# *Impaired Visual Disengagement in Autism: Can this be due to stimulus effects and inherent interest?*

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# Impaired Visual Disengagement in Autism:

## Can this be due to stimulus effects and inherent interest?

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Thesis submitted for the Degree of Doctor of Philosophy

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# Abstract

Atypicalities in the disengagement of attention have been proposed to play a crucial role in the origins of autism. Yet to date, there is disagreement over the existence of these atypicalities, due to conflicting evidence. In this thesis, it is proposed that this apparent disagreement may in part be due an implicit assumption in the paradigm used to measure disengagement. That is that attentional engagement towards the initial fixation point will always be to the same degree irrespective of motivational factors such as stimulus interest. It is here argued that this assumption is false and that disengagement, as a function of this initial engagement, can be altered through the manipulation of stimulus. As such, it is the purpose of this thesis to shed light on this hitherto ignored aspect of attention.

A literature review of the theoretical and empirical literature (Chapters 1 and 2) led to five experiments (Chapters 3-5). These studies were designed to examine the potential role of stimulus interest on attentional disengagement in children with Autistic Spectrum Disorder (ASD) and explored disengagement difficulties using both abstract and more naturalistic stimuli. The experiments in Chapter 3 indicated that children with ASD were slower to disengage attention from stimuli but also that this effect was confined to brightly coloured, dynamic abstract stimuli only. These experiments also showed that stimulus interest affected the response time for both groups to a similar degree. The experiments in Chapter 4 showed that disengagement differences for children with autism were not specific to the motion of the stimuli, their general form or the colour composition and that there was still an effect of stimulus interest when these variables were controlled. Finally, the study in Chapter 5 indicated that although stimulus interest had a general effect on the speed of disengagement from stimuli in children with ASD, it could not alone account for the extent of difficulty shown from abstract stimuli.

In summary, the results support the proposal that stimulus characteristics, including interest value, play a role in the disengagement of attention. Although children with ASD show dysfunction in attentional disengagement, this is only specific to certain types of stimuli. While stimulus interest is likely be a moderating factor in the disengagement and shifting of attention however, it cannot account for this dysfunction by itself. The findings argue for the importance of stimulus choice when conducting studies into the disengagement of attention and that research on effect of stimulus interest and autism could be a major benefit to clinicians, carers and in particular, to the educators of these children.

# Acknowledgements

I would like to thank firstly, the schools, staff and parents who allowed their children to take part in these experiments. This thesis would not have been possible without their permission and I was very grateful for how accommodating they were. Special thanks also go to the children themselves, who were a joy to work with. I hope that my work will eventually have some positive impact on their lives.

I owe my deepest gratitude to my supervisor John Findlay and co-supervisor Sue Leekam. Their enthusiasm and compassion were an inspiration to me and I have had no greater teachers. It was an honour for me to work with them and I am especially indebted to them for their continued support when my confidence failed me.

I would also like to thank the staff at Durham University and particularly the constant support of Ala Hola, who I respect deeply, Vincent Reid, Hannah Smithson, and Robert Metcalf. My gratitude also goes to my colleagues and friends throughout my time at Durham, Paige Davis, Pascale Engel, Anastasia Kourloukou, John Thoresen, Kin Chiew, Kate Cross, Lisa Webster, Jo Ross, Linda Iao, and Sue Fletcher-Watson.

On a more personal note, I'd like to thank my parents and family, without whom I would not be where I am today. Finally, there is no one I'm more grateful to than to my wife, Patricia Marquez Mezquita. Her unwavering support and unquestioning belief in me constantly surprises me. Not only has she been one of the greatest influences on me while doing this work and but has given me the greatest gift of all, my daughter Fiona. For this and so much more, I thank you.

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# Chapter 1. ATTENTION AND AUTISM

*"Millions of items in the outward order are present to my senses which never properly enter into my experience. Why? Because they have no interest for me. My experience is what I agree to attend to. Only those items which I notice shape my mind -- without selective interest, experience is an utter chaos."* (James, 1890, p. 405).

It is the purpose of this thesis to shed light on the attention mechanisms of children with Autistic Spectrum Disorders (ASD) in comparison to typically developed (TD) children. In particular, the intent is to elucidate the conflicting evidence on the capacity of ASD children to disengage and shift their attention (Landry and Bryson, 2004; van der Geest et al., 2001). It is also intended to examine the potential of motivational factors to account for these different findings. More specifically, the intention here is to explore the apparent slowing of these fundamental processes of attention in children with ASD paying particular attention to their interests and the preliminary state of engagement.

William James's statement quoted above is as true today as it was a century ago. It is well-known that children in particular are motivated by interesting material and interest has hence been a central feature of education literature. It has been shown to enhance meaningful processing of texts (Schiefele, 1991), influence affective response (Ainley, Hidi, & Berndorff, 2002), enhance ability to complete mathematical problems (Renninger, Ewen, & Lasher, 2002), and most importantly for this thesis, capture attention (Renninger & Wozniak, 1985). It has also been well established that children with ASD tend to have an unusual and narrow range of interests, resulting in an apparent difficulty to draw their attention away from items of interest to them (Murray, Lesser, & Lawson, 2005). Despite this, few researchers to date have made a bridge between these two areas. Our attention controls the environmental information that is presented to us, by selecting those aspects which are critical to our functioning in that environment. As such, any irregularities could enrich or impoverish our experience of the environment. Our interests direct and focus our attention and are an important factor to consider in any research on attention, especially into children with ASD.

The work for this thesis examines the comparative ability of ASD and TD children to disengage from different types of stimuli. It also develops a new paradigm for examining the effects of stimulus interest (how interesting the child finds the stimuli used in the trials) and considers how this relates to the engagement of the child's attention. It is proposed that although the child with ASD may have difficulty with some types of stimuli, this is by no means universal, and that both factors such as stimulus interest and features intrinsic to the stimuli themselves such as the movement of the stimulus contribute to the attention shifting patterns of both groups. In particular, it is believed that as interest contributes to our attention and as children with ASD show irregularities in their interest patterns, that group differences in attention pattern could to some degree be attributable to these interest patterns. It is also argued that these findings have implications for the education of those with ASD in particular, by furthering our understanding of what draws and keeps the attention of the child with ASD. It is also proposed that they have wider implications with regard to clinical treatment as techniques such as the paradigm presented have been suggested to be of use in the early diagnosis and screening of children with ASD (Zwaigenbaum et al., 2005).

With these aims in mind and because few researchers have attempted to bridge the gap between attention in ASD and interest, the first two chapters of this thesis will be devoted to reviewing and combining the relevant literature. Chapter 1 will begin with a brief description of the features of autism, followed by a summary of the history of research into attention with particular emphasis on the work of Posner and the paradigm he devised that plays a central part in this thesis. The role of attention in ASD as asserted by the three primary theories of autism will then be described. After this, the literature pertaining to attention and ASD will be reviewed to give the reader a firmer grasp of the general pattern of attentional irregularities in children with ASD.

Chapter 2 will start with a brief account on the nature of motivation and in particular, intrinsic motivation. This will be followed by accounts of the major theories relating to human interest, past and present. This will lead to an evaluation of these theories and a description of the view of interest which will be taken throughout this thesis. Once resolved, the research bridging interest and attention will be reviewed, followed by some theories of autism which include both attention and interest as contributing factors to its manifestations. After evaluating these theories, a rationale will be presented for the current line of research, culminating in a brief description of the aims and an outline of the structure of the thesis as a whole.

## 1.1. Features of Autism

*"Since 1938, there have come to our attention a number of children whose condition differs so markedly and uniquely from anything reported so far, that each case merits – and I hope, will eventually receive – a detailed consideration of its fascinating peculiarities." (Kanner, 1943, p 217)*

These insightful words, and the paper which followed them, were the basis for defining and describing the features of ASD for the first time. Kanner's 39 page article was a decisive point in the history of developmental psychology and instigated a new branch of research that persists to the present day.

The diagnostic criteria for autism in DSM-IV outline three essential features which should be present for a diagnosis of the disorder. These are: 1) impairments in social interaction such as problems with non verbal communication, 2) impairments in verbal communication usually manifested as a delay in language development and 3) a restricted repertoire of interests and activities including adherence to routines or repetitive behaviours. It is the third category that is of most relevance to this thesis and in particular the restrictedness of interests in ASD.

## 1.2. Overt and Covert Attention

The concept of attention has been described in different ways by different theorists . It has been described as a filter (Broadbent, 1958), a resource (Treisman, 1964), a spotlight (Posner, 1980) and a zoom lens (Erikson & Yeh, 1985), amongst others. Within the study of attention, most recent emphasis has been placed on visual attention and eye movements as an obvious way of studying shifting visual attention. Despite this apparently observable measure of attention, it has been known for some time that people can attend to peripheral objects without making these eye movements (Helmholtz, 1924), an ability commonly referred to as covert attention.

Overt attention is when attention and the fovea of the eye are focussed on the same object or in the same direction. As such, studies of overt attention primarily make use of eye and head movements and in particular, saccadic eye movements. Saccadic eye movements are rapid changes in the position of the eye and occur at the rate of three or four per second (Findlay and Gilchrist, 2003). While the eye is in motion the visual system shuts down and it is the stationary glimpses in between these shifts that allow vision to function. Through making these eye shifts, our perceptual system can get a vast amount of information from complex scenes and amalgamate them into a coherent whole. A large amount of research has been devoted to what drives these eye movements to select their next target. It seems apparent that they do not select areas at random. It also clearly appears to be the case that they are not solely driven by stimulus factors but are goal or purpose driven (Hayhoe & Ballard, 2004).

Covert orienting of visual attention in contrast, occurs when attention is focussed on somewhere other than where the eyes are fixated. This phenomenon is an important aspect to consider in any research into visual attention. Helmholtz's (1924) first demonstrated its existence by testing his ability to shift his visual attention independent of eye movements. To do this, he fixated on a pinhole of light located in the centre of a dark field. The field was made up of large printed letters and could be illuminated to display these with an electric spark. The letters were not visible for long enough to allow for an eye shift however, and by selecting which part of the field to attend to before its onset, he could read the letters in that area. Similar findings have also been found by other researchers (Hoffman & Nelson, 1981; Posner 1980). This robust finding led to one of the most prominent debates in visual attention literature. That is, what exactly is the relationship between overt and covert attention?

As it is clear that eye shifts and attention shifts are at least in part independent of each other due to the existence of covert attention, there are three main arguments which attempt to explain the extent of their relationship. These are a) that overt and covert attention are mediated by independent mechanisms (Klein, 1980), b) that covert attention shifts occur to plan an eye movement without executing it (Henderson, 1992), and c) that covert attention is a by-product of the action of motor systems (Rizzolatti, Riggio, Dascola, & Umilta, 1987). Each of these views will be discussed in turn.

### *1.2.1. Klein's Independent Systems Account*

Klein (1980) first proposed the notion that covert and overt attention could be mediated by completely separate mechanisms. He argued that if there was a close link between them, two clear predictions could be made. Firstly, that covert attention should facilitate eye movements to the attended location and secondly, that visual performance should be facilitated at this location. His results were mixed depending on the type of cue that was used. Critically, for endogenous cues (those with a more symbolic content e.g. arrows), Klein did not find evidence for either effect. Hence he argued that, although there was some evidence that exogenous cues attract both systems, it was not evidence enough that they were mediated by the same mechanism.

Using this research as a backdrop, Klein (1980) developed his account of the relationship between overt and covert attention. According to his viewpoint, under normal circumstances both types of attention occur together. However, he claimed that the two responses were not mediated by the same system but functioned independently of each other depending on the cues they were presented with. This view was also echoed by Remington (1980) who asserted that there is a loose relationship between the two systems but that both were drawn to peripheral events by similar but different mechanisms.

Despite this assertion, Klein's (1980) findings have not always been replicated and subsequent studies have found some evidence for possible facilitation effects between the two systems under different cueing conditions (Shepherd, Findlay & Hockey, 1986; Hoffman & Subramanian, 1995). Also, critically, there is considerable neurological evidence against this claim. Neuroimaging studies have shown significant overlap in the structures mediating both saccades and attention shifts (Beauchamp et al., 2001), indicating that these two systems are at least physiologically related. Further evidence from fMRI data indicate that both mechanisms also show many of the same functional anatomical areas of the brain (Wright & Ward, 2008). Finally, there is some evidence of damage to cortical areas that effect both saccades and covert attention (Posner et al, 1984).

### *1.2.2. Sequential Attentional Model*

Arguing for a closer relationship between overt and covert attention Henderson (1992) developed a *sequential attentional* model. The model relies on four basic stages. Firstly, an initial state is assumed where attention is allocated to a stimulus at the centre of fixation. Secondly, once this stimulus has been identified, attention is allocated to a new target. Thirdly, this attention shift co-occurs with the initiation of saccade programming towards the new location. Finally, attention at this new location allows higher level processing there. Essentially, the model argues that attention is a necessary precursor to eye movements and hence overt attention is led by covert attention.

Some support for this model comes from the work of Shepherd et al. (1986) who found subjects who were required to program a saccade in one direction were unable to attend to another location. However, there is considerable evidence that more than one saccade can be programmed simultaneously (Findlay et al,. 2001; McPeek et al., 2000; Sommer, 1994). Additionally, there is little evidence to suggest that covert attention shifts fast enough to process several targets sequentially before a saccade to account for these findings (Findlay & Gilchrist, 2003).

### *1.2.3. Pre-motor Theory*

Also known as a common systems model, the pre-motor theory was developed by Rizzolatti and his colleagues (Rizzolatti et al. 1987). This theory argues that both types of attention are mediated by a single system. According to the pre-motor theory of attention, covert orienting is mediated by the motor system responsible for generating saccades, although the physical movement is withheld. Within this framework, attention is essentially a by-product of the oculomotor system.

The theory arose largely from two distinct experimental findings that provide support for covert spatial attentional as a result of processing within the motor systems responsible for overt orienting. The first of these was a target detection experiment by Rizzolatti et al. (1987) which consisted of a fixation stimulus and the later onset of a lateral target in one of four locations. These target locations were equidistant from each other and arranged with the fixation stimulus in the centre. This target was preceded by a cue in one of the two target locations closest to the central stimulus and could either be valid (same location as the target) or invalid (different location to target). The critical manipulation of this experiment was that, for these invalid trials, the target was presented at the near location at the opposite side of the initial fixation stimulus or the far location on the same side. The reaction time to make an eye shift in the invalid condition was greatest when the cue was to the target appearing on the opposite side of the fixation stimulus despite both potential targets being equidistant from the cue. This was described as the meridian effect and according to the pre-motor theory, this occurs as the cost of shifting attention is a function of the extent of motor reprogramming necessary to attend to the target. More specifically, whereas both trials required reprogramming amplitude this "cross meridian" target also requires a change in direction, resulting in longer latencies. Hence, they concluded that covert attention had the same programming requirements as the eye movement system.

The second finding of relevance to this view comes from studies of saccade trajectories. Rizzolatti et al. (1987) required participants to make a saccade to a box directly below a fixation point in response to a cue which could appear in any of a horizontal row boxes above the fixation point. When they measured the horizontal deviation of these trajectories, they found that the saccades to the target were curved away from the cue's location. From this, they concluded that the allocation of covert attention thus had a direct spatial effect on the motor response.

Similar research conducted by Shepherd, Findlay and Hockey (1986) argue for the mandatory link between attention and saccades. They used a central arrow cue which pointed to a box on either side of fixation where a target could appear. This cue indicated the direction the saccade should be made and participants also were required to make a manual detection response when the target appeared. The probability of the location at which the target was to appear was manipulated and trials could either be congruent, where the target appeared in the cued location, or incongruent, where it appeared in the opposite location. Thus, when the saccade was directed away by the central cue from the most likely position where the target would appear, the targets for attention and eye movements were on opposite sides of the display. In this situation, the participants took longer to detect that target in the incongruent trials than in the congruent trials regardless of the probability with which they occurred. It was argued therefore that in these incongruent trials, the effects of preparation to make a saccade were stronger than the effects of attentional allocation until after its completion and from this, concluded that making a saccade required attention to be allocated to the target location first. However, it was also found that when no saccade was required, attention was always faster to the more probable side. Thus, they further argued that attention to a target location did not require a saccade to be made there.

Regardless of how the processes of covert and overt attention are related to each other, it is apparent that the allocation of attention cannot solely be determined by the direction of gaze. Additionally, even if mediated by the same system, ocular and attentional fixations are not the same thing. In any study into visual attention therefore, it is important to ensure that the observed effects are attentional and not just due to oculomotor responses. As will be shown later in this thesis, appropriate steps have not always been taken to ensure that attention has been captured when measuring the direction of gaze of participants, possibly leading to the contradictory results. It is further suggested that this may be especially true of children less inclined to attend to something at the request of a researcher such as those with ASD.

## 1.3. Factors Influencing Eye Movements

Though eye movements are arguably indirect measures of visual attention, as has been discussed previously, there is at least a functional relation between the two systems. Hence, with some consideration to the existence of covert attention, eye movements are a good indication of attentional shifts in experiments that do not require covert attention and eye fixation to be focussed to different spatial locations. It has long been established that the nature and physical characteristics of stimuli affect how they are processed, as measured by eye direction detection devices in both typically developed individuals and people with ASD. Eye fixations tend to focus on areas of high contrast (Mannan, Ruddock, & Wooding, 1997), corners, symmetry (Locher & Nodine, 1973), and irregular contours (Loftus & Mackworth, 1978; Richards & Kaufman, 1969). Individuals tend to look quicker at certain stimuli and have a preference for faces or animate objects (Fletcher-Watson, Findlay, Leekam & Benson, 2008).

Despite recognition of the importance of stimulus effects, there has been a move away from the bottom-up processing (stimuli driven) view of eye-movements and visual attention. Wolfe (1998) conducted a study using the kinds of features that people can effectively detect such as colour, orientation, size, texture, and motion. Rather than finding consistent differences in the salience of the features, participants could select which feature to attend in advance. In fact, a review of literature in this area indicates that the majority of eye movements appear to be mediated by internal strategies and desired goals (Hayhoe & Ballard, 2005).

Hayhoe and Ballard (2005) made two very important conclusions in their review of advances in eye movement literature. The first is that eye movement patterns are goal directed and hence can be learned over time. One of the examples they give of this process is in tea making, where observers must have learnt what objects in the scene are relevant because almost no fixations fall on irrelevant objects. This finding is important as it indicates that these movement patterns must be susceptible to the same forces which shape other aspects of behaviour such as operant conditioning, thus leading to their second important conclusion that eye movements are driven by prospects of reward.

## 1.4. Reward and Eye movements

At the forefront of research into this area, Takikawa, Kawagoe, Itoh, Nakahara, and Hikosaka (2002) attempted to explore the mechanisms underlying reward oriented eye movements by studying monkeys performing a memory-guided saccade task, called the one-direction-rewarded task. The task involved a central fixation point surrounded by four locations where a target stimulus could potentially appear. The monkeys had to fixate on the central target initially and while fixated, one of the surrounding targets would illuminate for 100ms. A valid response required the monkey to make a saccade to the cued location after the central target turned off. The critical manipulation in this study was that only one of these fixed directions was rewarded when a valid response was made. Their results showed that saccadic eye movements were indeed susceptible to reinforcement learning and found less errors and shorter latencies in the rewarded trials over time.

In the last decade, there has also been a strong focus of research dedicated to mapping the neurological correlates of reward. As a result of this focus there has emerged strong evidence that these neurological representations of reward and reward expectancies do exist in the brain (Hikosaka & Watanabe, 2000; Hikosaka, Nakamura, & Nakahara, 2006; Kawagoe, Takikawa, & Hikosaka, 1998) with areas such as the basal ganglia, orbitofrontal cortex and lateral prefrontal cortex being involved. Additionally, due both to the relative ease of measurement and the wealth of neurological data on their functioning, how reward relates to eye movements has been given a lot of attention. As a result, both the lateral prefrontal cortex (Kobayashi et al., 2002) and the basal ganglia (Hikosaka & Watanabe, 2000; Hikosaka et al., 2006; Kawagoe et al., 1998) have been pinpointed as functioning to transform reward signals into eye movements.

Hikosaka et al. (2006) in particular, emphasised the importance of the basal ganglia area of the brain in their review of the literature. To support this viewpoint, they firstly argued that the motor function of the basal ganglia is illuminated by various kinds of movement disorders such as Parkinson's disease. Secondly, they asserted that the basal ganglia plays an important role in the learning of habits and controlling motor behaviour through the opposing processes of dis-inhibition and enhancing inhibition. Finally, they point out that sensorimotor cognitive signals originating from the cerebral cortex pass through the basal ganglia and then return to the cerebral cortex. From these arguments, they concluded that this pivotal position of the basal ganglia is perfectly placed to control motor behaviours based on reward information. Specifically, they argue that the basal ganglia exert a modulatory influence on the superior colliculus to orient the eyes towards a position of reward. This manifests as a pre-target bias based on an internal drive rather than conscious thought.

In summary, these studies indicate three important factors to consider. Firstly, orienting is not solely driven by bottom-up processes, such as reacting to stimulus features. Internal features such as task goals and reward expectancy are important contributors to speed of orienting. Secondly, saccadic eye movements are susceptible to reinforcement learning. Thus, people should be able learn to respond more quickly to stimuli important to them in some way. Finally, there are precedents in the literature suggesting that at least some internal mechanisms of control have neurological correlates. The suggestion that orientation is not solely driven by basic drives is of principal importance for this thesis. What is especially noteworthy is the apparent capacity of internal drives and goals to affect these basic processes. These drives and goals do not occur in a vacuum but rather stem from the history and emotional state of the individual who forms them. As shall be seen, of particular importance to the formation of these goals are the interests of that individual and hence it is proposed, that these interests could be an important focus for future research into eye movements and attention shifts.

## 1.5. Posner's Model

One of the more influential researchers on attention is Michael Posner and he has conducted substantial work in the area. He views attention not as a single cognitive resource but as a set of interdependent functional networks each contributing to the working of attention in any individual. He argues that each of these cognitive systems has neurological counterparts and that they comprise of functional components: alerting, orienting, and executive control (Posner & Fan, 2008; Posner & Petersen, 1990).

The alerting attentional system in this model, relates to the capacity to increase vigilance to an imminent stimulus. It is the system which increases readiness to respond to targets after receiving a warning cue of some sort. It involves a change in the state of awareness of the individual in preparation for perceiving this target which inhibits competing activities. It is considered to be critical to any task involving higher cognitive functions and has been associated with thalamic, frontal, and parietal regions of the brain (Fan et al., 2009).

The orienting system controls the selection of specific information from more general sensory inputs. Posner & Petersen (1990) explains that it can function both a) in response to stimulus factors (exogenous), such as sudden target onset, or b) under more voluntary control (endogenous), such as in visual search. This system for visual stimuli is associated with the superior and inferior parietal lobule, frontal eye fields (FEF), and the thalamus (Fan et al., 2009).

The final system described by Posner is the executive control system whose description is similar to the internal mechanisms described in the Executive Functions model (see section 1.6.3). They are described as mental operations that prioritise and resolve cognitive conflict. It is important in any situation involving planning, novel responses, and overcoming habitual actions. This system has been associated with the anterior cingulate and lateral prefrontal cortex (Fan et al., 2009).

Despite the coordinated actions of these three systems in any task, it is Posner and Petersen's (1990) elaboration of the orienting system which has gained the most attention in the literature and is of most interest to this thesis. As has already been mentioned, Posner viewed the attention orienting system as equivalent to a spotlight moving location to bring targets into better attentional focus. When targets are in the beam of the spotlight, they are processed more efficiently, whereas while shifting attention the spotlight is turned off (Sperling & Weichselgartner, 1995). The process of turning on this spotlight and assigning attention to a target is called engagement and likewise, turning off the spotlight is called disengagement. Each of these processes is considered a separate component of the attention orienting system by Posner and takes time to complete. As such, according to his model, to shift attention from one focus to another requires first disengaging attention from the current focus, next moving attention to a new target, and finally engaging attention at the new target. This model for the shifting of attention is very similar to the current thinking on how the saccadic system functions (see section 1.2), which also turns off when in motion.

Also according to this model, visual attention blocks saccades to the new target as long as it is engaged by the current attentional focus. Thus, attention needs to be disengaged before an eye movement can be made (Hood & Atkinson, 1993). Similar to Posner's wider model of attention, he has argued that each of these components is correlated with specific brain areas: parietal cortex with disengagement, superior colliculus with shifting, and thalamus with engagement, highlighting their discrete nature (Kawakubo, Mekawa, Itoh, Iwanami, & Hashimoto, 2004).

Although Posner's theory is suggestive of attention as an independent system it should not be seen as opposing theories such as the pre-motor theory as described in section 1.2.3. Posner's description of the processes of attention says little about the relationship between overt and covert attention other than that these processes somewhat mirror the visual system by needing to be disengaged first, then moved and finally re-engaged. This mirroring in fact argues somewhat for the assertion of the pre-motor theory of attention, that attention is essentially a by-product of the oculomotor system. Of particular relevance to this argument however, is the conclusion by Shepherd et al. (1986) that attention does not require an eye movement to take place merely that eye movement required attention to be shifted in anticipation of an eye movement.

Despite these strengths of Posner's theory, the difficulty in observing these attentional processes such as engagement directly detracts from it. However, paradigms have been designed to counteract this difficulty somewhat. Foremost of these techniques, the gap paradigm has been developed to attempt to measure disengagement indirectly and has received much emphasis in the literature.

### *1.5.1. The Gap Effect and Disengagement*

As mentioned in section 1.5, the process of shifting attention according to Posner's model is firstly, to disengage it from the current focus, shift it to a new target and finally, to re-engage it on the new focus. This process can be measured by asking a participant to focus on a stimulus located directly in front of them and then presenting another stimulus to one side of this. The sudden onset of this new stimulus should trigger both an attentional and an ocular shift towards it, giving an estimate of the total time needed to complete the whole process. More specifically, in these 'Competing' trials, it is assumed that the reaction time to make an eye shift towards this second stimulus is equal to the sum of the reaction times to disengage from the central stimulus, shift their attention and engage on the new stimulus, as shown by the following formula.

RT(competing trials) = RT(disengagement) + RT(shift) + RT(engagement)

By extending this paradigm further and including trials where the initial stimulus turns off a short time (known as a temporal gap) before the onset of a peripheral stimulus, it is believed to be possible for attention to be automatically disengaged from the initial stimulus, giving an estimate of the total time needed to shift and re-engage attention. In other words, the reaction time to make an eye shift towards the second stimulus, in these 'Shift-only' trials, is equal to the sum only of the reaction times to shift attention and engage on the new target, as shown by the formula below.

RT(Shift-only trials) = RT(shift) + RT(engagement)

Hence, the underlying assumption is that by comparing the trials to each other, the reaction time to disengage can be approximated indirectly. This paradigm was first introduced by Saslow (1967) who found a significant difference between the saccadic latencies towards the peripheral stimuli for the two conditions. The finding was coined the Gap Effect to indicate the effect that the temporal gap has on the process of disengagement and has been a central feature of the attentional literature since.

One of the main reasons that this paradigm has received so much emphasis is due to the findings related to the development of the visual attention system in infants. In newborns, this system is thought to be largely overt in nature and exogenously driven until between approximately four and six months of age (Atkinson, 1984; Johnson, 1990). Throughout these first few months, there is a series of marked changes in the infant's visual and attention systems. Both systems develop in complexity until they become comparable to that of adults but one of the more prominent of these changes is the infant's capacity to disengage attention.

An often noted characteristic of any infant's behaviour is their tendency to fixate on stimuli in their environment. This tendency has been coined 'obligatory attention' by Stechler and Latz (1967) and 'sticky fixation' by Hood (1995). It is an unusual anomaly in the infant's attention system that is thought to be a result of an immature capacity to disengage attention (Hunnius & Geuze, 2004). In order to disengage attention, any individual must develop the capacity to resolve conflict between two competing functions: the tendency to maintain the focus of attention and gaze, and the tendency to shift attention and gaze to a new target.

The Gap paradigm has been used extensively to chart the development of this capacity in infants. For example, Johnson, Posner and Rothbart (1991) used the paradigm to examine the relative abilities of two, three, and four month old infants. Their findings indicated that only the older infants could consistently disengage attention and shift to a peripheral target. They also argued for a link between this development of visuo-attentional control and the changes in the infant's ability to interact socially with their primary caregiver. Similarly, Hood and Atkinson (1993) examined the time to initiate an eye movement from a central target to a peripheral stimulus in 1.5, three and six month olds whilst varying the extent of the gap in the gap trials. In accordance with Johnson et al. (1991) they found that these latencies decreased with age and that while reaction times were significantly longer during all the overlap conditions (where two stimuli competed for attention), this effect was strongest for the youngest group.

The consistent finding of 'obligatory attention' in young infants has led to greater understanding of how and to what extent the attentional system develops in infancy. The robust findings in this area amount to the idea that there are some definitive changes in the orienting system of young infants of typical development in their first few months of life. Whether this developmental trajectory is one which children with ASD follow is less clear as will be discussed in section 1.8.

### *1.5.2. Oculomotor or Attentional Disengagement*

The finding of the existence of covert attention has also had an impact on research into the gap paradigm. This has led to a strong debate about whether the saccadic delay is due to attentional disengagement or the visual-oculomotor system itself. Depending on which viewpoint on the relationship between covert and overt attention subscribed to, this question has a different level of relevance, with the pre-motor theory ascribing it the least amount of importance. Regardless, whether the gap effect reflects attentional or oculomotor disengagement has been a matter of strong debate (Fischer & Weber, 1993, Tam & Stelmach, 1993, Matsuzawa & Shimojo, 1997).

To attempt to answer this question, Tam and Stelmach (1993) used a modified version of the gap paradigm to test covert attention in adults. They used two central targets, one on which the participant were to focus their gaze, the other on which they were to focus their attention. They could then separate the two processes by switching off one of these central stimuli before the onset of the peripheral target. They found a slowing of latencies in both conditions but that the gap effect was stronger for the stimulus requiring oculomotor disengagement. From this they concluded that an ocular explanation was the most likely reason for the delay in disengaging from a stimulus with possibly a small attentional factor. This conclusion was later confirmed by Kingstone & Klein (1993) who found the size of the gap effect did not differ as a function of attentional manipulation in one of their experiments. A similar result was also shown by Walker, Kentridge and Findlay (1995).

There is little doubt that oculomotor factors are an important consideration when talking about disengagement however a number of studies have brought to light important findings supporting Posner's view that attention is also a major contributing factor. Firstly, a gap effect has been seen when manual responses rather than eye movements were required (Gomez et al., 1998). Secondly, a gap effect has also been seen when the initial stimulus was auditory rather than visual (Farah, Wong, Monheit, & Morrow, 1989). Finally, Machado and Rafal (2000) showed that by manipulating the likelihood of targets appearing, the gap effect was altered. From this finding, they concluded that the gap effect could not be solely sensory driven but is affected by other processes that interact with the oculomotor system.

Following up from the finding of Farah et al. (1989), Pratt, Lajonchere and Abrams (2006) conducted an experiment very similar to Tam and Stelmach (1993) but instead of using fixation points they used more complicated stimuli. Essentially, these stimuli appeared as an x but the diagonal lines were a different shade to each other. Either or both of these lines could be removed prior to the onset of the peripheral stimulus depending on the experimental trial. Participants were told to attend to one part of these stimuli while fixating on the other and by using this paradigm, attentional and oculomotor factors could be distinguished. They found an oculomotor effect in accordance with the findings of Tam and Stelmach (1993) but importantly, they also found faster saccades when the attended portion of the stimulus was removed than when the fixated portion was. Thus, they concluded that the gap effect was affected by attentional manipulation and their results are in stark contrast to their predecessors.

Although at first glance these seem like opposing arguments, taken together the research seems to indicate that both attentional and oculomotor disengagement needs to take place before an eye movement can take place. What the different results suggest however is the extent to which attentional factors play in the gap effect is variable and that it may depend on the nature of the initial target stimulus used. Thus, the point first raised in section 1.2 that in any study into visual attention, it is important to ensure that the observed effects are attentional and not just due to oculomotor responses, is reinforced by findings in this area. If the gap effect is to be an effective measure of attentional disengagement, steps need to be taken to ensure that attention, and not just ocular fixation, is engaged initially. This is especially true in any research into children with ASD who may not be as compliant to the experimenters' wishes as more typically developed children.

## 1.6. Major Theories of Autism

In the last thirty years there has been a rapid growth in research into autism that focuses on specific cognitive impairments of the disorder. In particular, three influential theories have been at the forefront of research into the area but each has taken a very different perspective on children with ASD. The first of these, the Theory of Mind model (Baron-Cohen, Leslie & Frith, 1985) emphasises the importance of mental state processing impairments. In contrast, the Weak Central Coherence model (Frith, 1989) focuses on more basic perceptual aspects of cognition. Finally, the Executive Functions model (Ozonoff, Pennington & Rogers, 1991) highlights potential impairments in the processes of regulation and cognitive control. A brief review of these three theories will highlight their perspectives on the role of attention in the development of ASD as well as some as yet unresolved issues inherent in each model.

### *1.6.1. Theory of Mind*

The Theory of Mind (ToM) model argues that impairments exist in the socio-cognitive facility necessary for mentally representing the psychological state of other people. According to these theorists most of the social and communicative deficits in autism can be explained as a result of this impairment (Baron-Cohen et al., 1996). In essence, it states people with autism find it difficult to recognise another's feelings and intentions. This, it is argued, has important implications for the development of the child's attention and subsequent development.

Despite the usefulness of this theory for describing some of the features of autism, numerous studies dispute this process as a primary impairment. In particular, typical ToM does not develop in typical children until the age of four, whereas symptoms of ASD are often well established by that age (Sigman, Mundy, Sherman, & Ungerer, 1995). Additionally, a lack of Theory of Mind is not exclusive to ASD and has been seen in those with other disabilities (Muris, Steerneman & Murchelbach, 1998). Finally, this theory does not account for the tendency of those with ASD to exhibit repetitive behaviours or explain their superior ability on some cognitive tasks (Plaisted, Swettenham, & Rees, 1999).

As an explanation, the late onset of ToM in children is thought to have its roots in joint attention (Sigman, Mundy, Sherman & Ungerer, 1986) and imitation (Rogers & Pennington, 1991). Joint attention is a critical milestone reached by typically developed children between 12 and 15 months of age and forms the basis of more complex social and communicative abilities (Bakeman & Adamson, 1984). It is the capacity of the child to follow another's gaze and share in their attention focus. Baron-Cohen (1995) has since focused on impairments in this ability for children with ASD which, it is thought, later results in deficiencies in their development of ToM. However, the exclusive focus on deficiencies prevents this model from fully describing ASD as it still cannot account for the superior ability of those with ASD on some cognitive tasks (Plaisted et al., 1999). In addition to this, differences in attentional patterns have been shown in infant siblings of children with ASD even before joint attention would typically develop (Zwaigenbaum et al., 2005), indicating the phenotypic roots of ASD may lie very early in the developmental trajectory.

### *1.6.2. Weak Central Coherence*

These theorists take the view that the core deficits in autism develop from a failure to integrate local details into a global entity (Frith, 1989). The theory was developed primarily to explain why those with autism appear to be superior in some cognitive tasks. Frith asserts that children with ASD are impaired in their ability to process information in context, and in processing wholes (global information), but not in their ability to process smaller details (local information). This tendency or bias affects their social and communicative abilities such as understanding the meaning of context- dependent language (Happé, 1997).

The basis for this model comes from the observations that children with ASD exhibit superior ability at tasks requiring detailed rather than global information processing, such as the Children's Embedded Figures Test (Shah & Frith, 1983) and visual search (O'Riordan, 2004). Its primary strength is its apparent ability to explain the strengths as well as the problems experienced by those with ASD as stemming from a unique and consistent abnormality of how they process information. However, there has also been some evidence against this model's assertion of enhanced local and impaired global processing.

The main argument of the Weak Central Coherence (WCC) model is that a deficit in global perceptual functioning drives the superior performance of local perceptual functioning in people with autism. Arguably, the most influential critique of this presumption was carried out by Plaisted, Swettenham and Rees (1999). Their argument was that the assumptions of the WCC model lead directly to the prediction that the dysfunctional processes of global perception in autism indicate that these individuals would not suffer the interference in perception by global processing in the Navon Task (large letters consisting of other smaller letters). They conducted a study based on this task using stimuli that could be responded to on a local and a global level. However, their findings indicated conversely that children with autism could overcome their perceptual bias to local stimuli when they were asked to selectively attend to the larger letter. This suggests that the local bias is not necessarily a consequence of a global processing deficit.

Also, in contrast to what the WCC theory predicts, O'Riordan and Plaisted (2001) used a similar visual search task but had participants search for targets amidst distracters which shared or features with these targets. They found that the ASD group discriminated the targets faster than matched controls at all search tasks. They argued that to discriminate the targets in this type of task, the participants needed to display a high level of automatic perceptual integration ability which contradicts the arguments of Frith (1989). Even more convincingly, other research suggests that people with ASD are just as susceptible to visual illusions which require attention to be directed to global rather than local features as comparison groups (Ropar and Mitchell, 1999), again indicating automatic visual integration.

### *1.6.3. Executive Function*

Executive functioning is the term given to describe a person's capacity to regulate their behaviour in a dynamic world. Executive functions are described as a range of skills related to goal-directed action including but not limited to planning, sequencing, and sustaining attention. They are the internal representations and processes people create and use to plan, organise, solve problems, direct attention and monitor progress towards a goal in any environment. They encompass a set of high level mental processes that influence more basic abilities like attention, memory and motor skills and connect past experience with present action. Examples of executive functions include set-shifting inhibition, planning and working memory and they have been typically associated with frontal lobe functioning (Goldberg, 2001).

This concept was introduced by Ozonoff (1995) and deficits in these processes have also been argued to be the core impairment in individuals with ASD. Sometimes known as executive dysfunction, these impairments have been used to explain the symptoms of a number of disorders including ASD (Meltzer, 2007). Ozonoff and Schetter (2007) describe some of the symptoms indicative of executive dysfunction in ASD as their singular focus on specific topics, their difficulty transitioning between activities, their repetitive behaviours, and their unusual manner of completing tasks.

Some of the initial research supporting this theory came from studies using the Wisconsin Card Sorting Test (WCST). This test requires the participant to deduce and follow the rule necessary to achieve an end goal, and has the added complication that this rule changes periodically and requires the participant to make a corresponding mental shift. Pennington and Ozonoff (1996) conducted a review of this literature and found the results to be fairly consistent with twelve out of fourteen studies showing that those with ASD exhibited poorer performance on this task than control groups. More recently, they have further narrowed the range of the hypothesised impairments to lie in planning and flexibility processes but not inhibitory functions (Ozonoff & Schetter, 2007). More specifically, deficits in flexibility and the ability to shift set at both the conceptual and attentional level have been argued to be indicative of this dysfunction and the primary impairment in those with ASD. This is of particular interest to this thesis as it suggests children with ASD would experience problems in the disengaging and shifting attention (Leekam & Moore, 2001). The research on these attentional processes is further discussed in section 1.8.

Despite this body of research, a number of factors detract from executive dysfunction being deemed a core determinant of the symptoms of ASD. Firstly, autism is not the only disorder which shows executive function problems. Disorders such as Obsessive Compulsive Disorder (Head, Bolton & Hymas, 1989), Attention Deficit Hyperactive Disorder (Benson, 1991) and Turner's syndrome (Romans, Roeltgen, Kushner, & Ross, 1997) have also been linked to executive dysfunction. Secondly, although the frontal lobe has been linked with problems in executive functioning, no consistent findings have been shown indicating abnormalities in this area in autism (Robbins, 1997). Finally, due to the difficulties in measuring this functioning directly, it is difficult to say whether it is the high level functioning or the more basic processes which are deficient.

More generally, the concept of executive functions has a broad definition and hence is difficult to examine experimentally. However, the more specific descriptions of regulation and cognitive set shifting do lend themselves to proposals about attention shifting and may help to specify the difficulties in regulating attention.

## 1.7. Research on Attention and Autism

It is apparent from the literature that none of these models can fully account for the attentional irregularities in children with ASD. What is also clear is that if there are early occurring visual deficits in children with autism, this will have consequences that could potentially impede the development of higher order cognitive and social skills, likely resulting in the types of symptoms highlighted by the major theories such as ToM. While, each of the major theories make contributions to understanding the literature on attention and autism, there seems to be a piece missing from the puzzle. This becomes even more noticeable when examining the literature on perceptual functioning in children with ASD.

Though the theories of autism emphasise the role of attention to different extents, none would discount its influence in shaping the child with ASD. The manifestations of the characteristics of ASD are highly complex and sometimes contradictory at even the most basic perceptual level. It is apparent that in order to understand these perceptual anomalies, they must be examined in more detail. What is it about a task that can result in both increased and reduced performance in the one participant if not a result of a deficit in processing global information? The answer lies in examining the literature on attention and orientation studies but what has been found is that these questions do not have simple answers. This is most likely because attention is multifaceted and dependent on a number of things including the type of task, the features of the stimulus itself and other internally motivating factors (Hayhoe & Ballard, 2004).

It has been shown that children and adults with ASD differ in how their eyes scan their environment (Klin, Jones, Schultz, Volkmar, & Cohen, 2002), process visual stimuli (Bertone, 2003; Bertone et al., 2005), and perform visual tasks (Plaisted, O'Riordan, & Baron-Cohen, 1998). The majority of the major theories described thus far would argue that these differences are symptoms of more general problems such as a tendency to focus on local features or a problem in the executive control of attention. However, some of the differences shown in this clinical group are at a very basic perceptual level and others seem to be specific to the social domain leading to a complex presentation of attentional irregularities. Both of these will be described more completely in the following sections.

### *1.7.1. Motion Perception in Autism*

One such low level perceptual difference is shown in research where an ASD sample displayed poorer ability when faced with some types of dynamic stimuli (Bertone, 2003; Gepner et al., 1995). It's perhaps best delineated by the findings of Milne et al. (2002) who examined motion coherence thresholds in children with ASD. To do this they used a Random Dot Kinematogram (RDK) paradigm, which consisted of white dots of 1 pixel on a black background. In any trial a number of these dots would move in the same direction, either left or right while others moved in a random pattern. The percentage of dots moving in this manner was controlled until the participant could no longer detect which direction they were moving in. Results indicated the children with ASD had a much higher motion coherence threshold, indicating more difficulty at detecting the motion of the dots. Milne et al (2002) interpreted this as a dorsal stream dysfunction and this has also been proposed by Spencer et al. (2000). Somewhat opposed to this interpretation, researchers such as Gepner et al. (1995) have put the focus on a more general motion-processing deficit but despite the differences between these viewpoints, both agree on a fundamental issue. Specifically, they agree that the dynamic nature of the stimuli leads to processing difficulties due to neurological deficits inherent in people with ASD.

Even this fairly general view has been challenged by researchers such as Bertone et al. (2003) who proposed complex motion sensitivity in autism might be explained by the reduced efficiency of neuro-integrative mechanisms. In this first experiment, they examined motion sensitivity for people with ASD using dynamic stimuli that required neural processing mechanisms of different levels of complexity. To manipulate this they compared responses to first order (luminance-defined) motion stimuli types to second order (texture-defined) stimuli types. They found that, when compared to matched controls, the motion sensitivity of those with ASD was similar to the TD sample for first order stimuli types but significantly decreased for the second order stimuli thus. Thus, this finding was seen as indicating individuals with ASD showed a different capacity to process when presented with different types of motion and that the problem was unlikely to be a general motion processing deficit.

To examine this further, Bertone et al. (2005) examined sensitivity to simple and complex static stimuli. Participants simply had to detect the orientation of specially designed flickering stimuli of first and second order types. They found a selective decrease in sensitivity to the complex but an increase in sensitivity to simple stimuli in participants with ASD, indicating that similar difficulties in perception could be shown in the absence of dynamic stimuli. Despite the arguments against their predecessors, their view does not differ much from the others. Simply put, this view does not discount that the dynamic nature of the stimuli could not be processed due to difficulties at a neurological level. Where it does differ, is in being a more diverse model as it emphasises that it is not the motion of the stimulus which is at the root of the difficulties but rather how complex it is with regard to the neurological resources needed to process its features.

The idea of a basic visual deficit such as the dorsal stream dysfunction argued for by Milne et al. (2002) is attractive in its simplicity and also somewhat supported by the similarities found between autistic individuals and people suffering from congenital blindness

(Hobson, 2003). However, it is difficult to see how a visual deficit could explain the wide range of symptoms shown in people with ASD. Additionally, the abstract nature and extent of detachment from real life events in experiments of this sort make it difficult to gauge how important their findings are when applied to a more natural setting. In particular, there has been a great deal of unusual findings on children with autism with regard to their attention to social aspects of their world which the theory proposed by Milne et al. would find difficult to explain, as described in the next section.

### *1.7.2. Perception of Social Stimuli in Autism*

Research into eye tracking and visual orienting has also yielded some unusual results concerning autism and the perception of specific types of stimuli. However, the most striking of these perceptual differences are those shown in response to stimuli that are social in nature. The prime example of these differences was a study conducted by Klin et al. (2002) which monitored the eye movements of people with ASD and a control group while they were watching a social interaction between two people on a video screen. They found that the members of the ASD group had markedly different scanning patterns to the control group when comparing the percentage of time spent looking at mouth, eyes, body and objects in the scene. Of these, the most predictive indicator of group membership was the percentage of time spent focusing on the actors' eyes on which the control group spent twice as much time focussing. This study also contained a measure of social competence and unusually, while the percentage of time the people with ASD spent looking at eye regions was not related to this measure, the percentage time they spent focusing on the mouth region was associated with higher social competence. This suggests the adoption of a fundamentally different strategy in facial perception and that their later social functioning depends on these different attention distribution strategies.

The work of Klin et al. (2002) suggests that instead of a general impairment in attention processing, individuals with ASD may have a specific deficit to social stimuli. Swettenham et al. (1998) had also previously examined this by looking at the gaze direction of children with ASD in a naturally occurring setting compared to a matched typically developed group. The children were filmed in a room with pre selected toys, their parents and two experimenters. The film was then coded according to when the children were looking at an object (the toys), someone's face, or unfocused. They predicted a general deficit in attention and that the deficit towards social stimuli would be no different than other disabled groups. However, they found that the ASD group spent a higher percentage of time focusing at objects than the other groups and less time looking at faces. It was also found that there were fewer eye shifts generally exhibited by the ASD group and somewhat anticipating the later findings of Klin et al. (2002) that the children with ASD exhibited a fundamentally different pattern of eye movements. Unlike the findings of Klin and colleagues, it was not the pattern of eye shifts within a target's face that they were looking at but the pattern between the faces and objects in this environment. The majority of shifts exhibited by children with ASD were object to object shifts (comparable to control groups), and fewer object to person, person to person shifts were seen than the other groups. They concluded that this was evidence of a domain specific impairment in attention shifting, where social stimuli such as faces were shifted to less often and for less time, rather than a general dysfunction in attention.

It could be argued that this could be explained by a visual motion deficit such as that described in section 1.7.1, due to the complex nature and rapid changes in expression in a person's face. However, it has been shown repeatedly that these social differences are not confined to visual attention. For example, research into the retrospective analysis of home videos has indicated that interactions such as failing to respond to being called by name can discriminate children with autism as young as 1 year old (Baraneck, 1999, Osterling & Dawson, 1994) and even predict a diagnosis of autism years later (Baranek, 1999).

Similar findings have also been shown in laboratory based studies. Dawson et al. (1998) carried out a study further examining the nature of this apparent deficit for social stimuli by examining responses to different types of sounds. They sought to examine autistic children's ability to orient to familiar social and non-social sounds that were delivered in a naturalistic manner. The sound of clapping hands and name calling were used as social stimuli and a rattle and 'jack in the box' the non-social stimuli. They expected a decline in ability to orient to social stimuli and compared this to level of shared attention exhibited by each participant. Their results suggested that children with ASD exhibit a general impairment in orienting ability, and that this impairment is more severe for social stimuli, findings that were mirrored in an unconnected study by Leekam, Lopez and Moore (2000).

These findings were later expanded on by Dawson et al. (2004) and Leekam and Ramsden (2006). The first of these studies used a wider range of stimuli and indicated that combined impairments in joint attention and social orienting could distinguish young children with ASD from TD children of similar mental age better than joint attention impairment alone. In contrast to this, the Leekam and Ramsden study used a more naturalistic design to examine the child's responses to a wider range of stimuli such as hand touches, waving and gestures, name calls, and other verbal bids for attention bids. Results of this study indicated difficulties in responding to all of these cues for attention. This is further support for the likelihood that the deficits in attention in ASD are specific to social stimuli which begs the question of why this might be.

As an attempt to answer this question, Dawson et al. (2004) stressed the nature of the stimuli to be processed. She proposed that social stimuli such as speech and expressions are complex, variable, and unpredictable and due to this, children with autism have difficulty processing and representing such stimuli, leading to a lack of attention towards them. The lack of attention to social stimuli limits the child's opportunity to engage in critical early social experiences which provide the foundation for social development. The brain develops rapidly in infancy and it is known that experience can and does play a role in selecting and establishing preferentially active synapses. Supporting this argument, Klin et al. (2002) notes there is some indication that rather than representing a face-specific deficit of a presumably neurofunctional region, abnormalities in autism may reflect a lack of expertise with facial stimuli by autistic individuals. This could further reflect a lack of repeated exposure to such stimuli early in life due to the person's history of social disengagement. However, there is a crucial flaw in interpreting the findings of differences in processing, orienting or attending to social stimuli as the core impairment in ASD. That is, the evidence of attentional differences in very young infants with dynamic abstract stimuli (Zwaigenbaum et al, 2005).

Although potential deficiencies in social processing are important findings in terms of the early diagnosis of autism, the theoretical implications are unclear. Arguably, these findings describe rather than explain a symptom of autism, a lack of interest in social stimuli but as is clear from the current directions theorists have taken with regard to autism (see section 1.5), attentional and perceptual differences are critical to understanding the nature of autism. Additionally, as has been argued, interest itself is a complex concept which is important in both learning and the mediation of attention and may lead to important potential implications if considered. Paramount amongst these implications is the possibility that if social attention impairments could be identified early in life and changes made to the manner in which the child attended to his or her social environment, children with autism might be directed towards the path of more typical development. This potential has led some theorists to attempt to make the link between interest, attention and autism and their theories will be described in Chapter 2. The important point to take from these studies and those involving motion perception is that children with ASD have profoundly different strategies of distributing attention and processing stimuli from those who have typical and delayed development.

## 1.8. Disengagement and Autism

Within the last decade, there has been increased interest in the possible link between disengagement difficulties and autism. This research has indicated a slower ability of children to disengage attention when compared to both typically developing (TD) and developmentally delayed (DD) samples (Elsabbagh, Volein, Holmboe, Tucker, & Csibra, 2009; Landry & Bryson, 2004). This tendency could also be the reason why children with ASD are often seen focussing on unusual details of objects. However, not all studies have shown this finding. Some studies show no difference between ASD and comparison groups or faster shifting of attention by children with ASD (Leekam, Lopez & Moore, 2000; van der Geest, Camfferman, Verbaten & van Engeland, 2001).

If it is the case that children with ASD have an impaired ability to disengage as has been suggested by some of this work, it might result in a similar ‘sticky fixation’ effect as seen in infants (Hood & Atkinson, 1993; Johnson et al., 1991). Though this tendency generally disappears by four months of age, there could be developmental delay in the development of attentional components in children with ASD resulting in later difficulties such as joint attention difficulties. This possibility would also help explain the tendency of children with ASD to exhibit fewer shifts in eye movements generally (Swettenham et al., 1998).

Some of the strongest evidence arguing for this viewpoint comes from a study by Landry and Bryson (2004) who used a version of the gap paradigm on children with ASD. Their experiment involved the use of very complex stimuli that were also visually abstract. Specifically, they used videos of falling, multicoloured shapes as both the fixation stimulus and the peripheral targets. Interestingly, they found that children with ASD were significantly slower in those trials where two stimuli competed for the child's attention (competing trials) than both TD and DD children. Their findings were also very striking as the ASD group took on average twice as long to disengage from the stimulus than the control groups. From this, they argued that children with ASD have a general impairment in disengagement and that this dysfunction underlies some of the core features of autism. The complexity of their stimuli sheds some doubt on whether this impairment is comparable to the 'sticky fixation' of infants since, as we have seen in the debate over oculomotor and attentional disengagement (see section 1.5.2), it is possible to manipulate the level of attentional involvement in the gap paradigm.

The main argument against adopting the viewpoint that children with ASD have a general impairment in disengagement is that although these findings are robust in the TD infant population, when applied to an ASD sample the results are far less consistent. For example, findings that shed doubt on this argument come from Chawarska, Klin, & Volkmar (2003) who conducted a study looking at face processing and gaze following with TD and ASD groups. They used pictures of faces with moving eyes and simulated eyes (SimEyes), which were a dynamic cue which was similar to the motion of regular eyes but did not look like eyes within a face. Surprisingly, they found that autistic individuals were actually quicker to disengage from the facial target in general than the control group but that with the

SimEyes there were no differences. More generally, they also found that the typically developed children spent a lot longer processing and disengaging from the face. This again brings up the question of the effects of the characteristics of the stimulus on performance, particularly social stimuli. However, without the presence of a gap trial in this paradigm it is difficult to directly compare these results to Landry and Bryson (2004) or to say to what extent disengagement played a role in their findings as there could have been underlying differences in their ability to shift and engage attention contributing to the eye movement latencies.

Findings which argue more directly against impairments in the process of disengagement come from a study by Leekam et al. (2000). As part of their work on joint attention impairments in children with ASD, they conducted a study to see if more general attentional difficulties could underlie these problems. They adapted Posner's paradigm by using mechanical toys appearing from boxes rather than using displays on a screen. These mechanical boxes could reveal a 'Thomas the Tank Engine' toy when triggered and were arranged according to the format of the gap paradigm with a central fixation toy and two peripheral targets. They found that children with ASD were as fast as those with DD to shift attention in both trials where the central stimulus remain on and trials where it turned off upon the onset of a peripheral stimulus. Surprisingly, they also found that Low IQ children with ASD were significantly faster than children with DD at responding in the trials where stimuli were presented simultaneously. They concluded from this that there was no general impairment in disengagement for children with ASD. Aside from the different type of stimuli used, two factors of this experiment lend to it being difficult to compare the results to Landry & Bryson's (2004) findings. Firstly, no gap was introduced between the offset of the central stimulus and the onset of the peripheral ones. As such, it is unlikely that automatic disengagement could have occurred. In fact, there was little if any difference between the two types of trials in either group, supporting this argument. Secondly, the peripheral stimuli were much further from the central stimulus than in other experiments using this paradigm and were essentially outside the child's field of vision so the exogenous cue to trigger the attentional shift was much less salient than in other experiments of this sort.

Probably the most directly comparable study to Landry and Bryson (2004) was a study conducted by van der Geest et al. (2001). They used older high functioning children with ASD with a mean age of ten, matched both by IQ and CA to TD children and used simple abstract stimuli. They used a fixation stimulus of a white cross and a peripheral target of a white square on a black background. They found that the children with ASD exhibited a higher number of fast responses called express saccades (saccades of less than 150 ms) than TD children in the competing trials and no difference between their average latencies. Thus, they concluded ASD is characterised by impairments in engagement rather than disengagement. This argument has a clear logic but perhaps this is a difference between the relative salience of the task for each of the groups. As has been argued in section 1.5.2, the level of initial attentional engagement can be manipulated possibly resulting in differences in the extent of the gap effect. This confounds the results somewhat but is not sufficient to detract from the contribution these results have for the argument against a general attentional disengagement deficit.

This resolution of this debate is very important to the understanding of the nature and source of autism as since it is such a fundamental process which develops so early in an infant's life there is a potential for developing a diagnostic tool for very young children. This would have important implications for both research into, and service provision for, children with ASD. These stimulus choices could have influenced the results for various reasons. Most obviously, the level of complexity and abstractness of the stimuli differed across the studies. Indeed these findings have become the focus of subsequent research and two recent studies have worked with infant siblings of ASD children (Elsabbagh et al., 2009; Zwaigenbaum et al., 2005). Using this paradigm, these researchers have found that infant sibling groups could be differentiated from similarly aged TD infants through their ability to disengage in the task, supporting this argument. As such the primary focus of the studies presented in this thesis will be to resolve if there is a disengagement deficit in children with ASD and if this can be manipulated by different stimuli.

## 1.9. Conclusions

Landry and Bryson's (2005) work into attentional disengagement and autism has great importance for practice and research if shown to be reliable. It is certainly undeniable than children with ASD have profoundly different strategies of distributing attention and processing stimuli (see section Section 1.7.2). However, the inconsistency in the literature on whether children with ASD have consistent impairments in this area sheds doubt on their findings. This inconsistency likely comes from the different methodologies used and in particular the stimuli. One thing which all the major theories on autism now take into account is that children with autism have profoundly different experiences of the world than those of the child of typical development. As such, it would be unwise to expect them to react to all stimuli as a typical child would. However, if there is a stimulus effect on this pattern of attention, the question remains, what is this effect and when does it manifest?

The attention literature may give some insight into this. In particular, the work into covert attention and the differences shown between ocular and attentional engagement suggests the possibility that different types of disengagement are occurring between the studies of Landry and Bryson (2004), van der Geest et al. (2001) and Leekam et al. (2000). As stated in section 1.5, the principle issue with Posner's conception of attention as a spotlight is the internal nature of attention which makes them difficult to measure directly. The gap paradigm outlined in section 1.5.1 goes some way towards overcoming this issue but as can be seen from the research into oculomotor and attentional disengagement in section 1.5.2, the extent to which attention is engaged on a target is still an unknown factor with some stimuli.

This unknown factor, initial attentional engagement is most often ignored, but it will be argued in this thesis that it is imperative to understanding its effect on disengagement and the gap paradigm. In essence, it is argued here that the relationship between these two components can be summed up as if attention is to be disengaged it needs first to be engaged and therefore disengagement is a by product of this initial engagement. As an analogy, a water tank with two connected to it can be seen as the processes of attention (see Figure 1.1). The water tank itself represents attention with the water in the tank representing the level of attention engaged on a stimulus. The two taps represent the processes of engagement and disengagement. Turning on the first tap fills the tank, representing the processes of engagement as the water level rises resulted in the attention becoming more engaged on the target. Turning on the second tap empties the tank, representing the process of disengagement.

Continuing this analogy further explains the processes involved in the gap paradigm. Although this paradigm is assumed to measure the reaction time of disengagement, how long the second tap is open in the water tank analogy, the duration depends on how much water is currently in the tank. This level is directly dependent on how long the first tap was on (initial engagement). Therefore it is difficult if not impossible to separate disengagement from engagement and the implicit assumption of the gap paradigm that the reaction time difference between competing and shift-only trials (see section 1.5.1) as an indirect measure of disengagement is not completely accurate. In other words, using the water tank analogy, slow reaction times may mean that the second tap wasn't opened fully (disengagement difficulty) or that the tank had a large amount of water in it (high level of initial engagement. Alternatively, quick reaction times may mean that the second tap was opened fully (good ability to disengage) or that the tank was almost empty to start with (low level of initial engagement).

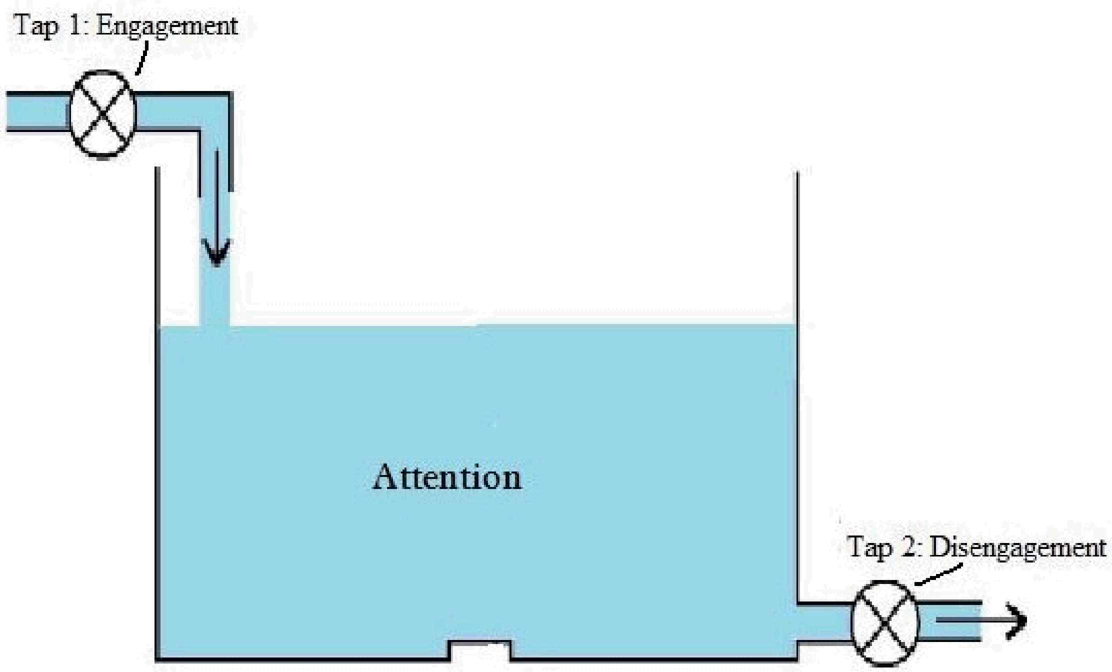


*Figure 1.1:* The water tank analogy of visual attention. The first tap represents engagement, the second tap represents disengagement and the water level represents attention already engaged on a target.

This has large potential implications for the previously mentioned studies in particular as it is possible that the stimuli used did not capture attention to the same degree in all of the groups. Additionally, as shown in section 1.2, there is some doubt about how much orienting as a whole is driven by bottom-up processes such as stimulus features or by top-down internal agendas. This research has largely concluded that top-down mechanisms have a much larger influence than previously thought. These conclusions have strong implications for research into the gap effect and when methodologies differ to such an extent as in the previously cited studies, the possible interference of internally driven mechanisms needs to be considered.

The possibility of internal processes in the gap paradigm in particular, needs to be examined in greater detail. Though it is beyond the scope of this thesis to account for all possible internally driven forces, it is intended to take a step on that path by focussing on one which, it is thought, would also help to counteract the problem of initial attentional engagement. It is a concept which not only has been neglected in the literature until relatively recently (Silvia, 2006) but also is cited to be fundamentally different in many children with ASD (Murray, Lesser, & Lawson, 2005). It is the concept of *interest*.

# Chapter 2. INTEREST

It's been over a century since William James's statement quoted at the beginning of this thesis, yet interest, as a concept, is arguably one of the most misunderstood aspects of psychology today. The varied interests of participants are often either ignored completely or only given a vague mention when conducting research. When these variations are tackled, they are usually defined in terms of reward or motivation, yet this definition is fundamentally incomplete in its simplicity. One of the most profound peculiarities of human behaviour is that when we are given a choice, people will often choose not to engage in activities despite clear benefits. The schoolchild who does not write their essay even for a clear reward, the adult who procrastinates on finishing work resulting in failure to get a payment and the person who refuses to take medication they need are all potential examples of this. As a race, we behave in a way that can only be seen as irrational at times. Attempts by others to enforce us to do the beneficial actions are mostly limited in their potential, because to benefit, the action must be sustained over time. Why we act this way is a constant source of stress to us and individuals can spend considerable time trying to rationalize this behaviour. Often though, we can only answer in one way, we simply weren't motivated to do it. In contrast when something is of interest to us, we have no problem devoting a lot of effort and attention to it. The same schoolchild who fails to complete his essay may have an almost encyclopaedic knowledge of football statistics and the adult who puts off work might be devoting all his time and thoughts to writing a novel. Why? The simplest answer is that these things don't capture their interest.

Interest, as a source of intrinsic motivation, is fundamental to the types of activities we engage in and also how long we choose to persist in them (Sansone & Thoman, 2005).

There is also research to suggest it plays a critical role in what and how well we learn information (Garner, 1992; Alexander, 1996). Even more critical for this thesis, interest has been suggested to moderate attention (Hidi, 1990).

Despite the fundamental influences interest has in our lives, very little research has been dedicated to it outside of the educational literature. Even within this literature, not enough focus has been given to operationalising and defining interest in a practical sense, due to an almost exclusively theory driven approach. Likewise, the unusual interests of children with ASD has been neglected and has largely focussed on lower level repetitive behaviours. This thesis will attempt to attend to this gap in the literature by re-examining the relationship of autism and attention in the context of interest.

As an attempt to address these issues, the first part of this chapter will be dedicated to exploring the concept of interest in both a theoretical and experimental context with a view to forming a working definition that encompasses previous research. This will be followed by an examination of the relevant research into interest and its effect on attention and a description of the theories of autism that have attempted to include both interest and attention in their outlook. The chapter ends with a rationale for the studies presented in the thesis and some general predictions.

## 2.1. Motivation

Though the concept of motivation is used widely in everyday language, in human cognitive psychology it has largely fallen out of fashion. Essentially, the term means ‘to be moved to act’ and it is a trait or personality construct assumed to be inherent in people. As such, a motivated person is seen to be active and enthusiastic about the tasks they partake in, whereas someone with no impetus to act is said to be unmotivated. In psychology, motivation and drive theories have mostly been assimilated into other fields such as social and personality theories. This was partly due to being an antithesis to the approach of the behavioural theorists, who were at the centre of psychological research throughout the middle of the last century. As a result, there was very little focus on internal needs or motives with external triggers and consequences being the main impetus at the time. However, after the staunch behaviourism of the past had fallen from favour, a renewal of interest into some aspects of motivational theories has developed, particularly within the last 20 years (Silvia, 2006).

Despite this new direction, there are three principal difficulties in trying to account for motivational factors in any psychological study. Firstly, the term motivation is abstract and not directly observable. Motivation is a catch-all term for a variety of mental states that bring about action. Hence, it can only be quantified subjectively through indirect means such as self report accounts or, in certain cases such as hunger and sexual arousal, physiological measures. Secondly, it is a multidimensional construct. Motivation cannot be understood as a single drive or force but is a term given to any psychological or biological impetus for action. As such, any conceptualisation of a motivational variable is unlikely to apply to the full range of concepts encompassed by this term. Finally, motivation is transient in nature. It is not stable but a dynamic construct that not only varies between individuals but within the same individual across time. Hence any measurement of motivation is only valid for a short space of time.

Despite these drawbacks, the inclusion and consideration of motivational variables would add considerable strength to any experiment and could be the missing variable behind unanticipated or conflicting results. However, with these points in mind, it is apparent that any study attempting to include a motivational variable should only focus on limited aspects of the concept in order to conserve a meaningful context. As such, the first task in any experiment including motivation as a variable is to describe and operationalise the aspects most pertinent to the outcome.

## 2.2. Intrinsic Motivation

Intrinsic motivation was first acknowledged in psychology in animal behaviour studies (White, 1959). Here it was noticed that many animals engage in curiosity driven and playful actions in the absence of reinforcement. These acts, although clearly adaptive for the creature, appeared not to be performed for a particular function but for the enjoyment of the activity itself. According to current theorists, intrinsic motivation is not the only type of volitional control of our behaviours, but it is an important yet often dismissed one (Deci & Ryan, 2008). From the moment of their birth, people, are active, curious, and playful. They show an ability and desire to learn and don't need separable consequences to do so. This critical tendency is vital for initial and further cognitive, social, and physical development and truly defines the human race. As a result, probably the most established distinction in motivation literature is that of intrinsic and extrinsic motivation with over 800 publications devoted to it (Vallerand, 1997). This distinction is explored primarily through the Self-Determination Theory as described by Deci and Ryan (2008).

Self-Determination Theory has been the driving force between the renewal of emphasis on motivation research and draws on the previous goal-orientation models in that the distinction between intrinsic and extrinsic motivation is based on the different goals inherent in each concept. More specifically, intrinsic motivation refers to performing an action which is inherently interesting or pleasurable, whereas extrinsic motivation refers performing an action for an external separable outcome. As a clarification, Ryan and Deci (2000) give the example of a student who is highly motivated to do homework out of curiosity and interest as displaying intrinsic motivation. Alternatively, one who does his homework because he or she wants the approval of a teacher is exhibiting extrinsic motivation.

The primary focus in Self-Determination Theory is on the desire to act without external pressure or rewards and, according to this model, the basic dimension of motivation is how self determined it is. Ryan and Deci (2000) define this concept as a sense of being willing to partake in an activity due to what they describe as the three fundamental human needs of autonomy, competence, and relatedness. These needs in turn are described as the sense of experiencing oneself as the centre of action, the sense of accomplishment and the sense of connectedness to other people (Ryan & Deci, 2000). These self determined actions can either be behaviours that are intrinsically motivated as previously described, or behaviours whose values have been internalised into the self. The second type of action are those which despite being unpleasant, people wish to perform because they feel like they are acting in line with their true selves.

Self-Determination Theory has been especially popular in the education literature due to its focus of this internalisation process and how it could be facilitated in those uninterested in learning (Ryan & Deci, 2000). However, in spite of its descriptive usefulness and the limitation of fundamental human needs to just three basic needs which drive intrinsic motivation, it still falls foul of the main criticism of its predecessors in motivational psychology. That is, what exactly are these needs and where do they reside? As described, they are a force that brings about action, yet there is no explanation as to the source of this force. This inherent gap in theories such as this one has brought about a new emphasis in the literature within the last 20 years. An emphasis on the source of the motivational force rather than the impetus for action it brings about. It is this new direction which this thesis will focus on. It is, of course, the psychology of interest.

## 2.3. Interest and Pleasure

Some theorists consider affective states such as pleasure an important part of interest (Krapp, 2005, Hidi, 1990, Schiefele, 1991). However, the first point to make about interest is that it is not synonymous with reward or positive feelings as can be shown by the work of Aitken (1974). In this study, randomly generated polygons of varying complexity were presented to the participants who had to rate them in complexity, interestingness and pleasantness. The results indicated different patterns for ratings of pleasantness and interestingness dependent on how complex the stimuli presented were, with the stimuli rated as more interesting tending to be more complex than those rated as more pleasant. This strongly argues for interest and pleasure having different antecedents. Similar findings have also been shown with other stimuli such as anagrams (Boykin, 1977), further strengthening this claim.

Further evidence for the distinction between interest and pleasure is presented by Silvia (2005) who conducted a number of studies examining the appraisal structure of each state. The first of these also presented randomly generated polygons to the participants but instead of asking the participant for ratings of the images, he asked one group to circle the most pleasing image and another to circle the most interesting one. He found a significant difference between the groups which polygons were chosen and also noted that the 'interesting' ones tended to be more complex in structure than those considered pleasant.

Berlyne (1963) provided more behavioural evidence for these claims. In this experiment, participants were briefly presented with two images that had previously been rated for interest or pleasantness. The participant was then required to choose one of these to view for a longer period. It was found that people generally chose the interesting as opposed to the enjoyable image. This finding is relatively consistent in the literature (Berlyne & Crozier, 1971) and indicates that it is possible to discriminate between the interest and pleasure using behavioural measures. Elaborating on this last point Silvia (2006) describes a number of studies which indicate that interest is a better predictor of viewing time than pleasure.

The distinction between interest and pleasure is an important point to raise when establishing an operational definition of interest. It indicates that the feeling of interest cannot be wholly understood as a behavioural consequence in an operant conditioning model. Rather, it could potentially function as both an internal antecedent actively inciting us to explore complex aspects of the world and a consequence when that initial impetus is fulfilled. It is apparent from this that interest is a complex construct in need of further attention.

## 2.4. Theories of Interest

In motivation literature interest is sometimes presented as a vague, everyday term synonymous with intrinsic motivation. Intrinsic motivation theorists such as Deci and Ryan, (1985) use the term throughout their work yet fail to ascribe any specific meaning to it. Despite this oversight, interest has been considered an important aspect in psychology ever since the 1800s (Schiefele, 1991) with even William James adding to the discussion who considered it a central force in the mind's workings as shown by this chapter's initial quotation. However, as noted above, with the emergence of behaviourism as the central emphasis in psychology, the concept of interest fell out of favour among the theorists of the time.

In comparatively recent years, there has been a renewal of emphasis on this neglected concept across different branches of psychological thought. Interest has emerged in studies by researchers on emotion (Silvia, 2009), personality (Graham, Tisher, Ainley, & Kennedy, 2008), aesthetics (Silvia, 2005), education (Krapp, Hidi, & Renninger, 1992) and vocation research (Holland, 1997), all with slightly different focus. Despite the different approaches and the relative recent nature of this rebirth, their general arguments for the structure, causes and functions of interest are remarkably similar, though they do differ on the specific details. To further elaborate on these distinctions a brief description of each of the key theories of interest follow.

### *2.4.1. Information Conflict*

Though not a widely known theory of interest, Nunnally's (1981) information conflict model is noteworthy in that, it was the first of its type to exclude motivational concepts as imperative for understanding why people act. Rather he stated that feelings of interest result from cognitive variables and that this results in an impetus to act. In Nunally's opinion, drives, motives, arousal level and physiological factors are not an adequate set of sources by themselves and had no place in his model. Interest is experienced when the individual encounters stimuli or information with contradictory qualities such as a flying sailing ship, motivating the person to act accordingly. Novelty and familiar objects in unfamiliar places are also included as examples of information conflict according to this model.

Despite being too simplistic to describe interest as a whole, Nunnally's (1981) model was a vital step towards the more current theories of interest. Its main flaw however, was that it takes an implicitly behavioural stance on interest by relying on stimulus features and external events as its source. Thus the theory cannot explain why different individuals fail to show interest in the same stimulus and why even within the same individual interest levels for a single stimulus will vary across time (Silvia, 2006). To resolve this issue, later theories placed greater emphasis on the emotional components of interest.

### *2.4.2. Situational-Individual Interest Models*

Probably the largest body of work on interest in recent years has been conducted in the field of educational psychology. This research has been at the forefront of recent theorising on interest and emphasises both cognitive and emotional aspects of interest. Most of this theorising has stemmed from the distinction first described by Hidi (1990) between individual and situational interest. Individual interest is conceived of as a relatively enduring preference for certain topics, subject areas, or activities (Hidi, 1990; Renninger, 1990; Renninger & Wozniak, 1985; Schiefele, 1991). She distinguished this from the more transitory situational interest, which is interest caused by external environmental cues (Hidi, 1990; Hidi & Baird, 1986, 1988). Essentially, the distinction between these two concepts is the difference between interests that a person has held for some time and the interest they feel when presented with something new and unusual. Another concept, actualised interest was later added to describe the feeling of interest when an individual pursues their individual interests (Krapp et al., 1992). Since this initial classification, subsequent researchers have expanded and modified this simple model into a variety of distinct theories (Silvia, 2006). The two most influential are introduced below.

#### 2.4.2.1. *Schraw and Lehman's Taxonomy of Interest*

Perhaps the most complex of all the theories on interest, Schraw and Lehman's (2001) taxonomy of interest attempted to review and combine the interest literature to create a schematic framework to combine the terms described in the literature. It is more of an attempt to encompass the rapidly diverging field into one overarching framework than a theory in itself. As such, it summarises the views of many researchers in the area and attempts to solidify the descriptions of interest into a coherent whole. The resulting model is shown in Figure 2.1.

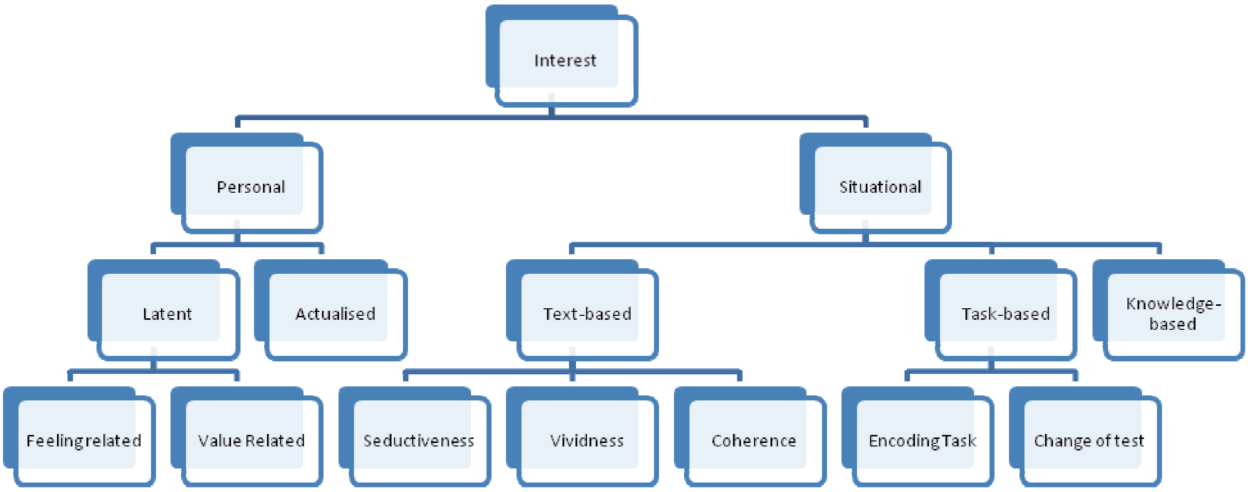


*Figure 2.1:* Schraw and Lehman's (2001) taxonomy of interest.

The most prominent distinction in this model remained the separation of individual from situational interest. However, individual interest was renamed personal interest to encompass the term topic interest which researchers such as Schiefele (1991) had adopted despite essentially meaning the same. Within the category of personal interest whose basis they say was pre-existing knowledge, experiences and emotions relating to a specific topic they further differentiated between latent and actualized personal interest. Latent interest was said to refer to long-term dispositions towards topics and an intrinsic characteristic of the individual. This concept was segregated even further into feeling-related and value-related interest which were concepts introduced by Schiefele (1991). Feeling-related interest was said to occur when an individual experienced positive affect in a particular topic whereas value-related interest in contrast occurred when personal significance was assigned to a topic. Still under the umbrella of personal interest, the description of actualized interest diverges somewhat from previous definitions and is described as a momentary motivational state similar to situational interest, but which arises as a result of internal rather than external features. Little further elaboration is given on this description and it is unclear why this is perceived as a separate construct.

Their definition of situational interest remains consistent with older descriptions and refers to information that is of temporary value and environmentally activated. This concept they further subdivided into text-based, task-based, and knowledge-based situational interest. Text-based interest refers to properties of information that affect interest, task-based interest refers to interest generated by changing aspects of the task and knowledge-based interest refers to interest generated from relevant prior knowledge.

While Schraw and Lehman (2001) efficiently reviewed the literature of interest in the education literature, the complexity and breadth of their model is more a hindrance than a benefit. Very little evidence is cited for distinguishing between so many categorisations of interest. In particular, actualised and situational interest as described, only differ in their causes rather than the experience of the individual. Similarly, the subdivisions of situational interest also appear to be distinguished in this way. As such, it is doubtful that the majority of these conceptualisations exist as separate constructs, whether emotional, motivational or cognitive. As an overarching theory, this model does not really succeed in explaining interest but rather confounds the concept in vague and inconsistent terminology in an attempt to be as inclusive as possible with regard to the research in the area. Where it did succeed was in highlighting the divergence in the literature as to the meaning of the different concepts of interest and the need to bring the literature together.

#### 2.4.2.2. *Person-Object Theory of Interest*

The person object theory of interest (POI) was formulated by Krapp (2002, 2005) and included a description of how interests develop. The concepts of individual and situational interest are again used within this framework but three key aspects to this model were not previously emphasised. The first was the focus on the conceptualisation of interest as the relationship between the individual's experience of the object of interest and its features. This conceptualisation is central to the model and is what gives it its name. According to this perspective, the different types of interest were no longer seen as separate processes but rather as lying upon a dimension, with situational at one extreme and individual at the other. The type of interest experienced would depend on where it lies upon this dimension and characterised by to what extent it results from internal or external features.

The second point of note in this model was the dual nature of the state of interest. Krapp (2005) argued that any experience of interest consists of both cognitive and affective components. According to the model, the extent to which each of these components influence the experience again depends on where on the dimension between situational and individual interest the experience lies. The POI perspective describes how the development of interest into a long lasting personality characteristic is maintained by this cognitive-emotional regulation system. The system is said to be made up of two interrelated subsystems, the first of which is primarily based on emotional experiences that provide feedback about the individual's state of functioning and the requirements of the situation. The second subsystem is a cognitive one, which responsible for conscious effort to overcome obstacles to goals of interest.

These assertions lead on to the final aspect, and that is the emphasis of the model on the development of interest. Interest, Krapp (2002, 2005) said gradually strengthens from situational to personal interest through repeated experience of the object by the person if both of these subsystems are experienced in a positive way. This may eventually cross a threshold into becoming individual interest by being internalised into the person's self concept. In doing so, the emerging interest passes through three relatively distinct stages: initial situational interest, maintained (or sustained) situational interest, and finally individual interest. The middle stage relates to interests which has not yet been internalised but consistently maintain the focus of the individual when they occurs. Hidi and Renninger (2006) later extended this into a four-phase model by also included an emerging individual interest stage to further illustrate the gradual process of interest development.

### *2.4.3. Evaluating the Situational-Individual Interest Models*

The principle issue with evaluating situational-individual interest models is also paradoxically what makes them difficult to criticise on other dimensions. It is the lack of agreement within the literature on the meaning of the concepts they present. While some models such as the taxonomy of interest make a distinction between actualised and situational interest, others, like the POI approach, do not. Even when the same terminology is used, researchers have sometimes defined the terms differently in quite fundamental ways (Silvia, 2006).

A second but no less critical problem with the work in this area is that the theories seem to have been developed with little thought of how critical measurements can be made.

In fact, it is very likely that this theoretically driven approach has led to the disparity of views in the area. Very few examples are given on how to measure the constructs described leading researchers to come up with their own interpretations and definitions. Even the common distinction between individual and situational interest, though very descriptive, is extremely vague on where the threshold lies between them, leading to difficulty in their measurement particularly for the more complex and arguably more important, individual interest.

Despite the inconsistencies in this approach, the areas where these researchers do agree have contributed greatly to the understanding of interest as a concept. Broadly speaking, all models in this category have two elements in common. The first is the general distinction between situational and individual interest in that one is considered momentary and the other an enduring predisposition. This delineation marks an important distinction between two very different but related concepts. One of these concepts relates to a feeling of interest which is experienced in a general way when presented with certain types of situation, and the more specific individual interests which are integral to a person's outlook. This provides scope for examining how each contribute to the behaviours of the individual as well as a potential framework for under what conditions the former can develop into the latter. However, to make specific predictions about the existence of different types of interest, agreement on the details of these concepts is tantamount. The second element that these models have in common is that interest involves both cognitive and affective processes. This is an important consideration, and highlights the complex nature of interest and how it is central to our psychological make-up. Unfortunately, the descriptions provided of the inter-relation of these two processes are often vague and, for the most part, untested, severely limiting the potential impact on psychology at large.

As a final point, the focus on a more developmental approach to interest in the POI approach is a useful shift in perspective from the idea of the individual as a static organism.

However, apparent in models such as this one is still an implicit behavioural perspective on interest development. More specifically, that interest develops through repeated exposure to the experience of situational interest and positive emotions in the presence of an item or topic. The difficulty with this outlook, aside from the differentiation of interest and reward as described in section 2.3, is that interest development is seen as a passive process. More specifically according to this argument interest development is dependent, at least initially, on arbitrary situational factors. For example, if an object or task is novel or complex it should provoke situational interest, motivating the observer to re-engage in it, gradually strengthening until it becomes an individual interest. Hence, this approach still struggles to explain why there is so much variation between individuals in what interests they develop.

### *2.4.4. Emotion-Attribution Model*

Silvia (2005, 2006, 2008) takes a similar approach to the situational-individual interest models in that, he also makes a distinction between momentary and predispositional interests. However, he avoids the difficulty with conceptualisation of these as fundamentally different processes by speaking more generally of 'interest' as an emotional state and distinguishing this from the more enduring 'interests' that are held by the individual. It is his characterisation of interest as an emotional state at the core of his model which distinguishes it from previous paradigms. Whereas previous models considered affective states such as pleasure an important part of interest (Krapp, 2005, Hidi, 1990, Schiefele, 1991), Silvia (2006) describes it as a distinctive feeling in itself and better understood using cognitive-appraisal theories stemming from the emotion literature.

The appraisal theorists consider all emotions to be a combination of physiological and facial patterns, cognitive appraisals, subjective feelings and an adaptive role in life (Lazarus, 1991). Silvia (2006) argues that felt interest has each of these components. Its physiological and facial components are suggested to be actions such as orientation, alertness and concentration and its function to motivate learning and exploration. This proposed function is consistent with other accounts of interest as being important in daily life due to its role in determining what actions individuals choose to partake in and how long they will continue to do them (Lepper & Henderlong, 2000). These assertions were nothing new but the appraisal structure of interest redefined it in a more dynamic framework. Silvia (2008) follows the proposal by appraisal theories of emotion that all emotions stem from subjective evaluations of experience. Hence, the experience of any situation lies within the person observing it. This is reminiscent of the POI approach in its removal of focus from the event or object being observed but goes further in suggesting the internal processes are paramount and the features of the event are secondary. The specific appraisals Silvia (2005) argue make up interest are firstly novelty/ complexity and secondly ability to comprehend. In this way, he is also able to differentiate interest from other states such as confusion, made up of novelty/ complexity and lack of ability to comprehend and surprise, made up of simply novelty/ complexity (Silvia, 2009).

The more enduring interests, Silvia (2006) argues are also products of a form of cognitive appraisals. More specifically, he proposes that they arise because people make causal attributions of their emotional experiences. People attribute interest as arising from certain events, then, as a result, form implicit expectations about what will happen when that event or similar events occur. This attribution is classed as an emotional knowledge which can establish itself as an enduring interest. In simple terms, Silvia (2006) considers an interest to be the knowledge that something has evoked interest in the past and the expectation that it will continue to do so in the future.

As a framework for initiating new research the interest/ interests division does have the advantage of avoiding the murky definitions of previous models. Additionally, the description of interest as an emotion not only ties to an experienced albeit subjective state rather than the insubstantial drives of motivational theories, but also provides an elegant description of how cognitive and emotional factors coordinate to produce this state than the POI approach. Finally, the implicit assumption of the individual as a dynamic entity is unique in that it can account both for the variability between people in what they find interesting and also the variability within an individual in the same interest across time. However, while elegant in its simplicity, this model is still relatively untested aside from Silvia's (1995) own work, even in comparison to other research in the area. Additionally, the internal nature of attributions and appraisals will make it very difficult to do so in the future.

## 2.5. Interest and Learning

In an essay on literacy, Mihaly Csikszentmihalyi strongly argued for the importance of intrinsic motivation in learning stating that, "...the chief impediments to learning are not cognitive. It is not that students cannot learn; it is that they do not wish to." (Csikszentmihalyi, 1991, p. 115). While this is a somewhat radical view, the crux of the argument, that motivation to learn is as important in learning as cognitive ability, is one that makes intuitive sense and the general consensus in the literature is that this is indeed the case (Hidi, 1995, 2001; Sansone & Thoman, 2005; Schraw & Lehman, 2001; Shirey & Reynolds, 1988; Wade, Buxton & Kelly, 1999; Wade, Schraw, Buxton & Hayes, 1993). In fact, many researchers argue that facilitating learning is the primary purpose of interest (Sansone & Thoman, 2005; Silvia, 2006).

Although most of the findings in this area relate to learning from text using cross-sectional design methodology, which somewhat limits their interpretability, a study by Rathunde and Csikszentmihalyi (1993) on high school students is unique for three reasons. Firstly, it had a rigid definition of interest and placed great importance on operationalising the concept of interest. Secondly, it measured the effects on a diverse range of topics such as maths, music and science and not just literacy. Finally, it was an extensive longitudinal study which looked at the progression of talents over a period of three years and took into account a number of other confounding variables such as family income and scholastic ability. After initial measures were taken, participants were monitored for a week to measure their interest levels. The researchers investigated what they called undivided interest, defined as when the subjective experience of interest coincided with goal directed interest (the perception that their task was important to their goals) and they measured this through the use of an electronic pager. Through the use of signals from the pager, they monitored the student's subjective experience as well as their location, thoughts and activities throughout the day by requesting them to fill out self-report forms. Three years later, data was again collected on their abilities. Their results indicated that when demographic details and scholastic abilities were factored out this measure of interest was positively correlated with three independent assessments of performance in the associated talent area three years later.

It is certainly true that, as a correlational study, the findings of Rathunde and Csikszentmihalyi's (1993) study cannot be evidence alone of interest as fundamental to learning. However, it does give rise to important implications for both educators and researchers. Additionally, when taken in the context of more experimental studies such as the one conducted by Shirey and Reynolds (1988) which indicated better recall for the content sentences rated interesting to participants, this argument becomes stronger. The study of Shirey and Reynolds also brings another factor into play, one that is more directly related to the purpose of this thesis. This factor is the role of attention in the relationship between learning and interest and both it and Shirey and Reynolds will be discussed in greater detail in the next section.

## 2.6. Interest and Attention

As already stated, studies on interest have mostly been conducted within the field of education. This is hardly surprising considering the importance of interest for learning (see section 2.5). This field has also led to some unusual findings in relation to interest and attention in education which has shed further light on attention generally. It would be difficult to deny the close relation of the interest to the process of attention when witnessing someone experiencing interest when watching their favourite television show or reading an exciting book. Intuitively, it seems likely that when a person is interested in something, attention is increased to it. Indeed, this apparent link has led some theorists to argue that interest is no more than an attentional state (Wilson, 1971). However, despite the appearance of focussed attention that seems characteristic of interest, a causal model of interest leading to high attention is an inaccurate picture of the relationship of the two processes (Shirey & Reynolds, 1988).

Shirey and Reynolds (1988) conducted a simple experiment to measure the effect of interest on attention. They requested university students to read single sentences randomly presented on a computer screen. These sentences had been previously rated for interest using an independent group of university students. Attention to the task was measured by their reading time but also their response time to a secondary task but simultaneous task, in which they had to press a button in response to a tone throughout the primary task. It was argued that if attention was focussed on the reading task both that the reading time and the response time to this secondary task would be slower. However, they found that although the content of the more interesting sentences was better remembered than the response time for the secondary task and the overall reading time was actually faster when these more interesting sentences were presented. They concluded from this that the students allocated fewer attentional resources to the interesting sentences and that attention did not function as a causal mediator between interest and learning.

Shirey and Reynolds' (1988) description of slower reading times being indicative of heightened attention is controversial and somewhat counter-intuitive. It is therefore unsurprising that they found the opposite effect that reading times were faster for interesting sentences. However, the inclusion of the secondary task does further validate their findings and indicate that fewer attentional resources were allocated to the interesting stimuli. Hidi (1990) attempted to elaborate on their finding by suggesting that interest leads to an automatic allocation of attention, whereas less interesting items required conscious effort to attend to them. According to this argument, the automatic attention elicited by interesting items frees up cognitive resources and allows for faster information processing and hence better recall of the content.

MacDaniel, Waddill, Finstad, and Bourg (2000) attempted to further examine the evidence for this proposal. They used a similar paradigm to the Shirey and Reynolds (1988) study but instead of individual sentences, they used short stories which were similarly structured. These were rated by university students according to interest. Attention was measured by response time to a secondary task identical to the one used by Shirey and Reynolds. They also found that response times to the secondary task were faster for the interesting texts but noted an additional finding that response times further increased as the less interesting texts progressed. This progressive slowing of attention was explained as a result of a more conscious effort required by the text to maintain attention which was not necessary for text considered interesting, further supporting the assertions of Hidi (1990) of potential automatic attention capture of interest.

A different approach which showed comparable results was taken by Wade et al. (1993). This article also examined the relationship between attention and interest but also took into account the quality of learning of the participants and what they called 'seductive details'. Seductive details essentially are interesting but unimportant information and largely refer to content such as personal anecdotes and details not directly relevant to the main points embedded in the text in an attempt to make the composition more interesting as a whole and hence more memorable. Wade et al. were interested in examining if these details fulfilled their purpose of making the text more memorable. In their first experiment they investigated the duration of attention and correct recall in college students for content that varied in both interest and importance to the main points. Sentences in a composition on Nelson were pre-rated according to their content and could fall into one of four categories: high interest/high importance, high interest/low importance, low interest/high importance, and low interest/low importance. Participants were presented the composition one sentence at a time and told that they would be examined on the content later. The amount of time the participants spent reading each sentence was recorded. The results indicated a complex relationship between interest, attention and learning. Similar to the findings of Shirey and Reynolds (1988) and MacDaniel et al. (1992), the participants spent the most time on important but low interest material and also remembered them the least whereas they spent little time on important, high interest material and recalled this information better. The findings for material low in importance were not consistent with this pattern however. The participants spent a small amount of time on the unimportant, low interest sentences and remembered them poorly, whereas they spent a large amount of time on the unimportant, high interest content (seductive details) and remembered them best out of all the categories. These findings have three implications: firstly, it adds to the evidence that interest facilitates learning as discussed in section 1.5; secondly, the results for the relevant content concurs with the assertions of Hidi (1990) that attention may be automatically engaged resulting in more resources for information processing; but thirdly, that interest can also interfere with learning as attention is often also drawn to and is maintained on unimportant but interesting material despite the goals of the reader. Additionally, accounts from the participants indicated that they were unaware of spending more time on these seductive details.

If it is the case that items of interest lead to automatic attention capture, it would have implications for orientation experiments such as the gap paradigm but this has yet to be studied directly. Roskos-Ewoldsen and Fazio (1992) conducted a study on the orienting value of attitudes to objects in a visual display that might suggest interests could affect orientation. That there is such a gap in this area of research may appear surprising initially until the principal difficulty with conducting research of this type is considered. That is, despite interest repeatedly being described as something either intrinsic to an individual, or a result of an idiosyncratic relationship between the person and specific content, all of the studies described in this section chose generic material deemed to be interesting to the population tested rather than tailoring the stimuli to the participants themselves. Hence they examine interest only at the shallowest level and do not delve into the effect the more strongly developed interests have on learning or on how these can be developed.

To date only one study has attempted to directly examine the orientation of attention and interests. Renninger & Wozniak (1985) attempted to design a study using the individual interests of its participants rather than using more general stimuli deemed to be potentially interesting. They did this by initially observing children interacting with toys in a natural setting during free play sessions. They then used the behaviour of the children in this free play session to determine the child's interest in specific toys. In the main study, pictures representing each individual child's strongest interests were presented with comparison pictures unrelated to their interests. Results suggested that children more frequently made their first saccade to the item that most interested them.

The results of this study suggest that shifts in eye fixations and hence visual attention seem to not only be influenced by the features of the object but also by the interest value that those items have for the individual. This certainly makes sense when we re-examine the arguments of Hayhoe & Ballard (2005) that there is an internal agenda mediating eye movements which is dynamic and is learnt through reinforcement. As we have seen, interests also are dynamic systems influenced by the experience of the individual and function to guide the memory and actions of the individual. Although these findings cannot in any way be considered conclusive, they do open the way for new research possibilities.

## 2.7. Summary towards a Definition of Interest

As has been described, there has been a large body of theoretical work on interest. Unfortunately, outside of research into interest and its effects on learning, comparatively little experimental work has been conducted into the area. This has led to a divergence in the literature over the definition and structure of interest. Despite these discrepancies and the gap in the literature, there is agreement on several key points and these will be the building blocks for the definition of interest used in this thesis.

Firstly, interest can be distinguished from simple reward and pleasure (see section 1.3). Hence, interest cannot be wholly understood as a behavioural consequence in an operant conditioning model. It is not just a consequence but can persist in the face of frustration and displeasure, functioning as an antecedent to explore content further.

Secondly, interest is content specific and emerges from the interaction of the individual and their environment as opposed to being solely internally or externally driven (Krapp, 2002, 2005; Hidi & Renninger, 2005; Schiefele, 1991; Silvia 2006). In other words, interest is not a general trait in any individual but is focused on specific content that is unique to the individual and the environment they live in. Related to this point is that interests develop over time, becoming even more content specific and internally driven.

Thirdly, interest is made up of both cognitive and affective components and how these relate to each other may depend on how well developed the interest is (Krapp, 2002, 2005, Silvia 2006, Hidi & Renninger, 2005). Essentially, interest as a feeling is a complex state which depends on how the individual appraises particular content and also what his expectations of engaging with the content will be like. This can strengthen or weaken over time depending on how the actual experience matches up with the expectations (Silvia, 2006)

Fourthly, interest appears to facilitate and motivate individuals towards learning and exploration (Hidi, 1995; Sansone & Thoman, 2005; Silvia; 2008). This facilitation of learning may be done by aiding in the capture and maintenance of attention and freeing up cognitive resources for processing information but the exact relationship between learning, interest and attention is yet to be determined (see section 1.6).

In summary, interest is a multifaceted concept whose difficulty to define lies in its exact presentation depending on how internalised to an individual the interest is. There is the more general interest when presented with novel or surprising content or the more specific interests related to an individual's personal preference for a type of content. For the purposes of this thesis, the emphasis will be on the more strongly held interests, roughly equivalent to individual interest, as described by Hidi (1990) or interests, as described by Silvia (2006). This concept is more relevant to the current work due to the additional difficulty in determining a stimulus intrinsically interesting to both children with ASD and TD children by virtue of its features alone. The perceptual differences in people with ASD outlined in Chapter 1 would make it difficult to assume that the same stimulus features that interest a typical child could apply to one with autism. Additionally, the study is intended to focus more on intrinsic motivation than external rewards, something which is more characteristic of this type of interest.

In order to operationalise this, it is important to find a way to differentiate it from simply the presentation of a reward. To do this there are two factors, which need to be considered. Firstly, a consistent preference for that content and secondly, the ease in persistently attending to the information as displayed in the study by MacDaniel et al. (1992). Sansone and Thoman (2005) go as far as to argue that the experience of interest reliably predicts task choice and this persistence with which the individual engages in that task. While rewards reduce in salience over time, it is argued that something in which the participant has an interest will be resistant to this extinction.

There is one further issue that needs to be addressed here and that is the relationship of the concepts of persistence and disengagement. Persistence (of looking) is the amount of time voluntary attributed to a specific stimulus irrespective of the eye movements or attention shifts that take place between it and other stimuli. Disengagement however, is linked to eye movement by its definition and can be understood as the difficult to remove attention from that stimulus.

Therefore the definition of interest used in this thesis is persistent preference for stimuli with a particular content over other stimuli with different content. For something to be of interest to the participant, they must choose to look at it and must persist in looking at it when multiple options are available to them. It is argued that the best way to measure this is by presenting a fairly lengthy preference selection task to the participant before experimenting begins. This task, it is argued, will allow the experimenter to select appropriately interesting material for the participant.

## 2.8. Interest and Autism

Few theoretical models of attention and autism give a critical role to interest. One which does attempt to bridge this gap is the Social Orienting model (Mundy, 1995), which traces the symptoms of ASD back to an impoverished experience of the world due to a lack of interest in social stimuli. Additionally, a more general account of the relevance of interest in the child with ASD has been given by Murray et al. (2005). This approach takes a very broad perspective and argues that the differences in children with ASD can be traced back to their highly focussed but narrow range of interests.

### *2.8.1. Social Orienting Theory*

Social Orienting theory (Mundy, 1995) takes a more developmental point of view of the role in attention in ASD than some of the other models such as ToM. Central to it is the notion of joint attention and orientation responses considered to be integral to language and its development (Carpenter et al, 1998). Impairments in these skills can be seen as early as 12-18 months in children with autism, even before language develops completely. Mundy argues that dysfunction in the development of this skill could be at the root of the symptomatology of ASD. However, this model also can be said to encompass interest, in a limited sense, as Mundy goes further to posit that a primary social orienting impairment impinges on the ability of the child to learn this skill initially and that this in turn negatively affects the social and cognitive abilities of the child with ASD. Essentially, the child with

ASD does not find social stimuli interesting enough, impinging on their ability to develop shared attention.

Taken in its simplest sense, this model attempts to explain how this impairment could limit the experiences that the child with ASD is likely to have, which further perpetuates the symptomatology of the disorder. In other words, a child not interested in looking at someone or sharing their experiences with them is unlikely to develop an ability to mentally represent another's mental state. A potential benefit of the model is that it offers a way of separating children with ASD from other children at very young ages. Dawson et al (2004) further elaborates on the theory by suggesting that the development of the child with ASD is characterised by a negative feedback loop due to a faulty reward mechanism. In essence, they argue that social stimuli are not intrinsically rewarding to the child due to this and as such there is a lack of interest for the child with ASD in such stimuli. From this dysfunction, the opportunities for social information during childhood are restricted and this deprivation further disrupts normal brain and behavioural development, in turn affecting subsequent social development. This firmly positions interest at the centre of the model.

Certainly, this type of developmental progression is upheld by findings of Morton and Johnson (1991) that indicate early face processing abilities are served by a sub cortical neural system. This is then replaced by a less fragile and experience-dependent cortical system that emerges by 6 months of age. They interpret this as a "readiness" of the brain to incorporate specific type of information which would normally be experienced in the environment at that time such as exposure to faces. It is proposed that exposure at this time facilitates a neural system specialisation for faces. Abnormalities in face processing in autism could be due to a social attention defect or problems with the intrinsic reward mechanisms that draw attention to the eyes at a very early age.

However, like the ToM model, this model fails to explain how children with ASD may exhibit superior performance in some perceptual tasks such as visual search (Plaisted, 1999). Additionally, a number of studies have indicated that the unusual attention patterns exhibited by people with ASD are not specific to the social domain (Bertone, 2005; Bertone et al., 2003, Landry & Bryson, 2004). In fact, some large irregularities in the attention system not specific to social stimuli have been shown in even very young infants (Zwaigenbaum et al, 2005). Thus, while important in any consideration of the development of the child with ASD, the theory is too limiting in its scope to give a full account of ASD.

### *2.8.2. Monotropism*

This loose account posits the potential importance of interest and more specifically unusual interests, to the development of ASD. In this, Murray et al. (2005) attempted to argue that it was possible to trace all the features of autism back to the different strategies with which they distributed their attention due to their unusual patterns of interest. More specifically, people with ASD tend to have few interests highly aroused, the 'monotropic' tendency, whereas those of typical development have many interests less highly aroused, the 'polytropic' tendency.

Murray et al. (2005) asserted that by looking at people with autism as monotropic individuals, it is possible to reinterpret how major theories fit in the developmental trajectory of the child with autism. For example, the existence of others will only be recognised if they are engaged with fulfilling the child's interests. Everyone and everything outside of this beam of attention will not impact the child resulting in ToM deficits. In essence, it is not that the child cannot take the perspective of another but that he has no reason to.

Thus, their approach is similar to social orienting theory but wider in its application, assumptions and assertions. On the positive side it has a very optimistic view of the potential of people with ASD in that it argues strongly that the disorder is not characterised by incapacities but rather an unusual development of motivation and experience in certain domains leading to a fundamentally different skills profile. The difficulty with this model is that it is a descriptive account rather than a theory and is neither falsifiable nor testable. As such, it is very hard to test its assumptions directly or generate specific hypotheses for its assertions. As a result, it has very little supporting experimental evidence to support its claims.

## 2.9. Rationale

As discussed in section 2.6, there is some evidence for interest mediating attention. Hidi (1990) has even suggested that interest facilitates the automatic engagement of attention though this has yet to be tested directly. The eye movement literature is also somewhat in accordance with this argument as can be seen in Hayhoe & Ballard's (2005) review, which states how internal goals and reward expectancies have a strong control over orienting. It is exactly these processes that are mediated by the development of well developed interests as described by Silvia (2006).

Lack of interest in social situations and communication are two of the main characteristics of a diagnosis of autism, and the third includes a narrow range of specific interests. In conjunction with this, the evidence of unusual attention patterns and differences in the perception of social stimuli in people with ASD (section 1.6) give both the Social Orienting model and the model of a 'monotropistic' child some credence.

Due to the potential of interest to influence attention and the different attentional patterns exhibited by children with ASD with some stimuli, it would be advisable to consider how interest might contribute to the inconsistent findings in the research described in section 1.7. The arguments into the relevance of interest and internally driven motivation in understanding autism also have implications in the testing situation in general. For one, the testing situation itself is implicitly social in nature with the individual typically wishing to do well for the tester, a factor that is unlikely to be present in those with ASD. Additionally, as one of the features relevant to defining interest is its persistence over time, it is conceivable that slowing of attentional disengagement may be a significant factor in its manifestation.

When examined in this way, it is apparent that studies on attention with ASD and TD children using very different stimuli to each other should be compared with consideration given to the interest the task and the stimuli hold for each child. More specifically for this thesis, it is possible that the differences in disengagement exhibited in the children with ASD in the Landry & Bryson (2004) study were not primarily due to attentional or cognitive impairment but resulted from different levels of interest with that particular content between the groups. As repetitive behaviours and unusual interests are a feature of autism, it is conceivable that the ASD sample had well developed interests into the repetitive content of the abstract patterns used in this sample. In a similar vein, the stimuli used the van der Geest et al. (2001) study would have a very low interest content but whereas the TD group may have an inherent social interest in completing the task well the ASD children were unlikely to perform according to task demands which may have manifested itself as engagement. The complication comes in when also examining the Leekam et al. (2000) which used stimuli likely to be of interest to both groups. While the lack of group differences in the Leekam study could be explained by a similar level of motivation between the groups, the similarity of the results to van der Geest's findings indicate that interest while important may not be the sole contributing factor, which also needs to be examined.

For ease of reference, the term stimulus interest is used throughout the text. It should be noted however, that this is not intended to be an independent construct such as those described in Schraw and Lehman's (2001) taxonomy of interest (see section 2.4.2.1). Rather, it is used as a more general term to describe the level of inherent interest exhibited in the content of the stimuli being presented in each study. Using the definition of interest discussed in section 2.7, the stimulus interest can be categorised into high or low before experimentation throughout this thesis by examining the consistency of the participant's preference for the stimulus content when presented with similar items and the persistence of their interest over time. With this preliminary methodology, it is intended to examine the potential of these interests as motivational factors and mediators of attention in both TD children and those with autism. Also, for the reasons stated, it is intended to examine the effects of an individual's strongly held interests on different types of stimuli as well as examining if the differences in attentional disengagement from certain types of stimuli between ASD and TD children can be attributed to differences in their level of interest in those stimuli.

## 2.10. Outline of Experimental Studies

The experiments in this thesis will explore how interests and attentional disengagement are linked and how these might differ in an ASD population. Research in the past has attempted to examine attention by varying stimulus features but none has examined stimulus interest. The research reported in this thesis is unique in attempting to control stimulus interest effects in addition to stimulus feature effects. It also provides the opportunity to offer new insight into the apparent dysfunctions of attention in autism (see section 1.7).

The remaining part of the thesis is organized into five chapters. Chapter 3 will first attempt to replicate the findings of Landry & Bryson (2004) with abstract stimuli of similar design. Stimuli of high interest value to each of these participants will then be selected and these will be used for the second experiment which will examine how high and low stimulus interest affects the ability of each group to disengage. Chapter 4 is concerned with the dynamic nature of the stimuli. As such, it will examine if disengagement differences can be attributed to motion or other features of the stimuli rather than the content. It will first examine the abstract stimuli for both groups, comparing static to dynamic stimuli in order to determine if the motion of the stimulus is the source of the disengagement abnormalities in ASD children. It will then examine the potential effect of interest by using static stimuli which can be more easily matched according to stimulus features than the ones used in Chapter 3. Chapter 5 is intended to explore whether unusual patterns of stimulus interest could be the principal factor contributing to disengagement difficulties in children with ASD. It will take a more direct approach in attempting to measure stimulus interest for each participant towards the abstract, high interest and low interest stimulus categories. The ability to disengage from each of these categories will then be compared to this measure of interest to examine the extent to which it may contribute. The general findings and implications of the research will then be summarised and discussed in the final Chapter.

# Chapter 3. STIMULUS INTEREST AND DISENGAGMENT

There is increasing evidence that children with ASD have difficulty with disengaging attention. Disengagement refers to the speed with which the child relinquishes attention from one stimulus in favour of a second stimulus when both are competing for the child's attention. Research has indicated that children with ASD have a slower ability to disengage attention when compared to both TD and developmentally delayed (DD) samples (Elsabbagh et al., 2009; Landry & Bryson, 2004). However, not all studies have shown this finding and there have been studies that have shown no difference between ASD and comparison groups (Leekam et al., 2000; van der Geest, 2001). The aim of this and the subsequent Chapter was to examine these inconsistencies and the effects of different stimuli on the speed of disengagement. In particular, we wished to explore if a motivational factor, the child's interest in these stimuli, could have potentially accounted for some of these inconsistencies.

The literature on disengagement stems from Posner and Petersen's (1990) separation of the attention system into 3 processes: disengaging from a stimulus occupying attention, shifting attention, and re-engaging on a new stimulus. Most research to date, when examining disengagement, has used modifications of their visual orienting paradigm. At its simplest, this paradigm involves triggering a peripheral target once the participant has attended to a central fixation stimulus. The initial fixation stimulus either disappears at this point (Shift Only trials) or remains on (Competing trials), giving a measure of latency to disengage and shift attention relative to an attentional shift where disengagement is automatic. This approach has been productive in studying the developmental course of disengagement (Frick, Colombo, & Saxon, 1999; Hood & Atkinson, 1993; Johnson, Posner, & Rothbart, 1991; Matsuzawa & Shimojo, 1997) showing that there is substantial development of this process over the first 6 months of life, with a particularly interesting period of "sticky fixation" in the first 3 months.

The study of disengagement of attention in children with autism has produced mixed results. Leekam et al. (2000) examined whether problems in disengagement might explain impairments in joint attention, the ability to follow another's gaze. They adapted Posner's paradigm using mechanical boxes which could reveal a Thomas the Tank Engine toy on cue and found that preschool children with ASD were as fast as those with DD to shift attention in both types of trials (Competing and Shift Only). In addition, Low IQ children with ASD were significantly faster than children with DD at responding in the Competing trials. They concluded from this that there was no general impairment in disengagement for children with ASD.

A later study, by van der Geest et al. (2001) also used an adaptation of this paradigm, with different stimuli but showed a slightly different pattern of results. Instead of toys, they used a fixation stimulus of a white cross and a peripheral target of a white square on a black background. They tested an older group of high functioning children with ASD and reported that they exhibited significantly faster responding than TD children in the Competing trials. Thus, they concluded ASD is characterised by impairments in engagement rather than disengagement. Both Leekam et al, (2000) and van der Geest et al. (2001) therefore found no evidence for slower disengagement in ASD. Their results in fact both showed faster disengagement compared to comparison groups at least for a subset of their two samples, though not for the higher IQ subset in the Leekam et al. (2000) study. This difference could be due to differences in the age/IQ combination of samples in the two studies and the different control groups in each study (DD versus TD). For example it could be argued that the results from the van der Geest sample could be explained by a greater maturation of the perceptual system in the children with ASD so it is difficult to compare them directly.

Landry and Bryson (2004) also adapted Posner's paradigm but used videos of falling, multicoloured shapes as both the fixation stimulus and peripheral targets. Interestingly, they found that children with ASD were significantly slower in the Competing trials than both TD and DD children. From this, they argued that children with ASD have a general impairment in disengagement and suggested that this dysfunction may underlie some of the core features of autism. These findings have become the focus of subsequent research and two recent studies have worked with infant siblings of ASD children (Elsabbagh et al., 2009; Zwaigenbaum et al., 2005). Using this paradigm, these researchers have found that infant sibling groups could be differentiated from similarly aged TD infants by their ability to disengage in the task. Hence, they argue this paradigm could potentially be developed into a screening or diagnostic tool for autism as part of a more complete process.

This potential for developing a diagnostic tool for very young children could have exciting implications for both research into and service provision for children with ASD. However, the failure to replicate this difference in all studies remains a problem. Despite the methodological similarities, the conflicting studies differ in three key areas. Importantly, the three studies differed on their specific measurement of disengagement. Leekam et al (2000) and Landry and Bryson (2004) used the reaction time of the participant in the competing trials whereas, van der Geest et al (2001) used a composite score of both types of trials by subtracting the reaction time of the participants in the shift-only trials from their reaction time in the competing trials. Though this method adds an element of complexity to the calculation, it is arguably a stronger measure of disengagement as it removes the confounding factor of individual differences in shifting ability from the equation. Most obviously, the studies also differ by the types of stimuli they used to examine the effect. Leekam et al (2000) used real world stimuli, van der Geest et al (2001) used simple, motionless shapes, and Landry and Bryson (2004) used shapes in motion. The variation in the level of complexity and abstractness of these stimuli across the studies could potentially account for the differing results. Finally, somewhat related to the last point with regard to the differing stimuli used by the studies, they also differed in their consideration of the influence of motivation factors on the tasks conducted. More specifically, it is argued here that the different stimuli could have evoked different levels of interest in the task and the stimuli themselves potentially affecting how the participant performed.

It is well documented that autism is characterised by an unusual and narrow range of interests. Additionally one of the less emphasised aspects of Posner's model is that attention must first be engaged before disengaged. The underlying assumption of studies based on Posner's model is that disengagement starts from the same baseline level of engagement, though in reality the level of engagement could be more a continuum than a dichotomy. As such, the child's inherent stimulus interest could have important consequences in attention studies with ASD children. Though Landry and Bryson (2004) used the same stimuli for all groups, they used abstract, repetitive videos, which could have been particularly interesting to children with ASD as opposed to the other groups. In essence, the difference shown could be more a difference in the level of engagement with the stimuli due to this, rather than a difference in the child's more general capacity to disengage.

Consequently, the current study investigated different types of stimuli using the same disengagement paradigm to examine whether there is a general impairment for children with ASD relative to children with TD. We also examined what effect stimulus interest could have on these differences. Both experiments were closely based on the Landry and Bryson (2004) design. Experiment 1 attempted to replicate their procedure and used similar abstract videos. In Experiment 2 however, more naturalistic stimuli were employed and categorised into different levels of stimulus interest for each child. Following the reasoning above, it was expected that the ASD children would be slower than TD children to disengage from moving, abstract stimuli but that this group difference would disappear with more naturalistic stimuli if stimulus interest was the main factor contributing to the differences with the abstract stimuli.

## 3.1. Experiment 3.1

This aim of experiment was to replicate the design used by Landry and Bryson (2004), with almost identical stimuli using both their original measure of disengagement and that described by van der Geest et al (2001). Three monitors were positioned side by side and once the child's gaze was directed at a stimulus presented in the central screen, a display was initiated on one of the lateral screens. Time to shift gaze to this lateral target was recorded under two conditions: (1) the central stimulus remained on while the lateral stimulus played (Competing trials) or (2) the central stimulus was turned off 250 ms before the onset of the lateral stimulus (Shift-only trials).

It was predicted that both TD and ASD children would be significantly slower to shift gaze in the Competing than the Shift-only trials but that children with ASD would be slower to shift gaze in the Competing trials than the TD children. It was also predicted that attentional disengagement, as measured by a composite score of both trials would be significantly slower in the children with ASD than the control group.

### *3.1.1. Method*

#### 3.1.1.1. *Participants*

Participants with ASD for the experiments in this and later chapters were drawn from a list of specialist autism schools in North England. Special schools rather than children with ASD in mainstream schools were targeted as the researcher was interested in recruiting low functioning autistic children. The breakdown of results done be Leekam et al. (2000) indicated that there was a difference in the findings between high and low functioning children and these studies wished to avoid that complication. It was further believed that those who suffered mostly from basic attentional dysfunction such as that described by Landry and Bryson (2004) would be more susceptible to developing greater difficulties later. Hence, it was thought more appropriate to target this group in order to replicate their findings.

The list of schools was compiled by the researcher from web sources and numbered approximately 40 schools. Each of these were first contacted by phone, if possible, which was then followed up by an email containing further details of the experiment in question if there was deemed to be an interest in participating. For schools who indicated they may like to take part a presentation was first given clarifying the purpose and requirements for the study. Met with head teacher and sent out letters. Participants of near normal or un-measurable NVMA, as a result of not being able to complete the task for example were excluded from participating. Typically developed participants were recruited in much the same way but from lists obtained from the relevant council detailing schools in the respective areas.

Fourteen individuals (9 boys) with ASD, aged 6-11 years, were recruited from special schools for autism in the York and Durham areas. All had been diagnosed by experienced clinicians in a multidisciplinary team by the Autistic Spectrum Disorders Forum, held at York District Hospital using the criteria of the ICD-10, *International Classification of Disease (ICD-IO;* World Health Organization, 1992) guidelines. A comparison group of 14 individuals (6 boys) with typical development (TD) aged 3-6 years, was recruited from mainstream schools and nurseries in the Durham region. Written informed consent was obtained from the parents of each child prior to any testing. All participants had normal or corrected-to-normal visual acuity. Participants' non-verbal mental age (NVMA) was assessed using the Leiter International Performance Scale- Revised (Leiter-R; Roid & Miller, 1997) and matching was applied on both an individual and a group basis according to these scores. NVMA was deemed the most appropriate measure on which to match the children due to the visuo-spatial nature of the tasks and to ensure differences seen would not be due to developmental level (Burack, Iarocci, Flanagan, & Bowler, 2004). Nine out of the 12 pairs could be matched to within six months on NVMA, the other five pairs had a difference of 9-12 months, the children with autism having the higher score in all cases. Hence, the two groups did not differ significantly on NVMA, $t(26) = 0.86$, $p = .4$ but did on Chronological Age (CA), $t(26) = 8.68$, $p = .01$. See Table 3.1 for details.

Table 3.1

*Means and standard deviations of non-verbal mental age and chronological age in years for ASD and TD children*

| | Age | | NV Mental Age | |
|---|---|---|---|---|
| Group | Mean | Std Dev | Mean | Std Dev |
| ASD | 9.2 | 2.17 | 4.5 | 1.07 |
| TD | 4.0 | 0.55 | 4.2 | 0.69 |

### 3.1.1.2. *Materials*

Three identical 14” flat screen monitors were positioned side by side and the participants were seated approximately one meter in front of the central screen. To record the participant’s direction of gaze, an unobtrusive camera was fitted behind the central screen, attached to a portable DVD player situated behind the participant, with a further monitor providing the experimenter with a front view of the participant. A custom made indicator, consisting of three lights that illuminated when the corresponding screens were activated, was also positioned behind the participant but in view of the video recorder so that the video feed could later be coded. Figure 3.1 and 3.2 display this setup using an overhead and experimenter’s eye view.

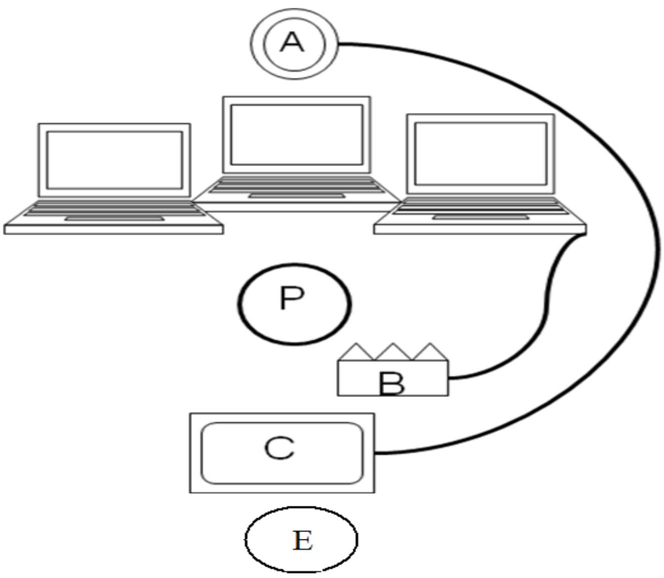


*Figure 3.1:* An overhead view of the experimental setup. The camera (A) was positioned above the central monitor and connected to a display (C) behind the participant (P). The

indicator (B) was also placed behind the participant but in view of the camera. The experimenter (E) watched the scene from behind the video output.


*Figure 3.2:* The experimenter's eye view of the experimental setup. The camera's (A) output was displayed on the experimenter's monitor (C) allowing him to see the participant's (P) gaze direction. The indicator (B) was also placed behind the participant but in view of the camera.

Videos modelled after those used by Landry & Bryson (2004) were generated through the use of the software program POV-Ray and converted to video format using AVI-tricks. These consisted of coloured (red, yellow, blue, and green) shapes (triangles, squares, and circles) that continuously fell from the top of the screen to the bottom. The shapes fell at different speeds and ranged in size. The same stimuli were presented for both central and lateral displays. Examples of stills from these videos are given in Figure 3.3 below.

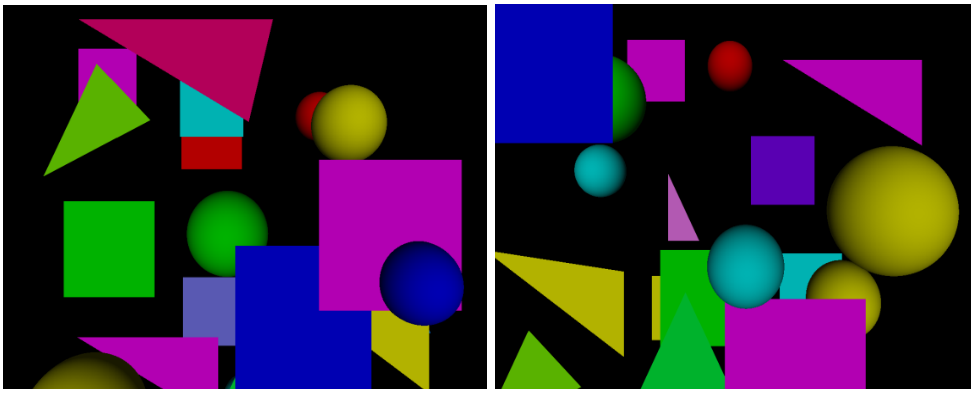

*Figure 3.3:* An example of stills from each of the abstract videos.

### 3.1.1.3. *Design*

The experiment used a mixed design with Group (ASD and TD) as the between-participants factor and Attention Type (Competing, Shift-only) as the within-participants factor.

### 3.1.1.4. *Procedure.*

*Attention task.*

Only one experimenter was used for all participants involved in the study. The child was seated approximately 1 meter from the central computer screen and made comfortable. The only parts of the experimental setup visible to the child in this position were the three monitors and the video camera (see Figure 3.4), though the child was free to look around the room if they desired. The child was then told that videos would appear on the screens in front of him and that they should look at them when they appeared. The child was also told that the first video clip would always appear in the central screen. The experimenter sat behind the child throughout the trials and gave positive feedback if the child appeared relaxed and interested in completing the task but not for looking at any particular screen over another.

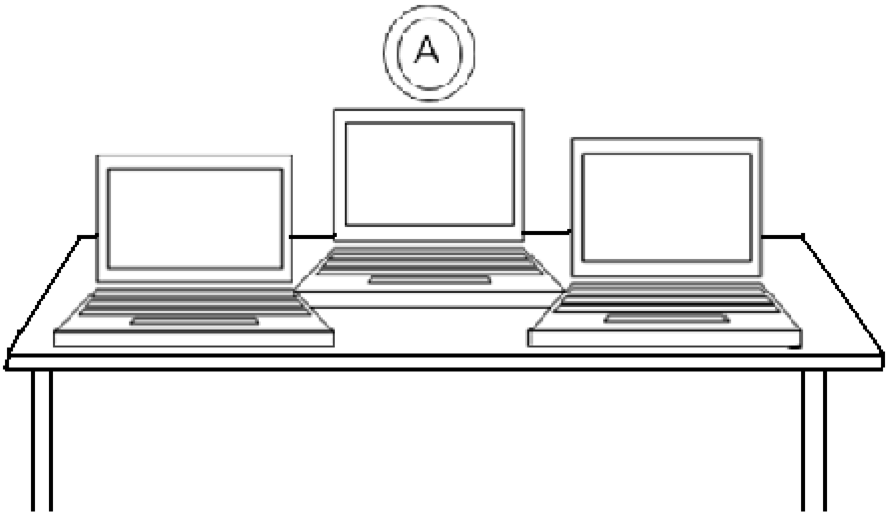


*Figure 3.4:* The participant's eye view of the experimental setup. Only the computer monitors and the video camera (A) was visible as all other materials were located behind the participant.

*Trial sequence.*

In all trials, a video appeared in the central monitor for up to 8 seconds. Once the child attended to it, the experimenter triggered a display on a lateral monitor with a delay of 250 ms. The time gap was chosen to be consistent with Landry and Bryson (2004) and to allow for automatic disengagement. It was necessary to use slightly shorter lateral clips in this study due to the processing power needed for the computer to buffer the video before presentation. The lateral monitor continued to be presented until the child made an eye or head movement towards it or for a maximum of 5 seconds. Thirty two trials were presented in a random order and divided equally into two types, Competing and Shift-only trials. In the Competing trials, the central video continued playing throughout the trial, whereas for the Shift-only trials, the central stimulus ceased playing when the lateral target was triggered see Figures 3.5 and 3.6 for graphical representations of the trial sequence. The presentations of the lateral target were equally distributed across the left and right monitors.  Trials could be replaced if deemed invalid, such as when the child looked away before a lateral stimulus was triggered.

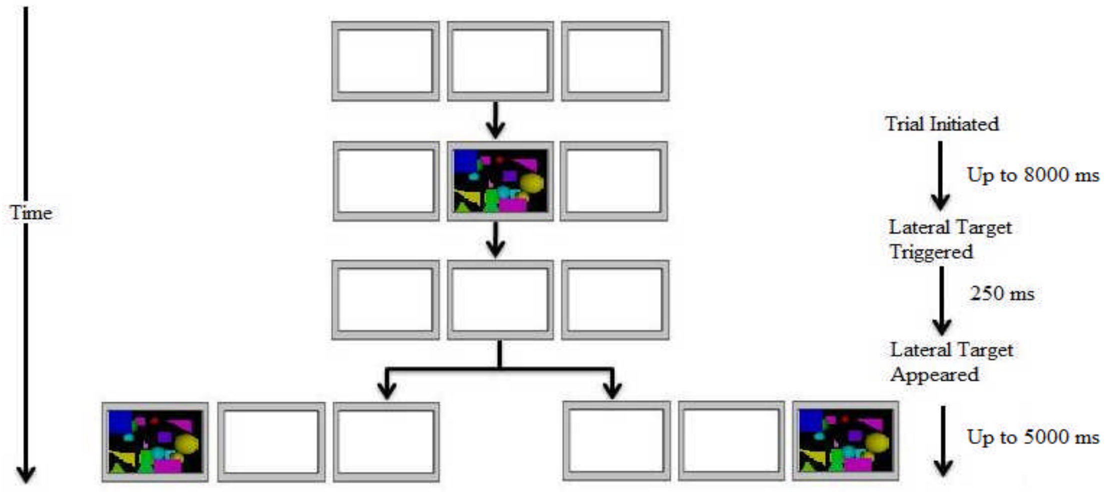


Figure 3.5: Graphical representation of the trial sequence for the Shift-only trials.

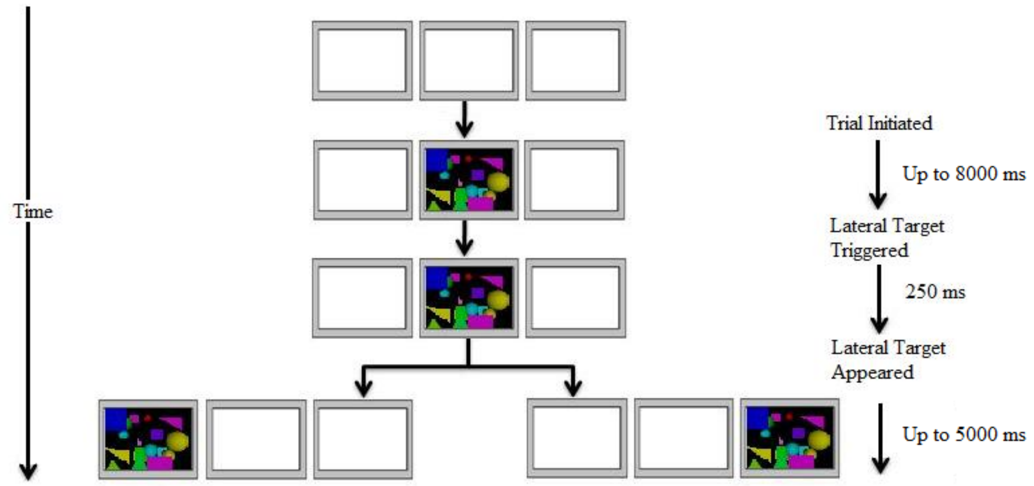


*Figure 3.6:* Graphical representation of the trial sequence for the Competing trials.

*Coding Procedure.*

Results were coded using the Observer XT software package. The experimenter was the primary coder of this output but was blind to which type of stimulus was being presented to the child during the coding procedure. Over 25% of the videos were coded independently by a second blind coder to check for reliability. Reliability was high, as the intraclass correlation coefficient was above .85. The video recordings were slowed and played back frame by frame. The onset of each lateral stimulus and the point at which a gaze shift occurred as measured by an eye or head shift towards that stimulus came to a rest on the correct stimulus were recorded for each trial. Latency to complete this shift was then calculated in milliseconds. Trials in which the participants were not looking at the central stimulus at the onset of a peripheral and trials with initial eye shifts to areas other than in the active target or where the participant shifted their gaze in the incorrect direction were deemed invalid and not included in the analysis. Trials of less than 150 ms were not included in the analysis as they were deemed to be anticipatory shifts. To adjust for the unequal number of trials completed by different children in each condition, we analyzed the proportion of correct responses. There were no differences in the proportion of completed trials between the ASD ($M$ = .96, $SD$ = .06) and TD ($M$ = .96, $SD$ = .05) groups, $t(26) = 0.413$, $p$ = .683.

### *3.1.2. Results*

For all analyses, homogeneity of variance was verified using Levene's test. Dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967). An ANCOVA was first carried out on all analyses with CA as a covariate. This factor was not significant so the simpler ANOVAs were used. All tests were performed at $\alpha = .05$.

Mean Reaction Time was analysed using a two-factor mixed design ANOVA, with one within-subjects factor Attention Type (Competing, Shift-only) and one between-subjects factor Group (ASD, TD). Results showed a significant main effect for Attention Type, $F(1, 26) = 71.5$, $p = .01$, $\eta^2 = .73$, reflecting that both groups were slower in the Competing condition. There was no significant main effect of Group, $F(1, 26) = 2.2$, $p = .14$, $\eta^2 = .08$, indicating that ASD children were not slower to respond than TD children overall.

There was a significant interaction for Group × Attention Type, $F(1, 26) = 10.98$, $p = .01$, $\eta^2 = .28$. Post-hoc t tests revealed a significant group difference within the Competing condition, $t(26) = 2.3$, $p = .03$, $d = 0.9$, but not the Shift-only condition, $t(26) = 0.82$, $p = .422$, $d = .32$. These analyses reflect that while both groups showed slower latencies in the Competing trials relative to the Shift-only ones, the ASD group were slower to respond (M = 0.97, SD = 0.34) than the TD group (M = 0.66, SD = 0.36) when the fixation stimulus remained on (see Figure 3.7).

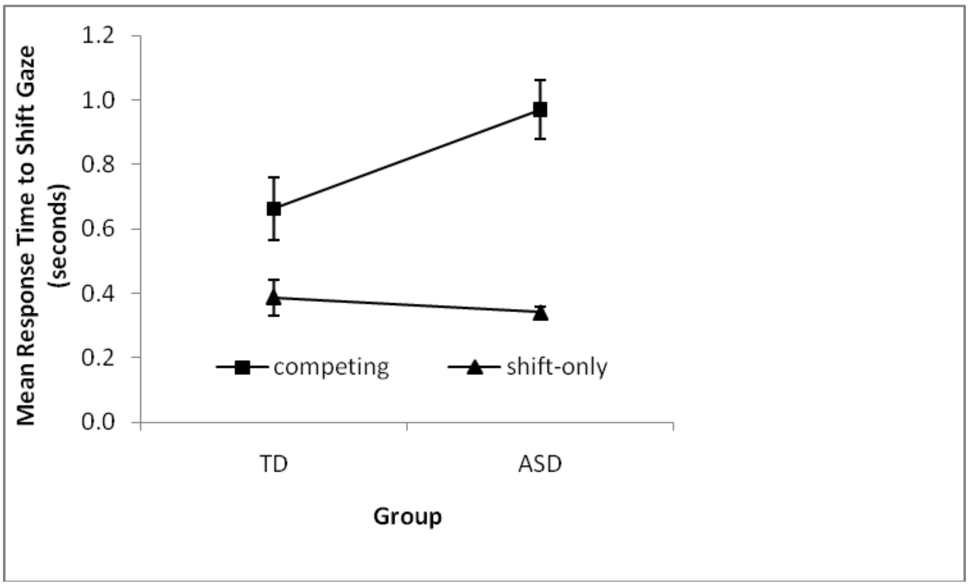


*Figure 3.7:* Mean latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions using abstract videos. Error bars depict standard errors of the means.

A second analysis was also conducted on the data using the measure of disengagement used by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data an independent t-test was conducted and results were consistent with the first analysis in indicating that attentional disengagement from dynamic abstract stimuli was slower for the children with ASD ($M = 0.63$, $SD = 0.32$) than for the TD group ($M = 0.31$, $SD = 0.24$), $t(26) = 3$, $p = .01$, $d = 1.18$. Figure 3.8 displays these results below.

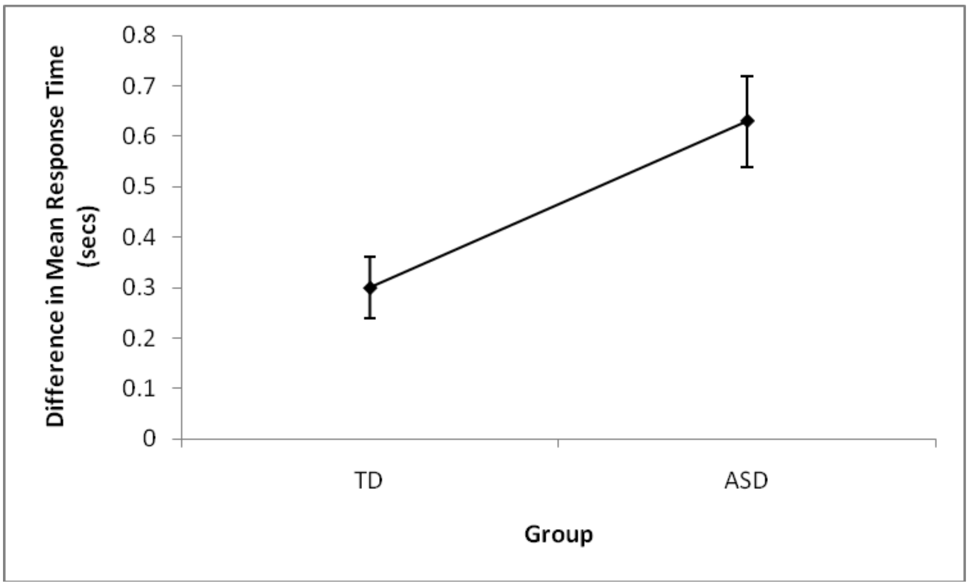


*Figure 3.8:* The difference in mean response time between the competing and shift–only trials for ASD and TD groups. Error bars depict standard errors of the means.

### *3.1.3. Discussion*

Both TD and ASD children were significantly slower to shift gaze in the Competing compared to the Shift-only trials, in accordance with the findings of Landry and Bryson (2004). Also, children with ASD were slower to shift gaze in the Competing trials than the TD children. The finding of slower attentional disengagement in children with autism than in TD children was mirrored in the second analysis which used a composite score of the two different attention trial types to account for individual variation in shifting ability.

While these findings may support the argument put forward by Landry & Bryson (2004) for a disengagement deficit in children with ASD, it is also possible, as van der Geest et al. (2001) pointed out, that attentional engagement rather than disengagement may be the source of this difference. More specifically, it is argued that the children in the TD group had a lower level of engagement in the central stimulus due to a lower level of stimulus interest. This is proposed as it is believed that the unusual characteristics of the stimuli, such as their brightness, colour or movement may be more attractive or interesting for children with ASD than for non-ASD children. This proposition is further explored in Experiment 3.2 which investigated how stimulus interest might affect disengagement.

## 3.2. Experiment 3.2

The same set-up and design as for experiment 3.1 was used, but the focus of this experiment was to look at the effects of stimulus interest on disengagement from non abstract stimuli. The intention was to compare reaction times for participant's disengagement from video clips of high and low interest. In an attempt to ensure that the high interest stimuli were similarly rewarding to all the children, each child was allowed to select videos of interest to them in a preliminary session. A second set of stimuli, found to be uninteresting to the children, was also selected. The chosen clips were presented in 4 types of trials. These were: a) high interest on the central and each lateral monitor (HH), b) high interest on the central monitor and low interest on each lateral monitor (HL), c) low interest on the central monitor and high interest on each lateral monitor (LH), and d) low interest on the central monitor and low interest on each lateral monitor (LL). In this way, the confounding variable of stimulus interest was controlled, allowing an examination of disengagement from more naturalistic stimuli than those used in experiment 3.1. Another potential factor, stimulus consistency (whether the central and lateral targets were the same or not) was also explored to ensure it did not confound the results for stimulus interest.

In all analyses, based on robust effects in the literature for both groups, it was expected that both TD and ASD children would be significantly slower to shift gaze in the Competing than the Shift-only trials. Based on the assumption that stimulus interest was indeed the main contributor to the group differences seen in experiment 3.1, four other predictions were also made. Firstly, it was not expected that there would not be any group differences using these types of stimuli within the Competing trials. Secondly, it was expected that there would be an effect of stimulus interest in the Competing trials. Thirdly, it was expected that stimulus interest would affect the speed of disengagement and that both groups would be significantly slower to shift gaze in the high interest Competing trials (HH) than in the low interest Competing trials (LL). Finally, it was expected that both groups would be slower to shift gaze in the Competing trials when the high interest clip was in the central (HL) rather than the lateral monitors (LH).

### *3.2.1. Method*

#### 3.2.1.1. *Participants*

Participants were the same as those in Experiment 3.1.

#### 3.2.1.2. *Materials*

Laminated selection boards, containing four images with content appropriate to the high interest stimuli, were created to enable all children to choose their preferred stimulus. Five contained images relating to the children's television programs and the other five contained images relating to the animated films. There were ten of these boards in total, each missing one of the videos in that category. Examples of the presented images can be seen in Appendix A.

The video stimuli came in two types: high and low interest clips. Ten sets of high interest clips were taken either from five children's television shows (e.g. Thomas the Tank Engine) or five computer-animated films (e.g. Shrek) whereas low interest clips were taken from old Open University shows (for examples of stills from the clips see Appendix B). The two categories of stimuli sets, children's shows and computer-animated films, were chosen to appeal to children of a variety of mental ages. For each source, two clips were chosen which were expected to have high interest content based on their visual appeal. They all consisted of the main characters interacting with each other within their environment. The low interest clips had been selected from old Open University programs and also contained people interacting with each other but were not very eventful and consisted of either scenes from interviews or everyday scenes such as someone waiting in a train station. These were chosen by the experimenter and were pilot tested with three university students to ensure they had the desired effect. None of the clips contained sound and were all in full colour though the low interest clips' colours were more muted.

### 3.2.1.3. *Design*

The experiment used a mixed design with Group (ASD and TD) as between-participants factor and Attention Type as one within-participants factor consisting of two levels: Competing and Shift-only, and Stimulus Interest as the second within-participants factor with four levels (HH, LL, HL, LH). Counterbalancing was used to account for order effects between this experiment and experiment 3.1.

### 3.2.1.4. *Procedure.*

*Preference Selection*

Each participant was presented with two selection boards simultaneously, one containing images of the television shows and one containing images of the animated films, and given the opportunity to choose their preferred stimulus. To ensure that one group did not disproportionately choose one video over the others, the selection board which did not contain the image of the video that had been selected by the most people in that group up to that point was presented to the child. To validate this preference and to ensure the selection was a persistent interest, the participant was then presented with a validation task.

*Validation Task*

Only the lateral monitors were used for this experiment. The clips were arranged into sets before the experiment began each containing four different clips from each interest group. The set which contained the favoured clip selected by the child was then presented. Each trial consisted of two of these clips being played simultaneously on the outer monitors for a period of up to 20 seconds until a clear preference was determined, defined as watching the clip for approximately five seconds longer than the alternative. Each video clip was shown twice, once paired with a video from the same interest category and once from the opposing interest category (low interest). No video was displayed on the same screen twice and the order of presentation of these trials was randomised. In the unusual event that the child did not preferentially attend to the clip they had chosen, the task could be abandoned and the child allowed another selection before re-presenting the task. Additionally, if the any of low interest clips were found to be interesting to the child, these could be removed from the attention task to avoid confounding the results.

*Attention Task.*

The general operation of the attention task was the same as in experiment 3.1 and was administered directly after it. The child was then told that videos would appear on the screens in front of him and that they should look at them when they appeared. The child was also told that the first video clip would always appear in the central screen. The experimenter sat behind the child throughout the trials and gave positive feedback if the child appeared relaxed and interested in completing the task but not for looking at any particular screen over another. There were 64 trials in total, consisting of 16 trials for each interest category (HH, HL, LH, and LL). Out of these trials for each interest category, eight were Competing and eight were Shift-Only trials. These trials were presented in a random order and the order of presentation of the trials was randomised across participants. Trials deemed invalid, such as those when the participant looked away before the lateral target was presented, were replaced as necessary.

*Coding Procedure.*

The coding procedure was the same as that used in experiment 3.1. Reliability was again high between coders, with an intraclass correlation coefficient of .89. The coders were blind to which type of stimulus was presented to the child. The proportion of completed trials was significantly higher in the TD group ($M$ = .92, $SD$ = .09) than the ASD group ($M$ = .78, $SD$ = .12), $t(26) = 3.6$, $p = .01$, although no participant completed less than 60% of the trials in any condition. To account for the unequal number of trials completed between the two groups a secondary analysis was conducted on just the first four presented trials of each condition. There was no difference in the proportion of completed trials of this subset of the data between the TD group ($M$ = .96, $SD$ = .02) than the ASD group ($M$ = .94, $SD$ = .03), $t(26) = 1.6$, $p = .11$. As the results were the same for the subset, the original full data set was used in the analysis.

### *3.2.2. Results*

There was a good distribution of stimuli selected for both groups with no more than three participants in any group selecting any video type. The patterns of selections were also very similar between the groups. All except one of the videos were either selected by the same number of participants in both groups or had a difference of one participant. The remaining clip was selected by two more participants in the ASD group than the TD group. Likewise, there was a similar distribution of selections across the two types of high interest stimuli, children's shows and computer animated films. The results are summarised in Table 3.2 below.

Table 3.2

*The frequency of selection of each type of stimuli for ASD and TD children. The initials stand for Winnie the Pooh (PO), Barney and friends (BA), Thomas the Tank engine (TH,) Bear in the Big Blue House (BE), Bob the Builder (BO), the Incredibles (IN), Finding Nemo (NE), Shrek (SH), Monster's Inc. (MO), and Bug's Life (BU) respectively.*

| | Children's Shows | | | | | | Computer Gen Films | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | PO | BA | TH | BE | BO | Total | IN | NE | SH | MO | BU | Total |
| ASD | 0 | 1 | 2 | 0 | 3 | 6 | 2 | 0 | 3 | 0 | 0 | 5 |
| TD | 2 | 0 | 3 | 0 | 2 | 7 | 1 | 1 | 2 | 0 | 0 | 4 |
| Total | 2 | 1 | 5 | 0 | 5 | 13 | 3 | 1 | 5 | 0 | 0 | 9 |

For all analyses on the reaction time data, homogeneity of variance was verified using Levene's test. Dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967). An ANCOVA was carried out on all analyses with CA as a covariate. This factor was not significant so the simpler ANOVAs were used. An analysis was conducted to examine general effects of stimulus consistency, comparing consistent trials (HH, LL) to inconsistent trials (HL, LH). No significant effects were found so this factor was discounted as a predictor.

The data were analysed using a three-way mixed design ANOVA, with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) and Stimulus Interest (HH, HL, LH, LL) as the within-subjects factors. Results showed a significant main effect for Attention Type, $F(1, 26) = 65.15$, $p = .01$, $\eta^2 = .72$, reflecting that both groups were slower to shift in the Competing condition, and for Stimulus Interest, $F(3, 26) = 4.54$, $p = .01$, $\eta^2 = .15$, which is analysed further below. There was no significant effect for Group, $F(1, 26) = 0.09$, $p = .77$, $\eta^2 = .01$, indicating that ASD children were as fast to respond as TD children. There was also no significant interaction for Group × Attention Type, $F(1, 26) = 1.53$, $p = .23$, $\eta^2 = .06$, Group × Stimulus Interest, $F(3, 26) = 2.09$, $p = .11$, $\eta^2 = .08$, or Group × Attention Type × Stimulus Interest, $F(3, 26) = 2.51$, $p = .07$, $\eta^2 = .09$ further highlighting that when using more naturalistic stimuli group differences seem to disappear. However, there was a significant interaction for Attention Type × Stimulus Interest, $F(3, 26) = 6.1$, $p = .01$, $\eta^2 = .19$, which warranted further analysis. Descriptive statistics can be seen in Table 3.3 below.

Table 3.3

*Mean, standard deviation and range for all interest pairings for both competing and shift-only trials.*

| Group | | Competing | | | | Shift-only | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HH | HL | LH | LL | HH | HL | LH | LL |
| TD | Mean | 0.69 | 0.72 | 0.35 | 0.53 | 0.33 | 0.36 | 0.34 | 0.42 |
| | Std dev | 0.36 | 0.26 | 0.08 | 0.20 | 0.05 | 0.07 | 0.08 | 0.22 |
| | Range | 1.37 | 0.70 | 0.23 | 0.67 | 0.18 | 0.29 | 0.32 | 0.82 |
| ASD | Mean | 0.71 | 0.65 | 0.62 | 0.51 | 0.32 | 0.35 | 0.31 | 0.36 |
| | Std dev | 0.37 | 0.32 | 0.38 | 0.18 | 0.09 | 0.09 | 0.07 | 0.13 |
| | Range | 1.28 | 0.99 | 1.19 | 0.57 | 0.32 | 0.34 | 0.21 | 0.44 |

Three planned comparisons were carried out. In the first, only the data from the consistent trials were used, that is the high interest (HH) and low interest (LL) conditions. These were analysed using a three-way mixed design ANOVA, with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) and the consistent Stimulus Interest trials (HH, LL) as the within-subjects factors. Results showed a significant main effect for Attention Type, $F(1, 26) = 48.09$, $p = .01$, $\eta^2 = .65$, and none for Group, $F(1, 26) = 0.1$, $p = .76$, $\eta^2 = .01$, or Stimulus Interest, $F(1, 26) = 2.26$, $p = .14$, $\eta^2 = .08$.

No significant interactions were found for Group × Interest, $F(1, 26) = 0.31$, $p = .59$, $\eta^2 = .01$, Group × Attention Type, $F(1, 26) = .21$, $p = .65$, $\eta^2 = .01$ or Group × Interest × Attention Type, $F(1, 26) = .01$, $p = .99$, $\eta^2 = .01$. There was a significant interaction seen for Interest × Attention Type, $F(1, 26) = 8.1$, $p = .01$, $\eta^2 = .24$ as expected and post-hoc t testing showed that there was a significant difference within the Competing condition, $t(27) = 2.43$, $p$

= .02, *d* =, 0.69 in the predicted direction with a higher latency in the high interest condition. This interaction shows that while participants have significantly slower latencies in the Competing trials, the magnitude of this latency is related to the interest the stimulus holds for the child. Figure 3.9 gives a graphical representation of the data.

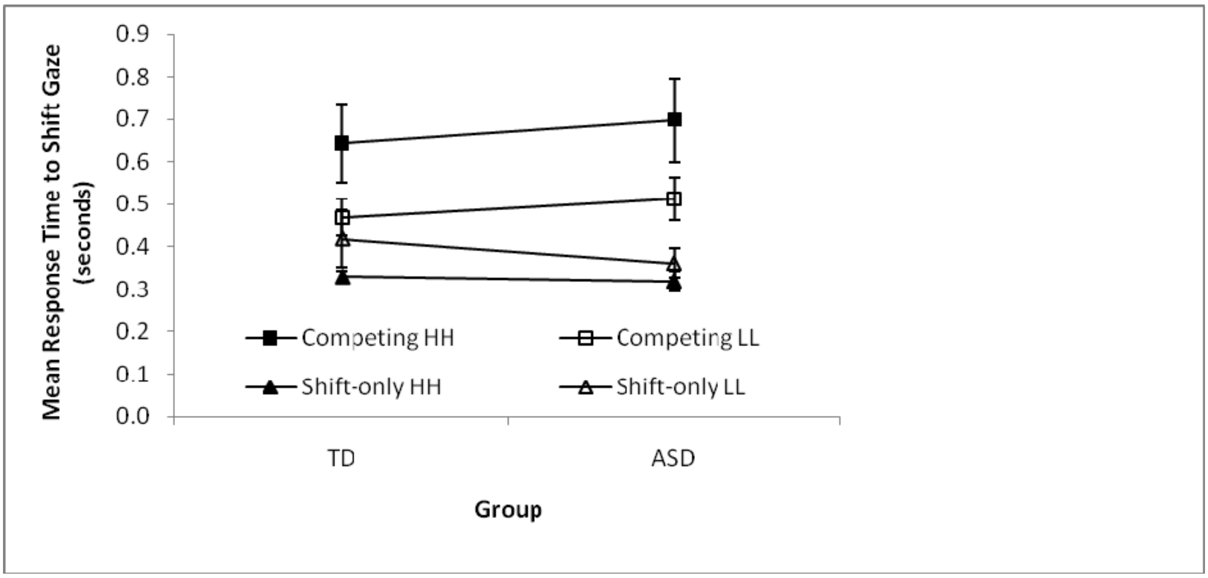


*Figure 3.9:* Mean latency to respond to the lateral stimulus for ASD and TD groups according to attention type and interest level. Vertical lines depict standard errors of the means.

To account for the potentially confounding factor of individual variation in baseline shifting ability, a second analysis was also conducted on the data for this planned comparison using the measure of disengagement outlined by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data a two-factor ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and the consistent Stimulus Interest trials (HH, LL) as the within-subjects factor. Results were consistent with the first analysis in that there was a significant main effect of Stimulus Interest, $F(1, 26) = 8.1$, $p = .01$, $\eta^2 = .23$, and none for Group, $F(1, 26) = 0.2$, $p = .65$, $\eta^2 = .01$, and no significant interaction was found for Group × Stimulus Interest, $F(1, 26) = 0.1$, $p = .99$, $\eta^2 = .01$, indicating that attentional disengagement from high interest stimuli took longer than from low interest stimuli for both groups.  Figure 3.10 is a graphical representation of the data.

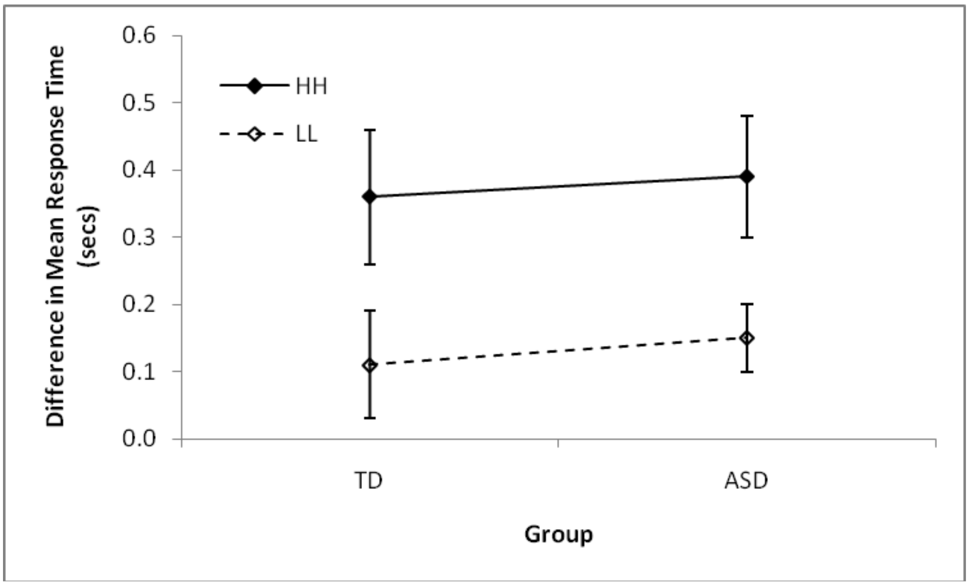


*Figure 3.10*:  Difference in Mean Response Time between competing and shift-only trials for ASD and TD groups according to and interest level. Vertical lines depict standard errors of the means.

The second planned comparison was designed to examine if there was an effect of Stimulus Interest on the inconsistent (different types of lateral and central targets) trials.  An additional analysis was conducted to examine and exclude the effect of Consistency.  This was deemed important to ensure any resulting effects were due to the content of the stimuli used and not a result of a novelty effect due to the screens playing different stimuli.  To do this, the data were collapsed across the Stimulus Interest variable into two levels, Consistent (HH, LL) and Inconsistent (HL, LH). These data were then analysed using a three-factor mixed design ANOVA, with two within-subjects factors Attention Type (Competing, Shift-only) and Stimulus Interest, and one between-subjects factor Group (ASD, TD). As only the main effect of Attention Type was significant, the influence of consistency alone on the reaction time was discounted and no further analysis was conducted on this variable.

For the third planned comparison, another three-way ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) as a within-subjects factor. The second within-subjects factor in this analysis was labelled Position (HL, LH). Results showed a significant main effect for Attention Type, $F(1, 26) = 46.23$, $p = .01$, $\eta^2 = .64$, and Position, $F(1, 26) = 8.17$, $p = .01$, $\eta^2 = .24$, but not for Group, $F(1, 26) = 0.89$, $p = .35$, $\eta^2 = .03$, in keeping with the earlier findings. The participants showing slower reaction times when the high interest stimulus was in the centre than when it appeared on the lateral monitors.

No significant interactions were found for either Group × Position $F(1, 25) = 3.67$, $p = .07$, $\eta^2 = .12$, or Group × Attention Type, $F(1, 25) = 2.75$, $p =.11$, $\eta^2 = .1$. Unexpectedly, there was a significant interaction for Group × Attention Type × Position, $F(1, 26) = 7.28$, $p = .01$, $\eta^2 = .22$, indicating potential group differences in some conditions. Finally according to expectations a significant interaction was seen for Attention Type × Position, $F(1, 26) = 6.69$, $p = .02$, $\eta^2 = .21$. Although post-hoc t-testing showed that there was a significant difference within the Competing condition, $t(27) = 2.59$, $p = .02$, $d = 0.74$, in the predicted direction, this cannot be seen as in support of our hypothesis due to the aforementioned three way interaction. Further analysis revealed that this difference lay within the TD group, $t(27) = 5.17$, $p = .01$, $d = 2.07$, but not the ASD group, $t(27) = 0.27$, $p = .79$, $d = 0.09$. Figure 3.11 displays these results.

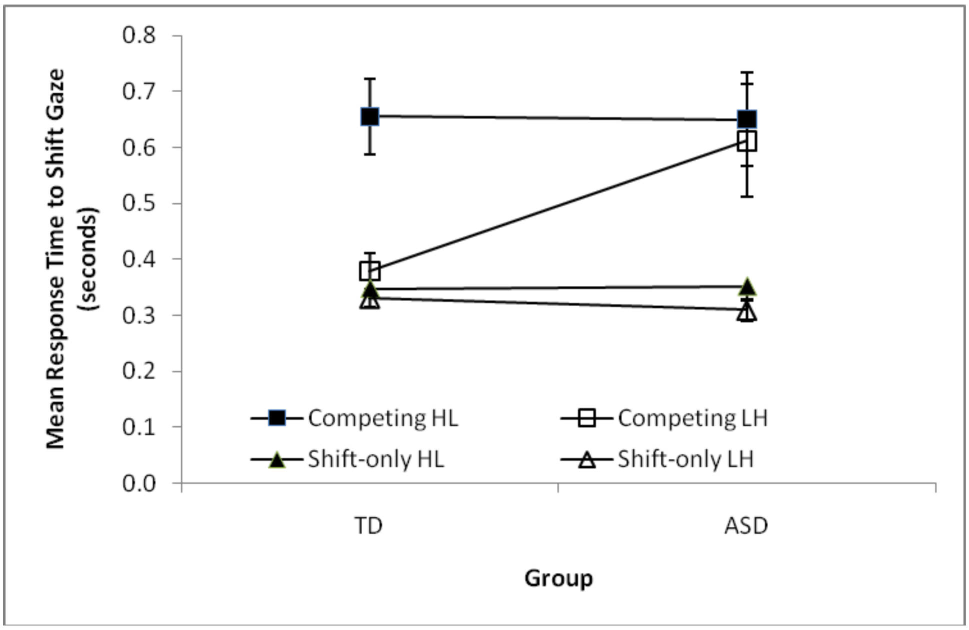


*Figure 3.11:* Mean latency to respond to the lateral stimulus for ASD and TD groups according to attention type and interest level. Vertical lines depict standard errors of the means.

Again, to account for the potentially confounding factor of individual variation in baseline shifting ability, a second analysis was also conducted on the data for this planned comparison using the measure of disengagement outlined by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data a two-factor ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and the consistent Position (HL, LH) as the within-subjects factor. Results were consistent with the first analysis in that there was a significant main effect Position, $F(1, 26) = 6.7$, $p = .02$, $\eta^2 = .21$, and none for Group, $F(1, 26) = 2.7$, $p = .11$, $\eta^2 = .1$, and a significant interaction was found for Group × Position, $F(1, 26) = 7.3$, $p = .01$, $\eta^2 = .22$, indicating that only the TD group showed longer latencies to disengage attention in the HL condition than in the LH condition. Results are displayed in Figure 3.12.

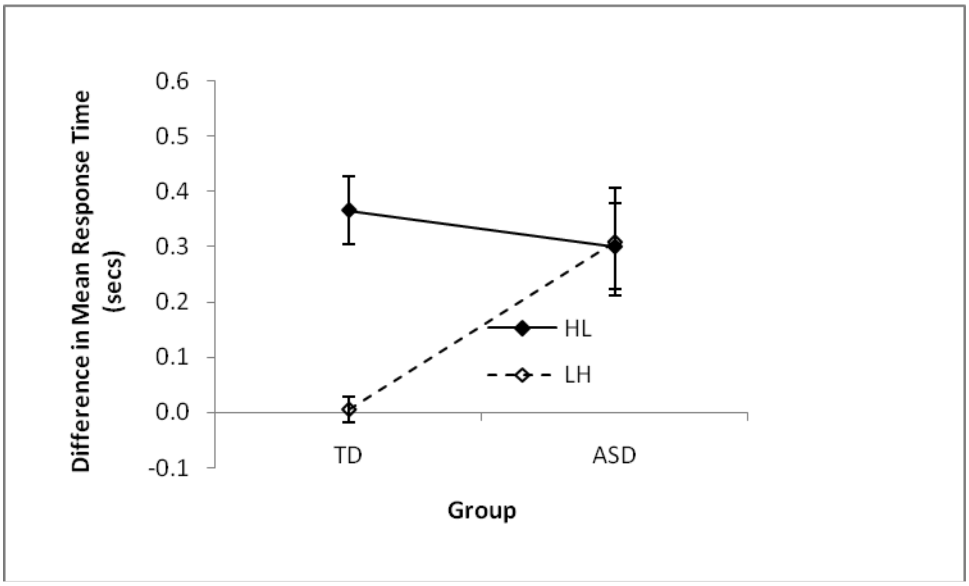


*Figure 3.12*: Difference in Mean Response Time between competing and shift-only trials for ASD and TD groups according to and interest level. Vertical lines depict standard errors of the means.

### *3.2.3. Discussion*

As expected, both groups were significantly slower in the Competing trials than the Shift-only trials. Importantly, no group effects were found using these naturalistic stimuli. An overall effect of stimulus interest was seen, however, with both groups being slower to shift attention in the high interest trials than the low interest ones in the Competing condition, suggesting a role for stimulus interest in a child's ability to disengage attention. The results for the inconsistent trials were less clear. Though the TD children were slower to shift attention when the high interest clips were in the centre as opposed to the low interest clips, the ASD children did not show this difference. The results were mirrored when using a composite score to account for individual variation in shifting ability.

It should be considered that there was a higher rate of incomplete trials for the ASD group but it is important to note that this was balanced across all conditions. It was found through conducting an analysis of the proportion of completed trials with only the first four presented trials of each condition that this higher rate was attributable to the length of experiment 3.2. An analysis conducted on this subset of data indicated no difference in the overall findings.

The primary limitation of this study was that by using different video clips for each child, it was not possible to completely separate the effects of visual stimulus characteristics (brightness, movement) from intrinsic interest. For the purposes of this experiment, it was more important to attempt to balance the level of interest in the clips rather than to match the clips themselves. However, to minimise this risk factor, a wide choice of clips were available to the children. This lead to a range of selected stimuli in each group which reduced the effects any one clip might have had. Further research is needed to compare these stimuli characteristics more directly.

## 3.3. General Discussion

The findings indicate that stimulus interest appears to be a contributing factor in the difference shown between children with ASD and TD children when disengaging from a stimulus. The results of experiment 3.1 replicated the findings of Landry and Bryson (2004) using similar but independently designed abstract stimuli. This highlights the robustness of the result using this stimuli type. However, contrary to these findings, no overall group difference was found with more naturalistic videos as shown in experiment 3.2. The factor that was influential was stimulus interest as within the Competing trials, the children shifted attention slower in the high interest than the low interest condition.

Given that the same children took part in both experiments, the divergence of the results of experiment 3.2 from the pattern found by Landry & Bryson (2004) suggests first, that the delay in disengaging shown in children with ASD may be stimulus specific rather than a general impairment. Second, it suggests that stimulus interest may be partly the reason for these different findings. Certainly, it seems likely that the repetitive, geometric patterns in Bryson's stimuli could hold more appeal for children with ASD generally than other groups, although more work will be necessary to examine this.

The proposal that stimulus interest is important for the shifting of attention has also been made previously. For example, the social reward hypothesis of Dawson et al. (2004) (see section 2.9.1) suggests that children with autism lack interest in social stimuli, thereby leading to impoverishment of the experiences of the child with ASD and a different developmental trajectory as a result. The findings lend some support to this theory and suggest that shifting away from uninteresting situations would be easier than interesting ones.

A more general implication of the findings is the importance of the emphasis on an initial level of engagement before disengagement can take place. It is proposed that altering stimulus interest essentially manipulates this level of engagement, highlighting the interdependence of the two attentional processes. As such, the slower shifting of attention seen in children with ASD under certain conditions may not be solely due to problems in disengagement. Irregular engagement patterns would also generate the same pattern and may be more in line with the diagnostic symptoms of autism. This will be further examined in Chapter 5.

An alternative factor that may have contributed to the differing findings is the different types of motion of the stimuli between the two experiments. Though both experiments used videos, those in experiment 3.2 presented relatively natural movement patterns as opposed to the rapid and repetitive motion in experiment 3.1. It is not clear whether the same group differences would occur in other types of abstract stimuli such as still images of shapes, an issue which will be further examined in Chapter 4. However, even if motion type does influence the group difference, it does not exclude the possibility that motivational factors also contribute to engagement, disengagement and shifting. The difficulty here is separating the demands of stimulus features from stimulus interest. Both of these could contribute to the initial level of engagement and further testing would need to be done to separate these factors.

In conclusion, the findings of this study have interesting implications for further research and clinical work. Given the interest in disengagement as a potential early marker for ASD, these findings have relevance for how stimuli should be presented in order to test disengagement of attention, in future screening and diagnostic settings. Also, if stimulus interest provides an index of disengagement speed, it might be possible to use disengagement paradigms more extensively to investigate the nature of interest and to develop interventions using interest to promote attention shifting. From the results of these experiments, it is not clear whether the key problem is disengagement per se, or whether the slower disengagement of the ASD group in experiment 3.1 reflects a higher prior level of engagement.  To test this, further research is needed that will separate these factors.

# Chapter 4. STIMULUS INTEREST AND DISENGAGEMENT FROM STATIC STIMULI

Children with ASD are often described clinically as showing inconsistent patterns of attention. They will attend for hours when it comes to their favourite activity, but be highly distractible on other occasions (Murray et al., 2005). It has already been shown in Chapter 3 that the peculiarities in their attention may, at least in part, be stimulus driven. In experiment 3.1, the findings of Landry & Bryson (2004) were replicated with similarly designed stimuli. In contrast to this, when the same participants took part in experiment 3.2 which used more naturalistic videos, no differences between the groups was found. These two experiments explored how differences in stimulus interest might be the determining factor in this difficulty. However, it has yet to be determined if these contrasting findings are a result of this interest in the specific content of the stimuli or an attentional demand characteristic due to particular physical features, such as the type of motion within the clips or the pattern of colours.

In the past, psychologists have separated attention systems in terms of bottom-up and top-down processing. Bottom-up processing is selective attention involuntarily driven by stimulus factors, such as those described earlier, whereas top-down processing tends to be more voluntary, goal-driven behaviour. Posner & Petersen's (1990) model of attention also divided the attention system into these two separate though related systems. Using this as a model, stimulus interest could be seen as an internalised top-down control setting guiding attention to appropriate locations and therefore it predisposes a child to prioritise stimuli relevant to these internal goals. Attention and, more specifically, attentional capture rarely relies on bottom-up processing alone as both processes are interdependent. An example of this in practice was given by Folk, Remington, and Johnston (1992) who examined a spatial cuing paradigm for cues of different physical characteristics. They found that the different types of cues only captured attention when the participant was told to search for the feature that was to change thus indicating that stimulus driven attention capture depends on top-down attentional control settings in conjunction with bottom-up processes.

The first factor other than stimulus interest which could explain the findings of experiment 3.1, is the motion of the stimulus. Looking at this purely from a bottom-up perspective, there is evidence to suggest that children with ASD have difficulty in processing rapidly moving stimuli and do not process motion in a similar manner to TD children. Gepner, Mestre, Masson, and de-Schonen (1995) looked at how children with and without ASD reacted to movement in the visual environment. They found that the ASD group showed less responsive postural sway when presented with environmental motion than the TD children. In addition, this apparent perceptual difficulty has been seen at fundamental levels of the perceptual system as they have been shown to have higher motion-coherence thresholds (Milne et al., 2002; Spencer et al., 2000), and to be less skilled at deciphering the direction of texture-defined moving stimuli (Bertone et al., 2003), when compared with TD children. The precise nature of these apparent difficulties in visual motion perception in people with ASD is strongly debated amongst those who believe them to be related to specific neural pathways (Spencer et al., 2000) and those such as Bertone et al. (2003) who argue for a neural integration deficiency for stimuli that require more complex neural processing.

Though these two premises appear to differ at a fundamental level both argue that those with ASD are impaired in processing some types of motion and that this impairment is at a neurological level. If it is the case that there is a fundamental difficulty in those with ASD for processing certain types of motion, it is likely that this would be reflected in their ability to disengage from and shift to stimuli of this sort. In the light of this supposition, the findings of the experiments in Chapter 3.1 should be re-interpreted as there was very different types of motion within the clips for the interest trials (experiment 3.2) than for the abstract trials (experiment 3.1). It is possible that the group differences seen in the first of these experiments could have been a result of neurological impairments in the ASD child's ability to process the fast moving, repetitive motion within the clips as opposed to the more naturalistic motion within the interest trials in experiment 3.2.

In line with this argument, Greenaway and Plaisted (2005) found a difference within their ASD and TD groups in a visual search paradigm for the impact of motion (onset) on attention. However, they also saw a differential effect within the ASD group between the impact of motion and the colour of the stimulus, with no group differences being found for colour. They concluded that attentional control might be stimulus specific in ASD with regard to abnormalities in top-down attentional control for dynamic stimuli but not for colour when dealing with static stimuli. Thus, accordingly, the results of experiment 3.1 could be explained as the motion of the stimulus impairing the top-down processes allowing for an attention shift rather than something occurring at a baser perceptual level. However, their model can't account for the findings of experiment 3.2 where the ASD group showed no differences despite the motion of the clips. There is also a difficulty generalising their findings to other types of motion other than stimulus onset.

Although the high and low interest stimuli in experiment 3.2 were chosen to be roughly equivalent in the type of motion displayed, the dynamic nature of the interest related stimuli made them difficult to match on other dimension such as form and colour. In general, the low interest clips in the previous experiment tended to have considerably more muted colours than the high interest clips. Also, the form of the clips differed in that the high interest clips included puppets or computer generated cartoons, whereas the low interest clips were more accurate representations of the world. It could arguably be the case that either or both of these physical factors in the high interest clips retained both groups' attention rather than the content of interest as has been suggested.

That the factors of form and colour would affect both groups similarly but that motion does not is consistent with the current literature. Though there is some evidence that children with ASD may perceive colour differently (Brian, Tipper, Weaver, & Bryson, 2003), this does not seem to extend to specific colours but rather manifests as general difficulties across all shades as shown in Franklin, Sowden, Burley, Alder & Notman (2008). Franklin et al. (2008) used a visual search task to assess the accuracy and speed of chromatic discrimination for ASD and TD groups. The participants had to identify the odd one out from 16 options. The children with ASD were significantly less accurate at identifying the target, indicating potential impairments in colour perception; however this was seen to be a general pattern across all colours. In addition, as a control variable they had equivalent stimuli which varied in their form or shape rather than colour. Unlike the colour trials, no between group effects were seen for this form alteration. Hence, this suggests that there might have been a general slowing of response times overall but no differential slowing between the high and low interest clips in experiment 3.2, as neither were black and white. Despite these findings the extent of the difference between the clips cannot be ruled out as a contributing factor.

To examine the factors of motion, form, colour and stimulus interest on our previous findings, three experiments were designed, again based on the Landry and Bryson (2004) paradigm but including static stimuli. The first experiment attempted to examine the effects of motion on the abstract stimuli. This was achieved by comparing the children's responses to both the abstract videos used in experiment 3.1 and stills taken from the same videos. The remaining two experiments excluded motion from the design. The purpose was to see firstly, if the same pattern of results were seen with non moving pictures with regard to stimulus interest, and secondly, to more easily balance the other factors of form and colour across the screens. In both of these experiments, the content and hence the stimulus interest was manipulated and, as previously outlined in experiment 3.2. What differed between these last two experiments was that in the first the general form of the pictures was matched while allowing the colour composition and content to vary, by using computer generated images as low interest stimuli. In the second of these experiments, the hue or colour composition were matched closely between the images while the form and content was varied by using pixelated versions of the high interest stimuli as the low interest ones.

For the first experiment, it was predicted that there would be a difference between the ASD children and TD children for the dynamic abstract stimuli for the competing trials. If this difference was due to features of the stimuli other than motion, there would still be a difference between the groups for the static abstract stimuli in competing trials. However, if it is the case that the type of motion was the reason for the disengagement difficulties in the ASD group, whether due to impaired top-down processing, their interest in that type of motion, or to an impaired capacity to process this type of motion, no group difference would be seen between the groups within the static abstract stimuli in competing trials. For the second and third experiment, results similar to experiment 3.2 were expected, in that there would be no group differences in any condition and that some effects of stimulus interest would be seen across trials.

## 4.1. Experiment 4.1

This aim of this experiment was to replicate the results of experiment 3.1 and to see if a similar pattern would be exhibited when using static abstract stimuli. Three monitors were positioned side by side and once the child's gaze was directed at a stimulus presented in the central screen, a display was initiated on one of the lateral screens. Time to shift gaze to this lateral target was recorded under two conditions: (1) the central stimulus remained on while the lateral stimulus appeared (Competing trials) or (2) the central stimulus was turned off 250ms before the onset of the lateral stimulus (Shift-only trials). In addition, trials were divided into static and dynamic types and were presented in a random order.

It was predicted, as shown by previous studies, that both TD and ASD children would be significantly slower to shift gaze in the Competing than the Shift-only trials. Secondly, it was predicted that children with ASD would be slower to shift gaze in the Competing trials than the TD children for the dynamic stimuli. Finally, if this group difference in the dynamic Competing trials was due to features of the stimuli other than motion there would also be a difference between the groups in the same direction for the static abstract stimuli for these trials. However, if the type of motion was the reason for the disengagement difficulties in the ASD group, it was believed that no group difference would be seen.

### *4.1.1. Method*

#### 4.1.1.1. *Participants*

Eleven children (10 boys) with ASD, aged 7-10 years, were recruited from special schools for autism in the Wakefield and Middlesbrough areas. This was an entirely new sample and had not been tested previously. All children were diagnosed by experienced clinicians. Diagnostic decisions were made by a multidisciplinary team using criteria from the international classification systems DSMIV and ICD-10. Five children were diagnosed according to the DSM IV criteria for ASD at James Cook University Hospital in Middlesbrough- Social Communication Assessment Team (SCAT). The team uses a variety of assessment tools to guide diagnosis including the CARS, 3Di, DISCO. The remaining six had been diagnosed by experienced clinicians in a multidisciplinary team by the Wakefield District Hospital using the criteria of the ICD-10, *International Classification of Disease (ICD-IO;* World Health Organization, 1992) guidelines.

A comparison group of 11 children (7 boys) with typical development (TD) aged 3-6 years, was recruited from mainstream schools and nurseries in the Durham region. These children had also not been tested before. Written informed consent was obtained from the parents of each child prior to any testing. All participants had normal or corrected-to-normal visual acuity. Participants' non-verbal mental age (NVMA) was assessed using the Leiter International Performance Scale- Revised (Leiter-R; Roid & Miller, 1997) and matching was applied on both an individual and a group basis according to these scores. Ten of the pairs could be matched to within five months in NVMA, the remaining pair had a difference of eight months, the children with autism having the higher score in all cases. Hence, the two groups did not differ significantly on NVMA, $t(20) = 0.57$, $p = .6$, but did on Chronological Age (CA), $t(20) = 11.3$, $p = .01$. See Table 4.1 for details.

Table 4.1

*Means and standard deviations of non-verbal mental age and chronological age in years for ASD and TD children*

| | Age | | | NV Mental Age | |
|---|---|---|---|---|---|
| Group | Mean | Std Dev | | Mean | Std Dev |
| ASD | 8.4 | 0.92 | | 4.1 | 0.88 |
| TD | 4.1 | 0.8 | | 3.8 | 0.95 |

#### 4.1.1.2. *Materials*

The experimental set up was the same for experiment 3.1. The same video clips, modelled after those used by Landry & Bryson (2004) were generated through the use of the software program, POV-Ray and converted to video format using AVI-tricks. These consisted of coloured (red, yellow, blue, and green) shapes (triangles, squares, and circles) that continuously fell from the top of the screen to the bottom (for examples of stills from these images see section 3.1.1.2). The shapes fell at different speeds and ranged in size. The same stimuli were presented for both central and lateral displays. Stills from these videos were used as the corresponding static stimuli.

#### 4.1.1.3. *Design*

The experiment used a mixed design with Group (ASD and TD) as the between-participants factor and Attention Type (Competing, Shift-only) and Motion (Dynamic, Static) as the within-participants factors.

#### 4.1.1.4. *Procedure*

*Attention task.*

The experimental setup was the same as that described in experiment 3.1. The child was told that videos would appear on the screens in front of him and that they should look at them when they appeared. The child was also told that the first video clip would always appear in the central screen. The experimenter sat behind the child throughout the trials and gave positive feedback if the child appeared relaxed and interested in completing the task but not for looking at any particular screen over another.

*Trial sequence.*

In all trials, a video appeared in the central monitor for up to 8 seconds. Once the child attended to it, the experimenter triggered a display on a lateral monitor with a delay of 250 ms. The time gap was chosen to be consistent with Landry and Bryson (2004) and experiment 3.1 and to allow for automatic disengagement. However, typical display time for the central stimulus was less than 1 second before the lateral targets were triggered. The lateral monitor continued to be presented until the child made a gaze shift towards it or for a maximum of 5 seconds. Thirty two trials were presented in a random order and divided equally into two types, competing and shift-only trials, with each of these types having an equal number of static and dynamic trials presented in a random order. In the competing trials, the central video continued playing throughout the trial, whereas for the shift-only trials, the central stimulus ceased playing when the lateral target was triggered. The presentations of the lateral target were equally distributed across the left and right monitors. Trials could be replaced if deemed invalid, such as when the child looked away before a lateral stimulus was triggered.

*Coding Procedure.*

Results were coded using the Observer XT software package. The experimenter was the primary coder of this output but was blind to which type of stimulus was being presented to the child during the coding procedure. The video recordings were slowed and played back frame by frame. The onset of each lateral stimulus and the point at which an eye shift towards that stimulus was made were recorded for each trial. Latency to complete this eye shift was then calculated in milliseconds. Coding was otherwise the same as was done in Chapter 3. To ensure a similar number of trials were completed between the groups, the proportion of correct responses was analysed. There were no differences in the proportion of completed trials between the ASD ($M = .86$, $SD = .1$) and TD ($M = .91$, $SD = .06$) groups, $t(20) = 1.6$, $p = .12$.

### *4.1.2. Results*

For all analyses, homogeneity of variance was verified using Levene's test. Dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967). An ANCOVA was first carried out on all analyses with CA as a covariate. This factor was not significant so the simpler ANOVAs were used. All tests were performed at $\alpha = .05$.

Mean Reaction Time was analysed using a three-factor mixed design ANOVA, with two within-subjects factors Attention Type (Competing, Shift-only) and Motion (Dynamic, Static), and one between-subjects factor Group (ASD, TD). Results showed a significant main effect for Attention Type, $F(1, 20) = 66.7$, $p = .01$, $\eta^2 = .77$, reflecting that both groups were slower in the Competing condition. There was also a significant main effect for Motion, $F(1, 20) = 19.8$, $p = .01$, $\eta^2 = .5$, indicating that the children were slower to shift attention from the dynamic stimuli than from the static ones. There was no significant main effect of Group, $F(1, 20) = 2.3$, $p = .27$, $\eta^2 = .06$, indicating that ASD children were not slower to respond than TD children overall. Descriptive statistics for all trial types are displayed in Table 4.2 below.

Table 4.2

*Mean, standard deviation and range for all dynamic and static conditions for both competing and shift-only trials.*

| Group | | Competing | | Shift-only | |
|---|---|---|---|---|---|
| | | HH | HL | HH | HL |
| TD | Mean | 0.71 | 0.52 | 0.42 | 0.47 |
| | Std dev | 0.24 | 0.15 | 0.12 | 0.13 |
| | Range | 0.70 | 0.49 | 0.40 | 0.37 |
| ASD | Mean | 0.78 | 0.48 | 0.32 | 0.31 |
| | Std dev | 0.16 | 0.20 | 0.14 | 0.08 |
| | Range | 0.58 | 0.47 | 0.47 | 0.27 |

No significant interaction was seen for Group × Attention Type × Motion, $F(1, 20) = 0.22$, $p = .65$, $\eta^2 = .01$. A significant interaction was seen, however, for Group × Attention Type, $F(1, 20) = 6.02$, $p = .02$, $\eta^2 = .23$, in accordance with expectations, warranting further analysis. A significant interaction was also seen for Attention Type × Motion, $F(1, 20) = 24.8$, $p = .02$, $\eta^2 = .55$, reflecting that the dynamic clips were more difficult to shift attention from than the static ones in the competing trials but not in the shift-only trials. However, no significant interaction was seen for Group × Motion, $F(1, 20) = 0.22$, $p = .65$, $\eta^2 = .01$.

Two planned comparison independent t-tests were conducted on the data to attempt to pinpoint where the group differences lay. The first was conducted on the dynamic competing trials, however no significant differences were found between the groups, $t(20) = 0.83$, $p = .45$, $d = 0.41$. This finding was counter to expectations and counter to the findings of experiment 3.1. The second analysis was conducted on the static competing trials and also showed no significant differences between the groups, $t(20) = 0.5$, $p = .62$, $d = 0.24$, indicating that static stimuli do not elicit a slower response for ASD children in competing trials, however this finding is difficult to interpret in the light of the lack of a significant group difference for the dynamic stimulus. Further post-hoc t tests revealed that the group difference lay within the static, shift-only condition, $t(20) = 3.5$, $p = .01$, $d = 1.5$, indicating that the TD group was slower to respond than the ASD group, again counter to expectations. Results are summarised on Figure 4.1.

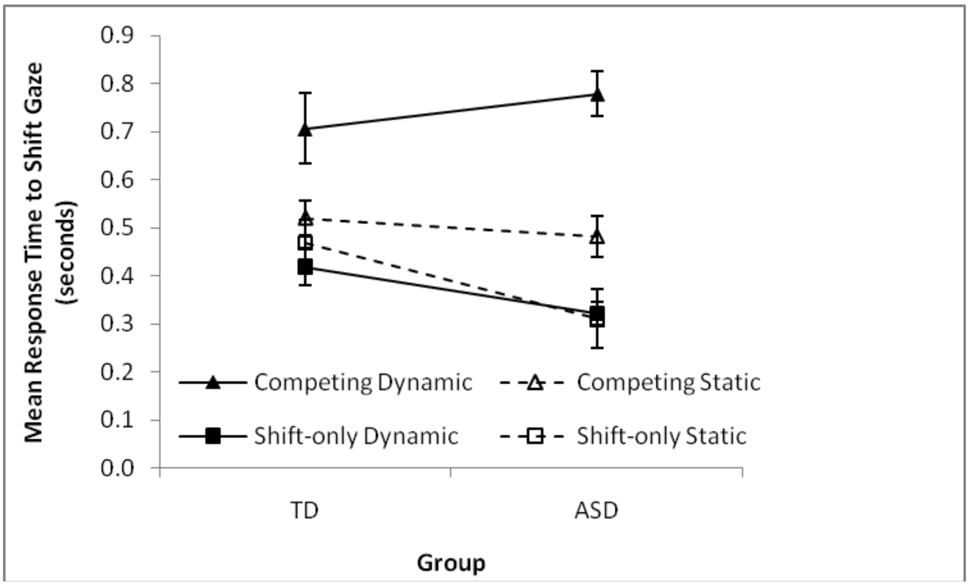


*Figure 4.1:* Mean Latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions for dynamic and static abstract stimuli. Error bars depict standard error of the mean.

The data were then transformed into an approximate measure of disengagement by following the procedure described by van derGeest et al. (2001), which served to control for the differences seen between the groups in the Shift-only trials as well as any individual variation in shifting ability. This was done by subtracting taking each child’s data in the

Shift-only trials from their data in the Competing trials in each condition. The data in the Shift-only condition gave an approximate measure of the reaction time to shift attention to that particular stimulus, hence could be factored out from the analysis. The data were then analysed using a two-factor mixed design ANOVA, with one within-participants Motion (Dynamic, Static); and one between-participants factor Group (ASD, TD). The results were similar to the previous analysis with regard to there not being a significant interaction for Group × Motion, $F(1, 20) = 0.22$, $p = .65$, $\eta^2 = .01$. There was also still a significant but stronger main effect for Motion, $F(1, 20) = 24.9$, $p = .01$, $\eta^2 = .6$, indicating that the children were slower to shift attention from the dynamic stimuli than from the static ones. However, importantly, there was a significant main effect of Group, $F(1, 20) = 6.01$, $p = .02$, $\eta^2 = .23$, indicating that ASD children were slower to disengage attention than TD children overall when individual differences in shifting ability were accounted for. Results are displayed in Figure 4.2.

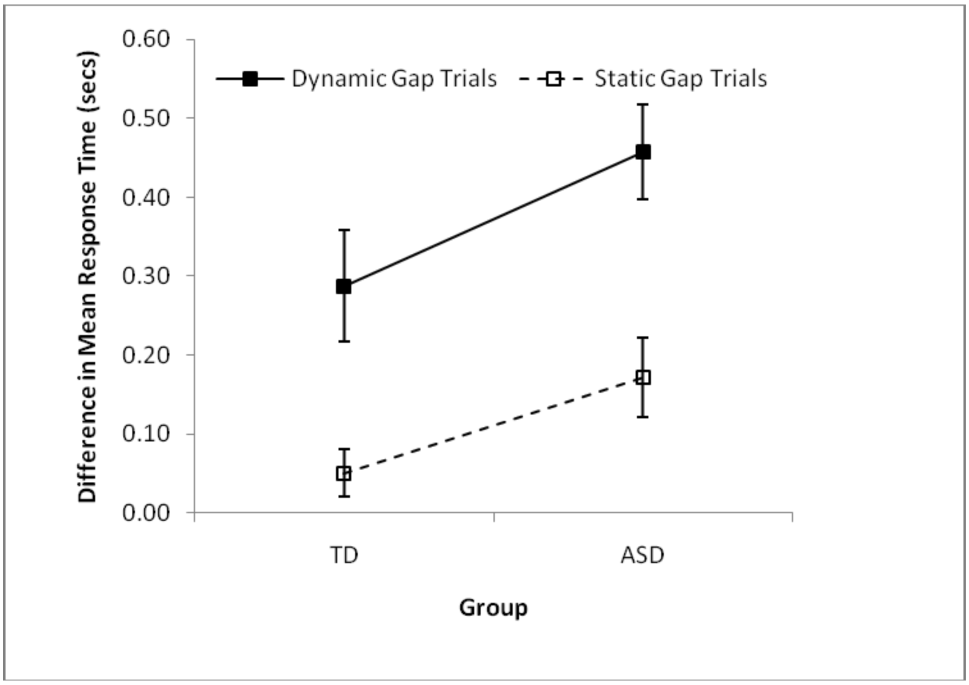


*Figure 4.2*: The mean difference in latency to respond to the lateral stimulus for ASD and TD groups between the Competing and Shift-only conditions for dynamic and static abstract stimuli. Error bars depict standard error of the mean.

### *4.1.3. Discussion*

Both TD and ASD children were significantly slower to shift gaze in the competing compared to the shift-only trials. In addition, no difference was seen between the groups in the static competing trials. This would seem to indicate that the type of motion of the central stimulus has a dramatic effect on the ability of the ASD child to disengage from it. However, unexpectedly, children with ASD were not significantly slower to shift gaze in the dynamic competing trials than the TD children as was shown in experiment 3.1 and was reported in Landry and Bryson (2004). Therefore, although there is a slight trend in the expected direction, it cannot be concluded that this type of stimulus consistently results in group differences in their speed of disengagement.

The failure to replicate the earlier finding of experiment 3.1 was unexpected as there was no difference between the stimuli used in this experiment. The most likely reason for this can be seen when examining the Shift-only trials, which give a measure of the groups' baseline shifting speed. Unusually, the response time for the children with ASD actually appeared to be faster than the TD group in the shift-only trials whereas they would be expected to be the same or slower. This is despite the fact that the group used was of a similar chronological and non-verbal mental age as the experiments in Chapter 3. Thus, there may be something unusual about the group selected unrelated to these factors which resulted in the inability to replicate earlier findings.

This issue was highlighted when individual differences in baseline shifting ability were factored out using the procedure described by van der Geest et al. (2001). This involved subtracting each child's data in the Shift-only trials from their data in the Competing trials in each condition. The data in the Shift-only trials gave an approximate measure of the reaction time to shift attention to that particular stimulus, hence could be factored out from the analysis to give a more accurate picture of disengagement. This resulted in the additional finding that ASD children were slower to disengage on both trial types when these were factored out. This analysis indicated the slower disengagement of children with ASD to be a to be a general slowing effect rather than affecting just the dynamic trials, indicating that the type of motion of the stimulus is unlikely to be at the root of the disengagement difficulties displayed in experiment 3.1. The score distributions between this experiment and experiment 3.1 are displayed in greater detail in Appendix E.

## 4.2. Experiment 4.2

This experiment attempted to explore if a stimulus interest effect on disengagement could be seen with static rather than dynamic naturalistic stimuli. Using the same setup, an attempt was made to ensure that the high interest stimuli were similarly interesting to the children, by allowing each child to select an example stimulus from a selection in a preliminary session. A second set of stimuli, found to be uninteresting to the children by pilot testing and a validation task, was selected from internet sources. These were selected to be similar in form to the high interest stimuli (computer generated images) but did not contain the readily recognisable characters. Four types of trials were presented: a) high interest on the central and the lateral monitor (HH), b) high interest on the central monitor and low interest on the lateral monitor (HL), c) low interest on the central monitor and high interest on the lateral monitor (LH), and d) low interest on the central monitor and low interest on the lateral monitor (LL).

It was expected that there would be a main effect between the competing and shift-only trials, with the competing trials retaining attention for longer. It was also predicted that within the competing trials, there would be an interaction between Attention Type and Stimulus Interest, where differences between the interest conditions would be seen within the competing trials. Thirdly, it was expected that stimulus interest would affect the speed of disengagement and that both groups would be significantly slower to shift gaze in the high interest Competing trials (HH) than in the low interest Competing trials (LL). Finally, it was expected that both groups would be slower to shift gaze in the Competing trials when the high interest clip was in the central (HL) rather than the lateral monitors (LH).

### *4.2.1. Method*

#### 4.2.1.1. *Participants*

Thirteen individuals (11 boys) with ASD, aged 6-12 years, were recruited from special schools for autism in the York and Wakefield areas. Eleven had been diagnosed in the Autistic Spectrum Disorders Forum by a multidisciplinary team by, held at York District Hospital according to the ICD-10, *International Classification of Disease (ICD-IO;* World Health Organization, 1992) guidelines. These had previously been participants in the experiments in Chapter 3 but there was at least a four month gap since last tested. The remaining two came from the Wakefield sample tested in experiment 4.1. They participated in this task on the same day, allowing for a short break in between the two. A comparison group of 13 individuals (8 boys) with typical development (TD) aged 3-5 years, was recruited from mainstream schools and nurseries in the Durham region. This was a new sample and had not previously been tested on these stimuli. Written informed consent was obtained from the parents of each child prior to any testing. Participants' non-verbal mental age (NVMA) was assessed using the Leiter International Performance Scale- Revised (Leiter-R; Roid & Miller, 1997) and attempts were made to individually match the children according to these scores. Eight out of the 12 pairs could be matched to within six months, the largest difference between the remaining pairs was 13 months. In all cases the child with autism had the higher score NVMA. All participants had normal or corrected-to-normal visual acuity. Hence, the two groups did not differ in NVMA [$t(24) = 1.2$, $p = .24$] but did in Chronological Age (CA) [$t(24) = 9.8$, $p = .01$]. See Table 4.2 for details.

Table 4.3

*Means and standard deviations of non-verbal mental age and chronological age in years for ASD and TD children*

| | Age | | NV Mental Age | |
|---|---|---|---|---|
| Group | Mean | Std Dev | Mean | Std Dev |
| ASD | 9.3 | 1.9 | 4.6 | 1.05 |
| TD | 3.9 | 0.6 | 4.1 | 0.83 |

#### 4.2.1.2. *Materials*

The experimental setup was the same as that used for experiment 4.1. The same laminated selection boards were also used in this experiment. The stimuli used in the experiment came in two forms: high interest and low interest. High interest stimuli were digital images of characters from popular animated films. A laminated sheet with examples of these images was prepared for the child so that they could select their preferred images before the task began. The low interest images in this experiment were computer generated images of unusual scenes such as a crystal ball, pyramids and a Chinese palace. These were chosen by the experimenter and were pilot tested with three university students to ensure they had the desired effect. While the novel nature of these scenes did appear rewarding to the children initially, this did not persist throughout the validation task. An example of a high interest and low interest stimulus is given in Figure 4.3 below. For more examples of the stimuli used, see Appendix C.

 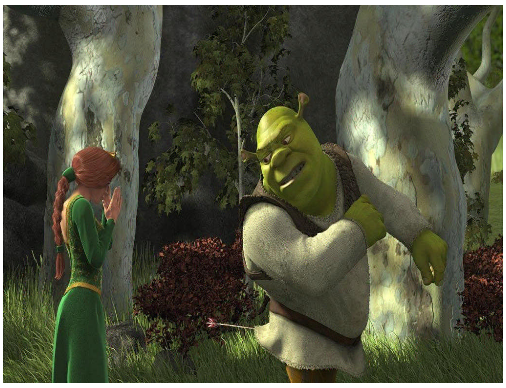

*Figure 4.3:* An example taken from the set of low interest (left image) and high interest (right image) stimuli.

#### 4.2.1.3. *Design*

The experiment used a mixed design with Group (ASD and TD) as between-participants factor and Attention Type as one within-participants factor, consisting of two levels: Competing and Shift-only. Stimulus Interest was the second within-participants factor with four levels (HH, LL, HL, and LH).

#### 4.2.1.1. *Procedure.*

*Preference Selection*

Each participant was presented with two selection boards simultaneously, one containing images of the television shows and one containing images of the animated films, and given the opportunity to choose their preferred stimulus. To ensure that one group did not disproportionately choose one video over the others, the selection board which did not contain the image of the video that had been selected by the most people in that group up to that point was presented to the child. To validate this preference and to ensure the selection was a persistent interest, the participant was then presented with a validation task.

*Validation Task*

Only the lateral monitors were used for this experiment. The images were arranged into sets before the experiment began, each containing four different images from each interest category. The set which contained the favoured image selected by the child was then presented. Each trial consisted of two of these images being presented simultaneously on the outer monitors for a period of up to 20 seconds until a clear preference was determined, defined as watching the image for approximately five seconds longer than the alternative. Each image was presented twice, once paired with an image from the same interest category and once from the opposing interest category (low interest). No image was displayed on the same screen twice and the order of presentation of these trials was randomised. In the unusual event that the child did not preferentially attend to the image they had chosen, the task could be abandoned and the child allowed another selection before re-presenting the task.

*Attention Task.*

After the pre-test had determined material of high interest to each individual child, the general operation of the attention task was the same as in experiment 3.2, however, in order to minimise the negative impact the length of the experiment had on the ASD children's ability to complete the full task, the total number of trials were halved for this experiment. There were 32 trials in total, consisting of eight trials for each interest category (HH, HL, LH, and LL). For each interest condition, four were Competing trials with the remaining four being Shift-only trials. These trials were presented in a random order and the order of presentation of the trials was randomised across participants. Trials deemed invalid, such as those when the participant looked away before the lateral target was presented, were replaced as necessary. The child was told that videos would appear on the screens in front of him and that they should look at them when they appeared. The child was also told that the first video clip would always appear in the central screen. The experimenter sat behind the child throughout the trials and gave positive feedback if the child appeared relaxed and interested in completing the task but not for looking at any particular screen over another.

*Coding Procedure.*

The coding procedure was the same as that used in previous experiments. The experimenter was the primary coder of this output but was blind to which type of stimulus was being presented to the child during the coding procedure. The proportion of completed trials did not significantly differ between the TD group ($M$ = .97, $SD$ = .05) and the ASD group ($M$ = .96, $SD$ = .1), $t(24)$ = 0.99, $p$ = .33.

### *4.2.2. Results*

There was a good distribution of stimuli selected for both groups with no more than three participants in any group selecting any video type. The patterns of selections were also very similar between the groups. All of the images were either selected by the same number of participants in both groups or had a difference of one participant. Likewise, there was a similar distribution of selections across the two types of high interest stimuli, children's shows and computer animated films. The results are summarised in Table 4.4 below.

Table 4.4

*The frequency of selection of each type of stimuli for ASD and TD children. The initials stand for Winnie the Pooh (PO), Barney and friends (BA), Thomas the Tank engine (TH,) Bear in the Big Blue House (BE), Bob the Builder (BO), the Incredibles (IN), Finding Nemo (NE), Shrek (SH), Monster's Inc. (MO), and Bug's Life (BU) respectively.*

| | Children's Shows | | | | | | Computer Gen Films | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | PO | BA | TH | BE | BO | Total | IN | NE | SH | MO | BU | Total |
| ASD | 1 | 0 | 2 | 0 | 1 | 4 | 1 | 2 | 3 | 2 | 1 | 9 |
| TD | 1 | 0 | 1 | 0 | 2 | 4 | 2 | 3 | 2 | 1 | 1 | 9 |
| | 2 | 0 | 3 | 0 | 3 | 8 | 3 | 5 | 5 | 3 | 2 | 18 |

For all analyses, homogeneity of variance was verified using Levene's test (Levene, 1960). Dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967) and the Shapiro-Wilk test (Shapiro & Wilk, 1965).

Mean Reaction Time was analysed using a three-factor mixed design ANOVA, with two within-subjects factors Attention Type (Competing, Shift-only) and Stimulus Interest, and one between-subjects factor Group (ASD, TD). Mauchly's test of sphericity was applied to confirm that the assumption of sphericity was valid. Results showed a significant main effect for Attention Type, $F(1, 24) = 57.31$, $p = .01$, $\eta^2 = .71$, reflecting that both groups were slower in the Competing condition. No main effect of Group was reported, $F(1, 24) = 0.02$, $p = .88$, $\eta^2 = .01$, highlighting that children with ASD performed the task as quickly as TD children matched by non NVMA overall. There was also a main effect of Stimulus Interest, $F(3, 72) = 4.5$, $p = .01$, $\eta^2 = .16$, indicating there was a difference in the performance of all children which depended on the stimulus presented. Descriptive statistics can be seen in Table 4.5 below.

Table 4.5

*Mean, standard deviation and range for all interest pairings for both competing and shift-only trials.*

| | | Competing | | | | Shift-only | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group | | HH | HL | LH | LL | HH | HL | LH | LL |
| TD | Mean | 0.42 | 0.43 | 0.37 | 0.42 | 0.29 | 0.32 | 0.33 | 0.33 |
| | Std dev | 0.09 | 0.09 | 0.09 | 0.13 | 0.07 | 0.08 | 0.07 | 0.06 |
| | Range | 0.29 | 0.27 | 0.29 | 0.41 | 0.28 | 0.31 | 0.26 | 0.22 |
| ASD | Mean | 0.46 | 0.52 | 0.36 | 0.41 | 0.29 | 0.31 | 0.29 | 0.32 |
| | Std dev | 0.11 | 0.19 | 0.12 | 0.15 | 0.04 | 0.09 | 0.08 | 0.06 |
| | Range | 0.35 | 0.61 | 0.40 | 0.54 | 0.15 | 0.32 | 0.33 | 0.18 |

No interaction was found for Group × Attention Type × Stimulus Interest, $F(1, 24) = 0.42$, $p = .52$, $\eta^2 = .02$, Group × Attention Type, $F(1, 24) = 2.2$, $p = .05$, $\eta^2 = .08$, Group × Stimulus Interest, $F(3, 72) = 1.9$, $p = .13$, $\eta^2 = .08$, further emphasizing that the ASD group responded as quickly as the TD children in all conditions. However a significant interaction was seen for Attention Type × Stimulus Interest, $F(3, 72) = 3.6$, $p = .02$, $\eta^2 = .13$, as expected. Results are displayed in Figure 4.4 below. Two planned comparison ANOVAs were then carried out to further explain this outcome.

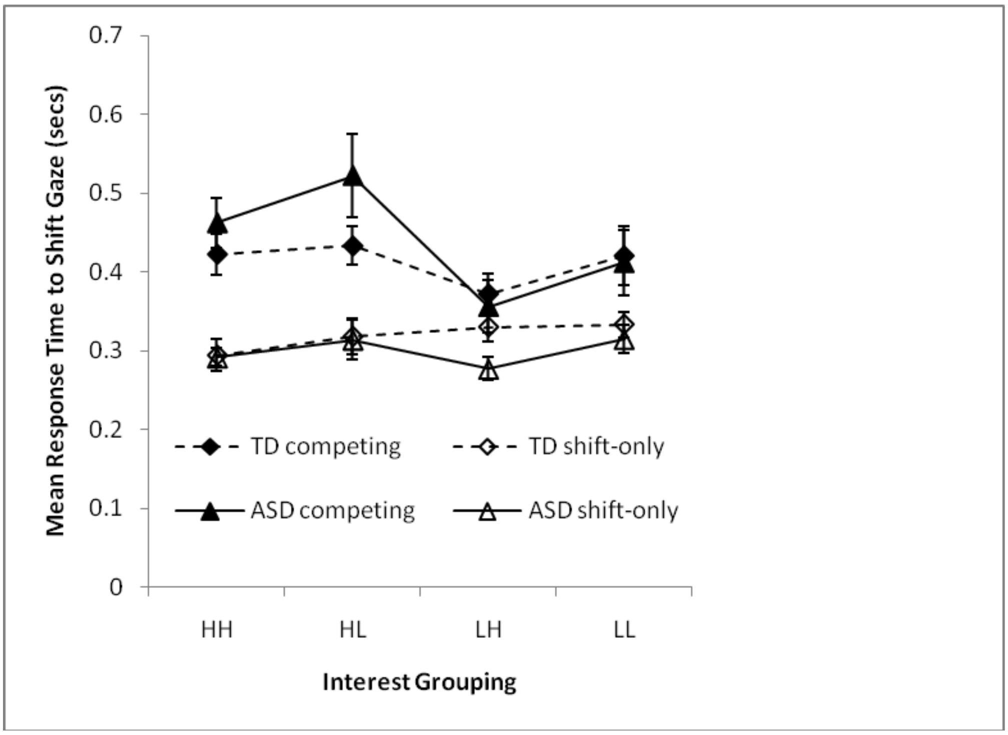


*Figure 4.4:* Mean latency to respond to the lateral stimulus in each interest grouping for ASD and TD groups in the Competing and Shift-only conditions using static targets matched by form. Error bars depict standard errors of the means.

The first of these used only the data from the high interest (HH) and low interest (LL) conditions. These data were analysed using a three-way mixed design ANOVA, with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) and Stimulus Interest (HH, LL) as the within-subjects factors. Results again showed a significant main effect for attention type, $F(1, 24) = 65.09$, $p = .01$, $\eta^2 = .73$. There was however, no significant main effect for Group, $F(1, 24) = 0.01$, $p = .92$, $\eta^2 = .01$ or for Stimulus Interest, $F(1, 24) = 0.02$, $p = .89$, $\eta^2 = .02$. No significant interactions were seen for any of the potential combinations: Group × Attention Type × Stimulus Interest, $F(1, 24) = 0.23$, $p = .64$, $\eta^2 = .01$, Group × Attention Type, $F(1, 24) = 0.76$, $p = .39$, $\eta^2 = .03$, Group × Stimulus Interest, $F(1, 24) = 0.67$, $p = .42$, $\eta^2 = .03$, Attention Type × Stimulus Interest, $F(1, 24) = 2.7$, $p = .11$, $\eta^2 = .1$. A dependent t-test was conducted on the data to answer the specific question of whether the children took longer to shift attention in the high interest (HH) competing trials ($M = 0.44$, $SD = 0.1$) than in the low interest (LL) competing trials ($M = 0.42$, $SD = 0.14$) confirmed that there was no significant difference, $t(25) = 0.8$, $p = .43$, $d = 0.25$. This latter finding goes against the predicted outcome. These results indicate that the differences seen within the Stimulus Interest variable as a whole are likely not due to the consistent trials and are displayed in Figure 4.5.

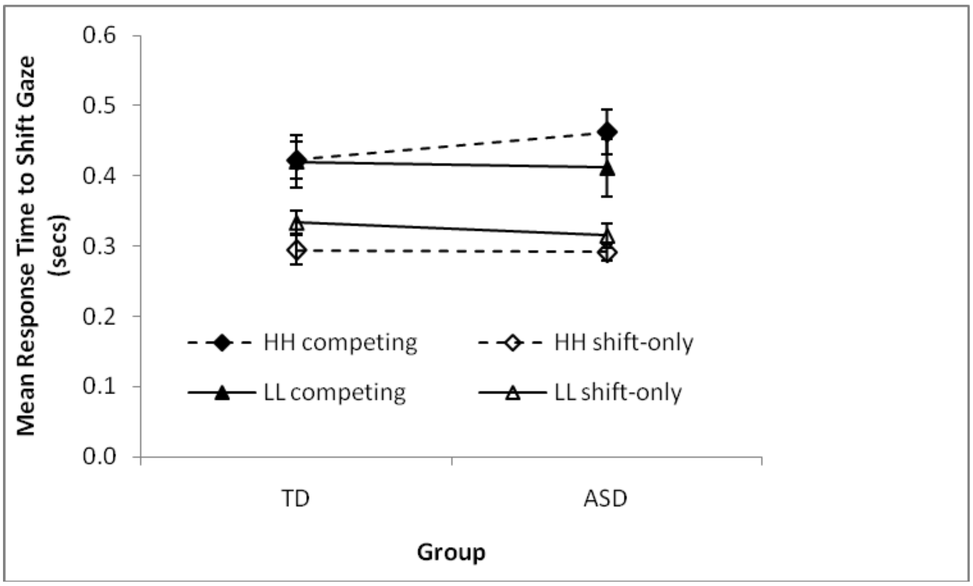


*Figure 4.5*: Mean latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions using static targets for the consistent trials. Error bars depict standard errors of the means.

To account for the potentially confounding factor of individual variation in baseline shifting ability, a second analysis was also conducted on the data for this planned comparison using the measure of disengagement outlined by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data a two-factor mixed design ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and the consistent Stimulus Interest trials (HH, LL) as the within-subjects factor. Results were consistent with the first analysis in that there was not a significant main effect of Stimulus Interest, $F(1, 24) = 2.7$, $p = .11$, $\eta^2 = .1$, or for Group, $F(1, 24) = 0.8$, $p = .39$, $\eta^2 = .03$. Additionally, no significant interaction was found for Group × Stimulus Interest, $F(1, 24) = 0.23$, $p = .64$, $\eta^2 = .01$, indicating again that the manipulation of stimulus interest did not evoke the expected results. However, a one-tailed dependent t-test was conducted to answer the specific question of whether the children took longer to disengage attention in the high interest (HH) trials (*M* = 0.15, *SD* = 0.09) than in the low interest (LL) trials (*M* = 0.09, *SD* = 0.14) did indicate a significant difference in the expected direction, $t(25) = 1.7$, $p = .05$, $d = 0.52$. Figure 4.6 is a graphical representation of the data.

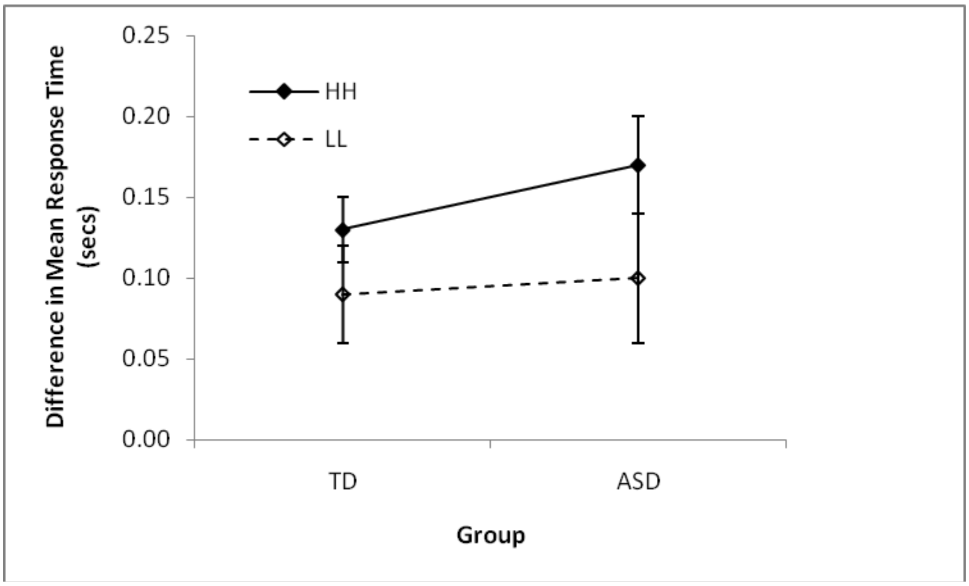


*Figure 4.6:* Difference in Mean Response Time between competing and shift-only trials for ASD and TD groups according to and interest level. Vertical lines depict standard errors of the means.

The second planned comparison was designed to examine if there was an effect of Stimulus Interest on the inconsistent (different types of lateral and central targets) trials. An additional analysis was conducted to examine and exclude the effect of Consistency. This was deemed important to ensure any resulting effects were due to the content of the stimuli used and not as a result of a novelty effect due to the screens playing different stimuli. To do this, the data were collapsed across the Stimulus Interest variable into two levels, Consistent

(HH, LL) and Inconsistent (HL, LH). These data were then analysed using a three-factor mixed design ANOVA, with two within-subjects factors Attention Type (Competing, Shift-only) and Stimulus Interest, and one between-subjects factor Group (ASD, TD). As only the main effect of Attention Type was significant, the influence of consistency alone on the reaction time was discounted and no further analysis was conducted on this variable. For this analysis, a final three factor ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) as one of the within-subjects factors. The second within-subjects factor in this analysis was labelled Position (HL, LH).

Results again showed a significant main effect for Attention Type, $F(1, 24) = 26.22$, $p = .01$, $\eta^2 = .22$, reflecting that the groups were slower in the Competing trials. There was not a significant main effect for Group, $F(1, 24) = 0.03$, $p = .89$, $\eta^2 = .01$, in keeping with the earlier findings. There was however, a significant main effect for Position, $F(1, 24) = 13.99$, $p = .01$, $\eta^2 = .37$, with the participants showing higher latencies when the high interest stimulus was in the centre than when it appeared on the lateral monitors.

No significant interaction effects were found for either Group × Attention Type, $F(1, 24) = 2.23$, $p = .15$, $\eta^2 = .09$, or Group × Attention Type × Position, $F(1, 24) = 0.47$, $p = .5$, $\eta^2 = .02$, consistent with the earlier findings for the consistent trials. However, a significant interaction was seen for Group × Position, $F(1, 24) = 5.23$, $p = .03$, $\eta^2 = .18$, somewhat against our expectations. Finally, a significant interaction was seen for Attention Type × Position, $F(1, 24) = 6.17$, $p = .02$, $\eta^2 = .2$, with the participants taking longer to respond in the Competing trials when the high interest stimuli was the fixation stimulus ($M = 0.48$, $SD = 0.15$) as opposed to lateral target ($M = 0.36$, $SD = 0.11$), $t(25) = 3.2$, $p = .01$, $d = .89$, reflecting that stimulus interest may have an effect on the speed of disengagement from a central target for static targets when the central and lateral targets differ. Figure 4.7 is a graphical representation of these findings.

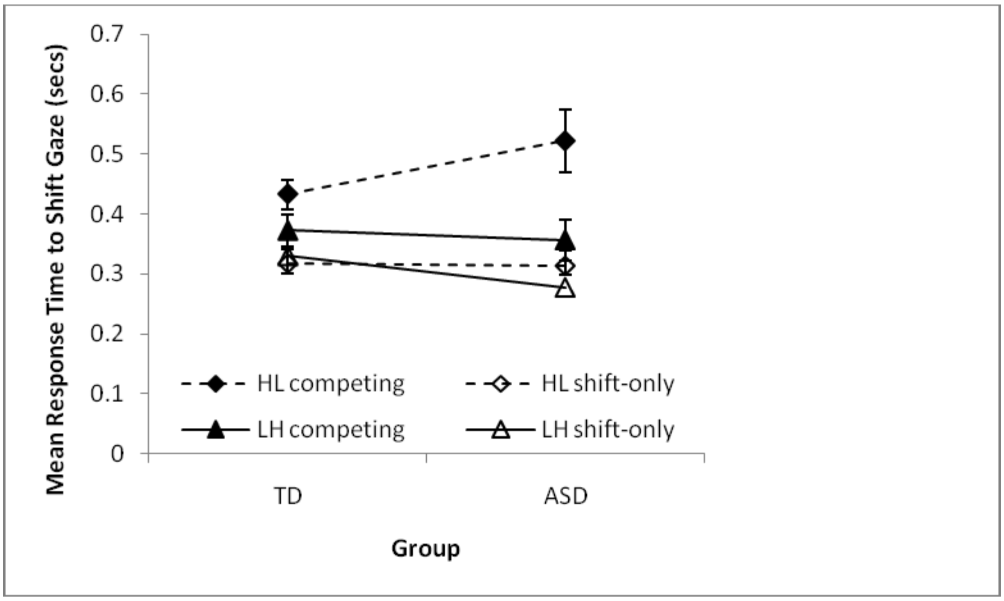


*Figure 4.7*: Mean latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions using static targets for the inconsistent trials. Error bars depict standard errors of the means.

Again, to account for the potentially confounding factor of individual variation in baseline shifting ability, a second analysis was also conducted on the data for this planned comparison using the measure of disengagement outlined by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data a two-factor ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and the consistent Position (HL, LH) as the within-subjects factor. Results were consistent with the first analysis in that there was a significant main effect Position, $F(1, 24) = 6.2, p = .02, \eta^2 = .2$, and none for Group, $F(1, 24) = 2.2, p = .15, \eta^2 = .08$. Additionally, no significant interaction was found for Group × Position, $F(1, 24) = 0.5, p = .01, \eta^2 = .02$, indicating that both groups showed longer latencies to disengage attention in the HL condition than in the LH condition. Figure 4.8 is a graphical representation of this data.

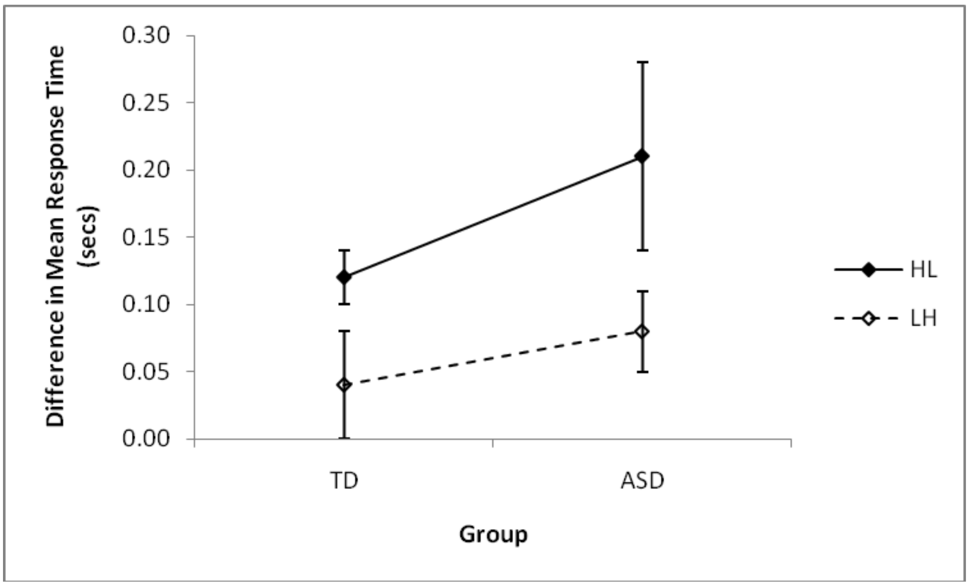


*Figure 4.8:* Difference in Mean Response Time between competing and shift-only trials for ASD and TD groups according to and interest level. Vertical lines depict standard errors of the means.

### *4.2.3. Discussion*

This experiment was conducted in order to test for interest effects on disengagement and expected, based on findings from experiment 3.2, that there would be slower disengagement from high interest stimuli in both groups. As expected, no group differences were seen in the ability to disengage from a central target, further indicating that the impairments seen in children with ASD in attentional disengagement are stimulus specific. Unexpectedly, no effect of stimulus interest was seen between the high and low conditions generally in the competing trials. This could indicate that the findings of experiment 3.2 may have been influenced stimuli features such as the colour differences between the high and low interest stimuli. However, when individual differences in baseline shifting ability were factored out using the procedure described by van der Geest et al. (2001) looking at the overall data, a significant difference in the expected direction did emerge. An effect of stimulus interest was also seen with both measures of disengagement when the central and lateral targets differed (the inconsistent trials) with slower disengagement from a central target when it is of high interest to the child.

## 4.3. Experiment 4.3

While attempts have been made to balance the form of the stimuli between the high and low interest conditions, this experiment was designed to balance the colour composition across conditions. For this experiment, the same four interest conditions were used as in experiment 4.2 (HH, HL, LH, and LL). However, to closely maintain the colour composition, pixelated versions of the high interest stimuli were used for the low interest stimuli.

It was expected that there would be a difference between the competing and shift-only trials, with the competing trials retaining attention for longer. It was also predicted that within the competing trials, there would be an interaction between Attention Type and Stimulus Interest, where differences between the interest conditions would be seen within the competing trials. Thirdly, it was expected that stimulus interest would affect the speed of disengagement and that both groups would be significantly slower to shift gaze in the high interest Competing trials (HH) than in the low interest Competing trials (LL). Finally, it was expected that both groups would be slower to shift gaze in the Competing trials when the high interest clip was in the central (HL) rather than the lateral monitors (LH).

### *4.3.1. Method*

#### 4.3.1.1. *Participants*

The same participants were used for this experiment as for those in experiment 4.2, however, two more ASD children were recruited from the Wakefield school. This led to 15 individuals (13 boys) with ASD in total, aged 6-12 years. It was possible to find two more matched pairs for the comparison group of 15 individuals (9 boys) with typical development (TD) aged 3-7 years, from the same mainstream schools and nurseries in the Durham region. Written informed consent was obtained from the parents of each child prior to any testing. Participants' non-verbal mental age (NVMA) was assessed using the Leiter International Performance Scale- Revised (Leiter-R; Roid & Miller, 1997) and attempts were made to individually match the children according to these scores. Ten out of the 15 pairs could be matched to within three months, the other 5 pairs had a difference of 7-13 months, the children with autism having the higher score in all cases. All participants had normal or corrected-to-normal visual acuity. Hence, the two groups did not differ in NVMA [$t(28) = 0.97$, $p = .34$] but did in Chronological Age (CA) [$t(28) = 11.7$, $p = .01$]. See Table 4.4 for details.

Table 4.6

*Means and standard deviations of non-verbal mental age and chronological age in years for ASD and TD children*

| | Age | | | NV Mental Age | |
|---|---|---|---|---|---|
| Group | Mean | Std Dev | | Mean | Std Dev |
| ASD | 9.5 | 1.58 | | 4.7 | 1.04 |
| TD | 4.2 | 0.75 | | 4.3 | 1.09 |

#### 4.3.1.2. *Materials*

The experimental set up and selection boards were identical to experiment 4.2 but the low interest stimuli were pixelated versions of the high interest ones. An example of each type of stimulus is given in Figure 4.9 below. More examples can be seen in Appendix C.

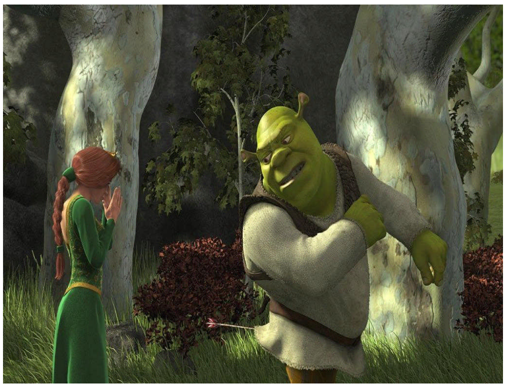

*Figure 4.9:* An example taken from the set of low interest (left image) and high interest (right image) stimuli.

#### 4.3.1.3. *Design*

The experiment used a mixed design with Group (ASD and TD) as between-participants factor and Attention Type as one within-participants factor consisting of two levels: Competing and Shift-only, and Stimulus Interest as the second within-participants factor with four levels (HH, LL, HL, LH). Counterbalancing was used to account for order effects between the 13 participants who took part in both this experiment and experiment 4.2.

#### 4.3.1.4. *Procedure.*

The selection task, trial sequence and coding procedure was the same as for experiment 4.2 but used the new low interest stimuli. The experimenter was the primary coder of this output but was blind to which type of stimulus was being presented to the child during the coding procedure. There was no significant difference in the proportion of completed trials between the TD group ($M$ = .96, $SD$ = .04) and the ASD group ($M$ = .94, $SD$ = .05), $t(28) = 1.46$, $p = .15$.

### *4.3.2. Results*

There was a good distribution of stimuli selected for both groups with no more than three participants in any group selecting any video type. The patterns of selections were also very similar between the groups. All of the images were either selected by the same number of participants in both groups or had a difference of one participant. Likewise, there was a similar distribution of selections across the two types of high interest stimuli, children's shows and computer animated films. The results are summarised in Table 4.7 below

Table 4.7

*The frequency of selection of each type of stimuli for ASD and TD children. The initials stand for Winnie the Pooh (PO), Barney and friends (BA), Thomas the Tank engine (TH,) Bear in the Big Blue House (BE), Bob the Builder (BO), the Incredibles (IN), Finding Nemo (NE), Shrek (SH), Monster's Inc. (MO), and Bug's Life (BU) respectively.*

| | Children's Shows | | | | | | Computer Gen Films | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | PO | BA | TH | BE | BO | Total | IN | NE | SH | MO | BU | Total |
| ASD | 2 | 1 | 2 | 0 | 3 | 8 | 1 | 2 | 3 | 2 | 1 | 7 |
| TD | 2 | 0 | 1 | 0 | 3 | 6 | 2 | 3 | 2 | 1 | 1 | 9 |
| Total | 4 | 1 | 3 | 0 | 6 | 14 | 3 | 5 | 5 | 3 | 2 | 16 |

Homogeneity of variance was verified using Levene's test (Levene, 1960). Dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967).

Mean Reaction Time was analysed using a three-factor mixed design ANOVA, with two within-subjects factors Attention Type (Competing, Shift-only) and Stimulus Interest, and one between-subjects factor Group (ASD, TD). Mauchly's test of sphericity was applied to confirm that the assumption of sphericity was valid for all factors. Results showed a significant main effect for Attention Type, $F(1, 28) = 45.49$, $p = .01$, $\eta^2 = .62$, reflecting that both groups were slower in the Competing condition. No main effect of Group was reported $F(1, 28) = 2.41$, $p = .13$, $\eta^2 = .08$, highlighting that children with ASD performed the task as quickly as TD children matched on non NVMA. There was a main effect of Stimulus Interest after the degrees of freedom were corrected using the Huynh-Feldt epsilon, to correct for a violation of the sphericity assumption, $F(2.6, 73.5) = 3.11$, $p = .04$, $\eta^2 = .1$, indicating there was a difference in the performance of all children which depended on the stimulus presented. Descriptive statistics can be seen in Table 4.8 below.

Table 4.8

*Mean, standard deviation and range for all interest pairings for both competing and shift-only trials.*

| | | Competing | | | | Shift-only | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group | | HH | HL | LH | LL | HH | HL | LH | LL |
| TD | Mean | 0.41 | 0.41 | 0.37 | 0.43 | 0.27 | 0.31 | 0.33 | 0.35 |
| | Std dev | 0.10 | 0.08 | 0.10 | 0.15 | 0.05 | 0.09 | 0.10 | 0.06 |
| | Range | 0.31 | 0.19 | 0.27 | 0.42 | 0.17 | 0.31 | 0.35 | 0.17 |
| ASD | Mean | 0.47 | 0.48 | 0.39 | 0.39 | 0.30 | 0.34 | 0.30 | 0.37 |
| | Std dev | 0.12 | 0.20 | 0.13 | 0.17 | 0.04 | 0.10 | 0.10 | 0.18 |
| | Range | 0.35 | 0.61 | 0.38 | 0.54 | 0.15 | 0.31 | 0.33 | 0.58 |

As in experiment 4.2, no interaction was found for Group × Attention Type × Stimulus Interest, $F(3, 84) = 0.18$, $p = .91$, $\eta^2 = .01$, Group × Attention Type, $F(1, 28) = 1.51$, $p = .23$, $\eta^2 = .05$, Group × Stimulus Interest, $F(2.6, 84) = 0.88$, $p = .47$, $\eta^2 = .03$, further emphasising that both groups responded as quickly as each other in all conditions. Findings are displayed on Figure 4.10 below. However, a significant interaction was seen for Attention Type × Stimulus Interest, $F(3, 84) = 11.04$, p = .01, $\eta^2 = .28$ , as expected. Two post-hoc planned comparison ANOVAs were then carried out. Results are displayed in Figure 4.10.

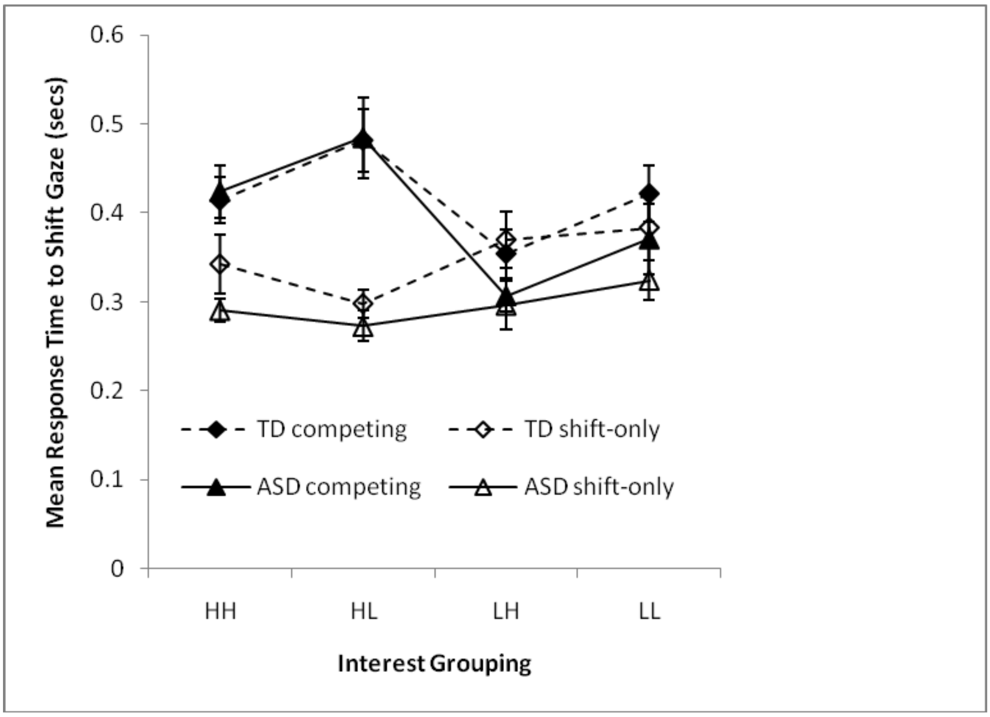


*Figure 4.10*: Mean latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions using static targets matched by colour. Error bars depict standard errors of the means.

The first used only the data from the high interest (H-H) and low interest (L-L) conditions. These data were analysed using a three-way mixed design ANOVA, with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) and Stimulus Interest (HH, LL) as the within-subjects factors. Results again showed a significant main effect for attention type, $F(1, 28) = 14.77$, $p = .01$, $\eta^2 = .35$. There was not a significant main effect for Group, $F(1, 28) = 1.87$, $p = .18$., $\eta^2 = .06$, or for Stimulus Interest, $F(1, 28) = 0.12$, $p = .73$, $\eta^2 = .01$.

No significant interactions were seen for any of the potential combinations: Group × Attention Type × Stimulus Interest, $F(1, 28) = 0.67$, $p = .42$, $\eta^2 = .02$, Group × Attention Type, $F(1, 28) = 0.85$, $p = .37$, $\eta^2 = .06$, Group × Stimulus Interest, $F(1, 28) = 0.67$, $p = .42$, $\eta^2 = .02$, or Attention Type × Stimulus Interest, $F(1, 28) = 3.39$, $p = .08$, $\eta^2 = .11$, the last of which was contrary to our expectations but consistent with the findings of experiment 4.2. A dependent t-test was conducted on the data to answer the specific question of whether the children took longer to shift attention in the high interest (HH) competing trials ($M = 0.42$, $SD = 0.11$) than in the low interest (LL) competing trials ($M = 0.4$, $SD = 0.14$) confirmed that there was no significant difference, $t(29) = 0.81$, $p = .42$, $d = .16$. This latter finding goes against the predicted outcome but is again consistent with the findings of experiment 4.2. These results seem to confirm that the differences seen within the Stimulus Interest variable are likely not due to the stimulus alone and are displayed in Figure 4.11 below.

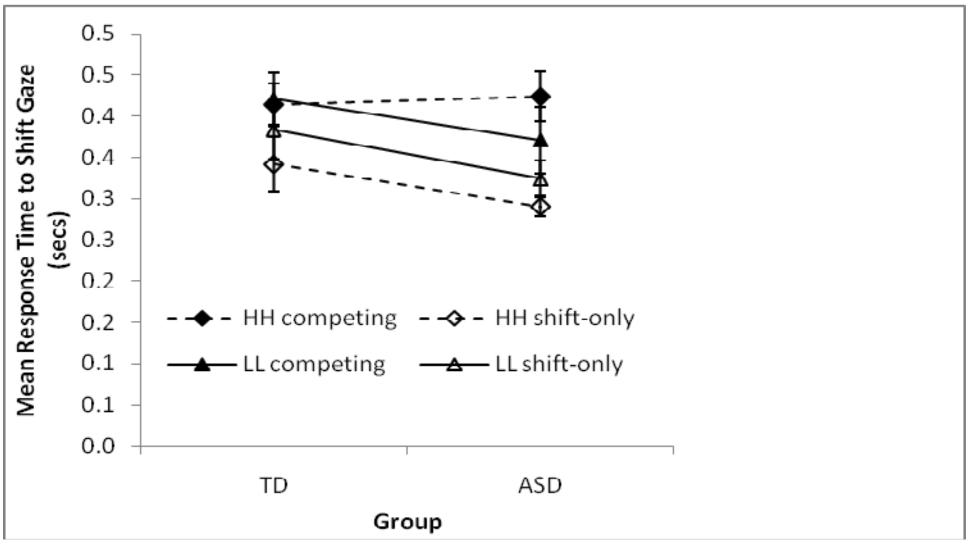


*Figure 4.11:* Mean latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions using static targets for the consistent trials. Error bars depict standard errors of the means.

To account for the potentially confounding factor of individual variation in baseline shifting ability, a second analysis was also conducted on the data for this planned comparison using the measure of disengagement outlined by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data a two-factor mixed design ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and the consistent Stimulus Interest trials (HL, LL) as the within-subjects factor. Results were consistent with the first analysis in that there was not a significant main effect Stimulus Interest, $F(1, 28) = 3.4$, $p = .08$, $\eta^2 = .11$, or for Group, $F(1, 28) = 0.9$, $p = .36$, $\eta^2 = .03$. Additionally, no significant interaction was found for Group × Stimulus Interest, $F(1, 28) = 0.73$, $p = .42$, $\eta^2 = .02$, indicating again that the manipulation of stimulus interest did not evoke the expected results. However, as in experiment 4.2, a one-tailed dependent t-test was carried out to answer the specific question of whether the children took longer to disengage attention in the high interest (HH) trials (M = 0.15, SD = 0.09) than in the low interest (LL) trials (M = 0.09, SD = 0.14) did indicate a significant difference in the expected direction, t(29) = 1.9, p = .04, d = 0.45. Results are depicted in

*Figure 4.12* below.

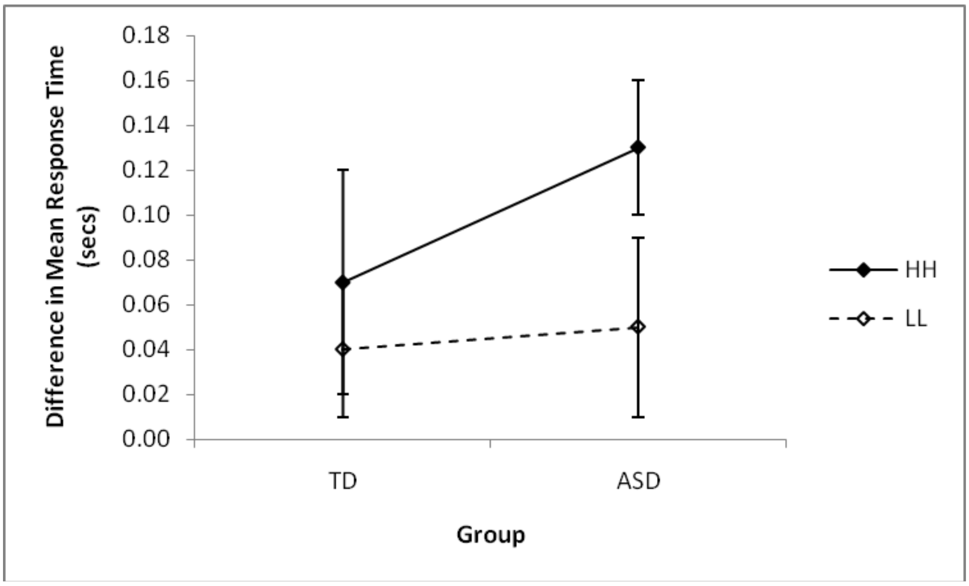


*Figure 4.12:* Difference in Mean Response Time between competing and shift-only trials for ASD and TD groups according to and interest level. Vertical lines depict standard errors of the means.

The second planned comparison was designed to examine if there was an effect of Stimulus Interest on the inconsistent (different lateral and central targets) trials. To ensure any resulting effects were due to the nature of the stimuli used and not that the screens were playing different stimuli, the data was first collapsed across the Stimulus Interest variable into two levels, Consistent (HH, LL) and Inconsistent (HL,LH). These data were then analysed using a three-factor mixed design ANOVA, with two within-subjects factors Attention Type (Competing, Shift-only) and Stimulus Interest, and one between-subjects factor Group (ASD, TD). As only the main effect of Attention Type was significant, the influence of consistency alone on the reaction time was discounted and no further analysis was conducted on this variable. For the comparison, a final three factor ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and Attention Type (Competing, Shift-only) as one of the within-subjects factors. The second within-subjects factor in this analysis was labelled Position (HL, LH).

Results again showed a significant main effect for Attention Type, $F(1, 28) = 31.16$, $p = .01$, $\eta^2 = .52$, reflecting that the groups were slower in the Competing trials. There was not a significant main effect for Group, $F(1, 28) = 1.82$, $p = .19$, $\eta^2 = .06$, in keeping with the earlier findings. There was however, a significant main effect for Position, $F(1, 28) = 10.59$, $p = .01$, $\eta^2 = .27$, with the participants showing higher latencies when the high interest stimulus was in the centre than when it appeared on the lateral monitors.

No significant interaction effects were found for either or Group × Attention Type × Position, $F(1, 28) = 0.01$, $p = .99$, $\eta^2 = .08$, consistent with earlier findings, and no significant interaction was seen for Group × Position, $F(1, 28) =2.13$, $p = .14$, $\eta^2 = .01$, against our expectations. Finally a significant interaction was seen for Attention Type × Position, $F(1, 28) = 24.49$, $p = .01$, $\eta^2 = .47$, with the participants taking longer to respond in the Competing trials when the high interest stimuli was the fixation stimulus ($M = 0.48$, $SD = 0.16$) as opposed to lateral target ($M = 0.33$, $SD = 0.09$), $t(29) = 5.45$, $p = .01$. This is consistent with the findings of experiment 4.2 and reflects that stimulus interest may have an effect on the speed of disengagement from a central target for static targets but only when the central and lateral targets differ. Results are displayed on

*Figure 4.13*.

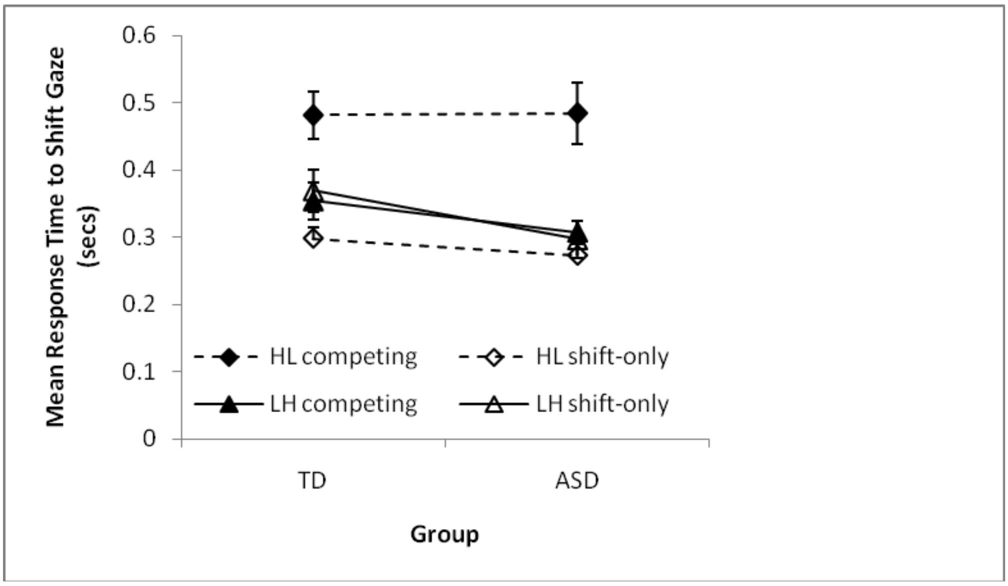


*Figure 4.13*: Mean latency to respond to the lateral stimulus for ASD and TD groups in the Competing and Shift-only conditions using static targets for the inconsistent trials. Error bars depict standard errors of the means.

Again, to account for the potentially confounding factor of individual variation in baseline shifting ability, a second analysis was also conducted on the data for this planned comparison using the measure of disengagement outlined by van der Geest et al. (2001). For this, each individual's mean reaction time in the shift-only trials was subtracted from their mean reaction time in the competing trials. To analyse this data a two-factor ANOVA was conducted with Group (ASD, TD) as the between-subjects factor, and the consistent Position (HL, LH) as the within-subjects factor. Results were consistent with the first analysis in that there was a significant main effect for Position, $F(1, 28) = 24.5$, $p = .01$, $\eta^2 = .47$, and none for Group, $F(1, 28) = 0.6$, $p = .42$, $\eta^2 = .01$. Additionally, no significant interaction was found for Group × Position, $F(1, 28) = 0.1$, $p = .98$, $\eta^2 = .01$, indicating that both groups showed longer latencies to disengage attention in the HL condition than in the LH condition. Figure 4.14is a graphical representation of this data.

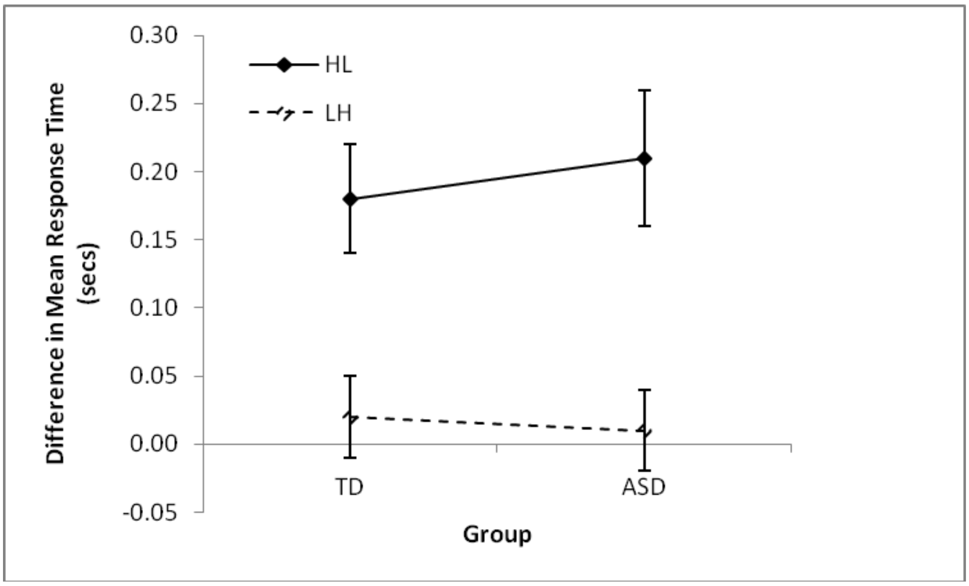


*Figure 4.14*: Difference in Mean Response Time between competing and shift-only trials for ASD and TD groups according to interest level. Vertical lines depict standard errors of the means.

### *4.3.3. Discussion*

As expected, no group differences were seen in the ability to disengage from a central target, further indicating that the impairments seen in children with ASD in attentional disengagement are stimulus specific. Unexpectedly, but consistent with the findings of experiment 4.2, no effect of stimulus interest was seen between the high and low conditions generally. However, once again, when individual differences in baseline shifting ability were factored out using the procedure described by van der Geest et al. (2001) looking at the overall data, a significant difference in the expected direction did emerge. Individually, this finding could indicate that the results of experiment 3.2 may have been influenced by the differences in the form of the images (i.e. reality against computer generated images) between the high and low interest stimuli in the high interest clips but an effect of stimulus interest was clearly seen when the central and lateral targets differed (the inconsistent trials). It should also be noted that there is considerable similarity between the pattern of data between this experiment and that of experiment 4.2.

## 4.4. General Discussion

The finding that there was slower disengagement from dynamic abstract stimuli in both groups in experiment 4.1 again highlights the importance of stimulus features when conducting studies of this nature. This tendency was consistent across groups rather than having a greater effect on the ASD children, as would have been expected if the type of motion explained the disengagement difficulties in the ASD group in experiment 3.1 and Landry and Bryson (2004). As such, it cannot be concluded that this specific type of motion would be more difficult for an ASD child to disengage attention from than more naturalistic motion types. Unfortunately, neither can it be concluded that features other than motion or more top-down mechanisms such as stimulus interest are the basis of the slowing of response time for the ASD children reported in experiment 3.1, as no group differences were seen in the any of the competing trials, against expectations. The lack of this ability to replicate previous findings makes interpretation difficult and sheds doubt as the existence of a specific impairment of the ASD child's ability to disengage.

Despite this drawback, on further analysis of the data, it emerged that the base shifting ability of the children with ASD was unusually fast when compared both with the TD children in this sample and with the ASD group in experiment 3.1. As the purpose of this study was to measure attentional disengagement and not this baseline measure, the alternative measure of disengagement used in the second analysis of the data was deemed a more valid measure in this case. This method involved subtracting each individuals response time in the shift –only trials from their response time in the competing trials thereby factoring out the individual variation in this ability. This analysis still did not indicate a differential group difference in disengagement for the dynamic abstract stimulus. Rather, there was a more general group difference with the ASD children being slower to disengage generally with both the dynamic and static stimuli.

The final two experiments in this chapter removed the motion of the stimulus from the equation to more fully examine stimulus interest and other features of the stimuli. The results of both experiments were markedly similar indicating that stimulus interest effects were present but not inevitable. As expected, no group differences were seen in the ability to disengage from a central target in either experiment, further indicating that the impairments seen in children with ASD in attentional disengagement may be stimulus specific. Unexpectedly, no effects of stimulus interest were seen between the high and low conditions generally in either experiment. This finding is contrary to the finding of experiment 3.2 and suggests that stimulus interest may not have been the factor contributing to the slower disengagement when the stimuli are of interest to the child. Significant effects were seen in both experiments when individual variation in shifting ability within the conditions were accounted for but it should be noted that in both cases the effect size of these calculations were considerably less than those found in experiment 3.2.

Despite these findings, an effect of stimulus interest was seen when the central and lateral targets differed (the inconsistent trials) in both experiments with slower disengagement from a central target when it is of high interest to the child. These findings were robust regardless of the measure of disengagement used. As the consistency itself was shown not to be a factor in these analyses and the physical features of the stimuli were balanced, it is argued that it was the preferential interest of the children for the stimuli which was at the root of the differences found in these trials.

Taken together, the results of the experiments in this chapter suggest that the role of stimulus interest may not have as strong an effect on disengagement as previously argued but rather may affect disengagement under restricted conditions. Neither is it completely clear how exactly the role of the motion of the stimulus plays within the ASD group due to the failure to replicate exactly the findings of experiment 3.1. What is clear is that both motion and stimulus interest do contribute to the ability of both groups to shift attention when two stimuli are competing for attention. It is also clear that they appear to contribute to both groups to a similar degree. Most interestingly, the findings relating to stimulus interest having a much stronger effect in the inconsistent trials indicates that the role of stimulus interest on disengagement is not as straightforward as was previously considered.

To help interpret these unexpected findings, it is necessary to consider the original model of attention put forward by Posner and Petersen (1990). The research on disengagement rarely emphasises the importance of attentional engagement in the gap paradigm as this method of experimentation is more commonly referred to. This is despite the importance placed on this process to occur as a necessary precursor to disengagement. If the central stimulus has not been engaged, when the child shifts their attention from it there is no need for them to disengage. By including the process of engagement in the interpretation of the findings of experiments 4.2 and 4.3, it is apparent that stimulus interest, as a top down process guiding attention shifts, likely affected both the disengagement from the fixations stimulus and the speed in engaging the lateral target. That engagement is also stimulus-specific has been indicated by work on attentional capture (Greenaway & Plaisted, 2005) and eye movement studies (Hayhoe, & Ballard, 2005).

The initial failure to replicate experiment 3.1 is problematic for interpretation. This finding might have been in part due to the limited sample size of this study. However, a power analysis based on Landry and Bryson’s (2004) data was conducted before any testing was carried out and indicated that even very small samples (12 per group) would be sensitive enough to show group differences due to the large effect size seen. Rather, what this lack of significance does imply is that impairments in disengagement from abstract stimuli are neither an obligatory nor a sufficient correlate of ASD. This does not disprove previous findings as there is likely a general tendency for ASD children to find this more difficult than their matched controls.

It is also possible that the children with autism in this sample who did not show impairments represented a subgroup less susceptible to these types of abstract stimuli. This interpretation is consistent with the finding that they seemed to be unusually fast responders in the Shift-only trials and the finding of a group difference in disengagement from both types of stimuli when these trials were factored out. Alternatively, the individual differences within the ASD group shown on this occasion could also arguably be seen as further evidence for the role of stimulus interest and/ or other top-down processes on the slowing of disengagement normally seen with these types of stimuli. That there are some individuals with ASD not as susceptible to this effect indicates that it may be a general tendency rather than a specific impairment.

The finding that the dynamic nature of a stimulus increased the latency to disengage from it could have had ramifications for the two static experiments. It was noted that the reaction times to shift attention in the competing trials in experiments 4.2 and 4.3 were much faster than in experiment 3.2 generally. This is consistent with the findings of experiment 4.1, that the motion of stimulus contributes to how quickly the participants can disengage. It is likely that with this reduction in the effect of the stimulus generally, the potential effect size of the experiments would also have been reduced and therefore a larger sample than anticipated was needed.

Related to the sampling difficulties encountered, a substantial portion of the ASD children in experiments 4.2 and 4.3 had previously been tested in Chapter 3. This was largely a result of limited access to children with ASD. Though there is a possibility that this could have influenced the findings, six months had passed between testing dates. Also, the total length of exposure to the abstract stimuli within the experiments was very short and it is unlikely that practice effects would have carried over to the second occasion.

In conclusion, it has been shown that both stimulus motion and interest are contributing factors in the speed of disengagement for both ASD and TD children. However, stimuli motion appears to have a similar effect on both groups and stimulus interest was only a factor when the fixation stimulus and lateral targets were inconsistent with each other in the absence of this motion. In addition, the divergence of the findings of experiment 4.1 from previous work in Chapter 3 with regard to group differences suggests that the slowing of disengagement from dynamic abstract stimuli in the ASD group may result from a general tendency rather than a specific impairment in this process.

# Chapter 5. STIMULUS INTEREST, ENGAGEMENT AND DISENGAGEMENT

Thus far, this thesis has attempted to examine the apparent slower disengagement of attention exhibited by children with ASD when presented with dynamic abstract stimuli in experiment 3.1. This was then extended to demonstrate that these same children showed typical attention patterns with other types of dynamic stimuli in experiment 3.2. It was noted within this latter type of stimuli that disengagement for both groups was slower when the stimuli were more intrinsically interesting for the participant.

As a follow up to these findings, experimentation was conducted to further examine the effects the physical features of the stimuli on the speed of disengagement. It was first noted that the motion of the stimulus had a strong effect on disengagement, with static targets resulting in faster response times to shift attention in experiment 4.1. However, the strength of this effect seemed to be equivalent across the groups. Secondly, it was shown in experiments 4.2 and 4.3 that when physical features of the stimuli were controlled, stimulus interest seemed to have less of an effect on disengagement. This sheds some doubt on the reliability on the argument that the apparent group difference shown disengaging from dynamic abstract stimuli could be due to interest factors.

Posner, Walker, Friedrich, and Rafal (1984) described attentional disengagement as a function of the depth of involvement in the task. As this component of attention was not possible to observe directly, they used the gap-overlap paradigm in which they compared attentional shifts when attention was engaged (Competing trials) to when it was not (Shift-only trials). This method is now one of the most widely used paradigms to measure disengagement. However, it is arguable that the assumption of this baseline level of engagement on the initial fixation stimulus, has led to researchers to conclude the existence of disengagement difficulties in some populations when in fact, the paradigm may equally be indicating differences in groups' initial engagement of the fixation point. As this initial engagement level would occur before the lateral target was triggered, top-down modulating factors such as stimulus interest or general task interest (the child's motivation to perform well in the experiment) could have dramatic effects on the strength of this initial engagement and thus the resulting disengagement latency.

Van der Geest et al. (2001) suggested and approached this paradigm differently by using a more direct measure to compare the two types of attention trials, subtracting the results from the Shift-only from the Competing trials. This resulted in a final score that they called "gap trials". According to the theoretical underpinnings of the gap paradigm, this would be an effective way of removing individual variation in the baseline shifting measures of the individual participants. They found that although no significant differences between ASD and TD groups were observed, this gap effect was significantly smaller in the autistic group than in the control group. They argued that the strength of attentional engagement to the initial fixation point was reflected by this difference and, consistent with this finding, the ASD children showed more express saccades than the control group. They concluded from this that children with ASD had problems with initiating engagement rather than disengagement.

There are two concerns with this conclusion. The first is the theoretical one already mentioned: that is the implicit assumption that the Shift-only trials encompass the full process of engagement once the eyes have reached their target. This is as a result of the widely held assumption that an eye movement cannot initiate until attention has fully engaged on the target. However, engagement is an internal process and it is hard to see how the termination of this process can be measured directly using this method. It could be argued that the Shift-only trials, rather than measuring the full process of attentional engagement, only measure the participant's ability to process the lateral target at some preliminary level and shift their focus to it.

The second concern is at a methodological level and that is that the lateral and central targets in their study were not consistent with each other. As we have seen from experiments 4.2 and 4.3 and for the TD children in experiment 3.2, the latency to shift to a lateral target on inconsistent trials was dependent on the stimuli used in each position. As a result, it cannot be concluded without question from van der Geest's et al. (2001) findings, that children with ASD have a general engagement difficulty. It is however, unlikely that the inconsistency in their stimuli was a major contributing factor, due to the simplicity of the stimuli used. Both central and lateral targets were simple abstract shapes and as has been made apparent from experiments 4.2 and 4.3 it is not inconsistency itself that resulted in slower disengagement but inconsistency in the stimulus interest between the targets. Inconsistent trials are however, likely to be important for studies involving more complex stimuli which have inherent differences in interest value such as those used in this thesis.

These drawbacks highlight a fundamental deficit in the gap paradigm itself rather than with the study of van der Geest et al. (2001). Essentially, the problem with conclusions based on this paradigm is that there is an inherent difficulty with separating the components of attention, as described by Posner et al. (1984). According to Posner, disengagement is how long it takes attention to be removed from a focus point, but it is also described as a function of the level of engagement in that stimulus. In other words, the strength of engagement in a stimulus is characterised by how difficult it is to disengage from. Hence, for the paradigm to accurately measure disengagement, the strength of the initial engagement needs to be factored out. By taking account and attempting to moderate the level of stimulus interest before recording the experiment itself, the studies in this thesis have made some progress in controlling this initial level of engagement. However, none of the studies thus far have made attempts to identify an accurate measure for stimulus interest and/ or engagement, in order to compare more directly the disengagement effects seen. As an attempt to accomplish this, measuring persistence of looking in a preferential looking task would give a comparative score of the strength of stimulus interest and also how engaging the different stimuli are for the participants.

Persistence and preference are the key determinants of "individual interest" as described by Ainley, Hidi, and Berndorff, (2002) and are how this thesis defined interest in general (see section 2.7). Before continuing, it is important to explain the difference between interest and engagement. What differentiates the two concepts primarily is that individual or stimulus interest also has cognitive and affective components and as such can be considered a top-down process as described in Chapter 1, whereas engagement is described as a basic attentional process which in theory may occur in the absence of interest. Essentially, interest as has been defined in this thesis, encompasses engagement when the stimulus has content or features which can be appraised as interesting and it is argued, the level of engagement is a function of that interest. Where no interest is experienced, engagement can occur alone however, as already argued, the influence of task demands such as social pressure in any testing situation makes the ideal situation of a pure engagement score difficult if not impossible to achieve. Hence, it is arguably better to use a measure of relative interest which encompasses both in determining a participant's ability to disengage from stimuli.

To accomplish this, a procedure using preference selection was designed to assess the children's relative preference for the three different types of stimuli (abstract, high interest, low interest). The purpose of this was twofold. Firstly, it was intended to use it to validate the clips that were chosen to be of high interest were looked at for longer than the low interest stimuli. Secondly, it was used to give an estimate of how engaging each participant found the different stimuli overall by giving a measure of relative interest.

A second task was then designed based on the gap paradigm used in previous chapters to examine comparative disengagement from these three stimulus types. The results of these tasks were then compared. Its goal was to explore the proposition that attentional disengagement from abstract stimuli is slowed in children with ASD because they function as stimuli of high interest for them. Only children with ASD were included in this study to examine more closely the profile of their performance. It was expected that if the initial level of engagement due to interest on a central target was the most important determinant in the speed of disengagement that the results of both of these experiments would follow the same pattern. More specifically, it was expected that children with ASD would both show a higher preference for and take longer to disengage from high interest and abstract trials compared with the low interest trials. Additionally, no differences were expected between the high interest and abstract trials on either measure if stimulus interest was the main contributor to the group differences exhibited in experiment 3.1.

## 5.1. Method

### *5.1.1. Participants*

Fifteen individuals (14 boys) with ASD, aged 6-11 years, were recruited from special schools for autism in the York and Middlesbrough areas. Nine of these participants had previously been exposed to the testing in the Chapter 3 and seven of these had also been participants in experiments 4.2 and 4.3. These had all been diagnosed by experienced clinicians in a multidisciplinary team by the Autistic Spectrum Disorders Forum, held at York District Hospital using the criteria of the ICD-10, *International Classification of Disease (ICD-IO;* World Health Organization, 1992) guidelines. The remaining six children were diagnosed according to the DSM IV criteria for ASD at James Cook University Hospital in Middlesbrough- Social Communication Assessment Team (SCAT) and five of these had been exposed to the testing in experiment 4.1. The team uses a variety of assessment tools to guide diagnosis including the CARS, 3Di, DISCO. At least 6 months had passed between testing occasions for those children who had been tested before. Participants' non-verbal mental age (NVMA) was assessed using the Leiter International Performance Scale- Revised (Leiter-R; Roid & Miller, 1997). See Table 5.1 for details.

Table 5.1

*Means and standard deviations of non-verbal mental age and chronological age in years for the ASD children*

| Age | | NV Mental Age | |
|---|---|---|---|
| Mean | Std Dev | Mean | Std Dev |
| 8.4 | 1.4 | 4.3 | 0.9 |

### *5.1.2. Materials*

The materials and experimental set up were the same as for the experiments conducted in Chapter 3. The abstract stimuli were the same as those used in experiment 3.1. The stimulus videos for the interest task came from the same sources as in experiments 3.2. These clips were all 10 seconds in length as the extra duration was needed to establish the relative preference for the different types of stimuli and measure the persistence of this preference.

### *5.1.3. Design*

The experiment used a within participant design with Stimulus Interest (High, Low, Abstract) as the within-participants factor. Counterbalancing was used to account for order effects between the two parts of the experiment.

### *5.1.4. Procedure*

#### 5.1.4.1. *High interest video selection task*

*Preference Selection*

Each participant was presented with two selection boards simultaneously, one containing static images from the television shows and one containing images from the animated films, and given the opportunity to choose their preferred stimulus. To ensure that one group did not disproportionately choose one video over the others, the selection board which did not contain the image of the video that had been selected by the most people in that group up to that point was presented to the child. To validate this preference and to ensure the selection was a persistent interest, the participant was then presented with a validation task.

*Validation Task*

This was a shorter version of the validation task used in Chapters 3 and 4. Only the lateral monitors were used for this experiment. The clips were arranged into sets before the experiment began each containing three clips from the high interest group. The set which contained the favoured clip selected by the child was then presented. Each trial consisted of two of these clips being played simultaneously on the outer monitors for a period of up to 20 seconds until a clear preference was determined, defined as watching the clip for approximately five seconds longer than the alternative. Each video clip was shown twice paired with other potential high interest videos. No video was displayed on the same screen twice and the order of presentation of these trials was randomised. In the unusual event the child did not preferentially attend to the clip they had chosen, the task could be abandoned and the child allowed another selection before re-presenting the task. This did not occur with any of the participants.

#### 5.1.4.2. *Interest task*

The experimenter sat behind the child and gave positive feedback if the child appeared relaxed and interested in completing the task. Feedback was not given for looking at any particular screen. At the beginning of the experiment, the child was instructed to look at the centre screen until the videos appeared, then to watch whichever video they preferred.

*Trial sequence.*

The general operation of the interest task was similar to the preference selection task in that only the two lateral screens were used. Each trial began with the experimenter asking the participant to look at the centre screen with all three screens blank. Once the participant complied the trial was initiated and each of the lateral monitors played one of the prepared video clips simultaneously. There were twelve 10 second trials in total, four for each video pairing (High-Low, High-Abstract, Low-Abstract). These were presented in sequence, then in the reverse order on the two lateral monitors to balance against any order effects. No positive feedback was given during the trials and it was not required for the participants to watch either monitor.

*Coding Procedure.*

Results were coded using the Observer XT software package. The video recordings were slowed and played back frame by frame. The location at which the child was looking was recorded as either: high, low, abstract or other (for when their gaze was not on either screen) throughout the trials and a mean duration looking at each stimulus over all the trials was calculated.

#### 5.1.4.3. *Attention task.*

At the beginning of this task, the child was instructed to look at the videos when they appeared. The experimenter sat behind the child during the task and gave positive feedback if the child appeared relaxed and interested in completing it. Feedback was not given for looking at any specific screen.

*Trial sequence.*

Trials were administered in three separate blocks according to stimulus type. These blocks were presented to each participant in a random order. In all trials, a video appeared in the central monitor for up to 8 seconds. Once the child attended to it, the experimenter triggered a display on a lateral monitor with a delay of 250 ms. The time gap was chosen to be consistent with Landry and Bryson (2004) and our previous experiments in Chapters 3 and 4. The lateral monitor presented another video of the same stimulus type and continued until the child made an eye or head movement towards it or for a maximum of 5 seconds. Each block consisted of 16 trials and were divided equally into two types, Competing and Shift-only trials which were presented in a random order within the block. In the Competing trials, the central video continued playing throughout the trial, whereas for the Shift-only trials, the central stimulus ceased playing when the lateral target was triggered. The presentation of the lateral target was equally distributed across the left and right monitors. Trials could be replaced if deemed invalid, such as when the child looked away before a lateral stimulus was triggered.

*Coding Procedure.*

Results were coded using the Observer XT software package. The video recordings were slowed and played back frame by frame. The onset of each lateral stimulus and the point at which an eye shift towards that stimulus was made were recorded for each trial. Latency to complete this eye shift was then calculated in milliseconds. Trials in which the participants were not looking at the central stimulus at the onset of a peripheral and trials with initial eye shifts to areas other than in the active target were deemed invalid and not included in the analysis. However, this amounted to less than 4 % of the total trials.

## 5.2. Results

There was a good distribution of stimuli selection from the range available with no more than three participants selecting any video type. The results are summarised in Table 5.2 below

Table 5.2

*The frequency of selection of each type of stimuli for ASD children. The initials stand for Winnie the Pooh (PO), Barney and friends (BA), Thomas the Tank engine (TH,) Bear in the Big Blue House (BE), Bob the Builder (BO), the Incredibles (IN), Finding Nemo (NE), Shrek (SH), Monster's Inc. (MO), and Bug's Life (BU) respectively.*

| Children's Shows | | | | | | Computer Gen Films | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PO | BA | TH | BE | BO | Total | IN | NE | SH | MO | BU | Total |
| 3 | 2 | 2 | 0 | 1 | 8 | 2 | 2 | 1 | 1 | 1 | 7 |

For all analyses, dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967). Dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967). For the analyses ANCOVAs were first carried out on all analyses with CA as a covariate. This factor was not significant so the simpler ANOVAs were used. All tests were performed at $\alpha = .05$.

*Analysis of Interest Task*

Mean duration spent looking at each stimulus was calculated across all trials. The data were then analysed using a one way repeated measures ANOVA Stimulus (High, Low, Abstract) as the within participants factor. A significant main effect was seen for Stimulus, $F(2, 28) = 4.2$, $p = .02$, $\eta^2 = .23$, as expected, indicating that the participants preferred the high interest videos over others generally. To pinpoint where these differences occurred, pairwise comparison testing was conducted on the data using LSD technique. Significant differences for mean duration of looking were found between the low interest stimuli and both the abstract, p = .01, and the high interest stimuli, p = .04, but no difference was seen between the abstract and high interest stimuli, p = .6. This indicates that ASD children spent more time looking at both the abstract videos (M = 4.8, SD = 1.61) and high interest videos (M = 5.28, SD = 1.51) on average than the low interest videos (M = 4, SD = 1.64) as would be expected if the children with ASD found them equally interesting. Results are displayed in Figure 5.1.

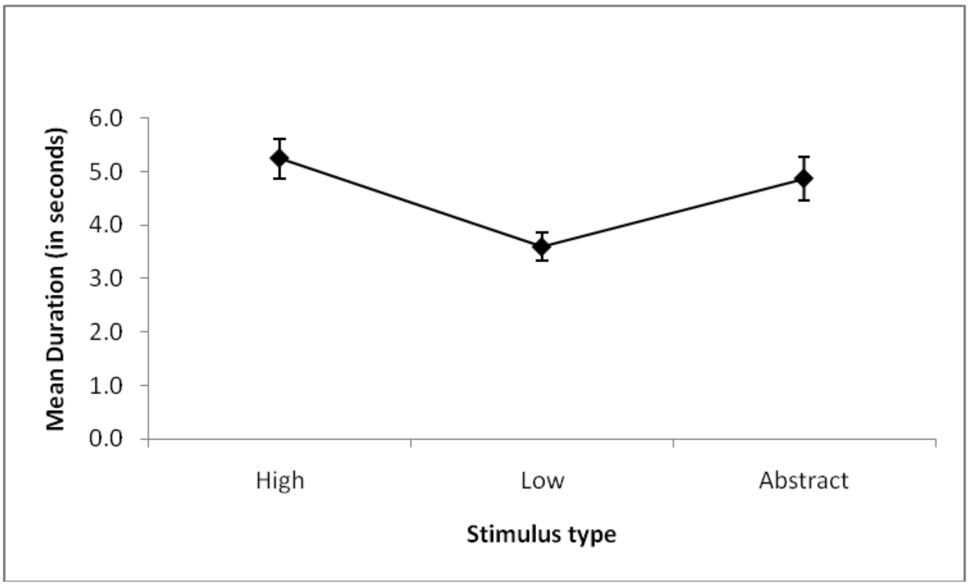


*Figure 5.1:* Mean duration spent looking toward each video type by children with ASD. Error bars depict standard error of the mean

This trend was mirrored when comparing the data from the individual video pairings. A related sample t-test conducted on just the data from the high-low video pairings indicated that the children spent significantly longer duration looking at the high interest stimuli relative to the low interest stimuli. Similar findings were found when comparing the abstract-low video pairings. The abstract stimuli were looked at for significantly longer than the low interest stimuli. The final related t-test was conducted on the high-abstract video pairings and the results indicated no significant difference between the mean duration spent looking at the abstract stimuli and the high interest stimuli, reflecting no clear preference between them.

These findings indicated that the ASD children strongly preferred both the high interest and abstract videos over the low interest ones but that their attention was divided when both the abstract and high interest stimulus were being displayed together.

*Analysis of Attention Task*

For all analyses, dependent variables were checked for normality by inspection of normal Q-Q plots and by using the Kolmogorov-Smirnov test with Lilliefors correction (Lilliefors, 1967). An ANCOVA was first carried out on all analyses with CA as a covariate. This factor was not significant so the simpler ANOVAs were used. All tests were performed at $\alpha = .05$.

The mean Reaction Time data were analysed using a two-factor repeated measures ANOVA. The two within-participants factors were Attention Type (Competing, Shift-only) and Stimulus Type (Abstract, High Interest, Low Interest). Results showed a significant main effect for Attention Type, $F(1, 14) = 82.4$, $p = .01$, $\eta^2 = .85$, reflecting that the children groups were slower in the Competing condition as would be expected from previous experimentation. A significant main effect was also found for Stimulus, $F(2, 28) = 34.3$, $p = .01$, $\eta^2 = .71$, indicating that there was a significant difference in responding dependent upon which stimulus was presented. Descriptive statistics can be seen in Table 5.3 below.

Table 5.3

*Mean, standard deviation and range for all stimulus types for competing and shift-only trials.*

| | Competing | | | Shift-only | | |
|---|---|---|---|---|---|---|
| | High | Low | Abstract | High | Low | Abstract |
| Mean | 0.58 | 0.35 | 0.90 | 0.29 | 0.28 | 0.29 |
| Std dev | 0.25 | 0.14 | 0.24 | 0.07 | 0.10 | 0.13 |
| Range | 0.72 | 0.51 | 0.66 | 0.19 | 0.37 | 0.45 |

A significant interaction was found for Attention Type × Stimulus, $F(2, 28) = 21.7$, $p = .01$, $\eta^2 = .61$, in accordance with expectations and warranting further analysis. Results can be seen in Figure 5.2

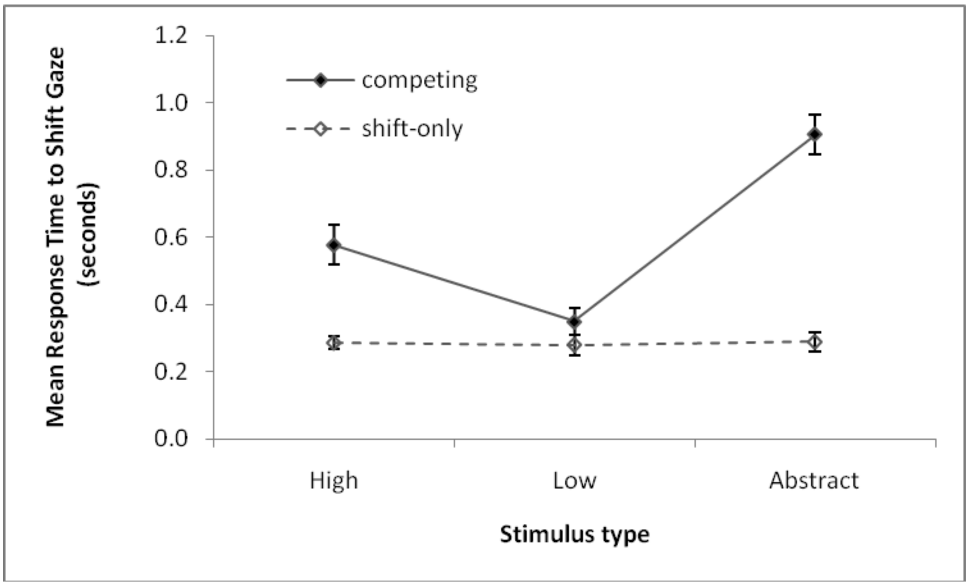


*Figure 5.2:* Mean reaction time for ASD children to shift gaze in competing and shift-only trials for each type of stimulus. Error bars depict standard error of the mean.

The data were then analysed for Competing and Shift-only trials separately. The first analysis was conducted on the Shift-only trials using a one-factor repeated measures ANOVA, with Stimulus (Abstract, High Interest, Low Interest) as the within-participants factor. No significant main effect for stimulus was found, $F(2, 28) = 0.1$, $p = .96$, $\eta^2 = .01$, reflecting that the participants did not show any differences in their baseline shifting speed to the different stimuli.

A second analysis using a one-factor repeated measures ANOVA was then conducted on the Competing trials, with Stimulus (Abstract, High Interest, Low Interest) as the within-participants factor. Results showed a significant main effect for Stimulus, $F(2, 28) = 23.6$, $p = .01$, $\eta^2 = .62$, indicating the type of stimulus used affected the speed of disengagement as expected. To pinpoint where these differences occurred, pairwise comparison testing was conducted on the data using LSD technique. Significant differences for mean duration of looking were found between the low interest stimuli and both the abstract, p = .02, and the high interest stimuli, p = .01, reflecting the same pattern as shown in the interest task with participants taking longer to disengage from both high interest and abstract than from low interest stimuli. However, against expectations, a significant difference was also seen between the abstract and high interest stimuli, p = .01, indicating that participants took significantly longer to disengage from the abstract stimuli than both the high interest and the low interest stimuli.

In the unlikely event that individual variation in the baseline shifting ability as measured by the Shift-only trials could have been masked by the group valuations, the data was then transformed into an approximate measure of disengagement by following the procedure described by van der Geest et al. (2001). This was done by taking each child's data in the Shift-only trials from their data in the Competing trials in each condition. The data in the Shift-only gave an approximate measure of the reaction time to shift attention to that particular stimulus, hence confounding stimuli effects were not a factor.

The resulting data were analysed using a one-factor mixed design ANOVA, with one within-participants Stimulus Type (Abstract, High Interest, Low Interest). Consistent with findings on just the Competing trial, a significant main effect was found for Stimulus, $F(2, 28) = 20.2$, $p = .01$, $\eta^2 = .59$, indicating the type of stimulus used affected the speed of disengagement. As before, to pinpoint where these differences occurred, pairwise comparison testing was conducted on the data using LSD technique. Results were the same as when the analysis was conducted on just the Competing trials in that significant differences for mean duration of looking were found between the low interest stimuli and both the abstract, p = .02, and the high interest stimuli, p = .01, again reflecting the same pattern as shown in the interest task with participants taking longer to disengage from both high interest and abstract than from low interest stimuli. However, a significant difference was still seen between the abstract and high interest stimuli, p = .01, indicating that participants took significantly longer to disengage from the abstract stimuli than both the high interest and the low interest stimuli. Results are displayed in Figure 5.3.

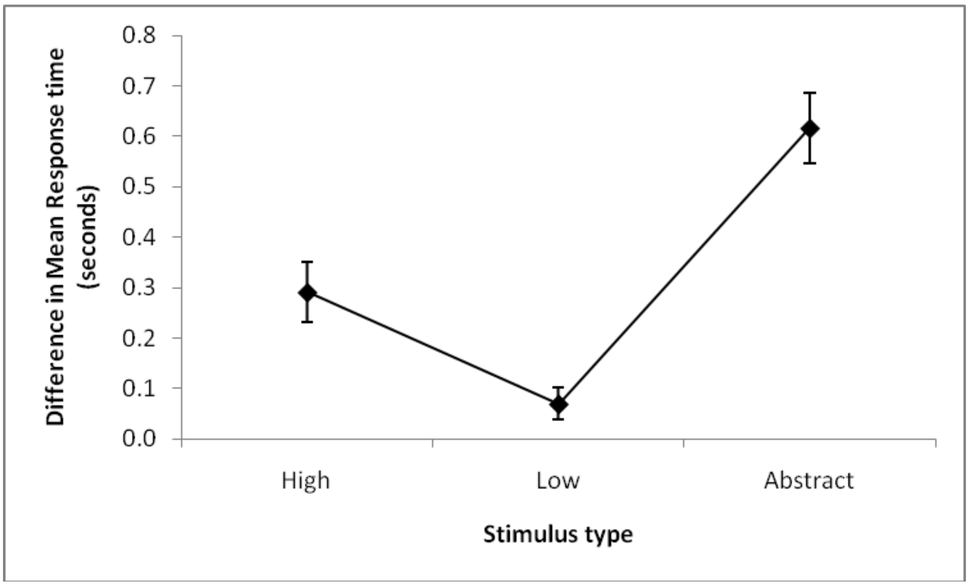


*Figure 5.3:* Mean gap reaction time for ASD children to shift gaze for each type of stimulus. Error bars depict standard error of the mean.

## 5.3. Discussion

The aims of this study were threefold. The first was to establish a valid measure of engagement as a result of interest. The second was to directly compare attentional disengagement from dynamic abstract stimuli to both high and low interest dynamic stimuli in children with ASD. The final goal was to establish if the slower disengagement by children with ASD was solely due to attentional engagement as a function of interest by comparing the two sets of results.

The results of the interest task firstly indicated that both high interest and abstract videos were watched for significantly longer than the low interest videos. No preferential looking differences were seen between the abstract and high interest videos. This pattern of results was as would be expected if the children with ASD found abstract and high interest videos equally interesting. This further suggests that dynamic abstract stimuli function similarly to high interest stimuli for children with autism giving credence to the notion that the slower disengagement from the abstract stimuli seen by these children in experiment 3.1 could be as a result of their initial attentional engagement in these stimuli.

The results of the attention task indicated that the children took longer to disengage from both abstract and high interest stimuli than from low interest stimuli as expected. However, against expectations, participants took significantly longer to disengage from abstract than from the high interest videos. These differences were apparent regardless of whether disengagement was measured by the competing trials of the paradigm alone or using the procedure outlined by van der Geest et al. (2001) to remove the effects on individual variation of baseline shifting ability.

The pattern of results in the interest task and attention task are similar in that both displayed longer times looking at abstract and high interest stimuli relative to low interest videos. However the results of the two tasks differed markedly in the extent of these differences. More specifically, whereas the results of the interest task suggest that participants find both abstract and high interest stimuli equally preferable and retained attention for an equivalent amount of time, in the attention task when the participant was required to disengage attention, the participants had significantly longer reaction times to make an eye shift away from the abstract stimuli than from the high interest stimuli. Thus, it can be concluded that there is an additional attentional imperative in children with ASD when presented with this type of abstract stimuli which delays attentional disengagement over and above the child's interest and initial level of engagement.

In essence, it appears that a repetitive abstract stimulus holds attention for the ASD child irrespective of how interesting or engaging they find it. As such, overall the findings replicate and reinforce the special nature of this sort of stimulus for the retention of attention in children with ASD. This unusual result also lends some support to the assertions of Landry & Bryson (2004) that a dysfunction specific to the process of attentional disengagement is present in children with ASD. However, it also reinforces the argument that this deficit, if it does exist, is dependent on the specific stimulus being attended to.

The implications of these results need to be tempered by potential practice effect issues which may have resulted from the majority of the sample having some experience of the experiments presented in previous chapters. This was largely a result of limited access to children with ASD. Though the possibility that this could have influenced the findings in some way should be considered, at least six months had passed between testing dates. It is argued that practice effects with the paradigm itself should not have a differential effect on the stimuli and would not explain the clear pattern of results found. The other issue that sometimes emerges from retesting are habituation effects, in other words the participant losing interest in some of the stimuli. As a study into the effects of interest, it was important that this did not occur for the high interest stimuli and the preference selection and validation tasks ensured a degree of resistance to this effect when using these stimuli. As this was not done for the abstract stimuli, it could be argued that previous exposure could have influenced the current results. The results themselves speak out against this argument, however. Specifically, they are contrary to what would be expected of a potential fatigue effect, the interest task indicated that the participants still wished to engage the abstract stimuli and the results were markedly different to those of the low interest stimuli in the attention task.

An additional problem with these conclusions arises as a result of not including a sample of TD children. More specifically, the lack of an TD sample brings up the issue of whether they would show similar patterns of attentional disengagement. Based on the relative magnitude of disengagement from the different stimuli in experiments 3.1 and 3.2, similar patterns of disengagement by the TD children can be considered unlikely. Specifically, whereas the speed of disengagement from abstract stimuli for children with ASD in experiment 3.1 was much higher than the mean speed of disengagement from high interest stimuli in experiment 3.2, a result verified as significant by this study, the speed of disengagement from abstract stimuli for TD children in experiment 3.1 was much lower than the mean speed of disengagement from high interest stimuli in experiment 3.2.

On a more conceptual level, there is also the issue of whether persistence of preference can be considered a good measure of engagement due to interest. As the strength of engagement in a target is a function of how difficult it is to disengage from, the measure suffers from the same drawbacks of any research into internal constructs in that it can only be measured indirectly. As such, any attempt to do so without monitoring brain activity can be an approximation at best. However, it is argued that the procedure does give a fuller understanding of potential attentional impairments in ASD children as it suggests there are some situations that hold the attention of these children despite their internal motivations.

# Chapter 6. GENERAL DISCUSSION

## 6.1. Summary of findings

This thesis presented a series of experiments that aimed to examine the apparent atypicalities of attentional disengagement in children with ASD reported in Landry and Bryson (2004). It secondly aimed to explore the potential of stimulus interest to affect the speed of disengagement from different types of stimuli in both children with ASD and TD. Finally, it hoped to explore whether the slower disengagement from abstract stimuli by children with ASD could be accounted for by a heightened interest in this type of stimuli.

The studies described in Chapter 3 had two primary aims. Firstly, to attempt to replicate the findings of Landry & Bryson (2004) with abstract stimuli of similar design and secondly, to select stimuli of high interest value to each of participant and use these to examine how stimulus interest affects the ability of children with ASD and TD children to disengage. With regard to the first of these aims, the findings of Landry & Bryson were upheld by experiment 3.1. More specifically, a significant difference was found between the speed of attentional disengagement for ASD and TD children with dynamic abstract stimuli. Thus, this established that, at least with some stimuli, there are differences in response time between ASD and TD children when attempting to disengage attention.

The second finding of import in this Chapter was that high stimulus interest was also found to be a contributing variable in the speed with which both groups disengaged their attention. Furthermore, when this new interest paradigm was explored, it indicated no reaction time differences between the groups. These findings, taken together not only supported the proposition of stimulus interest as a contributory factor in attentional disengagement but also suggest that this contribution could potentially explain the apparent difference in the speed of attentional disengagement between ASD and TD children. In other words, the findings argue for stimulus interest as potentially slowing the attentional disengagement of the child with ASD in some situations as opposed to solely the children's capacity for attention shifting.

To explore the findings of the initial experiment and also the effects of stimulus interest in more depth, the subsequent studies, reported in Chapter 4, attempted to place greater control on stimulus variables. Foremost, was the dynamic nature of the stimuli used. The type of motion displayed in the different stimuli in both studies in Chapter 3 led to some complications in the interpretation of the findings. Firstly, it made it more difficult to determine what feature of the abstract stimuli made them difficult for the children with ASD to disengage from. In other words, although motion itself was not enough to provoke the apparent disengagement deficits in the attention of the child with ASD as shown by the findings of experiment 3.2, it may have been the type of motion displayed, in that it was repetitive, fast moving and unidirectional. Secondly, in experiment 3.2, although the high and low interest stimuli were chosen to be roughly equivalent in the type of motion displayed, the dynamic nature of the interest related stimuli made them difficult to match on other dimension such as form and colour. With these difficulties in mind, the studies of Chapter 4 were designed firstly, to examine if the dynamic nature of the abstract stimuli differentially affected the groups in experiment 4.1 and secondly, to eliminate potential effects from stimulus differences other than the participant's inherent interest in them from the interest paradigm, in experiments 4.2 and 4.3.

The effects of the motion of the abstract stimuli were examined in experiment 4.1 by comparing the responses of both groups to static and dynamic abstract stimuli. Unfortunately, this investigation of the effects of stimulus motion on disengagement led to some inconsistent results. Specifically, the experiment failed to reproduce the significant group differences using dynamic stimuli seen in experiment 3.1. Critically, this unexpected finding seems to have been due to group differences in the base speed of responding as measured by the shift only trials. As such, when this was factored out through use of the method outlined in van der Geest et al. (2001) by subtracting the participants' response times in the Shift-only trials from the Competing trials for each condition, the children with ASD were found to disengage significantly later than the control group from the dynamic stimuli in accordance with the findings of experiment 3.1. Interestingly, these children were also found to have significantly higher response times than the TD children in the static trials when using this procedure. In other words, the findings suggest that while this type of repetitive unidirectional motion was seen to delay attentional disengagement for both groups when using the abstract stimuli, it did not appear to affect the groups differentially. Thus, motion in general and this type of motion specifically were ruled out as the core contributing factor to the group differences in experiment 3.1.

As already discussed, one of the difficulties with matching the general features of the high and low interest stimuli in experiment 3.2 was their dynamic nature. As such, when, motion was seen not to have a specific differential effect on the groups, the potential influence of other stimulus features on the interest paradigm could be explored in the experiments reported in Chapter 4 with more confidence using static stimuli. To examine this, attempts were made to control for the difference in form between high and low interest stimuli in experiment 4.2 and colour composition in experiment 4.3. The results of both of these experiments suggested stimulus interest effects were present when using these type of stimuli but not inevitable. More specifically, despite finding significant differences, when individual variations in shifting ability were accounted for in the predicted direction, this effect did not appear to be as strong as in Chapter 3. Overall, the results suggested that potentially both interest and motion contributed to the speed of disengagement generally but were inconclusive on whether they could have contributed to the specific group differences reported in Chapter 3.

The study in Chapter 5 was designed to examine more directly the performance of children with ASD by looking at whether their speed of disengagement from dynamic stimuli could be mediated by stimulus interest. This was attempted through the use of two tasks an interest task and an attention task. The interest task was conducted to explore the strength of the initial engagement of attention due to interest. The results of this task indicated that high interest and abstract videos were watched for significantly longer than the low interest videos. No preferential looking differences were seen between the abstract and high interest videos indicating that they were of equivalent interest value. Despite this finding, the results of the attention task indicated that although the children took longer to disengage from both abstract and high interest stimuli than from low interest stimuli as expected, they also took significantly longer to disengage from the abstract than from the high interest videos. As such, there appears to be an additional attentional imperative for the abstract stimuli which delayed the disengagement of attention for ASD children over and above the child's interest and initial level of engagement in them.

In conclusion, though stimulus interest is a mediating factor in the disengagement and shifting of attention in both a typical sample and children with ASD to some degree, it is not the only contributing factor for the slower disengagement seen in ASD samples when the same type of abstract stimulus was present for the fixation stimulus and the peripheral target. In particular, stimulus interest has been seen to influence results when the targets differ from each other even when the effects of stimulus consistency are factored out. Also, more generally, the findings imply the importance of stimulus choice when conducting studies into the disengagement of attention. Both internally driven factors such as stimulus interest, and more externally driven stimulus features such as motion were shown to contribute to the speed of disengagement for both groups to some degree.

## 6.2. Comparison with Previous Literature

The first important comparison to be made is the repeated replication of Landry and Bryson's (2004) finding of slower disengagement in an ASD sample when engaged in dynamic abstract stimuli. In experiment 3.1, increased reaction times were seen in the competing trials for ASD compared to TD children. Although this was not initially apparent in experiment 4.1, with further analysis this was seen to be due to the ASD group being unusually fast responders generally. It should however be noted that the size of the average reaction time in these studies did differ considerably from that seen in Landry and Bryson's study. This was likely due to the use of smaller cut off points for the lateral target as the difference between the conditions was just as striking in these studies. This cut off point for the lateral target offset was lower in these studies to reduce the effects of potential outliers and this would have reduced the average response time.

The replications of Landry and Bryson's (2004) are particularly of note as they were apparent with quasi-independently developed stimuli. Though some guidance was given by these researchers on what the stimuli should entail, a direct hand was not taken in their development. Hence, the replication indicated the robustness of this effect in the ASD population at large. The somewhat conflicting finding in experiment 4.1 detracted from this conclusion somewhat but as discussed in that chapter, the lack of significance displayed in the initial analysis implied that impairments in disengagement from these types of stimuli are not obligatory in every ASD child or a sufficient explanation of their symptoms. However, this does warn against using the paradigm as a diagnostic tool in itself as it indicates that there are at least some individuals with ASD not as susceptible to these stimuli.

One critical point where these studies do differ from Landry and Bryson (2004) was the consistent lack of significant group differences seen when using other types of stimuli. This was seen to be the case even when using the same coding methods, participants and in Chapter 5 task length. This strongly suggests that the delay in disengaging shown in children with ASD is specific to certain stimuli rather than the general impairment posited by their work. Though there is a difficulty in stating conclusively that the disengagement system of children with ASD can function normally with some stimuli, it can be seen from these studies that the proposed dysfunction is much less apparent and can be manipulated a great deal depending on the type of stimulus chosen.

This leads to the final important point to be made on the contribution of these studies into the understanding on the findings of Landry and Bryson (2004). It is apparent that although reaction time can be manipulated even within a TD population in disengagement tasks, the slower disengagement of ASD children from the abstract stimuli cannot fully or consistently be accounted for by the shapes themselves, their colour, the motion of the stimuli, or even as posited by stimulus interest. When individual differences in the speed of responding were accounted for children with ASD were slower to disengage from both static and dynamic abstract stimuli. Additionally, neither general form nor colour content seemed to differentially affect the disengagement speed of the children. Finally, though stimulus interest effects were seen to some extent in all experiments, they could not account alone for disengagement speed and were not as apparent in the static stimuli. Rather, the slower disengagement seen in children with ASD with abstract stimuli is likely a multidimensional issue resulting from all of these factors.

With regard to other research, the findings of disengagement impairments in children with ASD are also in accordance with the results of Elsabbagh et al. (2009). They used animated stimuli and found disengagement latencies in infant siblings of children with ASD. Although some of the high interest stimuli included in this thesis were also animated, their stimuli had more in common with Landry and Bryson (2004) and the dynamic abstract stimuli than these. Specifically, the central stimuli they used were either a clown or a sun which expanded and contracted regularly. This appears similar to the abstract stimuli in that they consisted of unusual repetitive motion and that were made up of bright isolated images on a plain background.

Directly comparing the findings of this thesis with the findings of Leekam, Lopez and Moore (2000) is difficult as they did not include a gap condition in their design. The lack of a temporal gap between the offset of the central fixation stimulus and the onset of a lateral target goes someway to explain why they did not find a difference between the overlap and non-overlap condition. However, what is important for reinterpreting their findings is the lack of group differences in disengaging and shifting attention in their overlap (competing) condition. The finding that some stimuli did not produce group differences was evident throughout this thesis and is consistent with these results, further supporting their findings. Additionally, it is evident that stimulus interest was unlikely to have interfered with their results for two reasons. Firstly, their central and lateral targets would have contained the same interest value for the participants as they were the same. This stimulus consistency was found to be an important factor for TD children in experiment 3.2 and both groups in Chapter 4. Finally, their choice of toy trains for the stimuli would likely have appealed to both ASD and TD groups, somewhat ensuring the initial attentional engagement of the children due to interest level which appeared as a contributing factor for ASD children in Chapter 5 and both groups in Chapter 3.

In order to directly compare the results of this thesis to van der Geest et al. (2001) their methodology of removing each individual's reaction time in the shift-only condition from the competing trials was used as a secondary analysis throughout this thesis. It needs to be noted however, that while this methodology was used, the theoretical conception of it was different in this thesis. Whereas, van der Geest et al. (2001) argued that this method was a measure of the strength of engagement, in this thesis it was considered to be simply removing the confounding variable of shifting ability from the equation and thereby was arguably a stronger measure of the child's disengagement than the competing trials alone. Despite the theoretical differences, the work in this thesis clarifies that the use of this different measure did not account alone for their different findings. This is apparent as throughout this thesis, their method has been a more powerful measure of disengagement differences as shown in the studies of Chapter 4. As such, it is argued that their findings must be attributed to the stimuli with which they conducted their experimentation. As outlined in this thesis, the removal of motion and stimulus interest lessens the effect on disengagement for both groups. As such, it is argued their findings of lower attentional engagement in children with ASD were as a result of the simplicity of the stimuli used. Further research would need to be conducted to explain precisely why this would affect the groups differentially however.

As suggested, the findings of van der Geest et al. (2001) of a reduced gap effect for children with ASD may be explained by their choice of stimuli. This does not however, discount the findings or their conclusion that children with ASD have difficulties with attentional engagement but neither does it argue against a disengagement dysfunction is at the root of autism. What is apparent from the results in this thesis, is that children with ASD may show difficulties with engaging, disengaging or show no difference at all to their matched controls depending on the stimuli being attended to. There does not seem to be a general dysfunction in one component of their attentional processes but rather more specific ones contingent on the environment that they are exposed to.

## 6.3. Limitations

Despite the time spent in designing the methodology for this thesis, there were some consistent limitations which need to be mentioned. Some of these were due to sampling availability but there were also more conceptual issues, such as the choice to use different stimuli for each individual in the interest experiments. Considering the general finding of at lthis thesis that disengagement in ASD is to some degree stimulus specific, this is a particularly important flaw in the methodology. However, it was decided to use a selection of stimuli as it was considered of more import to attempt to match the groups on their individual interests rather than something considered interesting to the general population. This approach of using a fixed set of stimuli would have an obvious problem in that interest would differ for each individual. It was also thought that the approach used would result in more persistent interest throughout the experiment rather than the more momentary interest experienced in the face of novel or unusual stimuli. This, in particular, was seen to be important in the ASD sample at the initial testing stage, whose focus was more difficult to maintain. To further account for this limitation, attempts were made to balance the general type of stimuli between groups through the use of specially made selection boards.

Related to this issue is if of the preference selection and validation tasks were effective in providing high interest content. With regard to the preference selection task, despite getting a good distribution of selected stimuli in individual experiments, it is apparent when looking at the choice of stimuli across experiments (see Appendix D) that some were consistently more popular. For example, the clip BE was never chosen by any participant in any experiment. This disparity points to a need to spend more time on choosing and piloting the content of stimulus selection boards before using them in experiments of this sort. Additionally, forcing a choice of one stimulus based on an array of pictures could lead to the child simply choosing a picture because he prefers it for other reasons other than having a particular interest in the content, such as liking the colours. Rather than this method a two alternative forced choice (2AFC) selection task may have produced a more valid rating of interest level on each potential stimulus than the selection boards and would not have taken much longer. This would have resulted in a rank ordering of stimuli according to preference and give a good indication of the strength and persistence of interest in the specific content. However, it was considered that the validation task presented was sufficient to ensure the content chosen was of high interest to the participant.

The third conceptual issue regards how disengagement was measured. Throughout this thesis disengagement was measured by both reaction time and an adjusted measure of reaction time used by van der Geest et al (2001). The main weakness of both of these is their susceptibility to extreme scores. As one of the primary aims was to replicate the findings of Landry and Bryson (2004), it was important to be as faithful as possible to their methodology and replicate their measures using reaction time in the competing trials. Therefore, the later experiments were also analysed using similar variables to be consistent with this methodology. However, part of the difficulty with comparing the current literature was the inconsistency of their coding procedures. Thus, throughout the thesis a modified measure of reaction time was also used, which attempted to account for individual variation in shifting ability by subtracting the mean response time in the shift-only trials from that of the competing trials. This secondary measure was included for three reasons. These were firstly, because it aided in the interpretation of and comparisons to the work of van der Geest et al. (2001). Secondly, it could account for variations in base ability to shift attention between groups which could otherwise have confounded the measure of speed of disengagement such as in experiment 4.1. Finally, this measure controlled for individual variation of shifting ability, which in theory should reduce variation not attributable to the speed of disengagement.

There is also the more general issue of using latency of gaze shifts as measures of attention to be considered. As seen in section 1.2, the existence of covert attention limits the assumptions that can be made from the results due to it not being possible to measure attention directly. This is particularly true in the gap paradigm as seen in the work differentiating oculomotor and attentional disengagement, described in section 1.5.2. Attempts were made throughout this thesis to acknowledge this limitation characteristic of most experimentation into the gap effect. In fact, the results of Chapter 5 particularly emphasises the importance of attempting to engage the child's attention at the initial stage of the trials when comparing high to low interest trials. Additionally, measures of the level of the interest in the stimuli were done throughout the studies to at least some extent. As such, this is not considered a major flaw in the studies in this thesis.

Possibly the most important issues in this thesis are those relating to the samples used. Due to the difficulty involved in finding children of such a young age matched on non verbal mental age to a control group, a number of issues emerged, which could not be rectified to full satisfaction. Generally, the ASD groups were much older chronologically than the TD groups. This was an important factor to consider due to the rate of maturation of the attention system. However, it was believed that it was more important to match the children on their NVMA than chronological age as was done by Landry and Bryson (2004). This inevitably resulted in the children with ASD having comparatively low non verbal IQ. The exclusive use of autistic children with low NVMA limits the generalisability of the findings to children with ASD as a whole. It is debatable as to whether children with ASD would show similar attentional pattern. To account for this, it would have been useful to include developmentally delayed group other than children with ASD. This was not possible due to time constraints but it is argued that it has already been established that DD groups perform similar to TD children in this type of task from the work of previous studies (Landry & Bryson, 2004; Leekam, Lopez, & Moore, 2000). Additionally, as previously argued in Chapter 3, it was believed that those who suffered mostly from basic attentional dysfunction such as that described by Landry and Bryson (2004) would be more susceptible to developing greater difficulties later. Hence, it was thought more appropriate to target this group in order to replicate their findings.

The second issue to emerge when considering the validity of these finding, was the low sensitivity of these experiments due to relatively small sample sizes. The sample sizes were chosen based on a power analysis using the findings of Landry & Bryson (2004) as a base, which indicated a large effect size and small sample sizes are fairly typical in research into attention. However, there remains the possibility that there are still smaller between group differences in the other conditions that the analyses were not sensitive enough to pick up. This potential limitation is somewhat reinforced by the findings of Chapter 5 that there seems to be an attentional imperative aside from stimulus interest for children with ASD in dynamic, abstract stimuli. However, the principle question of the thesis was could interest alone account for the between group differences seen. As such, it was important that the analysis was just sensitive enough to answer this question. Even if the lack of significant group differences seen in experiments 3.2, 4.2 and 4.3 were as a result of the sensitivity of the measure, this just further emphasises the strength of the effect of the abstract stimuli on the ASD children when compared to videos that retain attention due to their subject content.

## 6.4. Theoretical Implications

The principle aim of this thesis was to make a bridge between the research on autism, attention and interest. Hence, the work has a number of theoretical implications with regard to both children with autism and the population as a whole. These implications will be discussed in turn, starting with the theories that attempt to link the attentional abnormalities in autism to interest.

### *6.4.1. Autism and Interest*

As presented in Chapter 2, there has been two accounts of autism that attempt to make a link between the symptomatology and the unusual interests and attentional patterns they exhibit. This work has an impact on both the social orientation model and the wider but less concrete account of the child with ASD as monotropistic given by Murray et al. (2005).

#### 6.4.1.1. *Social Orientation Theory*

The finding of slower disengagement of attention from non-social abstract stimuli in children with ASD is evidence against the social orientation theory as the central root of autism. Rather these results add to the large number of studies that indicate unusual attention patterns exhibited by people with ASD are not specific to the social domain (Bertone et al., 2003, 2005; Landry & Bryson, 2004). Thus, the social orientation model seems to fall short of being considered a central theory of the causes of autism. The difficulty stating this conclusion un equivocally however, is that it could also be argued that general attentional dysfunction of this sort could have its roots in the impoverishment of experience of shifting attention due to a social orientation problem.

Despite this argument, the findings that indicate interest has some contribution to the attentional system provide support for the elaboration on the theory by Dawson et al. (2004). A lack of interest in social situations is a central component in the diagnosis of autism and not an issue. What is in contention is how early this occurs in the child with ASD. The findings in these studies implicate that interest can to some extent influence the processes of attention at a very early level. Therefore, if the child with ASD does indeed lack an interest in social content at an early age as the work of Dawson et al. (2004) argues, the opportunities for social information would be restricted as the model suggests. This is something which warrants further investigation but care should be taken not to consider the model as all encompassing.

#### 6.4.1.2. *Monotropism*

This largely untested account of autism by Murray et al. (2005) due to the difficulties in formulating predictive hypotheses from it, has a core assumption that children with ASD exhibit different and unusual patterns of interest than the TD child and that this results in a different perception of the world. It further argues that the difference in interest exhibited by those with autism is manifest in the different strategies with which they distribute their attention. Essentially, they say unusual interest leads to unusual attentional patterns, resulting in the unusual features manifest in those with ASD.

The results of this thesis cannot support this causal model as it stands. It is evident that interest can play a role in the distribution and mediation of attention in some situations for both TD and ASD children from the studies presented as predicted in the model. Also, the finding that children with ASD can perform equivalent to matched controls when stimulus interest is taken into account supports the argument that interest is an important aspect of autism to consider. In spite of these arguments however, the finding of an additional attentional imperative for the dynamic abstract stimuli in children with ASD in Chapter 5 aside from the inherent interest value the content of these stimuli had, strongly argues against interest as the primary cause of the unusual attention patterns of this group. Therefore, although interest should not be discounted as a potential contributing factor, the model's position that autism stems from an unusual development of motivation and experience in certain domains does not tell the whole story of autism. It is apparent that there are differences and dysfunctions in these children's attentional system but what is important to note is that there are situations and stimuli with which it is possible to overcome these difficulties.

### *6.4.2. Interest Theory*

Aside from the potential role of interest on the attentional patterns of children with ASD, a secondary goal of this thesis was to add to the literature on interest within a typical population. In experiment 3.2, disengagement in the high interest condition was slower than in the low interest trials. Also in both Chapters 3 and 4, shifting from a high interest to a low interest stimulus was faster than from a low interest to a high interest condition. At first glance, these findings firmly argue that different levels of interest have a role in attention at a basic level. It also suggests that Hidi's (1990) explanation of interest as automatically engaging attention may have merit and could be examined in further orientation studies such as those conducted by Renninger & Wozniak (1985).

As this was a secondary goal in this thesis, the potential role of interest on the attentional process of a typical sample was not followed to its culmination and remains inconclusive. This is largely because the finding of the mediating role of interest on attention was not always found to the same extent as is apparent in the consistent trials of the studies in Chapter 4. Also, it should be noted that the differences that were found within the samples were almost exclusively limited to the competing trials and not the shift-only trials, which is somewhat unusual as if interest facilitates attention capture or engagement significant differences would also expected in these trials.

However, it is possible that the measures were not sensitive enough due to the low sample size to account for small differences in the shift-only trials. The samples for these studies were based on a power analysis on the findings of Landry and Bryson (2004) as it was primarily intended to examine the unusual attention patterns of the child with ASD and if these could be as a result of an unusually high level of interest. As such, the studies were designed to be sensitive enough to measure this effect and see if interest was a strong enough contributor to explain the difference. Finally, these findings highlight the large gap in the attention literature as regards to the potential role of interest and interests on orientation and disengagement which should be addressed in the future.

### *6.4.3. Alternative Theoretical Implications*

As it was found that unusual interests play an important role but are not the only factor in the attentional abnormalities seen in children with ASD, it is important to consider the findings in the light of the other major models of autism and also typical functioning. For this purpose, the two most important findings to discuss of the stimulus specific nature of the slower disengagement seen in children with ASD, and also that stimulus interest has at least some effect on the attentional processes of both groups.

#### 6.4.3.1. *Theory of Mind*

The ToM approach does not account for the unusual disengagement differences seen with dynamic abstract stimuli as its core assumption is that the primary deficit in children with ASD is in their interaction with others. The finding of a basic attention dysfunction that cannot be traced to and emerges earlier than joint attention or a lack of ToM takes the line against the supporters of this theory as a description of the root of autism. It however, does not preclude the possibility that the model describes the later development of the child with ASD.

As previously discussed, the late onset of ToM in children with ASD is thought to have its roots in joint attention (Sigman, Mundy, Sherman & Ungerer, 1986) and imitation (Rogers & Pennington, 1991). That these two milestones are delayed in these children could be in part due to the attentional disengagement dysfunction shown here and in Landry & Bryson (2004). It is possible that due to unusual and non-social stimuli capturing and holding the child's attention, a negative feedback loop as described by Dawson et al. (2004) occurs. Thereby, the child limits their own experience of the social world and fails to learn the fundamental social skills which are at the root of ToM.

When considering the finding that interest also may play some role in the attention of children with ASD, this type of developmental trajectory seems even more likely. As one of the core traits of the autistic child is a lack of interest in social situations, it stands to reason that attention is less likely to be held and slower to shift towards socially related stimuli.

Hence, social interest or a lack thereof, may become a facilitating factor in the child's developmental trajectory.

#### 6.4.3.2. *WCC*

The findings have less of an impact on the weak central coherence model. They say little about the specific claims of the theory that the core deficits in autism develop from a failure to integrate local details into a global entity (Frith, 1989). However, at a more general level, the findings do support the importance of the basic perceptual system and attention in the development of autism. Also, the finding of the stimulus specific nature of the difficulty in attentional disengagement agrees somewhat with the argument that sometimes children with autism perform just as well or better than matched controls depending on the context.

With regard to those who have found evidence against this theory as a core precursor to the development of autism, Plaisted et al.'s (1999) study in which they found that depending on what was asked the local perceptual bias may disappear can be re-examined in the light of the impact of interest and task goals. As previously stated, this suggests that the bias is not necessarily a consequence of a global processing deficit but a strong tendency to attend in a particular way. The finding of interest playing a role in the mediation of attention combined with the work described by Hayhoe and Ballard (2004) on task goals and eye movements in the normal population, indicate that perhaps with some preparation this important aspect of autism can be circumvented in the environment of the child. Again, this local perceptual bias may be limiting the experience of the child with ASD but what the studies in this thesis suggest is that the tendency is far more transient than first made out.

#### 6.4.3.3. *Executive Function*

The implications for the Executive Functioning model are mixed. On the one hand, the finding of a deficient ability to disengage from dynamic abstract stimuli not contingent on the stimulus interest points to bottom-up difficulties in the attentional system of the child with ASD. On the other hand, the finding of interest contributing to the speed of disengagement in both ASD and TD children suggests that the gap paradigm does not solely measure bottom-up processes but is also mediated by higher order top-down systems. Essentially, interest and in particular, interests, using the terminology of Silvia (2006), conform to the general definition of what executive functioning is. That is, internal representations used to plan, organise, solve problems, direct attention and monitor progress towards a goal in any environment. Hence, the inclusion of interest in their model would not detract from their perception of autism as stemming from executive dysfunction.

The stimulus specific nature of the problem also suggests contradictory arguments for the contribution of executive functioning on the root of autism. From one standpoint, this specificity would be more easily explained by difficulties in the perceptual system for a specific type of aspect of the environment rather than a more general control mechanism. Whereas from the opposing standpoint, if it were a simpler perceptual deficit at fault, it is difficult to explain the evidence seen from studies from a different perspective also showing perceptual and attentional differences (Shah & Frith, 1983, Plaisted, 1998). Therefore, while the inclusion of interest and interests would fit neatly into this theory and the evidence points to controlling mechanisms and mediators of attention rather than the perceptual system itself to be at fault, the studies in this thesis cannot resolve if interests contribute to executive functioning or dysfunction.

### *6.4.4. Wider Implications*

Aside from the main theories of autism, there are wider implications for the findings. For example, the finding of the motion of a stimulus impacting on the speed of disengagement has an impact for the research conducted on motion sensitivity in autism. The debate of autism being characterised by either a motion-processing deficit (Gepner et al., 1995), or a dorsal stream dysfunction (Spencer et al., 2000; Milne et al., 2002) and Bertone et al.'s (2003) alternative of the reduced efficiency of neuro-integrative mechanisms is relevant to any study that uses dynamic stimuli. This was the primary reason why experiment 4.1 was included to examine whether the type of motion within the stimuli could account for the differences in disengagement for the abstract shapes.

Unfortunately, the results of this study were somewhat inconclusive due to not fully replicating previous findings of longer latencies to disengage in the ASD group for the dynamic stimuli. Therefore, despite the motion of the abstract stimuli appearing to have a clear effect on the speed of disengagement, it did not appear to have a significant differential effect between the two groups. It should be noted though, that when group differences in base shifting speed were factored out a significant difference was found for both the static and dynamic abstract stimuli.

It is also not clear what specific feature of the abstract stimuli can explain the unusual disengagement patterns of children with ASD from them. Potentially, it could be argued the result of slower gaze shifts with dynamic abstract stimuli may still not be attentional difficulties but rather to do with processing ability. Perhaps children with ASD were better at predicting the motion of the stimuli due to their tendency to focus on local details as described in WCC theory. As a result, they may be more likely to persist in looking at them than TD groups. This interpretation however is deemed unlikely due to the results of the experiments in Chapter 5. Persistence of looking has been argued to be different to the phenomenon displayed in the gap paradigm which results in an automatic disengagement and reengagement of attention. The measure of interest for experiment 5.1 took account of the participants' tendency to persist in looking at the different stimuli and still found higher response times for ASD children disengaging from dynamic abstract stimuli.

With regard to neurological implications, the studies in this thesis don't offer any direct insight into what neuroanatomical substrates might be involved in eye movements, attention and autism. However, two general findings indicate that neurological factors are important to consider when understanding the unusual attention patterns displayed by children with ASD.

Firstly , the finding that there was an attentional imperative to resist moving attention from repetitive abstract stimuli but not motion generally indicates that there may be some basic underlying neurological difference causing the in children with ASD. This is in line with the argument for a dysfunctional motion processing system as described in section 1.7.1. What is clear from there being no differences between the groups with the other dynamic stimuli which had more naturalistic motion. Hence, neurological components associated with the perception of motion are unlikely to be the reason behind the differences shown in both experiment 3.1 and the Landry and Bryson (2004) study. This is further supported by the work of Villabolos, Mizuno, Dahl, Kemmotsu and Muller (2005) who found intact functioning connectivity between V1 and superior parietal areas suggesting intact dorsal stream connectivity. Therefore, the thesis as a whole favours the assessment of Bertone et al. (2003) that the complexity of the stimuli with regard to the neurological resources needed to process its features is at the root of the perceptual abnormalities. To simplify this point somewhat, it is not the motion of the stimulus but the difficulty in processing it.

Secondly, the finding that by altering the level of interest in the stimuli used, the gap effect can be manipulated further supports the role of reward and top-down functioning being vital for the shifting of gaze and eye movements as described in section 1.4. That this was also seen in children with autism makes an argument for some of the unusual attention patterns in attention displayed by children with ASD could be traced to problems in the regions responsible for higher level visual functioning and reward. Certainly this has been argued by Hadjikhani et al (2004) who attempted to map cortical areas in a group of individuals with HFA. They found early visual areas were organised as in typical controls and concluded that any visual processing atypicalities in autism come from higher level visual areas and the result of top down influences. Also in favour of this is the review by Simmons, Robertson McKay Toal McAleer and Pollick (2009) who cite that many authors have come to the conclusion that an attentional difficulty results in unusual visual experience and development particularly for involuntary eye movements.

## 6.5. Practical Implications and Applications

The finding of a significantly slower ability to disengage when presented with dynamic abstract stimuli reinforces the work of Zwaigenbaum et al. (2005). In this article, they used similar stimuli in a gap paradigm as part of a diagnostic tool for children with ASD as young as 6 months of age. To be able to indicate if infants of this age are at risk of developing autism would be a major breakthrough in diagnosis. Although this thesis largely supports this application of the procedure, there are two major points that it highlights. Firstly, the failure to replicate the finding to the same extent in experiment 4.1 emphasises that although there appears to be a general tendency for children with ASD to respond in this way, it is not necessarily always the case. Secondly, that the disengagement effect is not present in every type of stimuli. This suggests that in any attempt to use this method in the diagnosis of autism, care needs to be given to the development of the stimuli to be presented, as well as more time devoted to exactly what aspect of the stimuli gives rise to the sought after difference.

Aside from diagnosis, the findings have important implications for the teaching environment of children with ASD. For instance, it appears that some types of stimuli override the child's internal mechanisms of attention and are difficult for the child to disengage from regardless of distractions, as displayed by their reaction to the dynamic abstract stimuli. For this reason, the results suggest the importance of controlling the child's learning environment and in removing repetitive, brightly coloured objects or other items with unusual features which seem to absorb the child's attention from the child's field of vision before commencing.

The potential influence of interest on attention in children with ASD as seen in this thesis, could have further applications in the education of the child with autism. Of principal importance, the findings emphasise the importance of the content of the teaching material. They indicate that content of interest to these children can retain attention to a similar degree as with TD children, highlighting the need to format work and lessons in a manner that is intrinsically interesting to avoid the child becoming distracted. It gives an optimistic view of the capacity of the child to attend to and hence improve their opportunity to learn when the work is tailored to their interests.

Finally, there are potential implications of interest as a mediating factor for further work in attention. What has been highlighted in these studies is that the gap effect, which has been thought to be largely as a result of bottom-up processes, can at least to some degree be manipulated by internal factors. Whether this is due to attentional versus oculomotor disengagement or a more direct influence of stimulus interest on attention has yet to be discovered. However, the significance of the findings for considering what stimuli to use in the paradigm is paramount.

## 6.6. Future Research

The debate over the disengagement of attention in children with ASD still has a number of unresolved issues and there are a number of areas where research could proceed on this. In addition, research into interest and in particular, interest and autism is a relatively new line of enquiry and has great scope for advancement in the near future. Of particular import is the finding of the proposed specificity of the disengagement difficulty to certain stimuli. Now that this has been established, it is important to attempt to discover what characteristics of these stimuli result in the slowing of disengagement for children with ASD. Comparisons between the stimuli of this study, Landry and Bryson (2004) and Elsabbagh et al (2009) would seem to suggest that abstract and repetitive motion could be the main contributors but other features such as colour contrast may be factors.

Related to this suggestion, another important line of inquiry is if stimuli of this sort not only retain the attention of children with autism but attract it as well. Although there was little evidence of different shifting patterns in the shift-only trials of Chapter 5, it is likely that the power of the experiment would be too low to show these comparatively low effect sizes. An investigation into the attention capture potential of stimuli of this type could examine if children with ASD are doubly impaired within their environment and possibly help to explain some of the more unusual attentional patterns to non social stimuli, such as those displayed by Swettenham et al. (2001).

The relatively new experimental finding of stimulus interest having an influence on the attention of the child with autism at least to some degree opens up some potential new areas of research. In particular, research on interest and learning such as the work of MacDaniel et al. (1992) could be examined in relation to groups with ASD. Any research that could shed light on how to help focus the attention of the child with autism on a learning task and minimise distractions would have far reaching practical applications, such as in the design of lessons, computer programs, or even textbooks specific to their needs. As part of this study on researching interest and autism, it became apparent that very little work has been done on the specific interests of individuals with autism outside of repetitive behaviours. That interest has been shown to be relevant to their attention emphasises the need to explore these interests in a more general context. In other words, it would be of benefit to the literature on autism to attempts to categorise what types of content interest children with autism of certain demographics and explore the common traits or features of these interests.

With regard to a typically developed population, there is also room to explore interest and interests. As has been seen in this thesis (Chapters 3 and 4), interests can influence attentional processes thought to be mainly driven by bottom up processes. Further work into the nature of interests and how it may influence the orienting of attention with regard to disengagement or attention capture could further enhance our understanding of this process. Additionally, the literature on eye movements and reward such as that done by Takikawa et al. (2002) could also benefit from including the concept of stimulus interest into their methodology and perhaps also exploring the neurological correlates of intrinsic as opposed to extrinsic motivation.

In conclusion the recommendations for future research could be summarised as follows.

- Examine what characteristics of the specific stimuli that result in the slowing of disengagement for children with ASD. In particular repetitive motion and colour contrast could be the main contributors.

- Investigate if dynamic abstract stimuli also capture the attention of children with ASD faster than they capture the attention of TD children.

- Research on the effect of interest and learning could be examined in relation to groups with ASD.
- Attempts to categorise what types of content interest children with autism of certain demographics and explore the common traits or features of these interests.
- Further work into the nature of interests and how it may influence the orienting of attention with regard to disengagement or attention capture.
- Further work into the effects on inconsistent stimuli (different stimuli on lateral and central monitors) used in the gap paradigm and how the salience difference between the different stimuli may effect the gaze response.

## 6.7. Conclusions

It has been argued in the past that children with ASD have marked differences in their capacity to shift attention to typically developed children. This debate is particularly focussed on their capacity to disengage attention (Landry and Bryson, 2004, van der Geest et al., 2001). The findings of this thesis, while replicating some of the findings on which this idea was based, show no additional support for a general dysfunction in the disengagement subsystem of attention. However, the results of this thesis do indicate a deficit dependent on the stimulus being attended to.

Stimulus interest was found to be factor influencing the speed of disengagement for both ASD and TD children to varying degrees dependent on the type of stimuli used. However, this finding was not always consistent and seemed to be more apparent when the interest value of the lateral and central targets differed (see experiment 4.2 and 4.3). Despite this influence, a difference in stimulus interest between the two groups was not found to be strong enough to account for the groups' difference in their speed of disengagement from the dynamic abstract stimuli as shown in Chapter 5. This deficit seen in children with ASD also seemed to be evident when the child's potential interest in the stimulus had been considered, suggesting the impairment lies in lower level bottom-up functioning related to the ability to process the specific features of the affected stimulus.

Research into interest and intrinsic motivation is still in its infancy and little work has been done to apply its unique perspective on children with autism. In addition to the academic and theoretical benefits of conducting more work in this area, future research into this interest and autism would be a major benefit to clinicians, carers and in particular, to the educators of these children. Despite the different perspectives and theories on the roots and causes of autism, there is a general consensus that they grow up in a world that is profoundly different to ours due to their unusual and unique perceptual system. This thesis would support that notion by illustrating a small yet significant attentional anomaly. It is hoped that these findings have gone one step further to the development of understanding the uniqueness of experience of children with autism.

# Chapter 7. References


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# Chapter 8. Appendix

## 8.1. Appendix A: Selection board images

Five selection boards were made for each type of stimulus. Each of these had four of the five images present. The missing image was used to guard against the participants in one group from disproportionately choosing any one video. The children were presented with one selection board of each type simultaneously, allowing them a choice of eight videos.

### *8.1.1. Computer animated films*

Video clips were chosen from five popular animated films. Four of these had been created by Pixar Animated Studios entitled 'A Bugs Life', 'The Incredibles', 'Monsters Inc.', and 'Finding Nemo'. The final source was 'Shrek' by Dreamworks Studios. The selection boards were an A4 page and the four images were arranged into a 2x2 array using the portrait orientation.

*Figure 8.1*: Images used on the computer animated film selection boards.

### *8.1.2. Children's TV Programs*

Video clips were chosen from five popular children's TV programs. Two of these had been created by the Walt Disney company entitled 'Bear in the Big Blue House', and 'Winnie the Pooh'. The other three had been created by HIT Entertainment and were entitled 'Bob the builder', 'Thomas the Tank Engine', and 'Barney and Friends'. The selection boards were structurally identical to the computer animated film ones.

*Figure 8.2*: Images used on the children's television show selection boards.

## 8.2. Appendix B: Stimuli for Chapters 3 and 5

### *8.2.1. High interest video clips*

The following are example still images taken from the high interest stimuli sources as used in experiment 3.2 and throughout Chapter 5.

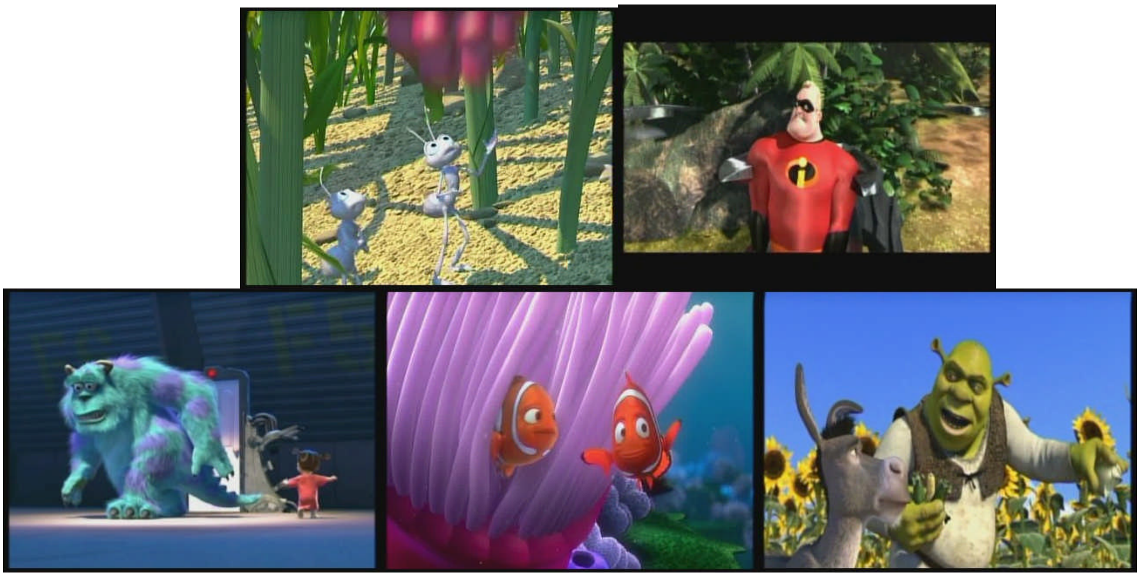

*Figure 8.3:* Examples of video stills from clips used as high interest stimuli from the computer animated film category.

*Figure 8.4:* Examples of video stills from clips used as high interest stimuli from the children's television show category.

*Figure 8.5:* Examples of video stills from clips used as low interest stimuli.

## 8.3. Appendix C: Stimuli for Chapter 4

Figure 8.6 displays examples from the paired stimuli from experiment 4.2. The images on the left are examples of the high interest pictures, whereas those on the right are examples of the low interest images. The low interest stimuli were chosen to be equivalent in brightness, colour complexity but lacking the specific content of interest to the participant.

*Figure 8.6:* Examples of paired stimuli from experiment 4.2.

Figure 8.7 displays examples from the paired stimuli from experiment 4.3. The images on the left are examples of the high interest pictures, whereas those on the right are examples of the low interest images. The low interest stimuli were pixelated versions of the high interest stimuli. This was in an attempt to match the specific colour content and brightness of the stimuli while removing the specific content of interest to the participant from the low interest images.

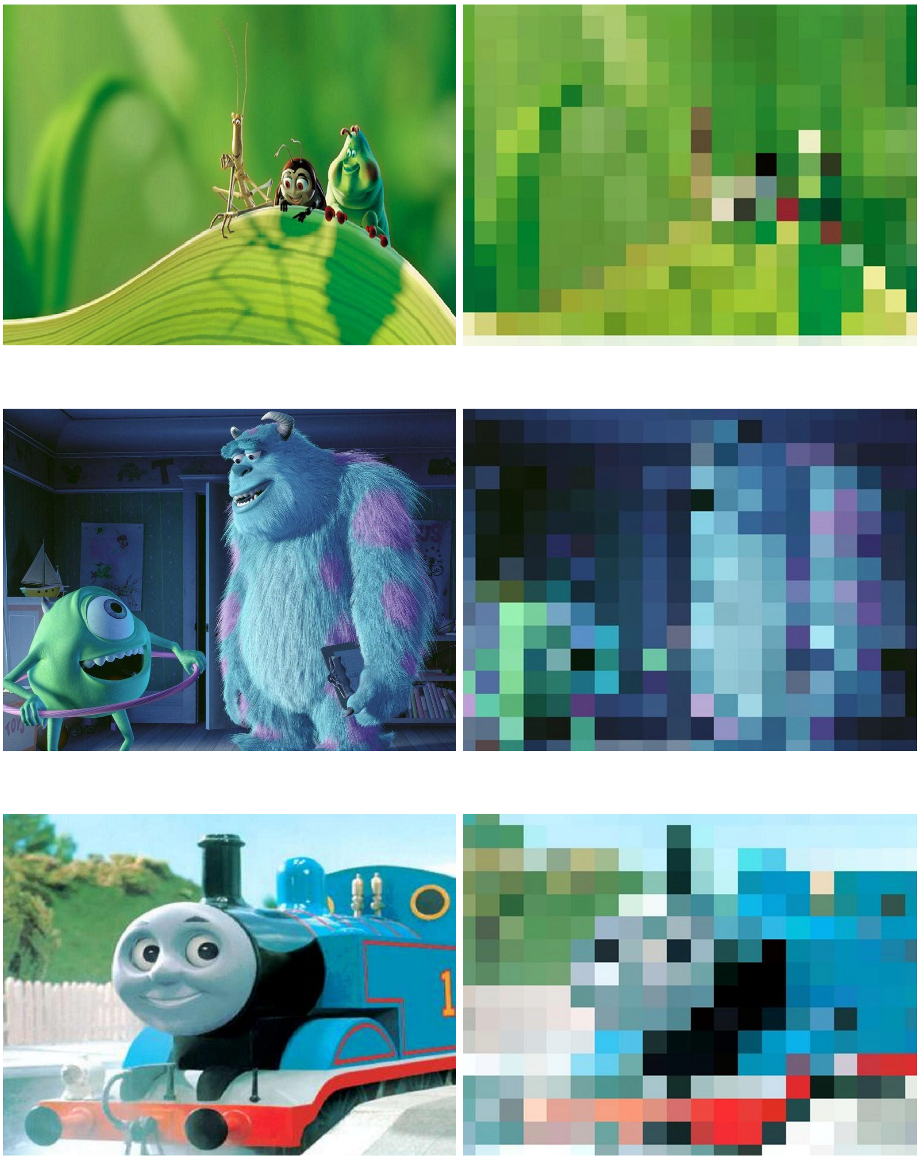

*Figure 8.7:* Examples of paired stimuli from experiment 4.3.

# 8.4. Appendix D: Stimulus Selection Results

Table 8.1

*Distribution of movie selections across experiments 3.2, 4.2, 4.3 and 5.1.*

| | | Movie | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exp | Grp | PO | BA | TH | BE | BO | IN | NE | SH | MO | BU | Total |
| 3.2 | ASD | 0 | 1 | 2 | 0 | 3 | 2 | 0 | 3 | 0 | 0 | 11 |
| | TD | 2 | 0 | 3 | 0 | 2 | 1 | 1 | 2 | 0 | 0 | 11 |
| | | | | | | | | | | | | 0 |
| 4.2 | ASD | 1 | 0 | 2 | 0 | 1 | 1 | 2 | 3 | 2 | 1 | 13 |
| | TD | 1 | 0 | 1 | 0 | 2 | 2 | 3 | 2 | 1 | 1 | 13 |
| | | | | | | | | | | | | 0 |
| 4.3 | ASD | 2 | 1 | 2 | 0 | 3 | 2 | 1 | 2 | 2 | 0 | 15 |
| | TD | 2 | 0 | 1 | 0 | 3 | 0 | 3 | 2 | 2 | 2 | 15 |
| | | | | | | | | | | | | 0 |
| 5.1 | | 3 | 2 | 2 | 0 | 1 | 2 | 2 | 1 | 1 | 1 | 15 |
| | | 11 | 4 | 13 | | 15 | 10 | 12 | 15 | 8 | 5 | 93 |

## 8.5. Appendix E: Comparison of Abstract Stimuli across Experiments

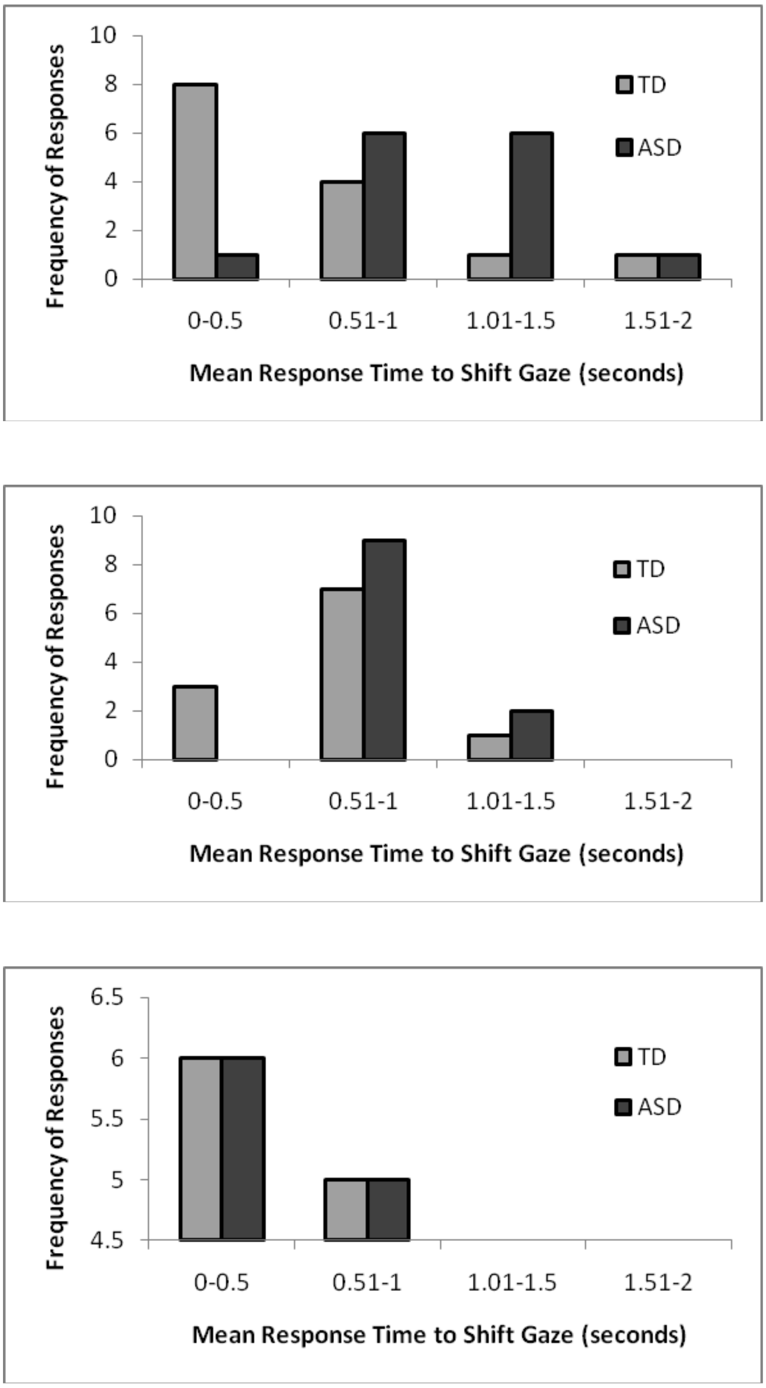


*Figure 8.8:* Comparison of the distributions of response times between the dynamic stimuli of experiments 3.1, 4.1 and the stills of experiment 4.1 respectively for competing trials.

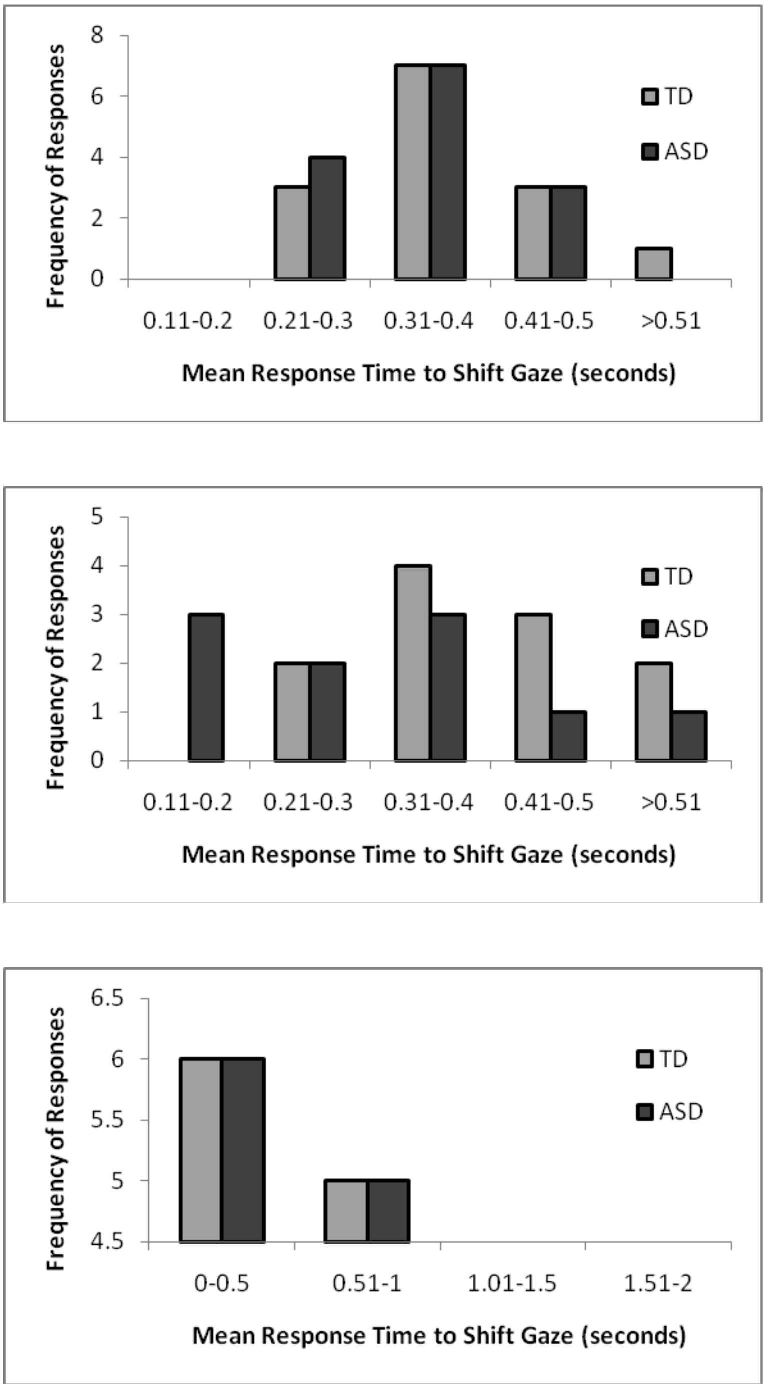


*Figure 8.9:* Comparison of the distributions of response times between the dynamic stimuli of experiments 3.1, 4.1 and the stills of experiment 4.1 respectively for shift-only trials.

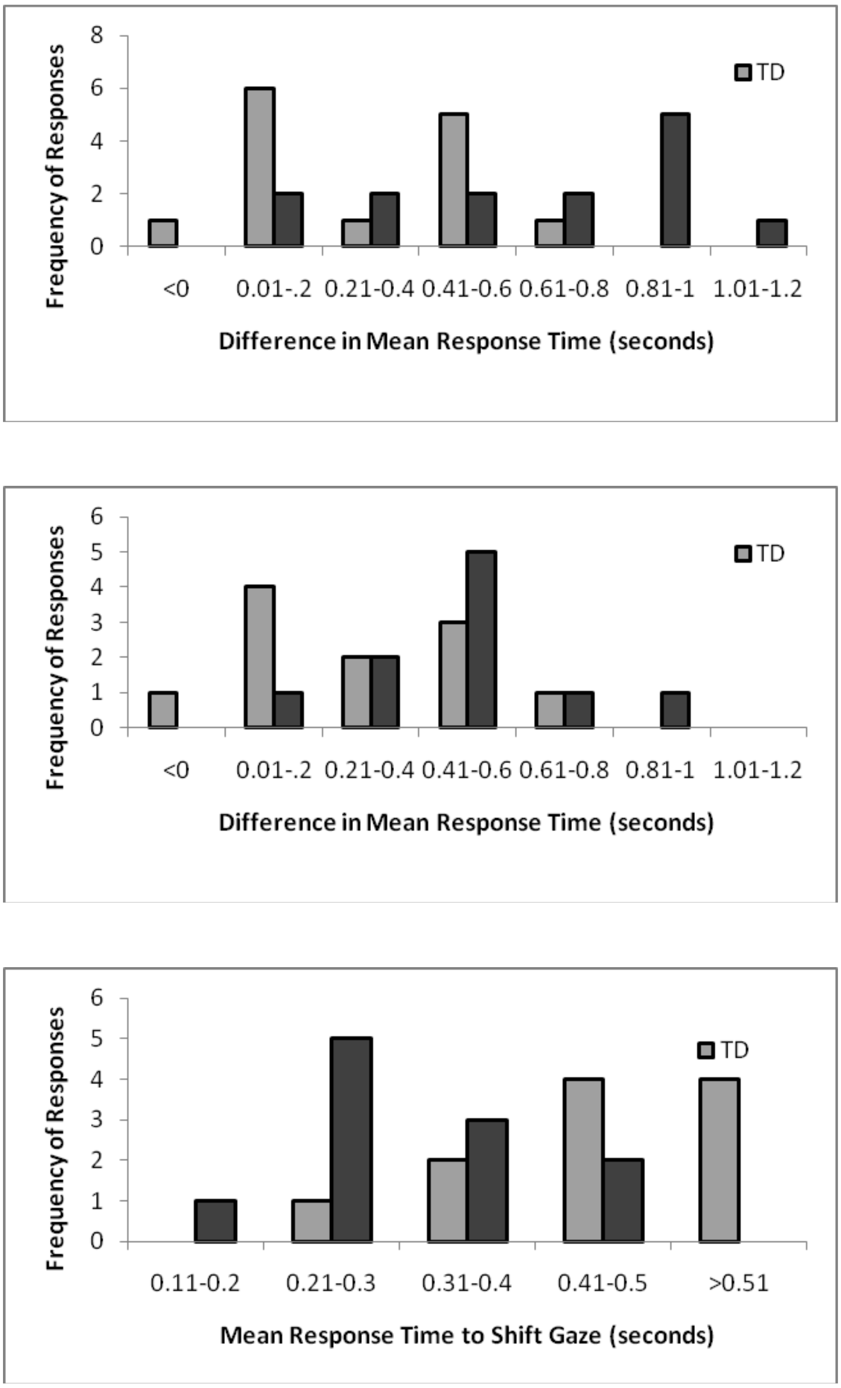


*Figure 8.10:* Comparison of the distributions of response times between the dynamic stimuli of experiments 3.1, 4.1 and the stills of experiment 4.1 respectively for gap trials.

# 8.6. Appendix F: Age and Gap Effect for Dynamic Stimuli

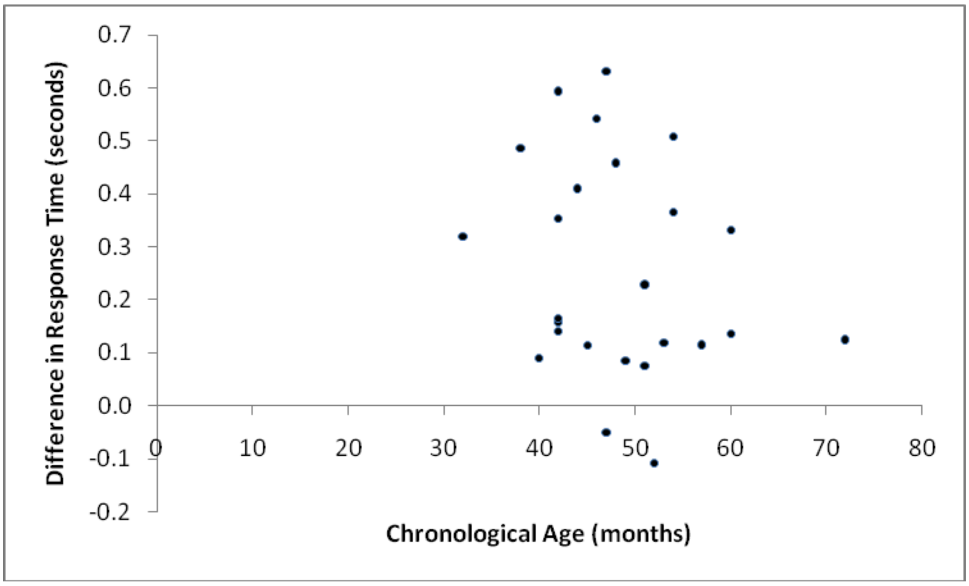


*Figure 8.11:* Composite comparison of mean gap response times between the dynamic stimuli of experiments 3.1 and 4.1 and chronological age for TD children.

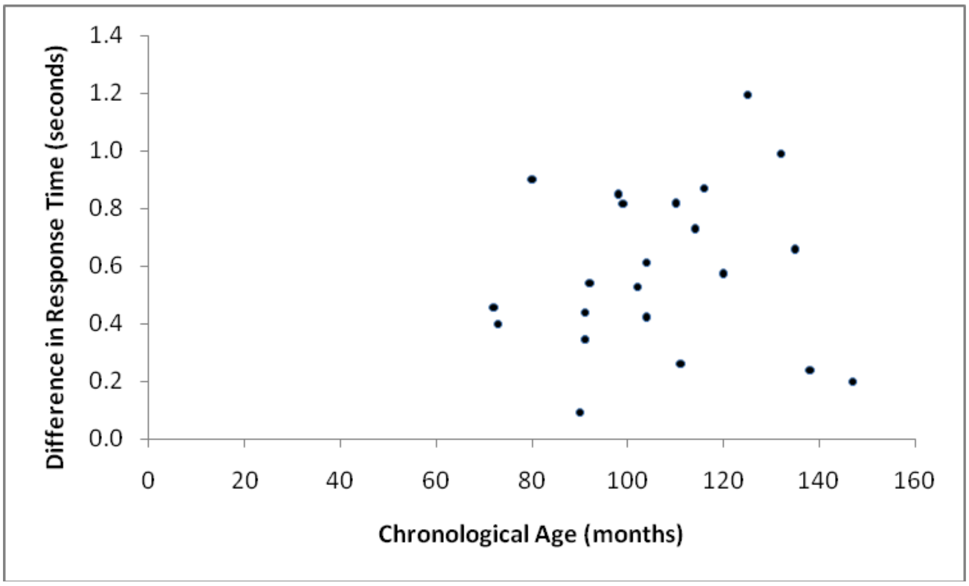


*Figure 8.12:* Composite comparison of mean gap response times between the dynamic stimuli of experiments 3.1 and 4.1 and chronological age for ASD children.

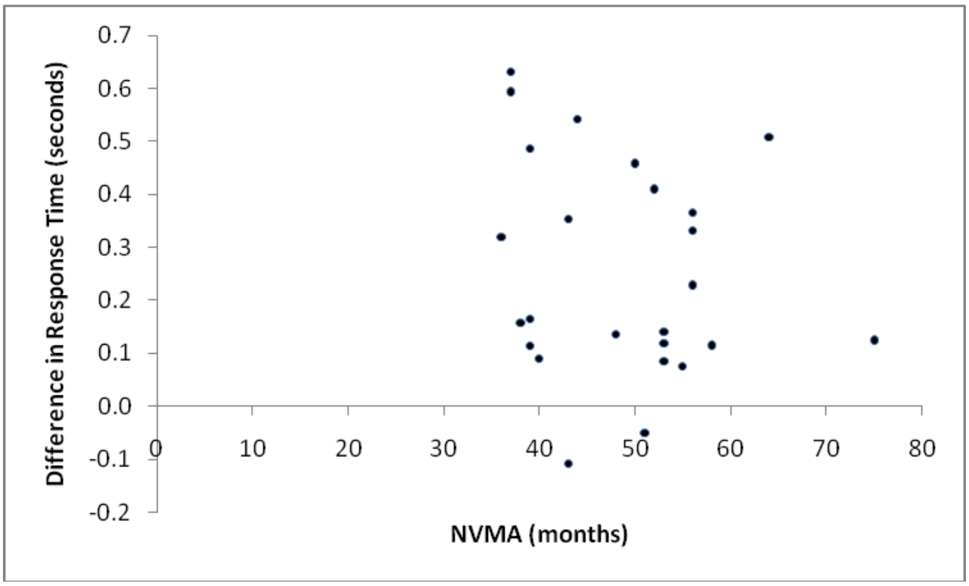


*Figure 8.13:* Composite comparison of mean gap response times between the dynamic stimuli of experiments 3.1 and 4.1 and non verbal mental age for TD children.

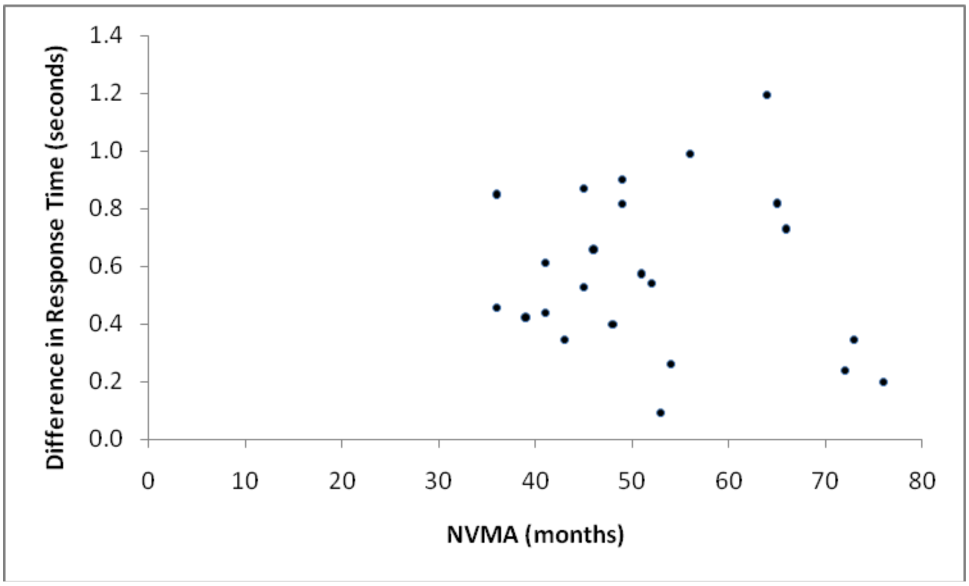


*Figure 8.14:* Composite comparison of mean gap response times between the dynamic stimuli of experiments 3.1 and 4.1 and non verbal mental age for ASD children.