss possible contributory factors in detail.

Interest and motivation

Parental diaries suggest that in addition to observational evidence in Part 2, participants in Part 1 were also motivated by the videos. All families were

instructed to cease the video modelling if their child had lost interest. The number of occasions when this was the case was by far outweighed overall by the number of occasions when the child was motivated. Three out of six participants wanted to watch the videos each time they were offered, two participants sometimes did not want to watch the videos but this coincided with periods of tiredness or illness and one participant declined when presenting as distractible. The three participants who were most motivated to watch the videos all learnt vocabulary from video vocabulary modelling. All participants wanted to watch the videos more often than not. High motivation to watch the videos may have been at least partly because the children were presented with toys that their parents had highlighted as motivating. The novelty of the toys may also have contributed. It is difficult to compare motivation for live presentation of the toys vs. video presentation since there were only two participants allocated to these conditions. There was tentative evidence associating higher motivation for the video than live presentation correlating with more word learning in the video condition for Participant 2, but no word learning in either condition associated with equal levels of disinterest in both conditions for Participant 1. In addition, participants were only selected for inclusion if they were able to attend to the videos for the minimum time necessary to participate, hence increasing the likelihood of motivation by the video presentation.

There may also have been some intrinsic properties of the videos which motivated the children to attend. Several studies have highlighted the motivating effects of video in children with ASD (e.g., Charlop et al., 2010; Mineo et al., 2009; Corbett and Abdullah, 2005; Nikopoulos and Keenan, 2003). One theory accounting for the increased motivation learning from videos might be that focussing on a screen is less anxiety provoking for individuals with ASD than learning through a live interaction (Hailpern, 2012). Alternatively, the decreased social demands of video modelling within the context of difficulties with social reciprocity in ASD (e.g., White et al., 2007), may have enabled increased visual attention (Cardon and Azuma, 2012). Finally, specific aspects of how the videos were filmed and edited to create maximum interest may have been significant, such as the use of an introductory song, no background

distractions, presentation of toys close to the actor's face and the actor's presentation style.

With regard to presentation style, the actor directed her speech as if talking to a child, with a relatively slow rate and combined with some exaggeration of speech contours as commonly found in child directed speech (CDS) (Kuhl et al., 2005). However, since use of this speech style was not accurately measured in the current study, any impact of this speech style in the current study must remain speculative. As noted in section 5.1.1, there is evidence that children with ASD have a reduced preference for CDS compared to typically developing children (e.g., Watson et al., 2012). Kuhl et al. (2005) also demonstrated that children with ASD often prefer analogue non-speech sounds to CDS. However, there is limited evidence of responses by children with ASD to CDS speech vs. other human speech forms (Cassel et al., 2014; Mahdhaoui et al., 2011). Differences in adult speech style may have contributed to outcomes when comparing live vs. video modelling conditions in Part 1, but this cannot be proved on the evidence available. Further research on the effects of using different speech styles with children with ASD of different ages and abilities is required to inform benefits and disadvantages of use in a video modelling context.

Joint attention

Several studies have highlighted the importance of joint attention in early word learning in typically developing children and the difficulties with joint attention in some children with ASD. Joint attention difficulties (i.e., difficulties with synchronised coordinated visual attention where there is awareness that the other person is attending to the same thing) are frequently found in young children with ASD (e.g., Murray et al., 2008). However, as the systematic review by Korhonen et al. (2014) highlights, joint attention may be intact in some children with autism, depending on individual characteristics of the participants, the task and context.

The use of video in the present study manipulated the context of joint attention for both the children and adults. Based on observation and parent report, most

children were attracted immediately to the video presentation for at least a short period as the toy was named and often for the duration of the toy naming repetitions. The actor's face in the video was filmed next to and looking at the named toy with no other visual distracters on the screen, potentially increasing the association with the word compared to more ambiguous environments, thus reducing the need for reliance on joint attention cues and making it easier to follow the actor's gaze direction to the toy.

Therefore potentially increased coordination of visual and auditory attention between the actor naming and looking at the toy and visual attention to the toy, may have supported word learning word in Part 1 video conditions and Part 2 overall. In addition, this potential increase in attention between the actor naming the toy and the toy, may have supported word learning in the video condition in Part 1 compared to the play condition for Participant 2, although there was no evidence of this in Participant 1.

The current study would have benefited from use of eye tracking technology to more precisely measure the children's visual attention in word learning. The study by Gliga et al. (2012) used this technique in looking at word learning in infants at risk of autism. They studied three year old children at high risk for ASD compared to low risk controls. However, Gliga et al. (2012) found that although the ability to follow eye gaze was an essential prerequisite to receptive word learning in the high risk children, it was insufficient to enable learning without the child also being able to infer meaning from the non-verbal cues. It is possible that in the current study as suggested by Lindsay et al. (2013), the restricted focus of the video selectively focussing the child's attention on the toy and the adult's face whilst excluding background distractions, may have helped the children infer the correct meaning of the word.

Looking at preschool children with ASD, Wilson (2013) compared visual attention in live vs. video modelling of social communication behaviour. Wilson found that attention to video modelling was greater than live modelling in three out of four participants, although positive visual attention did not always

coincide with positive learning outcomes. There is also evidence that children with ASD show joint attention difficulties associated with problems using mature strategies to fast map new words. For instance, Walton and Ingersoll (2013) found that typically developing toddlers can accurately follow where the adult is looking and fast map the names of objects, but children with ASD mis-map new words to what they are attending to. The typically developing children in the study fast mapped receptive words in all conditions, whereas the children with ASD mis-mapped words to the focus of their attention but tended to correct when they had an orienting cue. In the current study, adult direction to attend to the videos may have acted as an orienting cue supporting receptive word learning in the four out of the six participants who learnt receptive target words after video modelling in Part 1 and the seven out of eight participants in Part 2.

In the expressive trials in Watson and Ingersoll's (2013) study, there was more learning in both groups where the adult followed the child's focus than when the adult labelled their own attention focus. In the current study, the children were required to follow the adult's focus, albeit supported by the video. This may have contributed to the lower rates of expressive word learning, i.e., two out of six and five out of eight participants in Parts 1 and 2 respectively. Furthermore, the actor's attention focus switched between looking at the toy (to cue the word referent) and the camera, but as the video was pre-recorded, could not be adapted to take account of the child's attention. Thus in this sense, shared attention was not possible. Yu and Smith's (2012) study on embodied visual joint attention is also important in the contexts of findings from the present study in that it suggests a link between sensory motor behaviour and visual attention in early word learning. Yu and Smith (2012) found that the movement of the children actively influenced opportunities for joint attention.

Findings from the above studies predict that if the child's sensory motor learning is disrupted, as found in the Sensory Profile evidence in the current study, this might actively reduce the opportunities a parent has for effective word modelling in natural contexts and thus reduce word learning. In addition, even where the adult enables the child to follow their eye gaze, Gliga et al. (2012) suggest

children at risk of ASD might still have problems using these cues to learn correct word associations.

Cardon and Azuma (2012) suggest that key aspects of video modelling might reduce the impact of attention difficulties found in children with ASD by increasing visual attention span. They found that typically developing children looked and therefore potentially attended longer to both a live and video presented puppet show than the children with ASD and both groups attended longer to the video. In addition, the children with ASD showed a distinct visual preference for the video presentation, despite no additional adult cues to focus attention. However, Watson et al. (2012) found that children with ASD did not attend less to video than live presentations, just less than language matched controls, potentially reducing language learning opportunities but not supporting video compared to live modelling.

The observed and reported evidence in the current study of greater than expected attention to the videos (in the light of reported attention difficulties) support findings of Cardon and Azuma (2012) rather than Watson et al. (2012) and are consistent with the findings of a distinct preference for television viewing in children with ASD (e.g., Nally et al., 2000). However, as visual attention was not systematically measured in the current study, future research is required to verify the role of attention to video vs. live presentation. Cardon and Azuma (2012) cite Corbett and Abdullah (2005) in questioning whether the visual attention preference to video is because the screen helps the children focus their attention by limiting the impact of other distractions present in live presentations and thus increasing attention between the word and its' referent. As discussed earlier, this may have also been the case in the current study.

Visual attention effects on outcomes of the current study might be investigated by repeating the study using head cameras or other eye gaze technology to measure child and adult eye gaze in the video vs. non-video conditions in Part 1 and relative attention to the toy referent and actor's face in the video in both parts of the study. This is discussed further in the next section.

Relative visual attention to faces and objects

There was no measure of visual attention to objects vs. eyes or faces in the present study, other than general comments in parental diaries in Part 1, although as stated earlier, adding such measures in future research would deepen understanding of the outcomes. Tenenbaum et al. (2014) explored the influence of different patterns of attention to faces and objects on early word learning in 2-5 year old children with autism, language matched typically developing children and language delayed children. They found that more attention to the speaker's mouth was associated with higher scores on standardised language assessments in typically developing children and children with autism, but not language delayed children. The effect varied with age and cognitive ability in typically developing children. However, this was not the case for the children with autism. Furthermore, attention to the speaker's mouth and eyes whilst she was saying the novel words predicted faster word recognition in the children with autism. The authors suggest that atypical social attention may be a key factor in children with autism and delayed language. The lack of impact of age and cognitive ability on the findings of Tenenbaum et al. (2014) for children with autism is interesting in the light of the results of the present study and varying ages and cognitive ability. As lower cognitive ability, but not age was associated with less word learning in Part 1, it would have been interesting to see if this also correlated with less attention to the actor's mouth and eyes.

Although the current study did not investigate the relative influences of visual attention to the object vs. the speaker's mouth or eyes, evidence of attention, perceptual and sensory modulation difficulties from the *Sensory Profiles*, highlighted potential for disruption in the necessary components for making an association between a word label and its referent. Such difficulties may have disrupted the child's ability to make use of social cues such as eye gaze to connect the word with the correct referent and also potential account for some of the delay in early word learning at baseline.

Evidence in the literature from typically developing children highlights the importance of changes in relative attention to the speaker's eyes vs. mouth in addition to attention to the named object, at different stages in development

(e.g., Lewkowicz and Hansen-Tift, 2012). This differs in children with ASD in that attention to speaker's eyes compared to their mouth, is reduced at critical stages in development in comparison with typically developing children. In addition, the positive effect on language of attention to the mouth does not change with age and cognitive ability in children with ASD as it does in typically developing children.

Typically developing infants early in their language development focus their attention on the speaker's mouth (e.g., Lewkowicz and Hansen-Tift, 2012; Frank et al., 2012; Nakano et al., 2010) integrating sensory information about the word and how it is produced, whereas later, they also attend to the speaker's face and eyes (Lewkowicz and Hansen-Tift, 2012; Nakano et al., 2010), getting information about what the speaker is talking about, who to and the social-emotional context. Typically developing infants who attend to the speaker's mouth early in infancy have a larger vocabulary as toddlers (Young et al., 2009). It is suggested by these authors that this is because the infants can use visual information alongside auditory cues to process speech, integrating audiovisual information.

Any disruption to the processes discussed above such as that which may arise from the atypical sensory processing found in participants in the current study, has the potential to result in language delay and difficulties with word learning (Stevenson et al., 2014a). As to which factors are paramount in early word learning in children with autism and how these differ from typically developing children is the subject of debate. Chawarska et al. (2012) suggest that for children with autism, reduced attention to the mouth and faces is associated with atypical language development. Jones and Klin (2013) suggest that although infants who go onto develop autism focus their attention on the mouth early in their development, they attend less to the eyes than typically developing infants as they get older. Disruption of audiovisual integration in ASD (Fuxe et al., 2013; Collignon et al., 2013; Mongillo et al., 2008; Smith and Bennetto, 2007) is likely to affect speech perception and thus early word learning in children with autism. However, further evidence on audiovisual integration in young children with autism is required to explore whether poor attention causes

poor audiovisual integration or vice versa (Tenenbaum et al., 2014). Of particular interest from the current study are the outcomes from asynchronous vs. synchronous video modelling in Part 2. The asynchronous condition produced more evidence of fast mapping expressive vocabulary. This may have been because the participants did not attend to the asynchronous visual cues, attaching more importance to the auditory cues.

Summary of the impact of attention on word learning

The current study found frequent evidence of inattention/distractibility in participants, from *Sensory Profiles* data and supported by observation and parental diary information. In addition, video modelling was associated overall with reported and observed increased attention to the learning context and motivation and positive outcomes on vocabulary learning. Thus although it is not possible to say that increased attention and motivation watching the videos increased vocabulary learning, within the context of the literature, this is a possible explanation.

Further research is required to understand how specific aspects of auditory and visual attention (e.g., attention orienting, shifting attention, joint and shared attention, social vs. object attention, multisensory attention and attention span) relate to early word learning in children with ASD taking account of their unique sensory differences is required. This is particularly important in understanding how intervention might best be tailored to support attention to and integration of salient information when young children with ASD learn new words.

5.2.6: Generalisation of word learning

Whilst there was good evidence of video modelling improving fast mapping in Part 2 and word learning in Part 1 for most participants, there was some evidence in Part 1 that this was not generalised over time or contexts for some children, supporting predictions from Norbury et al. (2010). However, Hani et al. (2013) reported that children aged 3-6 years with ASD could learn to generalise new words using enhanced social cues and a relatively constrained learning

context, but recommend further research looking at generalisation over time and form and in less constrained settings.

It is not clear from the evidence available which factors were helpful in enabling generalisation of learning into functional communicative contexts. However, lack of generalisation was consistently associated with low baseline vocabulary, significant sensory processing difficulties and reduced attention. Autism severity and low cognitive ability reducing the influence of top down processing, may also have limited generalisation. There is evidence highlighting the influence of these factors on language growth in preschool children with ASD (Ellis Weismer and Kover, 2015).

In the two participants who demonstrated repetition but not spontaneous naming, there was some indication that low cognitive ability may have been a negative factor for one participant. However both participants had significant sensory processing differences including poor attention and low baseline vocabularies, which are likely to have contributed to limited generalisation. Limited baseline vocabulary and low cognitive ability were also factors for another participant who did not maintain expressive taught vocabulary learning at follow up, although learning of non-taught words with a higher repetition rate from the video was maintained. Understanding better which factors promote generalisation of learning from video modelling, or whether indeed video modelling is an inappropriate intervention for children with ASD who also have significant sensory processing difficulties, low baseline vocabularies and cognitive ability, is an area requiring further study. The following studies discuss some important considerations.

Studies of both live modelling (Charlop et al., 1983) and video modelling (Charlop et al., 2010; Nikopoulos and Keenan, 2004) in individuals with ASD, demonstrate that both can result in generalisation across contexts and be maintained over time. However, while some studies specify multifactor generalisation such as time, context, people or objects, e.g., Charlop-Christy et al. (2000), this is not always the case. The current study only looked at retaining learning over time and whether learning was transferred from the video to a picture assessment compared with parent report outside of the assessment

context. There was no opportunity in the current study to measure other aspects of generalisation which would help to further understand this important variable.

In support of the potential impact of individual participant differences on the generalisation of word learning, there is evidence from the literature on typically developing children and children with ASD, that variation in different abilities impacts on generalisation. For instance, Smith and Yu (2008) demonstrate that the ability of typically developing children aged 12-14 months to link a word with the correct referent not only depends on the attention, linguistic, social and representational limitations of the word learning context, but also on the child's ability to evaluate the evidence across several contexts. Bion et al. (2013) also suggest that the ability to select a novel object rather than a familiar one on hearing a new object name in an ambiguous context increases over time from 18 to 30 months in typical development. They assert that word learning is a gradual process and depends on the child making use of cross-situational, semantic, pragmatic and social cues.

Comparing generalisation of learning from live vs. video modelling in children with ASD, Charlop-Christy et al. (2000) discuss the importance of task complexity and participant ability. They question whether their finding of a lack of generalisation after live modelling was because the skills they targeted were relatively complex and the children had a range of ability levels. The participant cognitive ability level and vocabulary learning task in Part 1 of this study were similar to that of Charlop et al. (1983) who did find generalisation after live modelling. However, contrary to what might be expected from Charlop et al. (1983), but consistent with Charlop et al. (2010) and Charlop-Christy et al. (2000), the participant who learnt taught vocabulary after intervention from video rather than live modelling, was reported by parents to have maintained this at follow up. Yet in support of Charlop et al. (1983), the participant was also reported to have learnt the vocabulary from the live condition that was not evident on assessment immediately after intervention. It is not clear from the parent questionnaires what might have contributed to this delayed learning. Charlop et al. (2010) point to the importance of specifically training generalisation after video modelling.

Further evidence which might explain why some children did not generalise their word learning might be explained by the theory put forward by Norbury et al. (2010). As noted in section 5.1.1, they suggest that even where children with ASD use social cues to orient their attention to the referent, they are more likely to learn words through associative learning of the referent with phonological cues than integrate semantic and phonological cues to support understanding which is retained over time. This may also have been a factor explaining the expressive fast mapping advantage for asynchronous audiovisual presentation.

Thus generalisation of learning after video modelling across contexts and time was inconsistent amongst participants in the current study, consistent with evidence of the impact of individual differences in cognitive and other abilities as discussed in the case studies and in the literature. Therefore it would seem to be critical to take account of such differences in developmental profiles when practitioners consider using video modelling to support vocabulary learning in children with ASD. Furthermore, the learning context of the vocabulary modelling using video (divorced from a social interaction context) in conjunction with individual developmental profile differences (particularly for those with lower cognitive ability), were likely to have been salient variables in why some children did not generalise vocabulary learning. Lack of generalisation is important as this is a known area of difficulty for children with ASD (Plaisted et al., 2001). Extending the work of Hani et al. (2013) using cues to teach generalisation, might be a useful way forward, combining the benefits of video modelling with techniques associated with more sustained and generalised learning.

5.3: LIMITATIONS OF THIS STUDY

Both Part 1 and Part 2 primarily tapped associative word learning as the picture based assessment did not require the children to demonstrate a wider understanding of word meaning, although there was some limited evidence from parent report in Part 1 that some children had generalised their

understanding. However, there were no controls on additional factors after the intervention which might have contributed to this.

As highlighted earlier, case study material is important in the insights it can give, but also has its limitations, e.g., small sample size. This study was also constrained by practical considerations limiting generalisation of the findings including; participant variables, stimuli, contextual and time limitations, and reduced use of standardised assessments. In particular, use of a measure of autism severity and an age appropriate standardised cognitive assessment in Part 1 would have strengthened the findings on the impact of cognitive ability. However, the variable attention, low abilities and ages of the participants and lack of assessments standardised on an ASD population may still have compromised validity of the scores. Additional information on the nature of the speech sound difficulties in relevant participants would also have aided interpretation of the results.

This study relied heavily on parent reported information which may have been subject to bias, although the parent report tools used were either tools used frequently for this population in other studies or in the case of parent questionnaires, piloted and checked on interview.

Additional controls such as use of eye gaze measurements in Part 2 would have helped reduce to potential confound of variations in visual attention which might have accounted for some within group differences. However, further controls would still be needed for auditory attention and whether direction of eye gaze accurately reflected attention to the vocabulary target. Accurate objective measurement of attention would be easier within a laboratory setting rather than the functional learning contexts in the present study chosen for their ecological validity. Previous research discussed (e.g., Wilson, 2013) predicts that visual attention is likely to be variable but better in video than live modelling in this population, in line with observed and reported information for most of the participants.

The words selected as stimuli were chosen to increase ecological validity and have similar familiarity in terms of words young children are likely to have been

exposed to, whilst controlled as far as possible for phonological structure. However, the fact remains that there were some variations in phonological structure in both experimental and control vocabulary which may have particularly impacted on the participants with a speech sound disorder. In addition, it was not possible to control for potential differences in individual exposure to the words prior to the study or potentially during the experimental period in Part 1. This may have confounded the results given evidence of the influence of familiarity on word learning (Houston-Price et al., 2005). However, it is unlikely that unfamiliarity with screen based presentation was a confounding variable since all the children were assessed for this at recruitment.

5.4: IMPLICATIONS FOR THE THEORETICAL UNDERSTANDING OF AUTISM

The atypical responses to audiovisual asynchrony and wide ranging sensory differences found in this study lend support to theories of autism implicating Weak Central Coherence (Happé and Frith, 2006) and Enhanced Perceptual Function (Mottron et al., 2006). In addition, evidence of difficulties with attention and atypical responses to asynchronous presentation, may have been indicative of poor amodal processing (i.e., processing features such as rhythm, synchrony, tempo and intensity, which are not associated with a particular sensory modality) as suggested by Bahrick and Todd, 2012). Although the sensory profile data was suggestive of cross modal differences, examples of dissociation argue against a cross domain hypothesis for all individuals, but rather support variation in sensory processing differences across ASD phenotypes, consistent with studies such as Tomchek et al. (2014). However, methodological limitations in this area of research imply caution when making such interpretations.

The results also support a multisensory integration deficit in ASD, although whether this is the result of an extended multisensory temporal binding window (Stevenson et al., 2014b; Woynaroski et al., 2013; Foss-Feig, et al., 2010; Kwakye et al., 2010) is less clear. The positive effects of video modelling may

have been because the video acted as a cue to attend to global as well as local cues and reduced the impact of the attention difficulties reported in other contexts. This in turn supports Koldewyn et al. (2013) and Happé and Frith (2006) and in their theory that poor global processing is a disinclination rather than deficit. However equally, the lower processing load in video modelling may have reduced the global processing demand, thus enhancing success. Further evidence is required looking at the effects of the task and task context on individuals of different ages and abilities within the autism spectrum.

5.5: CLINICAL IMPLICATIONS FOR EARLY WORD LEARNING INTERVENTIONS IN YOUNG CHILDREN WITH ASD

The results of the current study are consistent with a range of evidence in the literature supporting the benefits of video modelling for language and communication in children with ASD (e.g., Wilson et al., 2013; Charlop et al., 2010; Shukla-Mehta et al., 2010; Rayner et al., 2009), although evidence on use of video modelling to support early word learning in young children with social communication difficulties and ASD is limited (Shepley et al., 2014; Wert and Neisworth, 2003). However, a review of evidence based practise on treatment of ASD (National Autism Center, 2015,) concluded that modelling including video modelling was an established treatment for communication in children with ASD, i.e., there is sufficient evidence that modelling is likely to be an effective treatment. In addition, Wong et al. (2015) concluded in their systematic review of 456 studies, that video modelling met the criteria for evidenced based practice for communication in 0-5 year olds with ASD, although this was primarily based on single case studies.

Given that advances in technology and an increase in the use of portable screen devices now means that young children with ASD are often exposed to a range of screen based media on a regular basis, it is important to examine potential benefits or drawbacks for learning. A potential clinical implication of the findings of this study might be to develop the findings of Cardon (2012). Cardon (2012) found that it was possible to teach caregivers to implement video

modelling intervention training (i.e., video modelling with additional use of specific prompts and praise) with fidelity using an iPad after only minimal training (twelve 40 minute sessions three times a week). Furthermore, this resulted in substantial gains in imitation skills alongside varying levels of improvement in expressive language (measured with the *Preschool Language Scales-5*, Zimmerman et al., 2011) in four children with autism aged 2-4 years. However, this was a small study and unlike the current study, focused on copying actions named by the caregiver. Nevertheless, this use of video modelling along with positive evidence of caregiver use of video modelling from the current study, has cost effective potential to enhance existing interventions in improving early language skills in young children with ASD. This is important given the well documented difficulties that many children with ASD have in learning new words. Lending further support, Kasari et al. (2014), although not using video modelling per se, found that combining speech modelling and play using a speech generating device resulted in significant rapid improvements in spontaneous spoken language in minimally verbal children between 5 and 8 years. Future research might examine whether combining play and video modelling based interventions were similarly fruitful.

Overall, the literature suggests that video modelling does not act in the same way as live modelling of vocabulary when young children with ASD learn new words, although does offer potential benefit (e.g., Shepley et al., 2014; Shukla-Mehta et al., 2010; Charlop et al., 2010; Corbett and Abdullah, 2005). There is a range of evidence supporting the use of live modelling embedded in social interaction to increase language and communication in both typically developing children and children with ASD (e.g., Green et al.), but equally many children with ASD do not learn to talk despite opportunity to learn from naturally occurring social contexts. The results of this study cautiously suggest that use of video modelling might support vocabulary learning for some children with ASD who have had particular difficulty learning to speak by other means, including those with ASD and speech sound difficulties. However, the results also suggest that video modelling in itself may not address difficulties with generalising learning across contexts (Shepley et al., 2014; Charlop et al., 2010) or, although not assessed, reduce core difficulties with social

communication. Video modelling is likely to be most useful in developing an initial interest in learning new words where a familiar adult is also available to mediate attention and provide opportunities to support generalisation and social use of the words learnt. There was however only minimal evidence from this study to support artificially slowing speech and minimal difference in outcomes from modelling words in quiet vs. background noise within a video modelling context. This finding does not preclude potential benefits from naturally slow speech such as increasing pauses or from reducing background noise in other contexts, particularly given the evidence of atypical multisensory processing.

Arguably, video modelling as an intervention may have been successful for some children because it incorporated key factors important for learning in this population, i.e., it supported attention, linked social and non-social high interest stimuli and afforded repeated learning opportunities with synchronous multisensory stimuli whilst reducing processing demands from competing stimuli. Video modelling may also be an easier method of learning than live interventions for some children with ASD as it involves reduced social demands. Kuhl et al. (2013) suggest that atypical ERP responses in young children with ASD when processing spoken words, might reflect reduced brain reorganisation to learn from social experience compared to typically developing children.

The results of this study support the importance of a minimum levels cognitive ability, attention and motivation for children to benefit from video modelling as a learning tool, but cannot specifically predict which children will or will not benefit from video modelling. Kasari et al. (2005) highlight the importance of age, cognitive skills and language abilities on the success of interventions in ASD. Maglione et al. (2012) also found from their systematic review, that there was some evidence that greater intensity and duration of intervention led to better outcomes. With regard specifically to video modelling, Shukla-Mehta et al. (2010) state the need for further research but based on their systematic review, recommend a detailed assessment of a range of child abilities and that the child is able to attend to the video for at least one minute. They also suggest that video clips should be between 3 and 5 minutes, watched twice a day, and

include use of prompts and reinforcements to be of benefit, but do not make specific recommendations on overall intervention duration.

However, despite the above recommendations, there is currently a lack of evidence to state which specific ability levels are critical for effective use of video modelling in teaching vocabulary in young children with ASD. There is also a lack of evidence for optimum video modelling frequency and duration. Although exploratory in nature, two studies have considered factors in successful video modelling in language interventions for young children with ASD. Wert and Neisworth (2003) and Shepley et al. (2014) reported some success in 3-6 year old children with a range of language (preverbal to age to near age appropriate) and cognitive abilities (only reported by Shepley et al., 2014). In addition, the intervention used by Wert and Neisworth (2003) consisted of 5 consecutive sessions at home watching a 5 minute video self modelling tape made at school and the Shepley et al. (2014) intervention procedure consisted of 5 repetitions of each video trial per word with additional generalisation and maintenance teaching. Along with the current study outcomes, the evidence suggests that video modelling duration and intensity may not need to be high to achieve positive fast mapping outcomes across a range of abilities. However, both the current study and evidence from communication interventions such as PACT (Green et al., 2010), suggest additional intensity and duration implications for functional generalised language learning. However, such assertions can only be made with extreme caution, given the limited evidence available.

In summary, there is now more evidence suggesting beneficial effects from use of video modelling to support communication generally. However, there is a need for additional large scale methodologically rigorous studies to confirm or refute the benefits of video modelling as an intervention when used specifically to support early word learning in young children with ASD. There is also a need for more detailed information on prerequisite child abilities and age restrictions and on critical intervention characteristics such as intensity, frequency, use of prompts and reinforcements, optimum model-response time lag and duration. Most of the available evidence to date suggests that video modelling might be

most useful as an intervention tool in early word learning when used alongside other interventions supporting functional and social communication. In addition, this and other exploratory research highlights the positive role caregivers may have in using video modelling, important in terms of generalisation and cost implications.

The findings of this study also confirm evidence in the literature suggesting that sensory differences are of key importance when considering why children with ASD are successful or experience difficulties in early vocabulary learning. Furthermore, this study provides some evidence that difficulties with attention play an important role. Use of eye gaze measurements in future research would help to confirm this. The extent to which early word learning depends on unimodal, multisensory or top down influences remains open to debate, but this study lends support to previous evidence of atypical multisensory processing. This study also highlights the prevalence of atypical auditory processing in young children with ASD, an important consideration when considering preschool learning environments to support the development of language and communication in these children. Many preschool inclusive settings are busy, visually stimulating and noisy with poor acoustics. The sensory profile data from this study suggests that such sensory complex environments might have a significant negative impact on early word learning for young children with ASD without environmental adaptations (Hazen et al., 2014).

This study supports previous research (e.g., Tomchek et al., 2014) in finding significant variation in abilities amongst young children with ASD, in terms of cognitive ability, language and communication and sensory profiles and how these factors might interact to support or limit learning (e.g., Lane et al., 2014; Kern et al., 2007). Assessing these variations (in particular sensory differences) and adapting interventions to take account of differing abilities, is of key importance when considering whether video modelling or another intervention might be more appropriate.

Sensory differences are considered a key part of ASD diagnosis in the *DSM-5* guidance (APA, 2013). Basic assessment of sensory behaviours already forms part of recommended gold standard diagnostic tools, which can be used by

trained psychologists or speech and language therapists in the current multidisciplinary diagnostic team to inform a post diagnostic intervention plan (NICE, 2011). However, detailed assessment of sensory processing is beyond the professional remit of the speech and language therapist and core members of the multidisciplinary diagnostic team. Such assessment requires a highly specialist occupational therapist. The most recent diagnostic guidance (NICE, 2011) highlights the need for the multidisciplinary diagnostic team to either include or have access to an occupational therapist. There are, however significant time and cost implications for employing specialist occupational therapists with training in use of detailed sensory assessments for all ASD diagnostic assessments. Further research is required to determine the value added benefit of detailed sensory processing assessment to inform decision making about communication interventions such as video modelling for different ages and ability profiles in children with ASD.

Finally, the variation in abilities found in the current study also validates the use of case study data in research, as case studies are able to demonstrate individual and potentially significant complexities which may affect learning, but which may not be evident in large studies with heterogeneous populations. The variation in abilities in children with ASD found in this study and the literature (e.g., Tomchek et al., 2014; Hudry et al., 2010) also urges caution in generalising research findings on different interventions across this group without a detailed assessment of individual ability profiles.

Chapter 6: CONCLUSION

This study suggested that video modelling had an overall positive impact on both fast mapping and learning new words compared to non-taught control vocabulary, but was not superior to live modelling. Difficulties with generalisation highlight the need for video modelling interventions to be considered alongside more functional play based live interventions rather than in isolation.

Given the potential benefits of video modelling in the light of difficulties with visual and auditory attention and motivation often found in other learning contexts for children with ASD, this intervention may be particularly helpful in supporting young children with ASD fast map or learn new words when they are struggling to do so by other means. This study also provided evidence that video modelling may be beneficial for some young children with ASD and speech sound difficulties.

However, there was no evidence in this study that artificially slowing speech improved word learning and only minor evidence of a positive effect for one participant on fast mapping words. In addition, at a group level, there was no disadvantage from background noise on fast mapping words within a video modelling context and only a minor disadvantage from background noise for word learning. This does not however preclude benefits for word learning of minimising background noise in other contexts. This is particularly important, given research such as Foxe et al. (2013) and Irwin et al. (2011), which highlights specific difficulties with speech perception in noise associated with multisensory integration difficulties in ASD. Evidence of attention and multisensory processing difficulties in this study and the literature (e.g., Akeshi and Kobayashi, 2014; Hazen et al., 2014; Stevenson et al., 2014a) also suggests benefits from reducing background noise. However, individual profiles of abilities also need to be considered. The atypical effects on fast mapping new words from asynchronous audiovisual presentation, is indicative of a multisensory integration deficit, but the extent to which this supports recent theories of an extended multisensory temporal binding window requires further research.

There are a range of methodological difficulties, both in this study and the literature, which imply caution when drawing conclusions. However, given the inherent difficulties in researching this population and limited evidence base, this study does at least explore the subject area in depth and highlights areas where further research may be warranted, an important benefit of case studies. The findings also add to the evidence suggesting poor amodal processing in ASD and support theories of autism implicating Weak Central Coherence (Happé and Frith, 2006) and Enhanced Perceptual Function (Mottron et al., 2006). However, most importantly the case studies in this research highlight the wide variation in abilities in young children with the diagnostic label of ASD, including in sensory processing. This has implications for the need for more consistent use of a detailed assessment of sensory processing to inform interventions supporting language and communication, but acknowledges the need for more evidence given the potential costs. The variation in abilities found in this study, also strongly argues against a one size fits all approach to intervention in ASD, but rather suggests that interventions for these children need to be specifically tailored to each child's unique profile of strengths and needs.

REFERENCES

- Adamson, A., O'Hare, A., & Graham, C. (2006). Impairments in sensory modulation in children with autistic spectrum disorder. *The British Journal of Occupational Therapy*, 69(8), 357-364.
- Agnew, J., Dorn, C., & Eden, G. (2004). Effect of intensive training on auditory processing and reading skills. *Brain & Language*, 88(1), 21–25.
- Ahissar, M. (2007). Dyslexia and the anchoring-deficit hypothesis. *Trends in Cognitive Sciences*, 11(11), 458–465.
- Ahn, R. R., Miller, L. J., Milberger, S., & McIntosh, D. N. (2004). Prevalence of parents' perceptions of sensory processing disorders among kindergarten children. *American Journal of Occupational Therapy*, 58(3), 287–293.
- Akechi, H., & Kobayashi, H. (2014). Referential gaze and word mapping in autism spectrum disorders. *Comprehensive Guide to Autism*, 503–517.
- Alcántara, J., Cope, T., Cope, W., & Weisblatt, E. (2012). Auditory temporal-envelope processing in high-functioning children with autism spectrum disorder. *Neuropsychologia*, 50(7), 1235–1251.
- Alcántara, J., Weisblatt, E.J., Moore, B.C., & Bolton, P.F. (2004). Speech-in-noise perception in high functioning individuals with autism or Asperger's syndrome. *Journal of Child Psychology & Psychiatry & Allied Disciplines.*, 45(6), 1107–1114.
- Alin-Akerman, B. And Nordberg, L. (1991) *Griffiths Developmental Scales I and II*. Stockholm: Psykologiforlaget AB.
- American Psychiatric Association. (2000). *Diagnostic & Statistical Manual of Mental Disorders, Text Revision (DSM-IV-TR)*. (4th ed.). American Psychiatric Association.
- American Psychiatric Association. (2013). *Diagnostic & Statistical Manual of Mental Disorders, (DSM-5)*. American Psychiatric Publishing.
- Amso, D., Haas, S., Tenenbaum, E., Markant, J., & Sheinkopf, S. J. (2014). Bottom-up attention orienting in young children with autism . *Journal of Autism & Developmental Disorders*, 44(3), 664–673.
- Anderson, S., & Kraus, N. (2010). Objective neural indices of speech-in-noise perception. *Trends in Amplification*, 14(2), 73-83.

- Anderson, D., Lord, C., & Risi, S. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. *Journal of Consulting & Clinical Psychology, 75*(4), 594–604.
- Anderson, D., & Pempek, T. (2005). Television and very young children. *American Behavioral Scientist, 48*(5), 505–522.
- Apple Inc. (2010). *iMovie '11*.
- ASHA (American Speech-Language-Hearing Association). (2005a). *Central Auditory Processing Disorders*. Retrieved June 7th, 2015, from www.asha.org/policy/TR2005-00043/
- ASHA (American-Speech-Language-Hearing-Association). (2005b). *Guidelines for Addressing Acoustics in Educational Settings*. Retrieved 29th January, 2015, from <http://www.asha.org/policy/GL2005-00023/>
- Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional, behavioural and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy, 62*(5), 564–573.
- Ausderau, K., Sideris, J., Furlong, M., Little, L. M., Bulluck, J., & Baranek, G. T. (2014). National survey of sensory features in children with ASD: factor structure of the sensory experience questionnaire (3.0). *Journal of Autism & Developmental Disorders, 44*(4), 915–925.
- Ayres, A. (1972). *Sensory Integration & Learning Disorders*. Los Angeles: Western Psychological Services.
- Baharav, E., & Darling, R. (2008). Case report: using an auditory trainer with caregiver video modeling to enhance communication and socialization behaviours in autism. *Journal of Autism & Developmental Disorders, 38*(4), 771–775.
- Bahrack, L. E. (2010). Intermodal perception and selective attention to intersensory redundancy: implications for typical social development and autism. In G. Bremner & T. D. Wachs (Eds.), *Blackwell Handbook of Infant Development* (2nd ed., pp. 120–166). Hoboken, NJ: Wiley-Blackwell.
- Bahrack, L. E., Lickliter, R., Castellanos, I., & Vaillant-Molina, M. (2010). Increasing task difficulty enhances effects of intersensory redundancy: testing a new prediction of the intersensory redundancy hypothesis. *Developmental Science, 13*(5), 731–737.
- Bahrack, L. E., & Todd, J. T. (2012). Multisensory processing in autism spectrum disorders: intersensory processing disturbance as a basis for atypical development. In B. E. Stein (Ed.), *The New Handbook of Multisensory Processes*. (pp. 657–674). Cambridge, MA: MIT Press.

- Baird, G., Douglas, H., & Murphy, M. (2011). Recognising and diagnosing autism in children and young people: summary of NICE guidance. *British Medical Journal*, *343*(7829), 900–902.
- Baldwin, D. (1993). Infants' ability to consult the speaker for clues to word reference. *Journal of Child Language*, *20*(2), 395–418.
- Bamiou, D. E., Campbell, N., & Sirimanna, T. (2006). Management of auditory processing disorders. *Audiological Medicine*, *4*(1), 46–56.
- Bamiou, D. E., Musiek, F. E., & Luxon, L. M. (2001). Aetiology and clinical presentations of auditory processing disorders - a review. *Archives of Disease in Childhood*, *85*(5), 361.
- Baranek, G. (1999). Autism during infancy: A retrospective video analysis of sensory-motor and social behaviors at 9–12 months of age. *Journal of Autism & Developmental Disorders*, *29*(3), 213–224.
- Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2006). Sensory Experiences Questionnaire: discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology & Psychiatry*, *47*(6), 591–601.
- Barbaro, J., & Dissanayake, C. (2012). Developmental profiles of infants and toddlers with autism spectrum disorders identified prospectively in a community-based setting. *Journal of Autism & Developmental Disorders*, *42*(9), 1939–1948.
- Bayley, N. (2006). *Bayley Scales of Infant and Toddler Development: Bayley-III* (Vol. 7). San Antonio, TX: Harcourt Assessment, Psychological Corporation.
- Bebko, J. M., Weiss, J. A., Demark, J. L., & Gomez, P. (2006). Discrimination of temporal synchrony in intermodal events by children with autism and children with developmental disabilities without autism. *Journal of Child Psychology & Psychiatry*, *47*(1), 88–98.
- Behrmann, M., Avidan, G., Leonard, G. L., Kimchi, R., Luna, B., Humphreys, K., et al. (2006a). Configural processing in autism and its relationship to face processing. *Neuropsychologia*, *44*(1), 110–129.
- Behrmann, M., Thomas, C., & Humphreys, K. (2006b). Seeing it differently: visual processing in autism. *Trends in Cognitive Sciences*, *10*(6), 258–264.
- Bellini, S., & Akullian, J. (2007). A meta-analysis of video modeling and video self-modeling interventions for children and adolescents with autism spectrum disorders. *Exceptional Children*, *73*(3), 264–287.
- Bellis, T., Chermak, G., Weihing, J., & Musiek, F. (2012). Efficacy of auditory interventions for central auditory processing disorder: a response to Fey et al. (2011). *Language, Speech, & Hearing Services in Schools*, *43*(3), 381–38.

- Ben-Sasson, A., Cermak, S. A., Orsmond, G. I., Tager-Flusberg, H., Carter, A. S., Kadlec, M. et al. (2007). Extreme sensory modulation behaviors in toddlers with autism spectrum disorders. *American Journal of Occupational Therapy*, 61(5), 584–592.
- Ben-Sasson, A., Cermak, S. A., Orsmond, G. I., Tager-Flusberg, H., Kadlec, M. B., & Carter, A. S. (2008). Sensory clusters of toddlers with autism spectrum disorders: Differences in affective symptoms. *Journal of Child Psychology & Psychiatry*, 49(8), 817–825.
- Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 39(1), 1–11.
- Bertone, A., Mottron, L., Jelenic, P., & Faubert, J. (2003). Motion perception in autism: a “complex” issue. *Journal of Cognitive Neuroscience*, 15(2), 218–225.
- Bhatara, A., Babikian, T., Laugeson, E., Tachdjian, R., & Sininger, Y. S. (2013). Impaired timing and frequency discrimination in high-functioning autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 43(10), 2312–2328.
- Bion, R., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. *Cognition*, 126(1), 39–53.
- Boets, B., Verhoeven, J., Wouters, J., & Steyaert, J. (2014). Fragile spectral and temporal auditory processing in adolescents with Autism Spectrum Disorder and early language delay. *Journal of Autism & Developmental Disorders*, 45(6), 1845–1857.
- Bogdashina, O. (2003). *Sensory Perceptual Issues in Autism and Asperger Syndrome: Different Sensory Experiences, Different Perceptual Worlds*. London: Jessica Kingsley Publishers.
- Bondy, A., & Frost, L. (1994). The picture exchange communication system. *Focus on Autism & Other Developmental Disabilities*, 9(3), 1–19.
- Bonnel, A., McAdams, S., Smith, B., Berthiaume, C., Bertone, A., Ciocca, V., et al. (2010). Enhanced pure-tone pitch discrimination among persons with autism but not Asperger syndrome. *Neuropsychologia*, 48(9), 2465–2475.
- Bonnel, A., McAdams, S., Smith, B., Bertone, A., Burack, J., Ciocca, V., et al. (2008). Low level auditory processing of simple and complex sounds in autism. *Journal of the Acoustical Society of America*, 123(5), 3564.
- Bonnel, A., Mottron, L., Peretz, I., Trudel, M., Gallun, E., & Bonnel, A. M. (2003). Enhanced pitch sensitivity in individuals with autism: a signal detection analysis. *Journal of Cognitive Neuroscience*, 15(2), 226–235.

- Bopp, K., & Mirenda, P. (2011). Prelinguistic predictors of language development in children with autism spectrum disorders over four–five years. *Journal of Child Language*, 38(3), 485–503.
- Bosseler, A., & Massaro, D. (2003). Development and evaluation of a computer-animated tutor for vocabulary and language learning in children with autism. *Journal of Autism & Developmental Disorders*, 33(6), 653–672.
- Bradley, J., & Sato, H. (2008). The intelligibility of speech in elementary school classrooms. *The Journal of the Acoustical Society of America*, 123(4), 2078–2086.
- Briganti, A., & Cohen, L. (2011). Examining the role of social cues in early word learning. *Infant Behavior & Development*, 34(1), 211–214.
- British Society of Audiology. (2011). *An Overview of Current Management of Auditory Processing Disorder (APD) - British Society of Audiology*. Retrieved May 25, 2015, from <http://www.thebsa.org.uk/resources/overview-current-management-auditory-processing-disorder-apd/>
- Brock, J., Brown, C. C., Boucher, J., & Rippon, G. (2002). The temporal binding deficit hypothesis of autism. *Development & Psychopathology*, 14(02), 209-224.
- Brooks, R., & Meltzoff, A. (2002). The importance of eyes: how infants interpret adult looking behaviour. *Developmental Psychology*, 38(6), 958–966.
- Brooks, R., & Meltzoff, A. (2005). The development of gaze following and its relation to language . *Developmental Science*, 8(6), 535–543.
- Brookes, R., & Meltzoff, A. (2008). Infant gaze following and pointing predict accelerated vocabulary growth through two years of age: a longitudinal, growth curve modeling study. *Journal of Child Language*, 35(01), 207–220.
- Bruckner, C., Yoder, P., Stone, W., & Saylor, M. (2007). Construct validity of the MCDI-I receptive vocabulary scale can be improved: differential item functioning between toddlers with autism spectrum disorders and typically developing infants. *Journal of Speech, Language, & Hearing Research*, 50(6), 1631–1638.
- Bruneau, N., Bonnet-Brilhault, F., Gomot, M., Adrien, J. L., & Barthelemy, C. (2003). Cortical auditory processing and communication in children with autism: electrophysiological/behavioral relations. *International Journal of Psychophysiology*, 51(1), 17–25.
- Burnham, D., & Dodd, B. (2004). Auditory–visual speech integration by prelinguistic infants: perception of an emergent consonant in the McGurk effect. *Developmental Psychobiology*, 45(4), 204–220.
- Cakiroglu, O. (2012). Single subject research: applications to special education. *British Journal of Special Education*, 39(1), 21–29. Retrieved 27th May, 2015, from <http://onlinelibrary.wiley.com/doi/10.1111/j.1467-8578.2012.00530.x/full>

- Calderon, M. (2015). The Impact of Popular Media on Infant/Toddler Language Development: Research-based Recommendations for Working with Families. In M. Heider, K., Renck Jalongo (Ed.), *Young Children & Families in the Information Age* (13th ed., pp. 227–243). Netherlands, Springer.
- Calvert, G., Brammer, M., & Iversen, S. (1998). Crossmodal identification. *Trends in Cognitive Sciences*, 2(7), 247–253.
- Calvert, S., Strong, B., Jacobs, E., & Conger, E. (2007). Interaction and participation for young Hispanic and Caucasian girls' and boys' learning of media content. *Media Psychology*, 9(2), 431–445.
- Cameron, S., & Dillon, H. (2008). The listening in spatialized noise-sentences test (LISN-S): Comparison to the prototype LISN and results from children with either a suspected (central) auditory processing disorder or a confirmed language disorder. *Journal of the American Academy of Audiology*, 19(5), 377–391.
- Cardon, T. (2012). Teaching caregivers to implement video modeling imitation training via iPad for their children with autism. *Research in Autism Spectrum Disorders*, 6(4), 1389–1400.
- Cardon, T. & Azuma, T. (2012). Visual attending preferences in children with autism spectrum disorders: a comparison between live and video presentation modes. *Research in Autism Spectrum Disorders*, 6(3), 1061–1067.
- Carpenter, M. and Liebal, K. (2011). Joint attention, communication, and knowing together in infancy. In Seemann, A. (ed) *Joint Attention: New Developments in Psychology, Philosophy of Mind, and Social Neuroscience*, MIT Press, Cambridge. 159-182.
- Carpenter, M., Pennington, B., & Rogers, S. (2002). Interrelations among social-cognitive skills in young children with autism. *Journal of Autism & Developmental Disorders*, 32(2), 91–106.
- Case-Smith, J., & Schaaf, R. (2012). *Response to Systematic Review of Sensory Integration Therapy for Autism Spectrum Disorders*. Retrieved 25th May, 2015, from <http://www.aota.org/-/media/Corporate/Files/Practice/Children/Response-to-Research-in-Autism.ashx>
- Case-Smith, J., Weaver, L., & Fristad, M. (2014). A systematic review of sensory processing interventions for children with autism spectrum disorders. *Autism*, 1(16), 1362361313517762.
- Cassel, R. S., Saint-Georges, C., Mahdhaoui, A., Chetouani, M., Laznik, M. C., Muratori, F., et al. (2014). Course of maternal prosodic incitation (motherese) during early development in autism. *Interaction Studies*, 14(3), 480–496.
- Čeponienė, R., Lepistö, T., Shestakova, A., Vanhala, R., Alku, P., Näätänen, R., et al. (2003). Speech–sound-selective auditory impairment in children with autism:

they can perceive but do not attend. *Proceedings of the National Academy of Sciences*, 100(9), 5567–5572.

Charlop, M., Dennis, B., Carpenter, M., & Greenberg, A. (2010). Teaching socially expressive behaviors to children with autism through video modelling. *Education & Treatment of Children*, 33(3), 371–393.

Charlop-Christy, M., Le, L., & Freeman, K. (2000). A comparison of video modeling with in vivo modeling for teaching children with autism. *Journal of Autism & Developmental Disorders*, 30(6), 537–552.

Charlop, M., Schreibman, L., & Tryon, A. (1983). Learning through observation: the effects of peer modeling on acquisition and generalization in autistic children. *Journal of Abnormal Child Psychology*, 11(3), 355–366.

Charman, T. (2003). Why is joint attention a pivotal skill in autism? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 358(1430), 315–324.

Charman, T. (2004). Matching preschool children with autism spectrum disorders and comparison children for language ability: methodological challenges. *Journal of Autism & Developmental Disorders*, 34(1), 59–64.

Charman, T., Drew, A., Baird, C., & Baird, G. (2003a). Measuring early language development in preschool children with autism spectrum disorder using the MacArthur Communicative Development Inventory (Infant Form). *Journal of Child Language*, 30(1), 213–236.

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Drew, A., & Cox, A. (2003b). Predicting language outcome in infants with autism and pervasive developmental disorder. *Journal of Language & Communication Disorders*, 38(3), 265–285.

Chawarska, K., Klin, A., & Volkmar, F. (2003). Automatic attention cueing through eye movement in 2-year-old children with autism. *Child Development*, 74(4), 1108–1122.

Chawarska, K., Macari, S., & Shic, F. (2012). Context modulates attention to social scenes in toddlers with autism. *Journal of Child Psychology & Psychiatry*, 53(8), 903–913.

Chen, Y., Norton, D. J., McBain, R., Gold, J., Frazier, J. A., & Coyle, J. T. (2012). Enhanced local processing of dynamic visual information in autism: evidence from speed discrimination. *Neuropsychologia*, 50(5), 733–739.

Cohen, W., Hodson, A., O'Hare, A., Boyle, J., Durrani, T., McCartney, E. et al. (2005). Effects of computer-based intervention through acoustically modified speech (Fast ForWord) in severe mixed receptive-expressive language. *Journal of Speech, Language & Hearing Research*, 48(3), 715–729.

- Cohen, D., Cassel, R. S., Saint-Georges, C., Mahdhaoui, A., Laznik, M. C., Apicella, F., et al. (2013). Do parentese prosody and fathers' involvement in interacting facilitate social interaction in infants who later develop autism? *PLoS ONE*, *8*(5). Retrieved 25th May, 2015, from <http://dx.plos.org/10.1371/journal.pone.0061402>
- Collignon, O., Charbonneau, G., Peters, F., Nassim, M., Lassonde, M., Lepore, F., et al. (2013). Reduced multisensory facilitation in persons with autism. *Cortex*, *49*(6), 1704–1710.
- Corbett, B., & Abdullah, M. (2005). Video modeling: Why does it work for children with autism? *Journal of Early & Intensive Behavior Intervention*, *2*(1), 2–8.
- Courchesne, E., Pierce, K., Schumann, C. M., Redcay, E., Buckwalter, J. A., Kennedy, D. P., et al. (2007). Mapping early brain development in autism. *Neuron*, *56*(2), 399–413.
- Crandell, C., & Bess, F. (1986). Speech recognition of children in a “typical” classroom setting. *ASHA*, *29*, 87.
- Crandell, C., & Smaldino, J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech, & Hearing Services in Schools*, *31*(4), 362–370.
- Crawley, A. M., Anderson, D. R., Wilder, A., Williams, M., & Santomero, A. (1999). Effects of repeated exposures to a single episode of the television program Blue's Clues on the viewing behaviors and comprehension of preschool children. *Journal of Educational Psychology*, *91*(4), 630–637.
- Crowe, B., & Salt, A. (2015). Autism: the management and support of children and young people on the autism spectrum (NICE Clinical Guideline 170). *Archives of Disease in Childhood-Education & Practice Edition*, *100*(1), 20–23.
- Dakin, S., & Frith, U. (2005). Vagaries of visual perception in autism. *Neuron*, *48*(3), 497–507.
- Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H. H., et al. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience*, *8*(4), 519–526.
- Dawes, P., & Bishop, D. (2009). Auditory processing disorder in relation to developmental disorders of language, communication and attention: a review and critique. *International Journal of Language & Communication Disorders*, *44*(4), 440–465.
- Dawes, P., Bishop, D. V, Sirimanna, T., Bamiou, D. E., Dawes, P., Bishop, D. V. M., et al. (2008). Profile and aetiology of children diagnosed with auditory processing disorder (APD). *International Journal of Pediatric Otorhinolaryngology*, *72*(4), 483–489.

- Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental Psychology, 40*(2), 271.
- Dawson, G., Webb, S., & McPartland, J. (2005). Understanding the nature of face processing impairment in autism: insights from behavioral and electrophysiological studies. *Developmental Neuropsychology, 27*(3), 403–424.
- De Gelder, B. D., Vroomen, J., & Van der Heide, L. (1991). Face recognition and lip-reading in autism. *European Journal of Cognitive Psychology, 3*(1), 69-86.
- De Jong, M. C., van Engeland, H., & Kemner, C. (2008). Attentional effects of gaze shifts are influenced by emotion and spatial frequency, but not in autism. *Journal of the American Academy of Child & Adolescent Psychiatry, 47*(4), 443–454.
- Delano, M. (2007). Video modeling interventions for individuals with autism. *Remedial & Special Education, 28*(1), 33–42.
- Desjardins, R., & Werker, J. (2004). Is the integration of heard and seen speech mandatory for infants? *Developmental Psychobiology, 45*(4), 187–203.
- Donohue, S., Darling, E., & Mitroff, S. (2012). Links between multisensory processing and autism. *Experimental Brain Research, 222*(4), 377–387.
- Drew, A., Baird, G., Taylor, E., Milne, E., & Charman, T. (2007). The Social Communication Assessment for Toddlers with Autism (SCATA): an instrument to measure the frequency, form and function of communication in toddlers with autism spectrum disorder. *Journal of Autism & Developmental Disorders, 37*(4), 648–666.
- Dunn, L. & Dunn, D. (2007). *Peabody Picture Vocabulary Test (4th ed.)*. San Antonio, TX: Pearson.
- Dunn, M., Gomes, H., & Gravel, J. (2008). Mismatch negativity in children with autism and typical development. *Journal of Autism & Developmental Disorders, 38*(1), 52–71.
- Dunn, W. (1991). The sensorimotor systems: A framework for assessment and intervention. In F. Orelove & D. Sobsey (Eds.), *Educating Children with Multiple Disabilities: A Transdisciplinary Approach (2nd ed.)*, 33–78. Baltimore, MD: Paul H Brookes.
- Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: a conceptual model. *Infants & Young Children, 9*(4), 23–35.
- Dunn, W. (1999). *The Sensory Profile: User's manual*. San Antonio, TX: Psychological Corporation.

- Dunn, W. (2001). The sensations of everyday life: empirical, theoretical, and pragmatic considerations. *American Journal of Occupational Therapy*, 55(6), 608–620.
- Edgin, J., & Pennington, B. (2005). Spatial cognition in autism spectrum disorders: superior, impaired, or just intact? *Journal of Autism & Developmental Disorders*, 35(6), 729–745.
- Eigsti, I., & Fein, D. (2013). More is less: pitch discrimination and language delays in children with optimal outcomes from autism. *Autism Research*, 6(6), 605–613.
- Ellis Weismer, S., Lord, C., & Esler, A. (2010). Early language patterns of toddlers on the autism spectrum compared to toddlers with developmental delay. *Journal of Autism & Developmental Disorders*, 40(10), 1259–1273.
- Ellis Weismer, S., & Kover, S. (2015). Preschool language variation, growth, and predictors in children on the autism spectrum. *Journal of Child Psychology & Psychiatry*. Retrieved 12th May, 2015, from <http://onlinelibrary.wiley.com/doi/10.1111/jcpp.12406/full>
- Elsabbagh, M., Divan, G., Koh, Y.-J., Kim, Y. S., Kauchali, S., Marcín, C., et al. (2012). Global prevalence of autism and other pervasive developmental disorders. *Autism Research : Official Journal of the International Society for Autism Research*, 5(3), 160–79.
- Elsabbagh, M., Fernandes, J., Webb, S. J., Dawson, G., Charman, T., Johnson, M. H., et al. (2013). Disengagement of visual attention in infancy is associated with emerging autism in toddlerhood. *Biological Psychiatry*, 74(3), 189–194.
- Fallon, M., Trehub, S., & Schneider, B. (2000). Children's perception of speech in multitalker babble. *The Journal of the Acoustical Society of America*, 108(6), 3023–3029.
- Farroni, T., Johnson, M., Brockbank, M., & Simion, F. (2000). Infants' use of gaze direction to cue attention: the importance of perceived motion. *Visual Cognition*, 7(6), 705–718.
- Farroni, T., Johnson, M. H., Menon, E., Zulian, L., Faraguna, D., & Csibra, G. (2005). Newborns' preference for face-relevant stimuli: effects of contrast polarity. *Proceedings of the National Academy of Sciences of the United States of America*, 102(47), 17245–17250.
- Fennell, C. T. (2012). Object familiarity enhances infants' use of phonetic detail in novel words. *Infancy*, 17(3), 339-353.
- Fenson, L., Resznick, S., Thal, D., Bates, E., Hartung, J., Pethick, S., et al. (1993). *The MacArthur Communicative Developmental Inventory*. San Diego, CA: Singular/ Thomson Learning.

- Ferguson, M., Hall, R., Riley, A., & Moore, D. (2011). Communication, listening, cognitive and speech perception skills in children with auditory processing disorder (APD) or specific language impairment (SLI). *Journal of Speech, Language, & Hearing Research, 54*(1), 211–227.
- Fey, M. E., Richard, G. J., Geffner, D., Kamhi, A. G., Medwetsky, L., Paul, D., et al. (2011). Auditory processing disorders and auditory/language interventions: an evidence-based systematic review. *Language, Speech, & Hearing Services in Schools, 42*, 246–264.
- Flom, R., & Bahrick, L. (2007). The development of infant discrimination of affect in multimodal and unimodal stimulation: the role of intersensory redundancy. *Developmental Psychology, 43*(1), 238–252.
- Foss-Feig, J. H., Kwakye, L. D., Cascio, C. J., Burnette, C. P., Kadivar, H., Stone, W. L., et al. (2010). An extended multisensory temporal binding window in autism spectrum disorders. *Experimental Brain Research, 203*(2), 381–389.
- Foxe, J. J., Molholm, S., Del Bene, V. A., Frey, H. P., Russo, N. N., Blanco, D., et al. (2013). Severe multisensory speech integration deficits in high-functioning school-aged children with Autism Spectrum Disorder (ASD) and their resolution during early adolescence. *Cerebral Cortex, 25*(2), 298–312.
- Frank, M., Vul, E., & Saxe, R. (2012). Measuring the development of social attention using free-viewing. *Infancy, 17*(4), 355–375.
- Friesen, C., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. *Journal of Experimental Psychology: Human Perception & Performance, 30*(2), 319.
- Frischen, A., Bayliss, A., & Tipper, S. (2007). Gaze cueing of attention: visual attention, social cognition, and individual differences. *Psychological Bulletin, 133*(4), 694. Retrieved 19th May, 2015, from <http://psycnet.apa.org/psycinfo/2007-09203-007>
- Geffner, D., & Goldman, R. (2010). *Auditory Skills Assessment*. San Antonio: Pearson, Inc.
- Gena, A., Couloura, S., & Kymissis, E. (2005). Modifying the affective behavior of preschoolers with autism using in-vivo or video modeling and reinforcement contingencies. *Journal of Autism & Developmental Disorders, 35*(5), 545–556.
- Gepner, B. (2008). From neuronal to human communication disorders: a novel approach to autism. *Interactions, 1*(1), 1–26.
- Gepner, B., & Féron, F. (2009). Autism: a world changing too fast for a mis-wired brain? *Neuroscience & Biobehavioral Reviews, 33*(8), 1227–1242.

- Gepner, B., Lainé, F., & Tardif, C. (2005). E-Motion mis-sight and other temporal processing disorders in autism. Invited Commentary. *Cahiers de Psychologie Cognitive/Current Psychology of Cognition*, 23, 104–121.
- Gepner B. & Massion J. (dirigé par) (2002). L'autisme : une pathologie du codage temporel ? *Revue TIPA* (Revue des Travaux Interdisciplinaire du Laboratoire Parole et Langage, 21, 177-218.
- Gepner, B., & Tardif, C. (2006). Autism, Movement, Time and Thought E-Motion Mis-Sight and other Temporo-Spatial Processing Disorders in Autism. *Frontiers in Cognitive Psychology*, 1–30. Retrieved 21st May, 2015, from <https://hal.archives-ouvertes.fr/hal-00250284/>
- Gillam, R. B., Loeb, D. F., Hoffman, L. M., Bohman, T., Champlin, C. A., Thibodeau, L., et al. (2008). The efficacy of Fast ForWord language intervention in school-age children with language impairment: a randomized controlled trial. *Journal of Speech Language & Hearing Research*, 51(1), 97–119.
- Gillberg, C. (1991). Outcome in autism and autistic-like conditions. *Journal of the American Academy of Child and Adolescent Psychiatry*, 30(3), 375–382.
- Gillespie-Lynch, K., Elias, R., Escudero, P., Hutman, T., & Johnson, S. P. (2013). Atypical gaze following in autism: a comparison of three potential mechanisms. *Journal of Autism & Developmental Disorders*, 43(12), 2779–2792.
- Gliga, T., Elsabbagh, M., & Hudry, K. (2012). Gaze following, gaze reading, and word learning in children at risk for autism. *Child Development*, 83(3), 926–938.
- Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report*, 8(4), 597–607.
- Gomot, M., Belmonte, M. K., Bullmore, E. T., Bernard, F. A., & Baron-Cohen, S. (2008). Brain hyper-reactivity to auditory novel targets in children with high-functioning autism. *Brain*, 131(9), 2479–2488.
- Gomot, M., & Wicker, B. (2012). A challenging, unpredictable world for people with autism spectrum disorder. *International Journal of Psychophysiology*, 83(2), 240–247.
- Goodman, J., Dale, P., & Li, P. (2008). Does frequency count? Parental input and the acquisition of vocabulary. *Journal of Child Language*, 35(3), 515–531.
- Gould, J. (1986). The Lowe and Costello symbolic play test in socially impaired children. *Journal of Autism & Developmental Disorders*, 16(2), 199-213.
- Graf Estes, K., & Hurley, K. (2013). Infant-directed prosody helps infants map sounds to meanings. *Infancy*, 18(5), 797–824.
- Grandin, T. (1992). An inside view of autism. In G. B. M. Eric Schopler (Ed.), *High-Functioning Individuals with Autism* (p. 107). New York u.a: Plenum Press.

- Grandin, T. (1995). How people with autism think. *Learning & Cognition in Autism*, 137–156.
- Green, J., Charman, T., McConachie, H., Aldred, C., Slonims, V., Howlin, P., ... & PACT Consortium. (2010). Parent-mediated communication-focused treatment in children with autism (PACT): a randomised controlled trial. *The Lancet*, 375(9732), 2152–2160.
- Groen, W. B., van Orsouw, L., Huurne, N., Swinkels, S., van der Gaag, R. J., Buitelaar, J. K., et al. (2009). Intact spectral but abnormal temporal processing of auditory stimuli in autism. *Journal of Autism & Developmental Disorders*, 39(5), 742–750.
- Gross, T. (2004). The perception of four basic emotions in human and nonhuman faces by children with autism and other developmental disabilities. *Journal of Abnormal Child Psychology*, 32(5), 469–480.
- Guiraud, J. A., Tomalski, P., Kushnerenko, E., Ribeiro, H., Davies, K., Charman, T., ... & BASIS Team. (2012). Atypical audiovisual speech integration in infants at risk for autism. *PloS One*, 7(5), e36428. Retrieved 21st May, 2015, from <http://dx.plos.org/10.1371/journal.pone.0036428>
- Gulsrud, A., Kasari, C., Freeman, S., & Paparella, T. (2007). Children with autism's response to novel stimuli while participating in interventions targeting joint attention or symbolic play skills. *Autism*, 11(6), 535–546.
- Haake, M., Hansson, K., Gulz, A., Schötz, S., & Sahlén, B. (2014). The slower the better? Does the speaker's speech rate influence children's performance on a language comprehension test? *International Journal of Speech-Language Pathology*, 16(2), 181–190.
- Haesen, B., Boets, B., & Wagemans, J. (2011). A review of behavioural and electrophysiological studies on auditory processing and speech perception in autism spectrum disorders. *Research in Autism Spectrum Disorders*, 5(2), 701–714.
- Hailpern, J., Harris, A., La Botz, R., Birman, B., & Karahalios, K. (2012). Designing visualizations to facilitate multisyllabic speech with children with autism and speech delays. In *Proceedings of the Designing Interactive Systems Conference* (126–135. ACM).
- Hall, J., Buss, E., Grose, J., & Dev, M. (2004). Developmental effects in the masking-level difference. *Journal of Speech, Language, & Hearing Research*, 47(1), 13–20.
- Hamilton, A., Brindley, R., & Frith, U. (2007). Imitation and action understanding in autistic spectrum disorders: how valid is the hypothesis of a deficit in the mirror neuron system? *Neuropsychologia*, 45(8), 1859–1868.

- Hamilton, A., Plunkett, K., & Schafer, G. (2000). Infant vocabulary development assessed with a British communicative development inventory. *Journal of Child Language*, 27(03), 689–705.
- Hani, H. B., Gonzalez-Barrero, A. N. A., & Nadig, A. S. (2013). Children’s referential understanding of novel words and parent labeling behaviors: similarities across children with and without autism spectrum disorders. *Journal of Child Language*, 40(5), 971–1002.
- Hanschmann, H., Wiehe, S., Müller-Mazzotta, J., & Berger, R. (2010). Speech perception in noise with and without FM technology. *HNO*, 58(7), 674–679.
- Happé, F., & Frith, U. (1996). The neuropsychology of autism. *Brain*, (119), 1377–1400.
- Happé, F., & Frith, U. (2006). The weak central coherence account: detail-focussed cognitive style in autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 36, 5–25.
- Hazen, E. P., Stornelli, J. L., O’Rourke, J. A., Koesterer, K., & McDougle, C. J. (2014). Sensory symptoms in autism spectrum disorders. *Harvard Review of Psychiatry*, 22(2), 112–124.
- Heaton, P. (2003). Pitch memory, labelling and disembedding in autism . *Journal of Child Psychology & Psychiatry*, 44(4), 543–551.
- Heaton, P., Hudry, K., Ludlow, A., & Hill, E. (2008a). Superior discrimination of speech pitch and its relationship to verbal ability in autism spectrum disorders. *Cognitive Neuropsychology*, 25(6), 771–782.
- Heaton, P., Hermelin, B., & Pring, L. (1999). Can children with autistic spectrum disorders perceive affect in music? An experimental investigation. *Psychological Medicine*, 29(06), 1405-1410.
- Heaton, P., Williams, K., Cummins, O., & Happe, F. (2008b). Autism and pitch processing splinter skills: a group and subgroup analysis. *Autism*, 12(2), 203.
- Hellendoorn, A., Langstraat, I., Wijnroks, L., Buitelaar, J. K., van Daalen, E., & Leseman, P. P. (2014). The relationship between atypical visual processing and social skills in young children with autism. *Research in Developmental Disabilities*, 35(2), 423–428.
- Herrera, G., Alcantud, F., Jordan, R., Blanquer, A., Labajo, G., & De Pablo, C. (2008). Development of symbolic play through the use of virtual reality tools in children with autistic spectrum disorders two case studies. *Autism*, 12(2), 143-157.
- Hillock, A. (2010). *Developmental Changes in the Temporal Window of Auditory and Visual Integration*. Vanderbilt University. Retrieved 21st May, 2015, from

<http://etd.library.vanderbilt.edu/available/etd-08062010-141517/unrestricted/HillockDissertationETDAug2010.pdf>

- Hillock, A., Powers, A., & Wallace, M. (2011). Binding of sights and sounds: age-related changes in multisensory temporal processing. *Neuropsychologia*, *49*(3), 461–467.
- Hillock-Dunn, A., & Wallace, M. (2012). Developmental changes in the multisensory temporal binding window persist into adolescence. *Developmental Science*, *15*(5), 688–696.
- Hobson, R.P. and Hobson, J.A. (2011) Joint attention or joint engagement? In Seemann, A. (ed) *Joint Attention: New Developments in Psychology, Philosophy of Mind, and Social Neuroscience*, MIT Press, Cambridge. 115-135.
- Hockley, N., & Polka, L. (1994). A developmental study of audiovisual speech perception using the McGurk paradigm. *The Journal of the Acoustical Society of America*, *96*(5), 3309–3309.
- Hollich, G. J., Hirsh-Pasek, K., Golinkoff, R. M., Brand, R. J., Brown, E., Chung, H. L., et al. (2000). Breaking the language barrier: an emergentist coalition model for the origins of word learning. *Monographs of the Society for Research in Child Development*, i–135. Retrieved 27th May, 2015, from <http://www.jstor.org/stable/3181533>
- Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*(2), 165–179.
- Houston-Price, C., Plunkett, K., & Harris, P. (2005). “Word-learning wizardry” at 1; 6. *Journal of Child Language*, *32*(01), 175–189.
- Howlin, P., Magiati, I., & Charman, T. (2009). Systematic review of early intensive behavioral interventions for children with autism. *Journal Information*, *114*(1), 23–41.
- Howlin, P., Mawhood, L., & Rutter, M. (2000). Autism and developmental receptive language disorder - a follow-up comparison in early adult life. II: social, behavioural, and psychiatric outcomes. *The Journal of Child Psychology & Psychiatry and Allied Disciplines*, *41*(05), 561–578.
- Hudry, K., Chandler, S., Bedford, R., Pasco, G., Gliga, T., Elsabbagh, M., et al. (2012). Infant neural sensitivity to dynamic eye gaze is associated with later emerging autism. *Current Biology*, *22*(4), 338–342.
- Hudry, K., Chandler, S., Bedford, R., Pasco, G., Gliga, T., Elsabbagh, M., et al. (2014). Early language profiles in infants at high-risk for autism spectrum disorders. *Journal of Autism & Developmental Disorders*, *44*(1), 154–167.

- Hudry, K., Leadbitter, K., Temple, K., Slonims, V., McConachie, H., Aldred, C., et al. (2010). Preschoolers with autism show greater impairment in receptive compared with expressive language abilities. *International Journal of Language & Communication Disorders, 45*(6), 681–690.
- Hunnius, S., & Geuze, R. (2004). Developmental changes in visual scanning of dynamic faces and abstract stimuli in infants: A longitudinal study. *Infancy, 6*(2), 231–255.
- Hus, V., Pickles, A., Cook, E. H., Risi, S., & Lord, C. (2007). Using the autism diagnostic interview-revised to increase phenotypic homogeneity in genetic studies of autism. *Biological Psychiatry, 61*(4), 438–448.
- Iarocci, G., & McDonald, J. (2006). Sensory integration and the perceptual experience of persons with autism. *Journal of Autism & Developmental Disorders, 36*(1), 77–90.
- Iarocci, G., Rombough, A., Yager, J., Weeks, D., & Chua, R. (2010). Visual influences on speech perception in children with autism. *Autism, 14*(4), 305–320.
- Irwin, J. (2007). Auditory and audiovisual speech perception in children with autism spectrum disorders. *Acoustics Today, 3*(4), 8–15.
- Irwin, J. R. ., Tornatore, L. A., Brancazio, L., & Whalen, D. H. (2011). Can children with autism spectrum disorders “hear” a speaking face? *Child Development, 82*(5), 1397–1403.
- Jarvinen-Pasley, A., & Heaton, P. (2007). Evidence for reduced domain-specificity in auditory processing in autism. *Developmental Science, 10*(6), 786–793.
- Johnson, J. A., Rosenblum, L. D., & Saldaña, H. M. (1994). The contribution of a reduced visual image to speech perception in noise. *The Journal of the Acoustical Society of America, 95*(5), 3009-3009.
- Johnston, K. N., John, A. B., Kreisman, N. V, Hall III, J. W., & Crandell, C. C. (2009). Multiple benefits of personal FM system use by children with auditory processing disorder (APD). *International Journal of Audiology, 48*(6), 371–383.
- Jones, R., Quigney, C., & Huws, J. (2003). First-hand accounts of sensory perceptual experiences in autism: a qualitative analysis. *Journal of Intellectual & Developmental Disability, 28*(2), 112–121.
- Jones, W. & Klin, A. (2009). Heterogeneity and homogeneity across the autism spectrum: the role of development. *Journal of American Academy of Child & Adolescent Psychiatry, 48*(5), 471.
- Jones, W., & Klin, A. (2013). Attention to eyes is present but in decline in 2-6-month old infants later diagnosed with autism. *Nature, 504*(7480), 427–431.

- Jones, C. R., Happé, F., Baird, G., Simonoff, E., Marsden, A. J., Tregay, J., et al. (2009). Auditory discrimination and auditory sensory behaviours in autism spectrum disorders. *Neuropsychologia*, *47*(13), 2850–2858.
- Joosten, A. V. ., & Bundy, A. C. (2010). Sensory processing and stereotypical and repetitive behaviour in children with autism and intellectual disability. *Australian Occupational Therapy Journal*, *57*(6), 366–372.
- Kagohara, D. M. (2010). Is video-based instruction effective in the rehabilitation of children with autism spectrum disorders? *Developmental Neurorehabilitation*, *13*(2), 129-140.
- Kaldy, Z., Giserman, I., Carter, A., & Blaser, E. (2013). The mechanisms underlying the ASD advantage in visual search. *Psychiatry*, *37*, 164–183.
- Kaldy, Z., Kraper, C., Carter, A. S., & Blaser, E. (2011). Toddlers with autism spectrum disorder are more successful at visual search than typically developing toddlers. *Developmental Science*, *14*(5), 980–988.
- Kasari Freeman, S., Paparella, T., Wong, C., Kwon, S., and Gulsrud, A., C. (2005). Early intervention in autism: focus on core deficits. *Clinical Neuropsychiatry*, *2*, 380–388.
- Kasari, C., Kaiser, A., Goods, K., Nietfeld, J., Mathy, P., Landa, R., et al. (2014). Communication interventions for minimally verbal children with autism: a sequential multiple assignment randomized trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, *53*(6), 635–646.
- Kawahara, H. (2001). Straight: an extremely high-quality vocoder for auditory and speech perception research. *Computational Models of Auditory Function*, *312*, 343.
- Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? An experimental approach. *Media Psychology*, *10*(1), 41-63.
- Keehn, B., Müller, R., & Townsend, J. (2013). Atypical attentional networks and the emergence of autism. *Neuroscience & Biobehavioral Reviews*, *37*(2), 164–183.
- Kemner, C., Verbaten, M. N., Cuperus, J. M., Camfferman, G., & van Engeland, H. (1995). Auditory event-related brain potentials in autistic children and three different control groups. *Biological Psychiatry*, *38*(3), 150–165.
- Kern, J. K., Trivedi, M. H., Garver, C. R., Grannemann, B. D., Andrews, A. A., Savla, J. S., et al. (2006). The pattern of sensory processing abnormalities in autism. *Autism*, *10*(5), 480–494.
- Kern, J. K., Trivedi, M. H., Grannemann, B. D., Garver, C. R., Johnson, D. G., Andrews, A. A., et al. (2007). Sensory correlations in autism. *Autism*, *11*(2), 123–134.

- Khalfa, S., Bruneau, N., Rogé, B., Georgieff, N., VeUILlet, E., Adrien, J. L., et al. (2004). Increased perception of loudness in autism. *Hearing Research*, 198(1-2), 87–92.
- Kjelgaard, M. M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: implications for genetic subgroups. *Language & Cognitive Processes*, 16(2-3), 287.
- Kjellmer, L., Hedvall, Å., Fernell, E., Gillberg, C., & Norrelgen, F. (2012). Language and communication skills in preschool children with autism spectrum disorders: contribution of cognition, severity of autism symptoms, and adaptive functioning to the variability. *Research in Developmental Disabilities*, 33(1), 172–180.
- Klin, A., Jones, W., Schultz, R., & Volkmar, F. (2003). The enactive mind, or from actions to cognition: lessons from autism. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 358(1430), 345–360.
- Koegel, R. L., Shirotova, L., & Koegel, L. K. (2009). Brief report: Using individualized orienting cues to facilitate first-word acquisition in non-responders with autism. *Journal of Autism & Developmental Disorders*, 39(11), 1587–1592.
- Koldewyn, K., Jiang, Y. V., Weigelt, S., & Kanwisher, N. (2013). Global/local processing in autism: not a disability, but a disinclination. *Journal of Autism & Developmental Disorders*, 43(10), 2329–2340.
- Korhonen, V., Kärnä, E., & Rätty, H. (2014). Autism spectrum disorder and impaired joint attention: a review of joint attention research from the past decade. *Nordic Psychology*, 66(2), 94–107.
- Krug, D., Arick, J. & Almond, P. (1980). Behavior checklist for identifying severely handicapped individuals with high levels of autistic behaviour. *Journal of Child Psychology & Psychiatry*, 21 (3), 221-229.
- Kuhl, P. (2007). Is speech learning “gated” by the social brain? *Developmental Science*, 10(1), 110–120.
- Kuhl, P., Coffey-Corina, S., Padden, D., & Dawson, G. (2005). Links between social and linguistic processing of speech in preschool children with autism: behavioral and electrophysiological measures. *Developmental Science*, 8(1), F1–F12.
- Kuhl, P. K., Coffey-Corina, S., Padden, D., Munson, J., Estes, A., & Dawson, G. (2013). Brain responses to words in 2-year-olds with autism predict developmental outcomes at age 6. *PLoS One*, 8(5), e64967. Retrieved 19th May, 2015, from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3666972/>
- Kuhl, P., Tsao, F., & Liu, H. (2003). Foreign-language experience in infancy: Effects of short-term exposure and social interaction on phonetic learning. *Proceedings of the National Academy of Sciences*, 100(15), 9096–9101.

- Kuhl, P., Williams, K., & Meltzoff, A. (1991). Cross-modal speech perception in adults and infants using nonspeech auditory stimuli. *Journal of Experimental Psychology: Human Perception & Performance*, 17(3), 829–840.
- Kumar, U. A., & Vanaja, C. S. (2004). Functioning of olivocochlear bundle and speech perception in noise. *Ear & Hearing*, 25(2), 142.
- Kwakye, L. D., Foss-Feig, J. H., Cascio, C. J., Stone, W. L., & Wallace, M. T. (2010). Altered auditory and multisensory temporal processing in autism spectrum disorders. *Frontiers in Integrative Neuroscience*, 4(129), 1–11.
- Kwok, E., Brown, H., Smyth, R., & Cardy, J. (2015). Meta-analysis of receptive and expressive language skills in autism spectrum disorder. *Research in Autism Spectrum Disorders*, 9, 202–222.
- Kylliäinen, A., & Hietanen, J. (2004). Attention orienting by another's gaze direction in children with autism. *Journal of Child Psychology & Psychiatry*, 45(3), 435–444.
- Lagace, J., Jutras, B., & Gagne, J. P. (2010). Auditory processing disorder and speech perception problems in noise: finding the underlying origin. *American Journal of Audiology*, 19(1), 17.
- Lainé, F., Rauzy, S., Tardif, C., & Gepner, B. (2011). Slowing down the presentation of facial and body movements enhances imitation performance in children with severe autism. *Journal of Autism & Developmental Disorders*, 41(8), 983–996.
- Lainé, F., Tardif, C., & Gepner, B. (2008). Slowing down biological motion and speech sounds enhances imitation and verbal comprehension in children and adolescents with autism. In *Proceedings Autism Neuroscience Conference*.
- Landry, R., & Bryson, S. (2004). Impaired disengagement of attention in young children with autism. *Journal of Child Psychology & Psychiatry*, 45(6), 1115–1122.
- Lane, A., Molloy, C., & Bishop, S. (2014). Classification of children with Autism Spectrum Disorder by sensory subtype: a case for sensory-based phenotypes. *Autism Research*, 7(3), 322–333.
- Lane, A., Young, R., Baker, A., & Angley, M. (2010). Sensory processing subtypes in autism: association with adaptive behaviour. *Journal of Autism & Developmental Disorders*, 40(1), 112–122.
- Lang, R., O'Reilly, M., Healy, O., Rispoli, M., Lydon, H., Streusand, W., et al. (2012). Sensory integration therapy for autism spectrum disorders: a systematic review. *Research in Autism Spectrum Disorders*, 6(3), 1004–1018.
- LeCouteur, A. Baird, G., & Mills, R. (2003a). *National Autism Plan for Children (NAPC): Plan for the Identification, Assessment, Diagnosis and Access to Early*

Interventions for Pre-school & Primary School Aged-Children. London: National Autistic Society. London: National Autistic Society.

- LeCouteur, A., Lord, C., & Rutter, M. (2003b). *Autism Diagnostic Interview Revised (ADI-R)*. Los Angeles: Western Psychological Services.
- Leekam, S., López, B., & Moore, C. (2000). Attention and joint attention in preschool children with autism. *Developmental Psychology*, 36(2), 261–273.
- Leekam, S. R., Nieto, C., Libby, S. J., Wing, L., & Gould, J. (2007). Describing the sensory abnormalities of children and adults with autism. *Journal of Autism & Developmental Disorders*, 37(5), 894–910.
- Lemos, I. C. C., Jacob, R. T. D. S., Gejão, M. G., Bevilacqua, M. C., Feniman, M. R., & Ferrari, D. V. (2009). Frequency modulation (FM) system in auditory processing disorder: an evidence-based practice? *Pró-Fono Revista de Atualização Científica*, 21(3), 243–248.
- Lepistö, T. (2008). *Cortical Processing of Speech and Non-Speech Sounds in Autism and Asperger Syndrome*. University of Helsinki. Retrieved 21st May, 2015, from <https://helda.helsinki.fi/handle/10138/19747>
- Lepistö, T., Kujala, T., Vanhala, R., Alku, P., Huotilainen, M., & Näätänen, R. (2005). The discrimination of and orienting to speech and non-speech sounds in children with autism. *Brain Research*, 1066(1), 147–157.
- Lepistö, T., Kajander, M., Vanhala, R., Alku, P., Huotilainen, M., Näätänen, R., & Kujala, T. (2008). The perception of invariant speech features in children with autism. *Biological Psychology*, 77(1), 25-31.
- Lepistö, T., Silokallio, S., Nieminen-von Wendt, T., Alku, P., Näätänen, R., & Kujala, T. (2006). Auditory perception and attention as reflected by the brain event-related potentials in children with Asperger syndrome. *Clinical Neurophysiology*, 117(10), 2161–2171.
- Lewkowicz, D. J. (2000). The development of intersensory temporal perception: An epigenetic systems/limitations view. *Psychological Bulletin*, 126(2), 281–308.
- Lewkowicz, D. J. (2010). Infant perception of audio-visual speech synchrony. *Developmental Psychology*, 46(1), 66.
- Lewkowicz, D., & Hansen-Tift, A. (2012). Infants deploy selective attention to the mouth of a talking face when learning speech. In *Proceedings of the National Academy of Sciences* 109, 1431–1436.
- Lewkowicz, D., Leo, I., & Simion, F. (2010). Intersensory perception at birth: newborns match nonhuman primate faces and voices. *Infancy*, 15(1), 46–60.
- Lewkowicz, D., & Flom, R. (2013). The audiovisual temporal binding window narrows in early childhood. *Child Development*, 85, no. 2(2), 685–694.

- Li, P., & Shirai, Y. (2000). *The Acquisition of Lexical & Grammatical Aspect*. Berlin and New York: Mouton de Gruyter. Retrieved 27th May, 2015, from <http://childes.psy.cmu.edu/derived/>
- Lindsay, C. J., Moore, D. W., Anderson, A., & Dillenburger, K. (2013). The role of imitation in video-based interventions for children with autism. *Developmental Neurorehabilitation*, 16(4), 283–289.
- Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006). Sensory and attention abnormalities in autistic spectrum disorders. *Autism*, 10(2), 155–172.
- Lombroso, P., Ogren, M., Jones, W., & Klin, A. (2009). Heterogeneity and homogeneity across the autism spectrum: the role of development. *Journal of the American Academy of Child & Adolescent Psychiatry*, 48(5), 471–473.
- López, B., Donnelly, N., Hadwin, J., & Leekam, S. (2004). Face processing in high-functioning adolescents with autism: evidence for weak central coherence. *Visual Cognition*, 11(6), 673–688.
- Lord, C., & Bishop, S. (2015). Recent Advances in Autism Research as Reflected in DSM-5 Criteria for Autism Spectrum Disorder. *Annual Review of Clinical Psychology*, 11, 53–70.
- Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (2002). *Autism Diagnostic Observation Schedule*. Los Angeles: Western Psychological Services.
- Lovaas, O. I., Ackerman, A., Alexander, D., Firestone, P., Perkins, M., Young, D.B., ...et al. (1981). *Teaching Developmentally Disabled Children, The ME Book*. Austin, TX: Pro-Ed.
- Love, T., Walenski, M., & Swinney, D. (2009). Slowed speech input has a differential impact on on-line and off-line processing in children's comprehension of pronouns. *Journal of Psycholinguistic Research*, 38(3), 285–304.
- Lowe, M., & Costello, A. J. (1988). *The Symbolic Play Test* (2nd ed.). London: GL Assessment Ltd.
- Luyster, R., Lopez, K., & Lord, C. (2007). Characterizing communicative development in children referred for autism spectrum disorders using the MacArthur-Bates Communicative Development Inventory (CDI). *Journal of Child Language*, 34(3), 623–654.
- Luyster, R., & Lord, C. (2009). Word learning in children with autism spectrum disorders. *Developmental Psychology*, 45(6), 1774–1786.
- Luyster, R. J., Kadlec, M. B., Carter, A., & Tager-Flusberg, H. (2008). Language assessment and development in toddlers with autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 38(8), 1426–1438.

- Ma, W., Golinkoff, R. M., Houston, D. M., & Hirsh-Pasek, K. (2011). Word learning in infant-and adult-directed speech. *Language Learning & Development, 7*(3), 185–201.
- MacDonald, J., & McGurk, H. (1978). Visual influences on speech perception processes. *Perception & Psychophysics, 24*(3), 253–257.
- MacWhinney, B. (2000). *The CHILDES project* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum. Retrieved 27th May, 2015, from <http://childes.psy.cmu.edu/derived/>
- Maenner, M. J., Rice, C. E., Arneson, C. L., Cunniff, C., Schieve, L. a, Carpenter, L., et al. (2014). Potential impact of DSM-5 criteria on autism spectrum disorder prevalence estimates. *JAMA Psychiatry, 71*(3), 292–300.
- Maglione, M., Gans, D., Das, L., Timbie, J., & Kasari, C. (2012). Nonmedical interventions for children with ASD: recommended guidelines and further research needs. *Pediatrics, 130*(Supplement 2), S169–S178.
- Mahdhaoui, A., Chetouani, M., Cassel, R. S., Saint-Georges, C., Parlato, E., Laznik, M. C., et al. (2011). Computerized home video detection for motherese may help to study impaired interaction between infants who become autistic and their parents. *Journal of Methods in Psychiatric Research, 20*(1), e6–e18. Retrieved 11th June, 2015, from <http://onlinelibrary.wiley.com/doi/10.1002/mpr.332/pdf>
- Manlove, E. E., Frank, T., & Vernon-Feagans, L. (2001). Why Should We Care About Noise in Classrooms and Child Care Settings? *Child & Youth Care Forum, 30*(1), 55–64.
- Marco, E., Hinkley, L., Hill, S., & Nagarajan, S. (2011). Sensory processing in autism: a review of neurophysiologic findings. *Pediatric Research, 69*(5, Part 2), 48R–54R.
- Marvin, C., Beukelman, D., & Bilyeu, D. (1994). Vocabulary-use patterns in preschool children: effects of context and time sampling. *Augmentative and Alternative Communication, 10*(4), 224–236.
- Massaro, D., & Bosseler, A. (2006). Read my lips: the importance of the face in a computer-animated tutor for vocabulary learning by children with autism. *Autism, 10*(5), 495–510.
- Mayer, J., & Heaton, P. (2014). Age and sensory processing abnormalities predict declines in encoding and recall of temporally manipulated speech in high-functioning adults with ASD. *Autism Research, 7*(1), 40–49.
- Mazzoni, D. and Dannenberg, R. (2000). *Audacity*. Retrieved 10th June, 2015, from <http://web.audacityteam.org/download/>
- McCoy, K., & Hermansen, E. (2007). Video modeling for individuals with autism: a review of model types and effects. *Education & Treatment of Children, 30*(4), 183–213.

- McDuffie, A., Yoder, P., & Stone, W. (2006). Fast-mapping in young children with autism spectrum disorders. *First Language*, 26(4), 421–438.
- McGregor, K. K., Rost, G., Arenas, R., Farris-Trimble, A., & Stiles, D. (2013). Children with ASD can use gaze in support of word recognition and learning. *Journal of Child Psychology and Psychiatry*, 54(7), 745–753.
- McPartland, J., Reichow, B., & Volkmar, F. (2012). Sensitivity and specificity of proposed DSM-5 diagnostic criteria for autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, 51(4), 368–383.
- Medical Research Council. (2014). *Medical Research Council Institute of Hearing Research BKB (Bamford-Kowal-Bench) Sentence Test*. Soundbyte Solutions.co.uk.
- Meints, K. & Fletcher, K. (2001). *Lincoln Toddler Communicative Development Inventory (CDI) Lincoln University UK version*.
http://www.lincoln.ac.uk/home/media/universityoflincoln/schoolofpsychology/CDI_todler.pdf
- Miller, L., Coll, J., & Schoen, S. (2007). A randomized controlled pilot study of the effectiveness of occupational therapy for children with sensory modulation disorder. *American Journal of Occupational Therapy*, 61(2), 228–238.
- Miller, L., & Lane, S. (2000). Toward a consensus in terminology in sensory integration theory and practice: Part 1: taxonomy of neurophysiological processes. *Sensory Integration Special Interest Section Quarterly*, 23(1), 1–4.
- Milne, E., Swettenham, J., Hansen, P., Campbell, R., Jeffries, H. & Plaisted, K. (2002). High motion coherence thresholds in children with autism. *Journal of Child Psychology & Psychiatry*, 43(2), 255-263.
- Mineo, B. A., Ziegler, W., Gill, S., & Salkin, D. (2009). Engagement with electronic screen media among students with autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 39(1), 172-187.
- Minshew, N., & Hobson, J. (2008). Sensory sensitivities and performance on sensory perceptual tasks in high-functioning individuals with autism. *Journal of Autism and Developmental Disorders*, 38(8), 1485–1498.
- Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., et al. (2006). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental and Behavioral Pediatrics*, 27(2), S69.
- Mody, M., & Belliveau, J. W. (2013). Speech and language impairments in autism: insights from behavior and neuroimaging. *North American Journal of Medicine and Science*, 5(3) 157-161.

- Mongillo, E. A., Irwin, J. R., Whalen, D. H., Klaiman, C., Carter, A. S., & Schultz, R. T. (2008). Audiovisual processing in children with and without autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 38(7), 1349–1358.
- Montgomery, J. (2004). Sentence comprehension in children with specific language impairment: Effects of input rate and phonological working memory. *International Journal of Language & Communication Disorders*, 39(1), 115–133.
- Moore, D. R., Ferguson, M. A., Edmondson-Jones, A. M., Ratib, S., & Riley, A. (2010). Nature of auditory processing disorder in children. *Pediatrics*, 126(2), e382. Retrieved 25th May, 2015, from http://www.researchgate.net/profile/Melanie_Ferguson/publication/45366151_Nature_of_Auditory_Processing_Disorder_in_Children/links/0912f50e1bd9cd7c0c000000.pdf
- Moore, M., & Calvert, S. (2000). Brief report: vocabulary acquisition for children with autism: Teacher or computer instruction. *Journal of Autism & Developmental Disorders*, 30(4), 359–362.
- Moore, D. R., Rosen, S., Bamiou, D. E., Campbell, N. G., & Sirimanna, T. (2013). Evolving concepts of developmental auditory processing disorder (APD): a British Society of Audiology APD special interest group 'white paper'. *International Journal of Audiology*, 52(1), 3–13.
- Mottron, L., Dawson, M., Soulières, I., Hubert, B., & Burack, J. (2006). Enhanced perceptual functioning in autism: an update, and eight principles of autistic perception. *Journal of Autism & Developmental Disorders*, 36(1), 27–43.
- Mullen, E. (1995). *Mullen Scales of Early Learning*. Oxford. Pearson Clinical Assessment UK.
- Mundy, P., Block, J., Delgado, C., Pomares, Y., Van Hecke, A. V., & Parlade, M. V. (2007). Individual differences and the development of joint attention in infancy. *Child Development*, 78(3), 938–954.
- Munro, N., Baker, E., McGregor, K., Docking, K., & Arculi, J. (2012). Why word learning is not fast. *Frontiers in Psychology*, 3, 41-41.
- Murray, D. S., Creaghead, N. A., Manning-Courtney, P., Shear, P. K., Bean, J., & Prendeville, J. A. (2008). The relationship between joint attention and language in children with autism spectrum disorders. *Focus on Autism & Other Developmental Disabilities*, 23(1), 5–14.
- Nakano, T., Tanaka, K., Endo, Y., Yamane, Y., Yamamoto, T., Nakano, Y., et al. (2010). Atypical gaze patterns in children and adults with autism spectrum disorders dissociated from developmental changes in gaze behaviour. *Proceedings of the Royal Society of London: Biological Sciences*, 1696(277), 2935–2943.

- Nally, B., Houlton, B., & Ralph, S. (2000). Researches in brief: the management of television and video by parents of children with autism. *Autism*, 43(3), 331–337.
- Nation, K., & Penny, S. (2008). Sensitivity to eye gaze in autism: is it normal? Is it automatic? Is it social? *Development & Psychopathology*, 20(1), 79–97.
- National Autism Center. (2015). *Findings and Conclusions: National Standards Project, Phase2*. Randolph, MA. Retrieved 11th June, 2015, from <http://www.nationalautismcenter.org/090605-2/>
- Newman, R. (2013). *How Autism Affects Speech Understanding in Multitalker Environments*. Maryland. Retrieved 21st May, 2015, from <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA591037>
- NICE [National Institute for Health and Care Excellence]. (2011). *Autism in Children and Young People*. Retrieved 11th May, 2015, from <http://publications.nice.org.uk/autism-diagnosis-in-children-and-young-people-cg128>
- NICE [National Institute for Health and Care Excellence]. (2013). *Autism: The Management and Support of Children and Young People on the Autism Spectrum. CG170*. Retrieved 24th May, 2015, from <https://www.nice.org.uk/guidance/cg170>
- Nieto del Rincón, P. L. (2008). Autism: alterations in auditory perception. *Reviews in the Neurosciences*, 19(1), 61-78.
- Nikopoulos, C., & Keenan, M. (2003). Promoting social initiation in children with autism using video modelling. *Behavioral Interventions*, 18(2), 87–108.
- Nikopoulos, C., & Keenan, M. (2004). Effects of video modeling on social initiations by children with autism. *Journal of Applied Behavior Analysis*, 37(1), 93–96.
- Nikopoulos, C. K., Canavan, C., & Nikopoulou-Smyrni, P. (2009). Generalized effects of video modeling on establishing instructional stimulus control in children with autism: results of a preliminary study. *Journal of Positive Behavior Interventions*, 11(4), 198–207.
- Norbury, C., Griffiths, H., & Nation, K. (2010). Sound before meaning: word learning in autistic disorders. *Neuropsychologia*, 48(14), 4012–4019.
- Norrelgen, F., Fernell, E., & Eriksson, M. (2014). Children with autism spectrum disorders who do not develop phrase speech in the preschool years. *Autism*, 1, 10. Retrieved 10th June, 2015, from <http://aut.sagepub.com/content/early/2014/12/03/1362361314556782.abstract>
- O'Connor, K. (2012). Auditory processing in autism spectrum disorder: a review. *Neuroscience & Biobehavioral Reviews*, 36(2), 836–854.

- O'Doherty, K., Troseth, G. L., Shimpf, P. M., Goldenberg, E., Akhtar, N., & Saylor, M. M. (2011). Third-Party social interaction and word learning from video. *Child Development, 82*(3), 902–915.
- O'Donnell, S., Deitz, J., Kartin, D., Nalty, T., & Dawson, G. (2012). Sensory processing, problem behavior, adaptive behavior, and cognition in preschool children with autism spectrum disorders. *American Journal of Occupational Therapy, 66*(5), 586–594.
- O'Riordan, M. A., Plaisted, K. C., Driver, J., & Baron-Cohen, S. (2001). Superior visual search in autism. *Journal of Experimental Psychology: Human Perception and Performance, 27*(3), 719–730.
- Oakes, L., & Ellis, A. (2013). An eye tracking investigation of developmental changes in infants' exploration of upright and inverted human faces. *Infancy, 18*(1), 134–148.
- Oram Cardy, J. E., Flagg, E. J., Roberts, W., Brian, J., & Roberts, T. P. (2005). Magnetoencephalography identifies rapid temporal processing deficit in autism and language impairment. *Neuroreport, 16*(4), 329–332.
- Parham, L. D., Cohn, E. S., Spitzer, S., Koomar, J. A., Miller, L. J., Burke, J. P., et al. (2007). Fidelity in sensory integration intervention research. *Intervention Research, 61*, 216–227.
- Parish-Morris, J., Hennon, E. A., Hirsh-Pasek, K., Golinkoff, R. M., & Tager-Flusberg, H. (2007). Children with autism illuminate the role of social intention in word learning. *Child Development, 78*(4), 1265–1287.
- Patrick, K. (2013). *Word-Learning Strategies of Children with Autism Spectrum Disorders: Understanding of Referential Intent*. Drexel University. Retrieved 19th May, 2015, from [https://idea.library.drexel.edu/islandora/object/idea%3A4302/datastream/OBJ/download/Word-Learning Strategies of Children with Autism Spectrum Disorders Understanding of Referential Intent.pdf](https://idea.library.drexel.edu/islandora/object/idea%3A4302/datastream/OBJ/download/Word-Learning+Strategies+of+Children+with+Autism+Spectrum+Disorders+Understanding+of+Referential+Intent.pdf)
- Patten, E., & Watson, L. R. (2011). Interventions targeting attention in young children with autism. *American Journal of Speech-Language Pathology, 20*(1), 60-69.
- Paul, R. (2008). Auditory processing disorder. *Journal of Autism & Developmental Disorders, 38*(1), 208–209.
- Paul, R., Chawarska, K., & Fowler, C. (2007). “Listen my children and you shall hear”: auditory preferences in toddlers with autism spectrum disorders. *Journal of Speech, Language & Hearing Research, 50*(5), 1350–1364.
- Pereira, A., Smith, L., & Yu, C. (2014). A bottom-up view of toddler word learning. *Psychonomic Bulletin & Review, 21*(1), 178–185.

- Pfeiffer, B. A., Koenig, K., Kinnealey, M., Sheppard, M., & Henderson, L. (2011). Effectiveness of sensory integration interventions in children with autism spectrum disorders: a pilot study. *The American Journal of Occupational Therapy: Official Publication of the American Occupational Therapy Association*, 65(1), 76.
- Phillips, D. (1995). Central auditory processing: a view from auditory neuroscience. *Otology & Neurotology*, 16(3), 338–352.
- Picard, M., & Bradley, J. S. (2001). Revisiting speech interference in classrooms: revisando la interferencia en el habla dentro del salón de clases. *International Journal of Audiology*, 40(5), 221–244.
- Pierroutsakos, S., & Troseth, G. (2003). Video verite: infants' manual investigation of objects on video. *Infant Behavior & Development*, 26(2), 183–199.
- Plaisted, K. (2001). *Reduced Generalization in Autism: An Alternative to Weak Central Coherence*. Retrieved 11th June, 2015, from <http://psycnet.apa.org/psycinfo/2001-01233-008>
- Plavnick, J. B., MacFarland, M. C., & Ferreri, S. J. (2014). Variability in the effectiveness of a video modeling intervention package for children with autism. *Journal of Positive Behavior Interventions*, 17(2), 105–115.
- Preissler, M., & Carey, S. (2005). The role of inferences about referential intent in word learning: evidence from autism. *Cognition*, 97(1), B13–B23.
- Pruett Jr, J. R., LaMacchia, A., Hoertel, S., Squire, E., McVey, K., Todd, R. D., et al. (2011). Social and non-social cueing of visuospatial attention in autism and typical development. *Journal of Autism & Developmental Disorders*, 41(6), 715–731.
- Ramdoss, S., Lang, R., Mulloy, A., Franco, J., O'Reilly, M., Didden, R., et al. (2011). Use of computer-based interventions to teach communication skills to children with autism spectrum disorders: a systematic review. *Journal of Behavioral Intervention*, 20(1), 55–76.
- Ramírez-Esparza, N., García-Sierra, A., & Kuhl, P. K. (2014). Look who's talking: speech style and social context in language input to infants are linked to concurrent and future speech development. *Developmental Science*, 17(6), 880–891.
- Rance, G., Saunders, K., Carew, P., Johansson, M., & Tan, J. (2014). The use of listening devices to ameliorate auditory deficit in children with autism. *The Journal of Pediatrics*, 164(2), 352–357.
- Rayner, C., Denholm, C., & Sigafos, J. (2009). Video-based intervention for individuals with autism: key questions that remain unanswered. *Research in Autism Spectrum Disorders*, 3(2), 291–303.

- Reichow, B., Volkmar, F., & Cicchetti, D. (2008). Development of the evaluative method for evaluating and determining evidence-based practices in autism. *Journal of Autism & Developmental Disorders*, 38(7), 1311–1319.
- Reynell, J.K. (1985). *Reynell Developmental Language Scales (2nd edition)*. Windsor: NFER Nelson.
- Richert, R. A., Robb, M. B., Fender, J. G., & Wartella, E. (2010). Word learning from baby videos. *Archives of Pediatrics & Adolescent Medicine*, 164(5), 432-437.
- Richert, R., Robb, M., & Smith, E. (2011). Media as social partners: the social nature of young children's learning from screen media. *Child Development*, 82(1), 82–95.
- Ristic, J., Friesen, C., & Kingstone, A. (2002). Are eyes special? It depends on how you look at it. *Psychonomic Bulletin & Review*, 9(3), 507–513.
- Roberts, J. (2014). Echolalia and language development in children with autism. In Arciuli, J. & Brock, J. (Eds.), *Communication in Autism (55–73)*. Philadelphia: John Benjamins North America.
- Robinson, C., & Sloutsky, V. (2004). Auditory dominance and its change in the course of development. *Child Development*, 75(5), 1387–1401.
- Rogers, S. J., & Ozonoff, S. (2005). Annotation: what do we know about sensory dysfunction in autism. a critical review of the empirical evidence. *Journal of Child Psychology & Psychiatry*, 46(12), 1255–1268.
- Rogers, S. J., & Vismara, L. A. (2008). Evidence-based comprehensive treatments for early autism. *Journal of Clinical Child & Adolescent Psychology: The Official Journal for the Society of Clinical Child & Adolescent Psychology, American Psychological Association, Division 53*, 37(1), 8.
- Ross, L. A., Molholm, S., Blanco, D., Gomez-Ramirez, M., Saint-Amour, D., & Foxe, J. J. (2011). The development of multisensory speech perception continues into the late childhood years. *European Journal of Neuroscience*, 33(12), 2329–2337.
- Russo, N., Nicol, T., & Trommer, B. (2009a). Brainstem transcription of speech is disrupted in children with autism spectrum disorders. *Developmental Science*, 12(4), 557–567.
- Russo, N., Zecker, S., Trommer, B., Chen, J., & Kraus, N. (2009b). Effects of background noise on cortical encoding of speech in autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 39(8), 1185–1196.
- Samson, F., Mottron, L., Jemel, B., Belin, P., & Ciocca, V. (2006). Can spectro-temporal complexity explain the autistic pattern of performance on auditory tasks? *Journal of Autism & Developmental Disorders*, 36(1), 65–76.

- Samson, F., Mottron, L., Soulières, I., & Zeffiro, T. A. (2012). Enhanced visual functioning in autism: an ALE meta-analysis. *Human Brain Mapping, 33*(7), 1553–1581.
- Samuelson, L. K., & Smith, L. B. (1998). Memory and attention make smart word learning: an alternative account of Akhtar, Carpenter, and Tomasello. *Child Development, 69*(1), 94–104.
- Santosh, P. J., Mandy, W. P., Puura, K., Kaartinen, M., Warrington, R., & Skuse, D. H. (2009). The construction and validation of a short form of the developmental, diagnostic and dimensional interview. *European Child & Adolescent Psychiatry, 18*(8), 521–524.
- Sato, H., & Bradley, J. S. (2008). Evaluation of acoustical conditions for speech communication in working elementary school classrooms. *The Journal of the Acoustical Society of America, 123*(4), 2064-2077.
- Schaaf, R. C., Benevides, T., Mailloux, Z., Faller, P., Hunt, J., van Hooydonk, E., ... & Kelly, D. (2014). An intervention for sensory difficulties in children with autism: a randomized trial. *Journal of Autism & Developmental Disorders, 44*(7), 1493-1506.
- Schafer, E. C., Mathews, L., Mehta, S., Hill, M., Munoz, A., Bishop, R., et al. (2013). Personal FM systems for children with autism spectrum disorders (ASD) and/or attention-deficit hyperactivity disorder (ADHD): an initial investigation. *Journal of Communication Disorders, 46*(1), 30–52.
- Schefflen, S., Freeman, S., & Paparella, T. (2012). Using video modeling to teach young children with autism developmentally appropriate play and connected speech. *Education and Training in Autism & Developmental Disabilities, 47*(3), 302–318.
- Schoen, S. A., Miller, L. J., Brett-Green, B. A., & Nielsen, D. M. (2009). Physiological and behavioral differences in sensory processing: a comparison of children with autism spectrum disorder and sensory modulation disorder. *Frontiers in Integrative Neuroscience, 3*, 29–29.
- Scientific Learning Corporation. (1997). *Fast ForWord-Language*: Scientific Learning Products [Computer software]. Oakland, CA.
- Scofield, J., Williams, A., & Behrend, D. (2007). Word learning in the absence of a speaker. *First Language, 27*(3), 297–311.
- Seeff-Gabriel, B., Chiat, S., & Roy, P. (2008). *Early Repetition Battery*. Oxford: Harcourt Assessment.
- Seemann, A. (2011). *Joint Attention: New Developments in Psychology, Philosophy of Mind, and Social Neuroscience*, MIT Press, Cambridge.

- Senju, A., Tojo, Y., Dairoku, H., & Hasegawa, T. (2004). Reflexive orienting in response to eye gaze and an arrow in children with and without autism. *Journal of Child Psychology & Psychiatry*, 45(3), 445–458.
- Shannon, R. V., Zeng, F. G., Kamath, V., Wygonski, J., & Ekelid, M. (1995). Speech recognition with primarily temporal cues. *Science*, 270(5234), 303–304.
- Sharma, M., Purdy, S. C., & Kelly, A. S. (2012). A randomized control trial of interventions in school-aged children with auditory processing disorders. *International Journal of Audiology*, 51(7), 506-518.
- Shepley, C., Lane, J., & Shepley, S. (2014). Teaching young children with social-communication delays to label actions using videos and language expansion models a pilot study. *Focus on Autism & Other Developmental Disabilities*, 1088357614552189. Retrieved 27th May, 2015, from <http://foa.sagepub.com/content/early/2014/10/15/1088357614552189>
- Shukla-Mehta, S., Miller, T., & Callahan, K. J. (2010). Evaluating the effectiveness of video instruction on social and communication skills training for children with autism spectrum disorders: a review of the literature. *Focus on Autism & Other Developmental Disabilities*, 25(1), 23–36.
- Sigman, M., & McGovern, C. (2005). Improvement in cognitive and language skills from preschool to adolescence in autism. *Journal of Autism & Developmental Disorders*, 35(1), 15–23.
- Silver Lining Multimedia Inc. (1999). *Picture This*.
- Simpson, A., Langone, J., & Ayres, K. M. (2004). Embedded video and computer based instruction to improve social skills for students with autism. *Education & Training in Developmental Disabilities*, 240-252.
- Skuse, D., Warrington, R., Bishop, D., Chowdhury, U., Lau, J., Mandy, W., et al. (2004). The developmental, dimensional and diagnostic interview (3di): a novel computerized assessment for autism spectrum disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, 43(5), 548–558.
- Sloutsky, V., & Robinson, C. (2008). The role of words and sounds in infants' visual processing: from overshadowing to attentional tuning. *Cognitive Science*, 32(2), 342–365.
- Smith, E., & Bennetto, L. (2007). Audiovisual speech integration and lipreading in autism. *Journal of Child Psychology & Psychiatry*, 48(8), 813–821.
- Smith, L., & Yu, C. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition*, 106(3), 1558–1568.
- Smith, V., Miranda, P., & Zaidman-Zait, A. (2007). Predictors of expressive vocabulary growth in children with autism. *Journal of Speech, Language, & Hearing Research*, 50(1), 149.

- Soto-Faraco, S., Navarra, J., & Alsius, A. (2004). Assessing automaticity in audiovisual speech integration: evidence from the speeded classification task. *Cognition*, 92(3), B13–B23.
- Sotto, C.D., Redle, E., Bandaranayake, D., Neils-Strunjas, J. & Creaghead, N. A. (2014). Fricatives at 18 months as a measure for predicting vocabulary and grammar at 24 and 30 months. *Journal of Communication Disorders*, 49 (1-12).
- Soulières, I., Dawson, M., Samson, F., Barbeau, E. B., Sahyoun, C. P., Strangman, G. E., et al. (2009). Enhanced visual processing contributes to matrix reasoning in autism. *Human Brain Mapping*, 30(12), 4082–4107.
- Sparrow, S., Cicchetti, D. & Balla, D. (2005). *Vineland Adaptive Behaviour Scales*. Circle Pines, MN: American Guidance Service.
- Spence, S. J., & Thurm, A. (2010). Testing autism interventions: trials and tribulations. *The Lancet*, 375(9732), 2124–2125.
- Stanley, G. C., & Konstantareas, M. M. (2007). Symbolic play in children with autism spectrum disorder. *Journal of Autism & Developmental Disorders*, 37(7), 1215-1223.
- Sterponi, L., & Shankey, J. (2014). Rethinking echolalia: repetition as interactional resource in the communication of a child with autism. *Journal of Child Language*, 41(2), 275–304.
- Stevenson, R. A., Segers, M., Ferber, S., Barense, M. D., & Wallace, M. T. (2014a). The impact of multisensory integration deficits on speech perception in children with autism spectrum disorders. *Frontiers in Psychology*, 5, 379–379.
- Stevenson, R.A., Siemann, J.K., Woynaroski, T.G., Schneider, B.C., Eberly, H.E., Camarata, S.M & Wallace, M.T. (2014b). Multisensory temporal integration in Autism Spectrum Disorders in Autism Spectrum Disorders. *Journal Neuroscience*, 34 (3), 691-697.
- Stevenson, R.A., Siemann, J.K., Woynaroski, T.G., Schneider, B.C., Eberly, H.E., Camarata, S.M & Wallace, M.T. (2014c). Arrested development of audiovisual speech perception in Autism Spectrum Disorders. *Journal of Autism Developmental Disorders*, 44 (6), 1470-1477.
- Strong, G. K., Torgerson, C. J., Torgerson, D., & Hulme, C. (2011). A systematic meta-analytic review of evidence for the effectiveness of the “Fast ForWord” language intervention program. *Journal of Child Psychology & Psychiatry*, 52(3), 224–235.
- Swettenham, J., Condie, S., Campbell, R., Milne, E., & Coleman, M. (2003). Does the perception of moving eyes trigger reflexive visual orienting in autism? *Philosophical Transactions of the Royal Society: Biological Sciences*, 358(1430), 325–334.

- Tager-Flusberg, H., & Kasari, C. (2013). Minimally verbal school-aged children with autism spectrum disorder: the neglected end of the spectrum. *Autism Research*, 6(6), 468–478.
- Tager-Flusberg, H., Rogers, S., Cooper, J., Landa, R., Lord, C., Paul, R., et al. (2009). Defining spoken language benchmarks and selecting measures of expressive language development for young children with autism spectrum disorders. *Journal of Speech, Language & Hearing Research*, 52(3), 643.
- Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X., Nagarajan, S. S., et al. (1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science*, 271(5245), 81–84.
- Tardif, C., Laine, F., Rodriguez, M., & Gepner, B. (2007). Slowing down facial movements and vocal sounds enhances facial expression recognition and induces facial-vocal imitation in children with autism. *Journal of Autism & Developmental Disorders*, 37 (8), 1469–1484.
- Taylor, N., Isaac, C., & Milne, E. (2010). A comparison of the development of audiovisual integration in children with autism spectrum disorders and typically developing children. *Journal of Autism & Developmental Disorders*, 40(11), 1403–1411.
- Tecchio, F., Benassi, F., Zappasodi, F., Gialloreti, L. E., Palermo, M., Seri, S., et al. (2003). Auditory sensory processing in autism: a magnetoencephalographic study. *Biological Psychiatry*, 54(6), 647–654.
- Teder-Salejarvi, W. A., Pierce, K. L., Courchesne, E., & Hillyard, S. A. (2005). Auditory spatial localization and attention deficits in autistic adults. *Cognitive Brain Research*, 23(2-3), 221–234.
- Tenenbaum, E. J., Amso, D., Abar, B., & Sheinkopf, S. J. (2014). Attention and word learning in autistic, language delayed and typically developing children. *Frontiers in Psychology*, 5, 490–490.
- Tenenbaum, E. J., Shah, R. J., Sobel, D. M., Malle, B. F., & Morgan, J. L. (2013). Increased focus on the mouth among infants in the first year of life: a longitudinal eye-tracking study. *Infancy*, 18(4), 534–553.
- Thurm, A., Manwaring, S. S., Swineford, L., & Farmer, C. (2015). Longitudinal study of symptom severity and language in minimally verbal children with autism. *Journal of Child Psychology & Psychiatry*, 56(1), 97–104.
- Tomchek, S. D., & Dunn, W. (2007). Sensory processing in children with and without autism: a comparative study using the Short Sensory Profile. *American Journal of Occupational Therapy*, 61(2), 190–200.
- Tomchek, S., Huebner, R., & Dunn, W. (2014). Patterns of sensory processing in children with an autism spectrum disorder. *Research in Autism Spectrum Disorder*, 8(9), 1214–1224.

- Travers, B. G., Bigler, E. D., Tromp, D. P., Adluru, N., Froehlich, A. L., Ennis, C., et al. (2014). Longitudinal processing speed impairments in males with autism and the effects of white matter microstructure. *Neuropsychologia*, *53*, 137–145.
- Tsao, F Tremblay, C., Champoux, F., Voss, P., & Bacon, B. (2007). Speech and non-speech audio-visual illusions: a developmental study. *PLoS One*, *2*(8). Retrieved 21st May, 2015, from <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0000742>
- Uchanski, R., Geers, A., & Protopapas, A. (2002). Intelligibility of modified speech for young listeners with normal and impaired hearing. *Journal of Speech, Language, & Hearing Research*, *45*(5), 1027–1038.
- van der Smagt, M. (2007). Brief report: can you see what is not there? Low-level auditory–visual integration in autism spectrum disorder. *Journal of Autism & Developmental Disorders*, *37*, 346.
- van Santen, J. P., Sproat, R. W., & Hill, A. P. (2013). Quantifying repetitive speech in autism spectrum disorders and language impairment. *Autism Research*, *6*(5), 372-383.
- Varner, A. (2014). *Vocabulary Development in Young Children through Television Programs: Doctoral Dissertation*. Northwest Missouri State University. Retrieved 27th May, 2015, from <http://www.nwmissouri.edu/library/researchpapers/2014/Varner, Ally.pdf>
- Volden, J., Smith, I. M., Szatmari, P., Bryson, S., Fombonne, E., Mirenda, P., et al. (2011). using the preschool language scale, to characterize language in preschoolers with autism spectrum disorders. *American Journal of Speech-Language Pathology*, *20*(3), 200–208.
- Volkmar, F., & McPartland, J. (2014). From Kanner to DSM-5: autism as an evolving diagnostic concept. *Annual Review of Clinical Psychology*, *10*, 193–212.
- Wechsler, D. (2005). *Wechsler Preschool and Primary Scale of Intelligence (Swedish Version)*. Stockholm: Psykologiforlaget AB.
- Walton, K., & Ingersoll, B. (2013). Expressive and receptive fast-mapping in children with autism spectrum disorders and typical development: the influence of orienting cues. *Research in Autism Spectrum Disorders*, *7*(6), 687–698.
- Wang, A. T., Lee, S. S., Sigman, M., & Dapretto, M. (2007). Reading affect in the face and voice: neural correlates of interpreting communicative intent in children and adolescents with autism spectrum disorders. *Archives of General Psychiatry*, *64*(6), 698–708.
- Wang, S.Y., Cui, Y. & Parrila, R., S. (2011). Examining the effectiveness of peer-mediated and video-modeling social skills interventions for children with autism spectrum disorders: a meta-analysis in single case research using HLM. *Research in Autism Spectrum Disorders*, *5*, 562–569.

- Watling, R., Deitz, J., & White, O. (2001). Comparison of sensory profile scores of young children with and without autism spectrum disorders. *American Journal of Occupational Therapy, 55*(4), 416–423.
- Watson, L.R., Roberts, J. E., Baranek, G. T., Poe, M., Boyd, B.A., Freuler, A & Lorenzi, J. (2011). Differential associations between sensory response patterns and language, social and communication measures in children with autism or other developmental disabilities. *Journal of Speech, Language and Hearing Research, 54* (6), 1562-1576.
- Watson, L. R., Roberts, J. E., Baranek, G. T., Mandulak, K. C., & Dalton, J. C. (2012). Behavioral and physiological responses to child-directed speech of children with autism spectrum disorders or typical development. *Journal of Autism & Developmental Disorders, 42*(8), 1616–1629.
- Werker, J. F., Cohen, L. B., Lloyd, V. L., Casasola, M., & Stager, C. L. (1998). Acquisition of word-object associations by 14-month old infants. *Developmental Psychology, 34*(6), 1289–1309.
- Wert, B. Y., & Neisworth, J. T. (2003). Effects of video self-modeling on spontaneous requesting in children with autism. *Journal of Positive Behavior Interventions, 5*(1), 30.
- Wetherby, A. M. and Prizant, B. (2002). *Communication and Symbolic Behaviour Scales Developmental Profile*. Baltimore, MD: Paul H. Brookes Publishing.
- White, S., Keonig, K., & Scahill, L. (2007). Social skills development in children with autism spectrum disorders: a review of the intervention research. *Journal of Autism & Developmental Disorders, 37*(10), 1858–1868.
- Whitehouse, A. J., & Bishop, D. V. (2008). Do children with autism “switch off” to speech sounds? An investigation using event-related potentials. *Developmental Science, 11*(4), 516–524.
- Wiggins, L. D., Robins, D. L., Bakeman, R., & Adamson, L. B. (2009). Brief report: sensory abnormalities as distinguishing symptoms of autism spectrum disorders in young children. *Journal of Autism & Developmental Disorders, 39*(7), 1087–109.
- Williams, J., Massaro, D., & Peel, N. (2004). Visual-auditory integration during speech imitation in autism. *Research in Developmental Disabilities, 25*(6), 559–575.
- Wilson, K. (2013). Teaching social-communication skills to preschoolers with autism: efficacy of video versus in vivo modeling in the classroom. *Journal of Autism & Developmental Disorders, 43*(8), 1819–1831.
- World Health Organization. (1992). The ICD-10 Classification of Mental and Behavioural Disorders. *International Classification, 10*, 1–267.

- Wong, C., Odom, S.L., Hume, K.A., Cox, A.W., Fettig, A., Kucharczyk, S., et al. Evidenced-based practices for children, youth and young adults with autism spectrum disorder: a comprehensive review. *Journal of Autism & Developmental Disorders*, 45 (7), 1951-1966.
- Woynaroski, T. G., Kwakye, L. D., Foss-Feig, J. H., Stevenson, R. A., Stone, W. L., & Wallace, M. T. (2013). Multisensory speech perception in children with autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 43(12), 2891–2902.
- Yoder, P., Watson, L., & Lambert, W. (2014). Value-added predictors of expressive and receptive language growth in initially nonverbal preschoolers with autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 45(5), 1254–1270.
- Young, G. S., Merin, N., Rogers, S. J., & Ozonoff, S. (2009). Gaze behavior and affect at 6 months: predicting clinical outcomes and language development in typically developing infants and infants at risk for autism. *Developmental Science*, 12(5), 798–814.
- Yu, C., & Smith, L. (2012). Embodied attention and word learning by toddlers. *Cognition*, 125(2), 244–262.
- Zack, E., Barr, R., Gerhardstein, P., Dickerson, K., & Meltzoff, A. N. (2009). Infant imitation from television using novel touch screen technology. *British Journal of Developmental Psychology*, 27(1), 13–26.
- Zimmerman, I., Steiner, V. & Pond, R. (1997). *Preschool Language Scale - UK (3rd ed.)*. UK: Psychological Corporation.
- Zimmerman, I., Steiner, V. & Pond, R. (2002). *Preschool Language Scale - UK (4th ed.)*. San Antonio, TX: Psychological Corporation.
- Zimmerman, I., Steiner, V., Pond, R. (2009). *Preschool Language Scale - UK (4th ed.)*. London: Pearson Assessment.
- Zimmerman, I., Steiner, V., Pond, R. (2011). *Preschool Language Scale (5th ed.)*. San Antonio, TX: The Psychological Corporation.

APPENDICES

Appendices 1-3 and Appendix 16 omitted, but available in hard copy from the University of Sheffield Library.

Appendix 6: Parent/carer consent form: Part 2

Date:

Participant Identification Number:

Title of Project: Word learning in children with Autism Spectrum Disorder

Name of Researcher:

Please initial boxes below

1. I confirm that I have read and understand the information sheet dated 14/1/13 explaining the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.
2. I understand that our participation is voluntary and that my child and I are free to withdraw at any time without giving any reason, and without affecting my child's care in any way. Should I wish to withdraw my son/daughter from the project, I can do so by contacting XXXX on XXXXX, or email at XXXXXX
3. I understand that all information about my son/daughter will be kept strictly confidential. I understand that his/her name will not be linked with the research materials, and that we will not be identified or identifiable in the report that results from the research.
4. I give permission for the researcher and staff from the University of Sheffield to look at the anonymised information about my child. I agree to the use of my anonymised responses to questionnaires in the project report.
5. I agree to the findings of the project being presented in oral and written reports. I understand that we will not be identified or identifiable in any such presentations or report.
6. I agree to my child's speech and language therapist (if applicable) being informed of our participation in the study.
7. I agree to take part in the above study and to allow my child to take part in the study.

Name of Child.....

Name of Parent.....

Signature of Parent.....Date.....

Name of Person taking consent

Signature of Person taking consentDate.....

When completed: 1 for parent/carers; 1 for researcher site file; 1 (original) to be given to parents/carers for keeping in speech and language therapy or medical notes.

Appendix 7: School consent form: Part 2

University of Sheffield, Dept of Human Communication Sciences

Dear Headteacher/SENCo,

You have expressed an interest in participating in the research project, 'Word learning in children with Autism Spectrum Disorder', which forms part of my PHD studies with the University of Sheffield. I am writing to formally request your permission to recruit and study pupils for this research project. Details about the research project are enclosed in the information sheet for participants. It is anticipated that between 12 and 24 young children (aged 4 years - 7 years 11 months) with ASD from local schools who meet the inclusion criteria in the information sheet, will be recruited.

If you agree to take part in the project, the home visit and intervention will be carried out by the researcher, but the project will also involve members of your staff in the following tasks.

1: A teacher or teaching assistant who knows the child/children well, will be asked to complete the questionnaire, McArthur Communicative Development Inventory Oxford UK. A copy for your information is attached. This is expected to take about 15 minutes per child prior to the session.

2: The staff member accompanying the child for intervention will be asked to highlight any behaviour or sensory preference issues which might affect the child's ability to participate safely in the study (10-15 minutes). The researcher will also check with the staff member regarding any signs of anxiety or potential exclusion criteria such as upper respiratory tract infection affecting hearing.

3: The staff member will be required to remain accessible throughout the intervention. A quiet room with minimal distractions, a table and two chairs child will be required. The intervention will take approximately 30 minutes in addition to the 10-15 minute discussion described above.

Please sign the reply slip below if you decide to give permission and return it me at, XXXXX . Please do not hesitate to contact me on XXXXXX or by email at XXXXXX should you have any queries about the project prior to giving permission or once the project is underway.

.....
I give my permission for researcher in the researcher project, 'Word learning in children with Autism Spectrum Disorder' to recruit and study children at XXXXX school. Signature of Headteacher/SENCo

Name.....Designation.....Date.....

Appendix 8: Participant information sheet: Part 1

Word learning in children with Autism Spectrum Disorder

I am a qualified speech and language therapist employed by XXXXX NHS Trust. I would like to invite you and your child to take part in a research study. Before you decide, please read this information sheet. It will explain why the study is being done and what it will involve. Then, if you want to find out more, please telephone and I will answer any questions. This could take about 15 minutes. If you decide to continue, I will arrange to visit you at home and explain the study. I will also answer any other questions before you finally decide whether to take part. Please talk to others about the study if you wish.

Part 1 of this information sheet tells you the purpose of this study and what will happen if you take part. Part 2 gives you more detailed information about the conduct of the study. Please ask if there is anything that is not clear. You can contact me on XXXX, return the reply slip or email me at XXXXXX

PART 1

What is the purpose of the study?

We want to find out more about how to improve early word learning in children with ASD (Autism Spectrum Disorder). This study builds on evidence that some individuals with ASD have difficulties processing what they hear, such as distinguishing speech from background noise and that some children with ASD may benefit from adults speaking at a slower rate.

Why have you and your child been invited?

An invitation to participate in the project is being sent to local families with a young child with ASD who meet the criteria below until six families have completed the project. The invitations are being sent out either by the person who diagnosed your child with ASD or by their secretary because your child's name is on the ASD data base held by the local diagnostic team. Your child is thought to be aged between 3 years 6 months and 6 years 11 months, have a diagnosis of ASD and have difficulties with spoken language. For this study, your child should have normal hearing and vision. The language spoken at home should be English. These factors are important so as not to confuse the results.

Do we have to take part?

It is up to you to decide whether to join the study. When I visit you, I will describe the study in more detail and go through this information sheet. If you agree to take part, I will ask you to sign a consent form. You are free to withdraw at any time without giving a reason. This would not affect the standard of care you receive from speech and language therapy or other services.

What will happen if I take part?

Stage 1: I will begin by visiting you at home to explain about the project. If you give consent to continue with the project, I will assess your child's communication and play skills. This will involve you answering some questions and your child attempting some simple play or early learning activities. After my visit, you will be asked to play a 5 minute video to your child on your TV or computer screen daily for 2 weeks. The video will be of an actor showing and repeating the names of two toys. Your child will need to wear headphones while watching the video. These will be provided by the researcher. You will sit with your child whilst s/he watches the video. You will be asked to keep a diary of your child's responses. If at any time, your child responds negatively to watching the video, you will be asked to stop the video and remove the headphones. You may try another time, but if problems persist, you should stop the intervention and contact the researcher.

Stage 2: Families who successfully complete Stage 1 will be invited to join Stage 2 of the project and sign a further consent form. I will visit you at home 4 times over a period of about 10-12 weeks. This will be to carry out some further simple assessments and briefly describe how to use the Stage 2 videos I give you. Two modified 5 minute videos of an actor showing and repeating the names of two toys in each will be given to you. These videos may be modified so that the sound track either includes background noise, or is slowed down. You may also be asked to help your child learn the names of toys through a five minute play session. You will be asked play the videos on the computer or TV to your child daily for 4 weeks, using the headphones provided.

I will also ask you to keep a diary of how your child responds to the videos. There will be a postal or telephone questionnaire on your child's vocabulary 6 weeks after the final visit.

Your child may continue with any other speech and language therapy they are getting during the study as advised by that service.

What are the alternatives?

The local NHS speech and language therapy service has an open referral system. Details are available on their website.

What are the possible disadvantages and risks of taking part?

Some children may dislike watching the videos or wearing headphones. This may be linked to sensory preferences. Some families may have difficulty watching the videos each day. There is also a time commitment required from you to play the videos with your child, answer questionnaires, complete a diary and support the child joining in with the assessments.

It is important that you check the sound level of the videos is set at a comfortable level for the child each time. You should sit with your child to supervise him/her whilst s/he is watching the videos to check that they are not experiencing any discomfort. Also, you must check that there is no danger from trailing wires or where the computer or TV is connected to the mains. You will be given some guidance on these aspects.

What are the possible benefits of taking part?

We cannot promise the study will help you, but information from this study will help our understanding of how to improve the treatment of children with ASD.

What happens when the research stops?

You will be given a summary of the results for your child. There is currently no provision for this specific intervention to continue after the study.

What if there is a problem?

Any complaint about the way you have been dealt with during the study or any possible difficulties experienced, will be addressed. Detailed information on this is given in part 2.

Will our taking part in the study be kept confidential?

Yes. We will follow ethical and legal practice. All information about you and your child will be kept securely and handled in strictest confidence following NHS

guidelines. Information not processed on NHS equipment will have your names and address removed so that you and your child cannot be recognised.

This completes Part 1. If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.

PART 2

What if relevant new information becomes available?

Sometimes we get new information which may affect the study. If this happens, I will tell you and discuss what this means for you.

What will happen if I don't want to carry on with the study?

You are free to withdraw at any time. If you don't want to carry on, I will ask for your consent to use the information and data collected about you so far.

What if there is a problem?

If you have a concern about any aspect of this study, you should telephone and ask for XXXX on XXXXX. I will do my best to answer your questions. If you remain unhappy and wish to complain formally, you can do this following the NHS complaints procedure. In the unlikely event of any harm resulting from negligence, usual NHS policies will apply. In this instance if you agree to take part, in the unlikely event of any harm incurring which does not arise from negligence, any legal costs would be borne by the participants. Please ask for details or see our website.

Involvement of the General Practitioner/Family doctor (GP) and child's usual Speech and Language Therapist

If you agree to participate, I will ask for your consent to inform your child's GP and local speech and language therapist if you have one. They will be given basic details of the study and your involvement. The speech and language therapist will be given a summary of the results. This is so that therapists can work in harmony as advised by the Royal College of Speech and Language Therapists.

What will happen to the results of the research study?

You will be given a summary of the results for your child. You will also receive a summary of the overall results. We will ensure that you are not identified in any report or publication of the study without your consent.

Who is organising and funding the research?

This research is monitored by XXXXXX and sponsored by the University of Sheffield as part of doctoral studies leading to a PhD.

Who has reviewed the study?

All research in the NHS is looked at by an independent group of people called a Research Ethics Committee, to protect your interests. This study will have been reviewed and given a favourable opinion by the Research Ethics Committee for this region.

.....

Please contact me. I would like to find out more about taking part in this research.

Name.....

Address.....

.....

.....

Telephone.....

Return to: XXXXXX

Appendix 9: Professional information sheet: Part 1

Word learning in children with Autism Spectrum disorder

Part 1 of this information sheet tells you the purpose of this study and what it is about. Part 2 gives you more detailed information about the conduct of the study. Please ask if there is anything that is not clear. You can contact me on XXXX or email me at XXXX

PART 1

What is the purpose of the study?

To look at the effects of background noise and speech rate on early word learning in children with ASD (Autism Spectrum Disorder). This study builds on emerging evidence that some individuals with ASD have difficulties processing what they hear. The study is part of my doctoral studies at the University of Sheffield.

Participants

An invitation to participate is being sent to relevant families on the local ASD data base. The study will recruit 6 -10 children with a diagnosis of ASD and significant difficulties with spoken language. They will have normal hearing and vision and be aged between 3 years 6 months - 6 years 11 months. The home language will be English. These factors are important so as not to confuse the results and make it difficult to draw conclusions from this particular study. Recruitment will stop when 6 children have completed both phases of the study. Families who contact the researcher will receive a follow up phone call. This will give them further information so they can decide if they want to proceed. Parents will be asked to sign a consent form to participate in the research at each stage.

What will happen?

Stage 1: I will begin by visiting families at home to explain about the project. I will always have an identification badge. If families give consent to participate in the project, I will then assess the child's communication and play skills. This will involve parents answering some questions and the child attempting some simple play or early learning activities. After my visit, parents will be asked to play a 5 minute video to their child on the TV or computer screen daily for 2 weeks. The video will be of an actor showing and repeating the names of two toys. The child will wear headphones

while watching the video. These will be provided by the researcher. Parents will sit with their child whilst s/he is watching the video. Parents will be asked to keep a diary of their child's responses. If at any time, the child responds negatively to watching the video, parents will be asked to stop the video and remove the headphones. They may try another time, but if problems persist, they will be advised to stop the intervention and contact the researcher.

Stage 2: Families who successfully complete Stage 1 will be invited to join Stage 2 and sign a further consent form. I will visit them at home 4 times over a period of about 10-12 weeks. This will be to carry out some further simple assessments, and to give out and briefly describe how to use the Stage 2 videos. Two modified 5 minute videos of an actor showing and repeating the names of two toys in each video will be given to families. These videos may be modified so that the sound track either includes background noise, or is slowed down. Parents may also be asked to help their child learn the names of the toys by playing with them for 5 minutes. Parents will be asked play the videos on the computer or TV to their child daily for 4 weeks using the headphones provided.

I will also ask parents to keep a diary of how their child responds to the videos. There will be a postal or telephone questionnaire for parents on the child's vocabulary 6 weeks after the final visit.

The child may continue with any other speech and language therapy they are getting during the study as advised by that service.

What are the alternatives?

The local NHS speech and language therapy service has an open referral system. Details are available on their website.

What are the possible disadvantages and risks of taking part?

Some children may dislike watching the videos or wearing headphones. This may be linked to sensory preferences. Some families may have difficulty watching the videos each day. There is also a time commitment required from families to play the video with their child, answer questionnaires, complete a diary and support their child joining in with the assessments.

Parents will be advised to check the sound level of the videos is set at a comfortable level each time. Children will need to be supervised watching the videos to check

that they are not experiencing any discomfort. Also, parents will be advised to check that there is no danger from trailing wires or where the computer or TV is connected to the mains.

What are the possible benefits of taking part?

We cannot promise the study will help, but information from this study will help our understanding of how to improve the treatment of children with ASD.

What happens when the research stops?

Parents will be given a summary of the results for your child. There is currently no provision for this specific intervention to continue after the study.

What if there is a problem?

Any complaint about the way families have been dealt with during the study or any possible difficulties experienced, will be addressed. Detailed information on this is given in part 2.

Will information from families in the study be kept confidential?

Yes. We will follow ethical and legal practice. All information about the families will be kept securely and handled in strictest confidence following NHS guidelines. Information not processed on NHS equipment will have names and address removed so that families cannot be recognised.

This completes Part 1. Please read the additional information in Part 2 for further details about the conduct of the

PART 2

What will happen if families don't want to carry on with the study?

They are free to withdraw at any time. If they choose to stop, I will ask for consent to use the information and data collected about so far.

What if there is a problem?

If there is any concerns about any aspect of this study, please telephone and ask for XXXX on XXXXXX. I will do my best to answer your questions. If you wish to complain formally, you can do this following the NHS complaints procedure. In the unlikely event of any harm resulting from negligence, usual NHS policies will apply. In the unlikely event of harm occurring during the research which does not arise from negligence, any legal costs will be borne by participants. Please ask for details.

Involvement of the General Practitioner/Family doctor (GP) or local Speech and Language Therapist

I will ask for consent from the parents to inform the child's GP and local speech and language therapist if relevant of the family's involvement in the study. Local speech and language therapists are advised to contact the researcher who will follow the Royal College of Speech and Language Therapist's 'Working in Harmony Guidelines'. The research does not require there to be any change to the child's usual therapy.

What will happen to the results of the research study?

Parents will be given a summary of the results for their child. They will also receive a summary of the overall results. If another speech and language therapist is involved, they will also be given a summary of the results.

Who is organising and funding the research?

This research is monitored by the local NHS Trust XXXX and sponsored by the University of Sheffield as part of doctoral studies leading to a PhD.

Who has reviewed the study?

All research in the NHS is looked at by an independent group of people called a Research Ethics Committee, to protect participant's interests. This study has been reviewed and given a favourable opinion by the Research Ethics Committee for this region.

Please contact me at XXXXXX if you have any queries or would like further information on this research project.

Appendix 10: Participant information sheet: Part 2

Project: Word learning in children with Autism Spectrum Disorder

I am a qualified speech and language therapist employed by XXXX NHS Trust and I am also studying for a PHD at the University of Sheffield. I would like to invite you and your child to take part in a research project. Before you decide whether or not to take part, please read this information sheet. It will explain why the study is being done and what it will involve. Then, if you want to find out more, please telephone or email or complete the reply slip and return it to your child's school. If you decide to continue, I will telephone you and answer any questions you have and arrange to visit you at home and explain the study. Please talk to others about the study if you wish. Please ask if there is anything that is not clear. You can contact me on XXXXX, return the reply slip or email me at XXXX

What is the purpose of the study?

We want to find out more about how to improve early word learning in children with ASD (Autism Spectrum Disorder). We know that some children with ASD have difficulties following speech when there is a background noise and that some children may benefit from adults speaking at a slower rate. The study will find out whether background noise and slower speech and the timing of speech with people's faces moving has any effect on the children's ability to learn some new words. This may help us to develop ways of working with children with ASD in the future.

Why have you and your child been invited?

You have been invited to participate because your child's school is involved in the project, and your child is aged between 4 years and 8 years 11 months, has a diagnosis of ASD on their Statement of Special Educational Need and does not use very many spoken words. We also think that your child has normal hearing and vision, and that the language mostly spoken at home is English. Between 12 and 24 children will take part in the study.

Do we have to take part?

It is up to you to decide whether to join the study. If you allow me to visit you, I will describe the study in more detail and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form. You are also free to withdraw yours and your child's participation at any time without giving a reason. Whether or

not you take part in the study will have no effect on the standard of care you receive from speech and language therapy or other services.

What will happen if we take part?

If you contact me, I will begin by phoning to explain the study, give you an opportunity to ask questions and decide whether you would like me to visit you at home. If you say yes, I will arrange a convenient day and time with you and will send you some questionnaires to complete about your child's current language skills, sensory preferences and diagnosis. We will finish completing these together when I visit.

My visit to you at home will take about an hour. I will explain the project further, you will have an opportunity to ask questions and I will ask you to sign a consent form if you wish to continue. I will then complete any questionnaires with you not yet completed. Your child will not need to be present for the visit. I will also ask staff at your child's school to complete a short questionnaire about the words that your child knows.

I will then visit your child at school and work with them for between 30 and 60 minutes in a quiet room in school with a staff member who knows your child present. First, I will ask your child to point to some photos and to name them. Your child will then watch some short video clips on an iPad computer of an actor playing with and naming some toys. Some video clips will have background noise, some will have the words spoken slightly slower than usual, some will have the sound and film slightly out of synch and some will have speech at the normal speed and without any background noise. At the end I will ask your child to point to the photos again and then name them. S/he will then have an opportunity to choose an activity to play.

If you agree to participate, I will ask for your consent to inform your child's local speech and language therapist if you have one. They will be given basic details of the study and a summary of the findings, so that the speech and language therapist knows what is happening.

I am a specialist speech and language therapist in ASD for children across XXXX and so may have access to some local participant's health records as part of that role. Any client needs relating to this role will take precedence over those associated with this research project and the family will be asked to withdraw from the study.

What are the possible disadvantages and risks of taking part?

Some children may not like watching the videos. This may be linked to sensory preferences. They may have difficulty in paying attention to the videos. A visual

timetable will be used to help your child understand what is happening. A member of staff that knows your child will be present or very nearby and the session will be discontinued if your child shows any signs of anxiety or distress, as guided by school staff.

What are the possible benefits of taking part?

There may not be any direct benefit for your child in taking part in the study. Your child may learn one or two words as a result of the session. The information we collect from this study may help our understanding of how to improve the work we do with children with ASD. Any school based vocabulary learning and speech and language therapy input your child currently receives will continue as usual, whether or not your child takes part in the study.

What happens if the study stops earlier than expected?

If for some reason the project is stopped earlier than expected you will be informed in writing and we will give you the reasons for this.

What if there is a problem?

If you have a concern about any aspect of this study, you should telephone me on XXXXX and ask for XXXXX. I will do my best to answer your questions. You may also contact the project supervisor XXXX by telephone on XXXXXX, or email her at XXXXXX

If you would like to speak to someone not related to the project you can contact the Head of the Department of Human Communication Sciences at the University of Sheffield: XXXXX by telephone on XXXXX, or email her at XXXXXX

If you are not satisfied your concerns have been dealt with satisfactorily, then you can write to The Registrar and Secretary of the University of Sheffield, Western Bank, Sheffield, S10 2TN

Will my child's participation in this project be kept confidential?

All the information we will collect about your child and your questionnaire responses will be kept strictly confidential. Information not stored on NHS premises will have

your names, address and any other identifying information removed so that you and your child cannot be recognised. We will adhere to the Data Protection Act 1998. You and your child will not be identified in any reports or publications. Any identifiable data about you or your child will only be kept the minimum time necessary to complete the research project and no longer than the duration of my PHD studies, no longer than 3 years. All identifiable data will be destroyed according to the Data Protection Act 1998 once it is no longer required. I will ask you for permission to tell your child's speech and language therapist (if s/he has one) about the study.

What will happen to the results of the study?

The results of the research project will be included as part of my dissertation for my studies at Sheffield University. I may also describe the study to other speech and language therapists and professionals at a conference and / or write about the study in articles for speech and language therapist and others. You and your child will not be identifiable in any presentation or written report.

You will also be given a summary of the results for your child.

Who is funding the study?

This study is part of my University studies leading to a PhD. These studies are funded by the East Midlands NHS Deanery.

Who has reviewed the study?

The project has been approved by the Department of Human Communication Sciences Research Ethics Review Panel within the University of Sheffield.

XXXX , Speech and Language Therapist

If you would like me to phone you to tell you more about the project, please return this reply slip by post to the address below. Or phone me on XXXXX, or email XXXXXXX

Alternatively, please return to your child's class teacher.

.....

Please contact me. I would like to find out more about taking part in this research.

Name.....

Address.....

.....

.....

Telephone.....Email.....

Return to: XXXXXXX

Appendix 11: Professional information sheet: Part 2

Word learning in children with Autism Spectrum Disorder

Part 1 of this information sheet describes the purpose of this study and what it is about. Part 2 gives more detailed information about the conduct of the study. Please ask if there is anything that is not clear. You can contact me on XXXX or email me at XXXXX

PART 1

What is the purpose of the study?

To look at the effects of background noise, audio-visual synchrony and speech rate on early word learning in children with ASD (Autism Spectrum Disorder). This study builds on emerging evidence that some individuals with ASD have difficulties processing what they hear. The study is part of my doctoral studies at the University of Sheffield.

Participants

An invitation to participate in the project is being sent to families with a young child with ASD who meet the criteria below and attend local schools who have opted in to this project. Recruitment will stop after at least 12 and no more than 24 families have completed the project. Families invited to join the study will have a child recorded as having a diagnosis of ASD on their Statement of Special Educational Need.

Children will be aged between 4 years and 7 years 11 months, have a diagnosis of ASD and have difficulties with spoken language (less than 20 spoken words). The children will not understand/say at least four of the words, 'cat', 'ball', 'cars', 'top', 'duck', 'pig', 'coil', 'kite', 'cup', and 'dog'. The children will also have normal hearing and vision and have English as the language mostly spoken at home. These factors were considered important so as not to confuse the results.

What will happen ?

Participating schools will send information to parents of relevant children.

The lead staff member (e.g. SENCO, Head teacher) will send the information sheet to all parents of children who meet the criteria for the study. They will contact families who have not responded after 2 weeks (as highlighted by the researcher) to confirm that these families do not want to participate.

Telephone response

Parents who have contacted the researcher in response to the invitation to participate will receive a phone call to explain about the project and confirm whether they do or do not wish to participate. Families who do not respond will be contacted by school staff to confirm they do not wish to participate.

Families who do wish to participate will be sent questionnaires to be completed at a home visit if they give signed consent to participate. The questionnaires will be about their child's current language skills, sensory preferences and diagnosis.

Home visit

This will take about an hour. I will explain further about the project and ask parents to sign a consent form if they wish to continue. They will have an opportunity to ask questions. I will then help parents to complete any questionnaires that have not yet completed. Their child will not need to be present for the visit.

School intervention

This will involve one 60 minute session per child in a quiet room in school with a staff member present. The child will watch a video of an actor playing with and naming toys on an iPad. Some video clips will be in quiet, some have background noise, some at a normal rate, some slightly slowed down and some with sound and film slightly out of synch. The idea will be to see which conditions if any, result in the child naming or demonstrating understanding of the toy names. To measure learning, the child will complete a photo lotto assessment of understanding and naming words before and after the video.

The child may continue with any other speech and language therapy they are getting during the study as advised by that service.

What are the alternatives?

Any school based vocabulary learning and speech and language therapy input the child currently receives will continue during the project.

What are the possible disadvantages and risks of taking part?

Some children may dislike watching the videos. This may be linked to sensory preferences. There may be issues with attention and cooperation with some children. A visual picture cue will be used to help the child understand expectations. However, the session will be discontinued if your child shows signs of distress, as guided by school staff.

There is also a time commitment required from parents to answer questionnaires, and be available for a home visit lasting about one hour.

What are the possible benefits of taking part?

We cannot promise the study will help children learn new words, but information from this study will help our understanding of how to improve the treatment of children with ASD.

What happens when the research stops?

Parents will be given a summary of the results for their child. There is currently no provision for this specific intervention to continue after the study.

What if there is a problem?

Any complaint about the way families have been dealt with during the study or any possible difficulties experienced, will be addressed. Detailed information on this is given in part 2.

Will information from families in the study be kept confidential?

Yes. We will follow ethical and legal practice. All information about families and their child will be kept securely and handled in strictest confidence. Information not processed on NHS equipment will have your names and address removed so that participants cannot be recognised.

This completes Part 1. Please read the additional information in Part 2.

PART 2

What will happen if families don't want to carry on with the study?

They are free to withdraw at any time. If they choose to stop, I will ask for consent to use the information and data collected about so far.

What if there is a problem?

If you have a concern about any aspect of this study, you should telephone and ask for XXXX on XXXXX. I will do my best to answer your questions. If you remain unhappy and wish to complain formally, you can do this following the University of Sheffield complaints procedure. In this case, please contact the Head of Department initially or if necessary, the University Registrar. Contact details are given below.

Head of the Department of Human Communication Sciences

31 Claremont Crescent, Sheffield

S10 2TA

Registrar for the University of Sheffield

Office of the Registrar and Secretary

Firth Court

Western Bank, Sheffield S10 2TN

Involvement of the General Practitioner/Family doctor (GP) or local Speech and Language Therapist

I will ask for consent from the parents to inform the child's GP and local speech and language therapist if relevant of the family's involvement in the study. Local speech and language therapists are advised to contact the researcher who will follow the Royal College of Speech and Language Therapist's 'Working in Harmony Guidelines'. The research does not require there to be any change to the child's usual therapy.

What will happen to the results of the research study?

Parents will be given a summary of the results for their child. They will also receive a summary of the overall results. We will ensure that they are not identified in any report or publication of the study without consent.

Who is organising and funding the research?

This research is monitored by the University of Sheffield as part of doctoral studies leading to a PhD. Doctoral study is funded by East Midlands NHS Deanery.

Who has reviewed the study?

The project has been reviewed by the Research Ethics Review panel of the Department of Human Communication Sciences at the University of Sheffield.

Please contact me at XXXXX or XXXXXX if you have any queries or would like further information on this research

Appendix 12: Example baseline parent/carer questionnaire: Part 1

What words does your child know now?

Participant Identification Number:

Thank you very much for your help with this project so far.

We would be very grateful if you could complete and return this questionnaire. The information is important because it will help us understand better about early word learning. It should only take about 15-20 minutes.

Please put a tick in the relevant response boxes for your child for each question.

Write your answers to questions with text boxes.

1. Can your child point to or give you these toys when you name them?

	Yes	No
Duck	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Pig	<input type="checkbox"/>	<input type="checkbox"/>
Top	<input type="checkbox"/>	<input type="checkbox"/>

2. Can your child repeat you saying the names of these toys?

	Yes	No
Duck	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Pig	<input type="checkbox"/>	<input type="checkbox"/>
Top	<input type="checkbox"/>	<input type="checkbox"/>

3. Can your child name these toys spontaneously or when you ask a question such as 'What's that?'

	Yes	No
Duck	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Pig	<input type="checkbox"/>	<input type="checkbox"/>
Top	<input type="checkbox"/>	<input type="checkbox"/>

4. Has your child learnt to say any other new words since my last visit?

Yes	No
<input type="checkbox"/>	<input type="checkbox"/>

5: Please write any new words your child has learnt to say below.

6. Write in the box below about anything which has made it difficult for your child to communicate since my last visit?

7. Tell me about anything you think has helped your child's communication since my last visit.

Thankyou. The questionnaire is now complete

Appendix 13: Example final visit parent/carer questionnaire: Part 1

What words does your child know now?

Participant Identification Number:

Thank you very much for your help with this project so far.

We would be very grateful if you could complete this questionnaire about your child's word learning now the intervention is finished. The information is important because it will help us understand better about if/how early word learning was affected by the intervention. It should only take about 15-20 minutes.

Please put a tick in the relevant response boxes for your child for each question.

Write your answers to questions with text boxes.

When the project is complete, you will receive a short summary of the findings. The findings will be made anonymous to prevent individuals being identified.

We hope you have found this project interesting. Thank you once again for taking part. Please telephone XXXXXXXX or email XXXXXXXX if you have any queries.

1. Can your child point to or give you these toys when you name them?

	Yes	No
Cat	<input type="checkbox"/>	<input type="checkbox"/>
Ball	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Dog	<input type="checkbox"/>	<input type="checkbox"/>

2. Can your child repeat you saying the names of these toys?

	Yes	No
Cat	<input type="checkbox"/>	<input type="checkbox"/>
Ball	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Dog	<input type="checkbox"/>	<input type="checkbox"/>

3. Can your child name these toys spontaneously or when you ask a question such as 'What's that?'

	Yes	No
Cat	<input type="checkbox"/>	<input type="checkbox"/>
Ball	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Dog	<input type="checkbox"/>	<input type="checkbox"/>

4. Has your child learnt to say any new words since my last visit?

Yes	No
<input type="checkbox"/>	<input type="checkbox"/>

5: Please write below the names of any new words your child has learnt to say.

6. Write in the box below about anything which has made it difficult for your child to communicate since my last visit?

7. Tell me about anything you think has helped your child's communication since my last visit.

Thankyou. The questionnaire is now complete and ready to post to XXXX

Appendix 14: Example follow up parent/carer questionnaire: Part 1

What words does your child know now?

Participant Identification Number:

Thank you very much for your help with this project so far.

The last part of the project is a short follow up questionnaire. We would be very grateful if you could complete and return this questionnaire to me in the stamped addressed envelope provided. The information is important because it will help us understand better about early word learning since the intervention. It should only take about 15-20 minutes.

Please put a tick in the relevant response boxes for your child for each question.

Write your answers to questions with text boxes.

When the project is complete, you will receive a short summary of the findings. The findings will be made anonymous as far as possible to prevent individuals being identified.

We hope you have found this project interesting. Thank you once again for taking part. Please telephone XXXXX or email XXXXXX if you have any queries.

1. Can your child point to or give you these toys when you name them?

	Yes	No
Car	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Ball	<input type="checkbox"/>	<input type="checkbox"/>
Dog	<input type="checkbox"/>	<input type="checkbox"/>

2. Can your child repeat you saying the names of these toys?

	Yes	No
Car	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Ball	<input type="checkbox"/>	<input type="checkbox"/>
Dog	<input type="checkbox"/>	<input type="checkbox"/>

3. Can your child name these toys spontaneously or when you ask a question such as 'What's that?'

	Yes	No
Car	<input type="checkbox"/>	<input type="checkbox"/>
Cup	<input type="checkbox"/>	<input type="checkbox"/>
Ball	<input type="checkbox"/>	<input type="checkbox"/>
Dog	<input type="checkbox"/>	<input type="checkbox"/>

4. Has your child learnt to say any new words since my last visit?

Yes	No
<input type="checkbox"/>	<input type="checkbox"/>

5: Please write any new words your child has learnt to say below.

6. Write in the box below about anything which has made it difficult for your child to communicate since my last visit?

7. Tell me about anything you think has helped your child's communication since my last visit.

Thankyou. The questionnaire is now complete and ready to post to

Appendix 15: Vocabulary questionnaire for parents/carers: Part 2

What words does your child know now?

Participant Identification Number:

Date:

We would be very grateful if you could complete and return this questionnaire. The information will help us in our study. It should only take about 15-20 minutes.

1. Can your child point to or give you these toys or items when you name them? Tick for yes.

Cat <input type="checkbox"/>	Cot <input type="checkbox"/>
Cup <input type="checkbox"/>	Park <input type="checkbox"/>
Pig <input type="checkbox"/>	Doll <input type="checkbox"/>
Cars <input type="checkbox"/>	Bird <input type="checkbox"/>
Ball <input type="checkbox"/>	Pool <input type="checkbox"/>

Kite <input type="checkbox"/>	Bed <input type="checkbox"/>
Coil <input type="checkbox"/>	Keys <input type="checkbox"/>
Duck <input type="checkbox"/>	Cows <input type="checkbox"/>
Dog <input type="checkbox"/>	Book <input type="checkbox"/>
Top <input type="checkbox"/>	Toes <input type="checkbox"/>

2. Can your child repeat you saying the names of these toys or items? Tick for yes.

Cat <input type="checkbox"/>	Cot <input type="checkbox"/>
Cup <input type="checkbox"/>	Park <input type="checkbox"/>
Pig <input type="checkbox"/>	Doll <input type="checkbox"/>
Cars <input type="checkbox"/>	Bird <input type="checkbox"/>
Ball <input type="checkbox"/>	Pool <input type="checkbox"/>

Kite <input type="checkbox"/>	Bed <input type="checkbox"/>
Coil <input type="checkbox"/>	Keys <input type="checkbox"/>
Duck <input type="checkbox"/>	Cows <input type="checkbox"/>
Dog <input type="checkbox"/>	Book <input type="checkbox"/>
Top <input type="checkbox"/>	Toes <input type="checkbox"/>

3. Can your child name these toys or items spontaneously or when you ask a question such as 'What's that?' Tick for yes.

Cat <input type="checkbox"/>	Cot <input type="checkbox"/>
Cup <input type="checkbox"/>	Park <input type="checkbox"/>
Pig <input type="checkbox"/>	Doll <input type="checkbox"/>
Cars <input type="checkbox"/>	Bird <input type="checkbox"/>
Ball <input type="checkbox"/>	Pool <input type="checkbox"/>

Kite <input type="checkbox"/>	Bed <input type="checkbox"/>
Coil <input type="checkbox"/>	Keys <input type="checkbox"/>
Duck <input type="checkbox"/>	Cows <input type="checkbox"/>
Dog <input type="checkbox"/>	Book <input type="checkbox"/>
Top <input type="checkbox"/>	Toes <input type="checkbox"/>

Thank you. The questionnaire is now complete.

Appendix 16: Screen shot from video modelling word “kite”

Omitted, but is available in hard copy from the University of Sheffield Library.

