THE ROLE OF CAUSAL PERCEPTION OF MOVEMENT IN THE EARLY SOCIAL DEVELOPMENT OF AUTISTIC CHILDREN

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THE ROLE OF CAUSAL PERCEPTION OF MOVEMENT IN THE EARLY SOCIAL DEVELOPMENT OF AUTISTIC CHILDREN

by

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A thesis submitted to the University of Plymouth in partial fulfillment for the degree of

Doctor of Clinical Psychology

Department of Psychology
Faculty of Human Sciences

In collaboration with the
Child Development Centre, Plymouth Hospitals NHS Trust,
and with Downham School, Mill Ford School
& South Trelawney Primary School, Plymouth

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ABSTRACT

The Role of Causal Perception of Movement in the Early Social Development of Autistic Children

by Martin Morris

Autistic children often lack social behaviours which are normally present by 8-12 months (Klin et al., 1992; Mundy et al., 1986), although current 'top down' theories about autism hypothesise later-developing conceptual difficulties in social cognition. Research indicates that there are abnormal 'bottom up' perceptual processes in autism (Moore, Hobson & Lee, 1995). Processing of unexpected dynamic visual information may occur to a diminished extent (Courchesne, 1987), whilst in normal infancy, causal perception of the movements of animate and inanimate objects is likely to be important for social cognition and affective relationships (Shultz, 1989; Premack & Dasser, 1990). It has been suggested that autistic children have difficulties with the unpredictable nature of perceived social information (Mundy & Sigman, 1989b; Dawson & Lewy, 1989).

On the basis of such previous research, it was proposed that the early social abnormalities of autistic children are a result of them tending not to notice, or process further, brief dynamic visual information about events unless these follow simple predictable patterns. To test this hypothesis, seven young autistic and seven developmentally delayed children, matched pairwise for verbal comprehension, were initially habituated to two computer-generated displays, of a cartoon-like 'boy' (Runner) running up to a 'wall' and back, and of a 'ball' moving towards the wall and apparently re-bounding back. Visual habituation was reliable and due to information encoding. The autistic children looked relatively less at the Runner habituation display, perhaps due to relatively diminished processing of animate dynamic information. After habituation criterion was reached, a time delay was introduced prolonging contact with the wall, so that the Ball display became 'impossible' whereas the Runner remained 'possible'. As predicted, recovery of visual fixation indicated that the delay was discriminated, and the autistic children recovered relatively less to the novel Ball display compared with the developmentally delayed children. The autistic children may not have perceived the anomaly in the novel 'impossible' Ball event. They either may have had a general expectation for inanimate objects to move independently, or a tendency not to notice altered significance in a repetitive visual event. However, the group differences could also have been due to the autistic children tending not to have real life expectations of cartoon images.

Consistent with the hypothesis, the scores of all 14 children both for pre-11 month social behaviours and for joint attention, were associated with relative recovery for the novel Ball display. As predicted from previous research, the autistic children engaged infrequently in these social behaviours.

It is proposed that how children perceive the dynamic animate and inanimate world affects how they develop socially during their first year of life. Relevant areas for future research and implications for early interventions are discussed.
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AUTHOR’S DECLARATION

At no time during the registration for the degree of Doctor of Clinical Psychology has the author been registered for any other University award.

The contents of this bound thesis are identical to the volume submitted for examination in temporary binding except for the amendments requested at the examination.

This study was conducted while the author was a Trainee Clinical Psychologist in the South West Region based in Plymouth Community Services NHS Trust. The research was conducted in collaboration with the Child Development Centre, Plymouth Hospitals NHS Trust, and with three Plymouth schools of the Education Department, Devon County Council: Downham School, Mill Ford School, and South Trelawney Primary School.

Seven of the reported language comprehension assessments (Reynell Developmental Language Scales) were carried out by Ms. Claire Lewis, Speech Therapist, Child Development Centre, Scott Hospital, Plymouth, the remainder by the author. The videotapes were re-scored by Dr. Emma Dales. The computer-animated displays were created by Mr. Chris Claxton, Technical Support, Department of Psychology, University of Plymouth.

Signed

Date 8.7.95
1. Overview

This Introduction reviews a wide-ranging area of research in both autism and normal infancy, with the aim of elaborating a testable hypothesis concerned with the developmental origins of the social abnormalities characteristic of autistic children. These social abnormalities are primary disabling factors in autism; we now know that they originate early in infancy and extend through adulthood. It is argued here that the early origins of the difficulties, and their particular characteristics, suggest that they may be consequences of information processing problems in 'low-level' visuo-perceptual processes. Some researchers favour this argument although others refute it. It is related here to other suggestions that autistic children have a particular difficulty with the unpredictable nature of social encounters. It is proposed that these two areas - perceptual abnormalities and the need for predictability - are linked, and this is supported by reference to recent research. This proposed link enables the generation of the experimental hypothesis by reference to the literature on how normal infants learn to distinguish animate (human) and inanimate objects, and their causal roles, on the basis of their perceived movements, both on a physical and a social level (these two levels being linked).

It is hypothesised that autistic children will not notice changes in the causal structure of animate versus inanimate events on the basis of perceived movements. A habituation/recovery methodology, measuring visual fixation, is described, in order to test a prediction from this hypothesis.

The literature review follows the pattern outlined above, starting with the diagnosis of autism.
(Section 2), describing the early social abnormalities observed (Section 3) and discussing theories about these abnormalities (Section 4). The need for predictability is examined (Section 4) and related to literature on sensory processing in autism (Section 5). Theorising and empirical research into the perception of causality in normal infancy is then discussed (Section 6) and related to the preceding literature on autism, to generate the hypothesis and experimental predictions (Section 7).

2. Diagnosis & Assessment of Autism

2.1 History: Multiplicity of Symptoms

Kanner (1943) described a group of children as having 'autistic disturbances of affective contact' that included lack of affective interaction, obsessional desire for sameness, fascination for hard objects and absence of, marked difficulties in, or abnormalities in, expressive language. He emphasised the early occurrence of symptoms, his term for the disorder being 'early infantile autism'. Creak (1961) broadened the range of diagnostic behaviours to nine dimensions which encompassed childhood schizophrenia. These included abnormal responses to perceptual stimuli, stereotyped behaviours (e.g. rocking, spinning objects) and "islets" of cognitive skills or, more commonly, retardation, particularly in verbal skills. Thus, there is a wide range of behavioural characteristics, or dimensions, that appear to cluster around the label 'autistic'. Wing's term 'the autistic continuum' (Wing, 1988) has now been widely adopted, but her alternative term 'spectrum of autistic disorders' (my italics) may convey more accurately her intention that an autistic individual should not be regarded as on a continuum between autism and 'normality', but as having a distinct condition in which "..the manifestations...vary widely in type and severity, and all kinds of combinations of impairments are seen in clinical practice."
2.2 Diagnostic Systems

In view of this varied spectrum of behaviours, there is potential for different diagnostic systems. Kolvin (1971) published research that distinguished between autism and childhood schizophrenia and this was a prelude to three contemporary diagnostic systems: 1) The U.S.A. National Society for Autistic Children (NSAC, 1978); 2) Rutter (1978); and 3) DSM-III-R (1987) of the American Psychiatric Association. All these systems agree on three basic criteria of autism:

1) onset before 30 months (DSM-III-R; 'during infancy or childhood');

2) impaired social development, which has a number of special characteristics and which is out of keeping with the child's intellectual level; and

3) delayed and deviant language development which also has certain defined features and which is out of keeping with the child's intellectual level (Rutter, 1978). Rutter and DSM-III-R also emphasise a fourth criterion;

4) 'insistence on sameness', as shown by stereotyped play patterns, abnormal preoccupations, or resistance to change.

Rutter thus identifies a 'triad' of behavioural features which may be described as delay or deviance in social relatedness, communication and behaviour/imagination. DSM-III-R requires the presence of a minimum of either one or two types of behaviour (according to the behavioural dimension) in each of the three dimensions from a 'choice' of 16 types overall, to give a total of at least 8 types of behaviour. Gillberg (1990) argues that onset before 3 years is sometimes difficult to establish from parents' accounts and is not an invariant feature. The NSAC definition, developed under the direction of Ritvo, also features a fifth criterion; (5) disturbances of response to sensory stimuli, which includes 'disturbances of motility' as a wider definition of stereotyped behaviour related to sensory abnormalities (e.g. hand clapping, oscillating, body rocking, head banging or rolling and...
twirling objects). Ornitz & Ritvo (1968), following the earlier work of Creak (1961) and Goldfarb (1956), identified disturbances of perception in all sensory systems and there has since been much research on perceptual abnormalities (see Frith & Baron-Cohen, 1987, for a review).

2.3 Validity and Reliability of Diagnosis

It may be difficult to make an unambiguous differential diagnosis between autism and receptive speech disorder, childhood schizophrenia, and, in particular, learning disability (Prior & Werry, 1985). However, cluster analysis gives construct validity for an autistic spectrum of behaviours Prior et al, 1975), when it is accepted that individual behaviours, or behavioural dimensions, overlap with other developmental disorders. The clustering of behaviours is what characterises autism (Gillberg, 1992). Autistic individuals are likely to have significant cognitive delay, with 75-95% achieving overall ability scores of IQ<70 (Bartak & Rutter, 1976; Gillberg, 1988). The primary difficulty in differentiation from a 'simple' learning disability is that a learning disability is often associated with autistic-like social impairments (Wing & Gould, 1979). The diagnostic criteria for autism emphasise social functioning out of keeping with intellectual level. There is a relationship between developmental level and the severity of autistic social impairment (Bartak & Rutter, 1976; Volkmar et al, 1989) and differential diagnosis is particularly problematic when abilities are low (Rutter & Schopler, 1987) or with young children (Prior & Werry, 1985).

A rating scale for observed behaviours offers potential for greater systematic objectivity of diagnosis and also for psychometric measurement of an individual’s spectrum and severity of behaviours. The Childhood Autism Rating Scale (CARS; Schopler, Reichler & Renner, 1988) is more reliable and has greater concurrent validity (against psychiatric diagnoses) than previous scales for clinical practice, diagnosis and research (Gillberg, 1990).
CARS measures most of the spectrum of behaviours described here as associated with a diagnosis of autism, identifying 14 behaviour dimensions, each rated on a seven-point scale by either behaviour type or severity. The score provides both a severity rating and a diagnostic cut-off, from validation with psychiatric diagnoses.

3. The Central Role and Nature of Social Abnormalities in Autism

3.1 Wing's Views on Diagnosis; Social Development in Autism

In contrast to the above three diagnostic systems and the CARS, Wing (1988) proposes that there is just one distinctive 'central problem' in autism, which is "...both necessary and sufficient for the diagnosis..." (my italics): "...an intrinsic impairment in development of the ability to engage in reciprocal social interaction...". The study of Wing & Gould (1979) found that degree of social impairment was the most reliable feature that distinguished autistic from non-autistic learning disabled adults.

Rutter (1978) describes the social abnormalities, when onset is before the second year, as lack of attachment behaviour with parents (but not physical withdrawal) and lack of anticipatory posture for being picked up. He also emphasises absence of eye contact for communication (eg. to gain attention, on being spoken to). After age 5, Rutter states that these difficulties may diminish, but that social difficulties persist in lack of cooperative play, failure to make friendships and lack of empathic understanding leading to socially inappropriate behaviour. The longitudinal study of Wing & Gould (1979) supports Rutter's view of the development of autistic social behaviours; they found a transition from 'aloof', through 'passive but responsive', to 'active but odd social initiation'. The authors describe the latter as varying from one-sided or idiosyncratic social approach with little interest in others' needs and feelings to a "...poverty of grasp of the most subtle rules of social
3.2 Early Autistic Social Behaviours: Importance for Research

Research aimed to elucidate underlying causal mechanisms in autism attempts to distinguish between such 'primary' autistic abnormalities and their consequences - 'secondary' abnormalities. By definition, primary abnormalities will not appear later in development than secondary abnormalities and they may well appear earlier, so the study of young autistic children is important (Ungerer, 1989).

Volkmar (1987) describes lack of social reciprocity, tenuous attachment, paucity of joint play and poor communication as the autistic social impairments in infancy. As discussed earlier, differential diagnosis in young children may be problematic. However, the research of Klin, Volkmar & Sparrow (1992) indicates that there are a number of pre-11 month social behaviours which tend to be absent (but not invariably) in young autistic children. The mothers of 29 autistic and 29 developmentally delayed children, mean ages approximately 4 years and matched on various IQ tests, were interviewed using the Revised Vineland Adaptive Behaviour Scales. The child's social behaviours were scored as 'not usually performed'/'usually performed' on the first 20 items of the Socialization Domain. The autistic group performed social behaviours less frequently than the controls on nine of the 20 items, even though the children's equivalent age ability scores would have predicted that these behaviours should be 'usually performed'. Six of the nine items described social behaviours whose median age of onset is no later than 7 months; interest in non-family children, interest in others' activities, simple interaction games, showing affection, reaching for a familiar person and showing anticipation of being picked up by a caregiver. The three items which described 8-11 month social behaviours included laughing or smiling in response to positive statements and imitating simple movements. Although this study
appears to give reliable evidence of early social abnormalities, it should be noted that between 38% & 69% of the autistic children did ‘usually perform’ the social behaviour on each of the 9 items and up to 21% of the control children did not, although only two of the 29 autistic children displayed all items up to to the age equivalent of 7 months. Also, 86% or more of the autistic children showed attachment behaviours on 3 of the 20 items and 93% expressed two or more recognisable emotions.

3.3 Attachment and the Expression of Emotion

As indicated by the above study of Klin et al (1992), some attachment behaviours are present in autism. Other researchers have found more social behaviours (proximity, looking, touching, vocalisation) towards caregivers than strangers, both before separation and on reuniting after 2 minutes (Sigman & Ungerer, 1984; Sigman et al, 1987). Thus attachment itself is not absent, although Mundy & Sigman (1989a) and Hobson (1989a) suggest that positive affect behaviours relatively diminished even within the attachment. Thus, autistic children may engage in cuddling and responsive smiling (Volkmar, Cohen & Paul, 1986), but 3 - 5 year old autistic children also make idiosyncratic affective vocalisations (Ricks & Wing, 1979). Raters find it difficult to identify a specific affect associated their facial expressions (Mundy & Sigman, 1989a) and they tend not to exhibit expressive gestures (eg. of friendship; Attwood, Frith & Hermelin, 1988).

3.4 Joint Attention, Gestural Behaviours and Imitation

Joint attention (looking at what another person is looking at), normally present at 8-10 months, and indicating behaviours (gestural communication - pointing to draw someones' attention to an object, showing an object and referential looking or alternating looking between object and person), normally present at 11-12 months, have been shown to be deficient in autistic children aged 3-13 years, compared with ability- and age-matched
controls (Baron-Cohen, 1989; Baron-Cohen, 1990; Goodhart & Baron-Cohen, 1993; Loveland & Landry, 1986; Mundy, Sigman, Ungerer & Sherman, 1986; Sigman et al, 1986). The deficit in joint attention predicts future language development (Mundy, Sigman & Kasari, 1990) and, when joint attention is observed with autistic children, it is associated with low levels of positive affect expression, whereas ability-matched children with developmental delay tend to show positive affect such as smiling (Kasari et al, 1990). Thus, Mundy & Sigman suggest that joint attention deficits constitute a central early social abnormality in autism. The theory they have developed around this is discussed later.

In contrast to joint attention, there is no specific deficiency in social interaction behaviours which involve the use of non-verbal behaviours or objects to initiate or maintain face-to-face interaction (eg, reaching, taking turns with another), nor in requesting/regulating behaviours (eg, reaching to a toy) that involve procedures to gain another’s aid in obtaining objects or events (Mundy et al, 1986; Mundy, Sigman & Kasari, 1990; Baron-Cohen, 1989; Attwood et al, 1988). Thus, autistic children may initiate physical or visual contact, or point to an object with the apparent aim of indicating to an observer that he or she 'should' make it available.

3.5 Perception of Faces and of Facial Expressions of Emotion

There has been research into mechanisms underlying affect in autism. There is a body of evidence, although not unchallenged, suggesting that autistic children have a difficulty in identifying facial expressions of emotion, beyond that of ability-matched learning disabled children (Ozonoff, Pennington & Rogers, 1990; Volkmar et al, 1989). Any such difficulty may originate both in difficulties in processing information about complex emotions, such as pride and embarrassment, and in abnormal mechanisms of facial perception (Tantam, Monaghan, Nicholson & Stirling, 1989; Hobson, 1991). Recent research by Hobson and
colleagues (Moore, Hobson & Lee, 1995) indicates that underlying perceptual abnormalities may be primarily responsible: Autistic children had acute difficulties in verbally labelling observed human behaviours representing states and emotions, but not in recognising actions, when the information was conveyed in point-light displays lacking real-life contextual information. In earlier research, they were more adept than ability-matched controls in matching pictures of faces by emotion and identity when they were presented upside-down (Hobson, Ouston & Lee, 1988) and in choosing emotion labels for the facial expression (Tantam et al, 1989), whereas the reverse was the case when the pictures were in the normal orientation. They may tend to use information from the lower part of the face (eg. mouth) rather than the upper part (eg. eyes) in emotion and identity recognition (Langdell, 1978).

Hobson and co-workers (Hobson et al, 1988) suggest that autistic children identify emotional expression not by 'emotional content' but by identification of associated perceptual features. Different aspects of faces may be salient for autistic individuals compared with ability- and age- matched controls. Indeed, faces themselves may not be salient, as Weeks & Hobson (1987) found that autistic children tended to sort pictures of faces by the hat worn rather than by facial expression, unlike ability- and age-matched controls. Hobson (1989) concludes that autistic children have a biological impairment of 'affective-conative relatedness with the environment' (i.e. impairment of affect and motivation) which impairs their 'personal relatedness' with others.

4. Theorising about Autistic Social Abnormalities

4.1 Introduction: the Role of Perceptual and Conceptual Levels of Explanation for Autistic Social Abnormalities
Dawson & Lewy (1989a) highlight two primary differences between inanimate objects and people as 'sources of information', as discussed by Gelman & Spelke (1981): 1) Objects cannot respond with independent action, so their movements are predictable from their physical properties and actions upon them, whereas people act and communicate in ways that are not fully predictable. 2) Objects are determinate, in being primarily characterised by their physical properties, whereas people are indeterminate in being characterised by their actions, intentions, motives and feelings.

These two differences, discussed in more detail in the following section, highlight two 'levels' of psychological functioning within social relationships and situations; Overt - the person responds to others on the basis of 'directly' perceived external features; and Covert - the person responds to others on the basis of inferred internal psychological states. These two levels may be regarded as mainly depending on, respectively, sensory-driven 'bottom-up', and conceptually-driven 'top-down', processing (Frith & Baron-Cohen, 1987). Theorists concerned with normal infant development (eg. Shultz, 1988; Premack & Dasser, 1990; Gelman & Spelke, 1981) have suggested that not only is 'low-level' perceptual processing significant in its own right for both infants and adults in accounting for, and predicting, social and non-social events (a suggestion which is explored later), but it is also a prerequisite in early infancy on which later developing, conceptual, levels of social explanation are dependent. A similar view is proposed by Hobson (1989), with reference to autistic children. Rather than proposing a clear distinction between the two levels, Hobson suggests that overtly observable features of a person - facial expression, directed gaze, gestures, posture (i.e. both non-intentional and intentional non-verbal communications) - convey information about covert internal states such as emotions and desires, and also about the external objects of those internal states. Thus affective or motivational states are perceived and this leads naturally to inferences of the objects of those internal states; thus
the person is attributed with covert 'intentional' mental states (i.e. thoughts, beliefs or intentions about objects or people in the world - eg., "He believes I am smiling at him", may be inferred from a observed reciprocated smile).

In contrast, other theorists propose that autistic children's social abnormalities are due to difficulties at the conceptual level - the inferencing of intentional mental states ('theory of mind' deficit hypothesis; see Frith, 1992 and Baron-Cohen, 1992, for reviews). The empirical evidence for this hypotheses, now the subject of controversy, will be evaluated in the Discussion. The concern here is the claim of such theorists that abnormalities that are apparently at the sensory/perceptual level actually represent the 'underlying' precursors of developing conceptual difficulties; i.e. they are the result of top-down, not bottom-up, processing difficulties (Leslie & Happe, 1989; Frith & Baron-Cohen, 1987).

Hobson (1989), as discussed earlier, proposes that autistic children have difficulties in 'direct' perception of others' affective expressions and gestures, and in their own emotional responsivity. On a similar theme, Boucher & Lewis (1992) found specific memory difficulties for faces in autistic children, which they suggest may cause social difficulties. Mundy & Sigman (1989a, b) also focus on autistic children's perception of others' non-verbal behaviours, but propose different mechanisms from Hobson. As discussed earlier, joint attention is relatively diminished in autism. In view of its normally early development, Mundy & Sigman propose that 'covert', top-down processing, accounts of its relative absence in autism that are based on later-appearing conceptual difficulties, such as in 'theory of mind', are unlikely, alone, to be adequate explanations of the early social difficulties. Similarly, as discussed earlier, Klin, Volkmar & Sparrow (1992) have argued that theory of mind difficulties are unlikely to explain other pre-12 month social abnormalities in autism. Mundy & Sigman (1989a) have found that joint attention behaviours are poor
predictors of pretend play, which are postulated as linked with theory of mind capability.

Mundy & Sigman (1989b) discuss how joint attention behaviours are associated with positive affect expressions, in normal children, unlike autistic children (as outlined earlier). As the expression of positive affect induces imitation, eg. smiling, from a caregiver, they propose that the normal child learns, by contingency, that his or her own expression of positive affect has 'signal value' in 'causing' the adult's smiles; thus joint attention behaviour becomes positively reinforcing. In contrast, as autistic children emit fewer positive affect expressions, they have correspondingly less opportunity to learn such contingency. Mundy & Sigman also draw on Dawson & Lewy's (1989) theory of autistic 'overarousal' in unpredictable social environments (discussed below), suggesting that autistic children also have an intrinsic difficulty in processing social contingency information.

Whilst the early relative absence of joint attention behaviours is likely to be of great importance in autistic social development, Mundy & Sigman’s proposal that it is based in an absence of affective expression places it as an abnormality secondary to another social abnormality; affect expression, about which they have no account. Also, the role of social unpredictability is not operationalised. There is an absence of empirical evidence for the mechanisms Mundy & Sigman propose, and a need for more specific proposals concerning the mechanisms underlying autistic children’s need for predictability and how the perception of social predictability may be linked with the early social abnormalities in autism, such as anticipation of caregivers approach, interest in others, affect expression and joint attention (Klin et al, 1992; Mundy & Sigman, 1989a).

4.2 Need for Predictability, Sensory Responses and the Autistic Social Abnormalities

There is much evidence that autistic children have a need for events to be predictable, their
'desire for sameness' and 'resistance to change' being diagnostic criteria, as discussed earlier. However, there has been little research to investigate any relationship between need for predictability and social abnormalities in autism. In support of their hypothesis, Dawson & Lewy (1989b) cite work indicating that behaviours such as eye contact, stereotypies and social responsiveness vary as a function of the structure, familiarity and predictability of the environment. They also cite Ferrara & Hill (1980), who found that autistic children, unlike younger normal children, handled dolls for shorter periods if there was an unpredictable interval between illuminating a miniature theatre 'stage' and the dolls appearing, compared with a predictable interval. This experiment suggests that the children were probably responding to predictability on a perceptual, rather than conceptual, level (i.e. the children are unlikely to have resorted to conceptual, mentalistic, reasoning to account for the unpredictability). However, it is not clear, given the tangible nature of the dolls, that either group of children were attributing animacy to them, and therefore the experiment cannot be regarded as an analogue of a 'social' situation.

Direct indications of a link between predictability, the animate/inanimate distinction, social fear and sensory/perceptual processing may be found in four first-hand accounts by autistic people of their experiences during childhood. One person (Joliffe, Lansdown & Robinson, 1992) describes the salience of various sensory experiences, such as an interest in colours, lights and shining metal surfaces, and the importance of tactile experiences such as rocking, spinning wheels, and opening and closing doors. The writer believed that he or she tended to look at the outline or parts, rather than the whole, of pictures or faces and found it difficult to look at faces, not realising that "...[my family] were people...and more important than objects". The writer had a particular fear of moving objects including the "sudden" movements of dogs, and found the "indecision" of events almost intolerable. There was also a fear of noises, both animate and inanimate. Bemporad (1979) gives an
account of a 31-year old man who was afraid of human contact in childhood; he described being in a "...frightening world presenting painful stimuli that could not be mastered. Noises were unbearably loud; nothing was constant; everything was unpredictable and strange. Animate beings were a particular problem. Dogs were remembered as eerie and terrifying...they were somehow humanoid (since they moved of their own volition, etc.)...they were especially unpredictable; they could move quickly without provocation". Grandin (1986) wrote that the "...people world was often too stimulating to my senses". Unexpected events were worst and she would feel overwhelmed, in social events, "...people moving about at different speeds, going in different directions, the constant noise and confusion, the constant touching, were overwhelming" (op. cit, p. 25). She would find it difficult to 'screen out' background noises and would 'retreat' to spinning herself or other objects. Similarly, a teenage boy wrote about his experiences when younger. His hearing and eyesight would "play tricks" on him, so that his eyesight would frequently "blurr" and could distort the sizes of objects, whilst words and noise would be confusing and "terrifying" (White & White, 1987).

Thus, sensory experiences can be overwhelming, whilst any sensory information may appear unpredictably salient with disregard to its 'everyday' relevance. Movements and sounds in particular may be incomprehensible and unpredictable aspects of the behaviours of people and animals. It appears that it is the experience of perceiving such animate movements, rather than necessarily the physical appearance or presence of a person or animal in itself, which produces the social fear.

Having established the basis for the ideas about sensory processing, predictability and social abnormalities, reviewed below is the empirical evidence about these factors in autism, and about the responses of autistic children to novelty and unpredictability.
5. Processing of Sensory Information by Autistic Children

5.1 Preference for Sensory Modalities by Autistic Children, and Cross-Modal Recoding

Hermelin & O'Connor (1970) carried out a series of classic experiments with autistic children. Of interest here are two of their overall findings: 1) The autistic children found sensory information in a tactual modality more salient than in a visual modality, which in turn was more salient than an auditory modality (e.g. speech). 2) The autistic children tended not to transfer information perceived in one sensory modality to another.

The tactual preference was indicated by their tendency to use tactile (e.g. outlines of edges) rather than visual information in assembling puzzles or when carrying out a tracking task where they were required to guide a metal stylus along a groove following tracks of varying complexity. The autistic preference for the visual over auditory modality was indicated by autistic children tending to recall the spatial (left to right) sequence of presentation when three letters were presented visually, with the middle one first, then the right one followed by the left one. In contrast, learning disabled and normal children recalled the temporal sequence, recoding the presentation in auditory-verbal mode.

5.2 Implications of Sensory Responses and Sensorimotor Learning for theories about Conceptual Cognition

One of Hermelin & O'Connor's (1970) primary conclusions, partly from their observations of 'proximal' tactual preference, was "...autistic children...have a tendency to process and make use of information from induced and active movements...(they) seem to rely more on perceptual activity than on perceptual analysis." Some subsequent research supports this view, and consideration of this clarifies the implications of these comments.
One difficulty in processing visual information may be autistic children’s tendency to focus attention on small areas of a complete image or object. Hobson’s and Langdell’s work (3.5 above) indicates that faces may be perceived by different features from other children, and this is confirmed by one of the first hand accounts (4.2 above; Joliffe, Lansdown & Robinson, 1992). Frith (Frith, 1989; Frith & Baron-Cohen, 1989) give examples of autistic children focussing on small objects in the environment and of an ability to locate ‘hidden’ geometric outlines in a complex design. Similarly, Rincover & Ducharme (1987) carried out research which is consistent with earlier research (see Frith & Baron-Cohen, 1987) indicating that autistic children tend to learn to discriminate only one element of a more complex display (stimulus overselectivity). These researchers found that such overselectivity was specific to displays with spatially separate elements, rather than simply a difficulty with complex displays, and the earlier research found that learning disabled children may have similar problems, if often not so acute.

Consideration of such selective responses to visual stimuli, together with autistic children’s preference for the tactual modality, may account for a body of evidence which indicates that conceptual learning is difficult when information is presented in an abstract visual format, but less so when presented in a more ‘concrete’ format available to tactile exploration. Prior & McGillivray (1980) found that autistic children were able to learn changing abstract matching rules (changing set) to obtain a reward (conditional matching learning set task) if the stimuli were coloured three-dimensional objects that could be handled, whereas they had difficulties (relative to ability-matched controls) in learning a conditional matching rule using cards with geometric black and white designs (Wisconsin Card Sorting Test, WCST; Prior, 1977; Ozonoff, Pennington & Rogers, 1991). Prior & McGillivray concluded that the children did not have a specific difficulty in learning abstract rules, but rather in using information from a visual-abstract modality in forming the rules.
In support of this position, there is a variety of evidence that autistic children can form both new abstract categories, as indicated by their performance on this aspect of the WCST (Ozonoff, Pennington & Rogers, 1991; Prior & McGillivray, 1980), and are aware of existing categories and concepts. For instance, the results of both sorting tasks and of a visual habituation/recovery procedure show they have a knowledge of various 'basic-level' categories of form and function and colour (Sigman & Ungerer, 1987; Sigman et al, 1987) and of 'superordinate' categories within either biological or artifactual domains; fruit/vegetable/animal or clothing/vehicle/furniture (Tager-Flusberg, 1985). Similarly, Eskes, Bryson & McCormick (1990), using the Stroop paradigm, demonstrated that autistic children can represent mentally both concrete and abstract word meanings, and Hobson & Lee (1989) found no difference between autistic and learning disabled control participants in their comprehension scores for abstract versus concrete words using the British Picture Vocabulary Scale.

In contrast, autistic children had difficulties learning sequencing rules, when asked to reproduce, from memory, sequences with repeating patterns of auditorially-presented words, of green and red counters, or of squares in order of decreasing size (Hermelin, 1976). Thus, autistic children may have difficulties with specific abstract concepts, or in using abstract visual materials. Authors concerned with linguistic functioning suggest that autistic children have difficulty with manipulating, rather than forming concepts and symbols in language. Consonant with the work on abstract spatial sequences and temporal sequences and concerning changing cognitive set (i.e. changing 'rule'), autistic children may have problems in comprehending the temporal relations (sequence) of events and in using verb tenses (Bartolucci et al, 1976; Paul, 1987). There may be 'simple' difficulties in the retrieval process: Tager-Flusberg (1991) found that, although autistic children had difficulties, relative to ability-matched children, in learning semantically-related word lists.
(versus unrelated lists), this difference between the groups disappeared when the children were given semantic and rhyme cues to aid recall. Boucher & Lewis (1989) similarly found that cueing, by the use of leading versus open-ended questions, substantially reduced or eliminated the event recall deficit of autistic children relative to learning disabled children which was apparent under free recall conditions. Cueing may also facilitate the production of conceptually-dependent behaviours: Lewis & Boucher (1988) found that, although pretend play is seldom spontaneously engaged in by autistic children, it may be elicited from them by the use of cues.

When given the opportunity for sensori-motor based skills (i.e. tactual cause and effect learning), it has been found that autistic children can both learn and retrieve relatively abstract rules and engage in problem solving (Sigman & Ungerer; 1981). These researchers found that the autistic children's sensorimotor skills were dissociated from, and in advance of, their language skills, unlike normal children, particularly if given a second opportunity to do the tasks after initial familiarisation. In particular, the autistic children searched for a hidden object and were able generate problem-solving solutions, for instance to use objects available as tools to retrieve inaccessible items. Thus, the availability of 'concrete' materials appeared to stimulate productive thought processes.

Summary:
In summary, in autism there is an apparent preference for tactualy-based, or for visual relative to auditory, sensory coding, and there are related difficulties in using sensory information presented in visual or auditory modalities, particularly if output is required in a different modality. There may be relatively intact sensorimotor learning, underlying an intact categorisation and abstracting capacity (relative to other children with similar verbal skills). However, there are areas where there are acute autistic difficulties in manipulating
symbols and abstract concepts (Ricks and Wing, 1976; Tager-Flusberg, 1989), particularly in the use of sequence and in changing abstracting rule 'set'. However, the use of cues may aid conceptual and retrieval processes.

A possible conclusion which is proposed here, is that the salience of both sensory input and of stored information is abnormal in autism. As a result, the extent of further information processing is affected via selective attention processes. In particular, this may determine the extent of cross-modal matching and utilisation of stored information in cognitive structures (e.g. categories, concepts and memories; 'top-down' processing). The first-hand descriptions support such a conclusion and connect it with autistic children's responses to the perceived unpredictability of events (4.2 above). Further evidence for this conclusion, including the relationship with predictability, comes from habituation/recovery experiments, considered in the next sections.

5.3 Habituation/Recovery Methodologies

Some further evidence for the above proposal comes from habituation/recovery experiments. As this methodology is used in this study, this is an appropriate place to introduce the principles and procedure.

Infants older than about 3 months visually attend to novel stimuli. This selective responsivity to novelty is utilised in both the paired comparison and the habituation/recovery(dishabituation) procedures. In the former, the infant is first exposed to a visual stimulus for familiarisation, and then is shown this original stimulus paired with a novel one, which typically is then given preferential attention. In the habituation/recovery procedure, a stimulus is successively presented until the participant's fixation times decrease, either after a fixed number of trials or to a predetermined level (habituation
criterion), and then a novel stimulus is presented. Speed of habituation is believed to represent speed of information processing, or memory formation, (see McCall, 1979 for a more detailed interpretation) and the total duration of fixation over the trials may represent salience of, and interest in, the stimulus, for instance tending to be greater for more complex stimuli (Martin, 1975; McCall, 1979). Recovery of attention to the new stimulus may represent discrimination of the degree of its perceptual discrepancy from the memory trace (or in the case of the paired comparison procedure, the observed familiarised stimulus; Rose et al, 1982), plus any further discrepancy due to interest in (processing of) unexpected ('surprising') features, for instance if the novel stimulus has anomalous properties (see, for instance, Leslie & Keeble, 1987; Baillargeon, 1994). However, further factors may influence extent of recovery, such as habituation opportunity, age of the infant and an inverted U-shaped function of recovery versus degree of novelty, so that highly discrepant stimuli attract relatively diminished recovery (Rose et al, 1982).

5.4 Physiological and Visual Responses by Autistic Children to Sensory Information: Novelty and Unpredictability

Most of the research in autism using habituation/recovery methods has involved measuring central or peripheral physiological responses to both visual and auditory stimuli, rather than the visual response modality discussed above and used in this study. Such physiological responses do not necessarily follow a similar habituation pattern to visual responses, but recovery responses may be comparable between modalities (McCall, 1979), as will be outlined. Of particular relevance here are the responses to novelty, where the novel stimulus has been defined as either the first stimulus, as a variant of the habituation stimulus (i.e. the recovery stimulus), or as a change in the pattern of repeated presentations (eg. the stimulus may be omitted or change location, or the participant may respond by a key press to a new stimulus in a reaction time procedure, after having been passive during
habituation). Inferences have also been made from the person's general state of arousal when presented with a stimulus, or series of stimuli.

Responses in the central nervous system:

Research has identified abnormalities, in autism, in two particular event-related potential components (ERP; EEG responses to specific events). ERP components are labelled according to their latencies after the stimulus event (i.e. timing), according to their voltage amplitude profiles, and according to the areas of the scalp over which their peak amplitudes are found. Research in autism had tended to find abnormal responses in two ERP components, labelled 'Ne' and 'P3':

Both components may be elicited in response to visual (eg. a letter 'A' or a red colour slide) and auditory (eg. a single frequency tone) stimuli. The Ne component is strongest over frontal cortex and its timing (latency after stimulus onset), its presence in control children when an expected stimulus is omitted and its increase in control children on a change in location of a visual stimulus (Verbaten et al, 1991) indicate that this component represents 'endogenous' processing, rather than being simply a response to sensory stimulation. Ne develops early in infancy and Courchesne (1987) presents evidence that it represents "...the focussing of internal attention on important information that has just occurred" (op. cit., p.306). The P3 component is strongest over the parietal or occipital lobes and has a longer latency than Ne, being regarded as measure of the 'deeper' information processing; specifically, the 'conceptual significance' that a participant gives to the stimulus (Courchesne, 1987).

The Ne component may be reduced, or absent, or opposite in autistic children compared with ability-matched children, and this is of particular interest when there is a failure to
respond either to the omission of a previously repeated stimulus, or to a change in the location of a visual stimulus. In other words, the autistic children appear not to have processed the unexpected new information (Courchesne, 1987). The P3 component may often be similar to controls in response to the first (i.e. novel) habituation stimulus that an autistic participant hears or sees. However, it then tends to be diminished relative to controls, again mainly on the unpredicted omission of both auditory and (but less marked) visual stimuli.

The P3 component is also reduced relative to controls after a change in spatial location of a habituated visual stimulus (i.e. novel relative to the habituation stimulus), despite a behavioural response being observed in the case of the altered location (i.e. altered direction of gaze). Similarly, changes in stimulus complexity did not give the increase in both components which was found in control children (Verbaten et al, 1991).

Courchesne (1987) concludes that these results indicate that autistic children categorise, but do not direct attention towards, significant new information. Such a conclusion is consistent not only with above results, but also with similar experiments which included a requirement for participants to respond behaviourally, by key press, to the stimuli. In the study of Strandburg et al (1984), children were asked to respond to two letters presented briefly among an array of other letters. As with the later study of Verbaten et al (1991), the N and P components (and also reaction times) did not change in response to increased complexity of the array, unlike the controls, despite their increased error rates indicated that they found the task increased in difficulty. In the study of Ciesielski, Courchesne & Elmasian (1990), 18 - 26 year old autistic men and normal controls were asked to respond either to specific rare flashes or to specific rare tones by pressing a key, according to condition, whilst being presented with stimuli in both modalities. Unlike controls, both the Nc and P3b
components were completely absent, even though the autistic men had a high accuracy in responding to the target rare stimuli. They also had a considerably higher 'false alarm' response rate than the controls and tended to continue to respond to the target stimuli from the previous condition (i.e. in the unattended opposite modality), even though they understood the task requirements.

*Peripheral physiological responses:*

As mentioned earlier, studies of peripheral responses to stimuli have generated a general theory that autism is associated with chronic 'overarousal', indicated by generally increased respiration, skin conductance and fluctuating heart rate. The theory proposes that autistic children are not receptive to new sensory information. This would be supported by a 'defensive', rather than a normal 'orienting' response (OR) to new stimuli, a normal OR being represented by a decelerating heart rate and moderate increases in skin conductance, compared with accelerating heart rate and larger conductance increases (defensive response).

The empirical data do not give the theory consistent support (Zahn, Rumsey & Van Kammen, 1987). Although measurements of resting skin conductance, respiration and heart rate of autistic participants are generally different from controls, this varies between studies. Two main confounding variables may be a child's initial response to being 'wired up' and desynchrony between the three measures, perhaps because respiration is particularly related to both central and autonomic factors (Zahn, Rumsey & Van Kammen, 1987).

Changes in these measures in response to presentations of new visual or auditory stimuli are again not all consistent. As with the research on central responses, it appears that some information processing does take place, as both autistic and control participants have differential peripheral responses according to the 'magnitude' (visual complexity or auditory...
intensity) of the stimulus (Barry & James, 1988). Some researchers have also confirmed a differential response between autistic and control participants (Barry & James, 1988; Palkovitz & Wiesenfeld, 1980), but others have not (Stevens & Gruzelier, 1984). Similarly, there may or may not be differences in habituation between the groups, Barry & James (1988) finding that autistic children did not habituate to either visual or auditory stimuli, whereas Stevens & Gruzelier (1984) did find habituation to tones, although there were minor group variations according to the measure used. Zahn, Rumsey & Van Kammen (1987) cite earlier work indicating both non-responders and fast habituators in autistic groups.

Again, as with the central responses, group differences may emerge when behavioural task responses are considered, and these may represent lack of anticipatory responding in the autonomic responses: In the study of Zahn, Rumsey & Van Kammen (1987), when participants were simply requested to listen to auditory tones (the requirement of most studies), there were few differences between autistic men and controls. However, when then asked to respond to a light by pressing a key until a beep sounded, the autistic men were less autonomicly responsive than the control participants.

Other differences in outcome between studies may have been due to differences in procedure, in stimulus mode (visual/auditory), intensity, complexity and duration, or in differences in the overall age and levels of cognitive and autistic disabilities of the participants, and on the parameters by which participants were matched (Zahn, Rumsey & Van Kammen, 1987; Barry & James, 1988).

Visual and motor responses:

There appears to have been only one study of autistic children measuring using
habituation/familiarisation and recovery of visual fixation (Sigman et al, 1987). Unfortunately, the details of this study do not appear to have been published, but it appears from this that a habituation/recovery methodology can yield useful results with fixation times as the measure. The authors used a paired comparison method and found that the children had a preference for a picture belonging to a different category (vehicles or fruit) from the familiarised stimuli (furniture). However, the children did not prefer to look at a face with a neutral expression after being familiarised with pictures of happy or sad faces.

Other researchers have measured fixation times for fixed duration single presentations of displays. Both Hermelin & O'Connor (1970) and, more recently, Boucher & Lewis (1992) found generally diminished fixation times for photographs among autistic children, compared with controls. The latter authors found a very wide variance in fixation times and no group differences between pictures of buildings and faces. Hermelin & O'Connor (1970) found that both the autistic and the control children had increased fixation times for more colourful and complex pictures, including faces. Similarly, Verbaten et al (1991) found that when autistic children were presented with abstract 4 or 16 bit 2 second information displays, they tended to have shorter fixation times than controls for both the simple and the complex displays, but with no group differences between the displays.

Contrary to their results measuring physiological responses, Verbaten et al (1991) found no group differences in visual fixation recovery to a change in the stimulus location, there being increases in both groups. However, Wainwright-Sharp & Bryson (1993) did find differences between 13 - 27 year old autistic men and age-matched normal controls in reaction times, in response to unpredicted locations of visual stimuli (consistent with the physiological results discussed above). The men were asked to press a button as soon as they saw a cross-shaped target stimulus appear on a display screen. This was preceded by
a 100 ms cue appeared in the centre of the screen, consisting of either a left- or right-directional arrow or a neutral line. The arrow cues usually, but not always, gave a valid indication of whether the target would appear to the right or left. There was no effect of either valid or invalid cueing on reaction times, unlike control participants whose reaction times either decreased or increased, according to cue validity. A longer valid 800 ms cue did stimulate shorter reaction times for the autistic participants, but if the cue was invalid, these men were much slower than the controls at disengaging their attention from the expected side of the screen to the location of the stimulus.

5.5 Summary

The complex response patterns in autism to sensory information may be summarised as follows: Visual and auditory input may be lacking in salience for autistic children relative to tactual stimuli, and relative to other developmentally delayed children. Autistic children may notice only a section of a complex stimulus, particularly if the elements are widely separated, and generally there may be relatively decreased attention and 'depth' of cognitive processing. This decreased processing may sometimes be related to increased arousal levels. ERP results are also suggestive of decreased attention and information processing, particularly for ongoing, repetitive stimuli. Changes in temporal or spatial stimulus pattern may not be 'registered' in some central neural systems which are likely to be concerned with 'conceptual', top-down, processing, rather than simple categorisation of stimuli (the latter often being intact). Thus, appropriate responding may often be evident behaviourally in reaction times and visual responses.

There is a relatively reduced level of anticipatory responding evident on both a central and a peripheral level, and this is seen behaviourally in terms of slow reaction times, particularly to brief or misleading cues. Autistic children find it difficult to disengage
attention from a previous pattern of responding even though their eye gaze may already be
directed at a change in stimulus location.

The above results and the limited information available about visual responses in autism,
indicate that relatively normal patterns of visual habituation and recovery to novelty may
be expected for static stimuli. However, differences may be evident between autistic and
control children when more complex dynamic displays are presented, where the novelty
element is contained within a short temporal segment of the display and where it represents
a 'conceptual', rather than a category, change of pattern.

6. The Role of Causal Perception in Normal Social Development

A fundamental process underlying the infant's development of social understanding, social
skills and communication, is the perception of, and inferencing from, physical and social
'causal' events. The infant becomes able to recognise, account for and predict events
involving both inanimate (physical) and animate (social) 'objects'. This enables him or her
to develop a repertoire of social behaviours to meet his or her own needs within the context
of observed events, by becoming an active participant in forming and maintaining
emotionally-based relationships.

6.1. Theorising about the Development of Causal Perception during Infancy; 'Self-
Propelled' Objects and Animacy

Poulin-Dubois & Shultz (1988) review the empirical evidence for the above view, proposing
that the development of perception of both physical and social causality is linked via the
development of discrimination between the causal properties of animate and inanimate
objects. They propose that initially infants perceive all animate objects as passive recipients
under their own control. Infants then expect 'independent agency' of all objects (animate and inanimate) and progress through discrimination between the independent agency of animate objects/humans and the passivity of inanimate objects, to an understanding of the role of psychological intentions in motivating human actions. Thus, conceptual 'theory of mind' ability ('covert' inferencing) may have its developmental origins in the 'overt' perception of independent agency. Poulin-Dubois and Shultz (Shultz, 1988; Poulin-Dubois & Shultz, 1988) do not attempt to account for the mechanisms underlying the observed developmental progression, but do highlight the relevance of the development of memory and the learning of rules from real-life feedback and analogical reasoning (Shultz, 1988, p. 363). Ogborn & Bliss (1990) have proposed a similar theory, involving the development of the concepts of living/non-living and independent agency from causal experience of motion, based on the Piagetian principle of sensorimotor learning.

The above authors thus propose (along with Premack & Dasser, 1990) that the development of the animate/inanimate distinction is a necessary 'first step' in the perception of independent agency. Poulin-Dubois & Shultz highlight the development of a concept of agency, whilst all three pairs of authors agree that an understanding of intention is an important 'end product' of this developmental path. They all state that the animate/inanimate distinction is based primarily (although not exclusively; Shultz, 1990) on the infant discriminating, from observation, between 'self-propelled' (i.e. animate) objects and non-self propelled objects (i.e. inanimate), a non-self-propelled object requiring a second object, or agent, to cause its movement. Thus, successful animate/inanimate categorisation may depend on the perception of physical causality in 'collision' events. Shultz proposes that the operation of a 'discounting heuristic underlies this process; the infant uses a dichotomous rule which 'states': "motion not externally caused = animate: motion externally caused = inanimate". The category of 'animate' is assigned, according
to Shultz, as a 'default' category if physical causality is observed *not* to have taken place (i.e. physical causality can be 'discounted').

Premack & Dasser (1990) take a similar approach to the above whilst clarifying particular aspects. They propose, as discussed earlier about Hobson's theorising in the field of autism, that there is an important distinction between *perception* and *conception*; i.e. implicit and explicit processes. Infants can 'directly' perceive the animate/inanimate distinction, based on the perceived properties of dynamic events, but must make a further 'higher-level' conceptual step to 'interpret' the event in terms of the participant's theory of mind (his or her intentions), and to then respond accordingly.

Poulin-Dubois & Shultz suggest that conceptual 'theory of mind' inferencing may be dependent, in terms of 'hierarchical', or chronological, development, on such a perceptually-based understanding of animate and inanimate movements. Shultz (1988) also discusses how events may be understood on a multitude of levels, from 'perceptual' to 'conceptual', terming the everyday multi-level descriptions and explanations of behaviours, the 'accordion effect'. Nevertheless, the infant can still make use of low-level perceptually based 'implicit' processes to respond to important aspects of the social world.

The above arguments may be extended to the perception of 'social' relationships between people: Premack & Dasser (1990) propose that, if there is more than one self-propelled (animate) object, there is the possibility (according to the objects' perceived dynamic spatial relationship) of 'directly' perceiving processes such as social goal formation - one person's intention to have influence on another - and reciprocity - two persons' intentions to influence each other in a dynamic equilibrium.
6.2 Empirical Evidence concerning the Development of Causal Perception during Infancy and Early Childhood

In support of the above theories, there is evidence for causal perception of 'overt' dynamic features in the following three types of event:

1) **Inanimate physical causality:**

Leslie (Leslie & Keeble, 1987) has investigated a scenario of the following type: *A billiard ball collides with another, which immediately moves away.* He tested the hypothesis that six month-old infants would detect the 'fixed' and 'causal' dynamic temporal and spatial relationships within such a collision, by habituating the infants to just such a cartoon-animated event and variants of it, but using two-dimensional squares rather than balls. He then measured recovery of visual fixation to further novel variants. The displays varied in direction of movement and in whether the event was 'impossible', due to either lack of contact (no collision) or a time delay during contact. The results indicated that the infants discriminated the 'impossible' events in such a way that it could be concluded that the infants were perceiving the 'irreversibility' of the causal collision event; the causal connection perceived was 'more' than simply a spatiotemporal contingency in the contact moment. Leslie argues that the irreversibility is perceived within the contact relationship on collision, but his results may also be regarded as showing that the infants discriminated role irreversibility; to the first square as 'actor' and to the second square as 'recipient'.

Although Leslie concludes that such 'causal' perception is 'hard-wired' rather than learned from either direct experience (i.e. not Piagetian sensori-motor learning) or observational experience, this conclusion rests simply on the young age of the infants. The conclusion may be weakened by reports that there are substantial individual differences in whether or not adults perceive such a causal connection in such displays (reviewed by Bruce & Green,
1990, p. 335) and Leslie's results cannot exclude such individual differences for the infants.

Baillargeon and colleagues (Baillargeon, 1994) have carried out a series of experiments of similar design to the above, which indicate that infants aged between 3 and 6 months expect inanimate objects to follow further physical laws, beyond the conservation of energy law observed in the above collision events, such as gravity (needing support to resist gravity), conservation of form (i.e. objects do not spontaneously change shape) and conservation of number.

2) Direct animate physical causality:

Golinkoff & Kerr (1978) investigated the following scenario; A man pushes a chair. They habituated 16 month-old infants to a film of such a real-life event and measured subsequent recovery of heart beat deceleration to a reversal, i.e. the chair 'pushing' the man. The results indicated that the infants discriminated the change of role and were thus making 'agent' and 'recipient' attributions, which is consistent with earlier results (Golinkoff, 1975) and with those of Robertson & Suci (1980), who used similar methodology to find that 18 month-old infants tended to monitor the 'actor', rather than the recipient, in a filmed scenario in which one 'animal' puppet pushed another.

There was no evidence from Golinkoff & Kerr's experiment that the children discriminated the 'impossible' element of the reversal (chair pusing the man), as recovery to this reversal was no greater than recovery to a 'possible' reversal of a man-pushing-man event. Thus, the infants did not appear to associate an actor role (independent agent) with a person, versus a recipient role with an inanimate object (i.e. they did not apply Shultz's 'discounting heuristic', which predicts that a child attributes agency to animate objects by discounting the possibility of external causes of their movements). However, there is evidence from
other research that infants do, in fact, associate agency with people rather than inanimate objects. Sexton (1983) found that 17 month-old, but not 11 month-old, infants turned to their mothers or the experimenter to re-create events from mechanical toys. Also, Poulin-Dubois & Shultz (1989) showed infants, in real-life, an 'impossible' event in which a ball appeared to set off independently from a resting position and then collide with another, which in turn hit a "wobbling doll". The 13 month-olds, but not 8 month-olds, failed to habituate within 10 trials of this repeated display, whereas the reverse pattern was found when the same infants watched a person push the same ball from rest, collide with another, etc. ('possible' event). In contrast, both age groups habituated to both a babywalker ("chair"; 'impossible') and a person ('possible') apparently moving independently in front of them. Thus, the older, but not the younger, infants may have been 'surprised' at the ball appearing to have independent agency, in contrast with the person, although this surprise did not extend to the apparently autonomous movement of the babywalker. The authors also found that the 13 month-olds, but not the 8 month-olds, were able to communicate with their mothers as agents, requesting her to re-create an event (using the same procedure as Sexton, 1983, described above). Thus, Poulin-Dubois & Shultz concluded that intentional communication by the infant was dependent on a concept of adults as autonomous agents.

Poulin-Dubois & Shultz's conclusions may not be as secure as the authors suggest. It is not clear why the 13 month-olds habituated to the 'impossible' autonomous babywalker. One possibility is that they had found an acceptable explanation for this event (for examples of the latter in habituation/recovery experiments, see Baillargeon, 1994). Another possibility is that the infants simply had a lower level of interest for this event, as indicated by their relatively low decreased overall fixation times. Interpretation of such a 'simple' fixed trials habituation procedure, with no novel recovery stimulus, may be confounded by uncontrolled features such as real-life novelty, attractiveness (eg colour, brightness) or complexity.
More secure evidence that young infants associate independent agency with people, or at least human hands, is provided by Leslie (1984). He habituated 6 month-old infants to filmed events, based on real-life footage, involving a hand picking up an 'inanimate' wooden Russian doll. By presenting various conditions of direction of approach and retreat, contact or lack of contact between agent and recipient, and the use of an inanimate "white oblong" in place of the hand, Leslie demonstrated that the infants appeared to be surprised at the 'impossible' events of the oblong 'picking up' the doll (versus the hand), and of the hand 'picking up' the doll without contact (versus the oblong). Thus the infants appeared to be surprised at an inanimate object apparently acting as an agent, although Leslie discusses the complication of whether the apparently gravity-defying contact between the oblong and the doll (infants expect inanimate objects to be subject to gravity; Baillargeon, 1994), or the agent role of the oblong, was the critical 'impossible' element of the displays, or alternatively whether the infants even perceived the oblong as being a separate object from the doll.

Summary:

Taken together, these experiments indicate that infants can attribute agent and recipient roles by early in their second year, at a similar time to the development of clearly recognisable intentional communication. They may also expect humans, or human hands, to act as independent agents in contrast (or by default; 'discounting heuristic') to *not* expecting inanimate objects to act as autonomous agents, although such a conclusion requires further research to support it.

3) **Animate Psychological and Social causality:**

As suggested by Hobson (1989), covert mental states may be attributed simply on the basis
of observed, overt, non-verbal behaviours and features. As discussed earlier, in the field of autism, Hobson has highlighted a possible role of perception of features (facial expression) and gestures 'on the surface' of one individual in inducing what we may term 'shared social experiences', whilst Mundy & Sigman (1989a,b) have highlighted the interactional nature of the perception of, and response to, intentional non-verbal communicative behaviours within an interactive dyadic relationship.

Causality may be inferred from the temporal and perhaps intensity contingency of events, and this applies to both non-social and social-events, the contingency in the latter being less clear (Watson, 1984). Thus, research with both normal adults and children has demonstrated that attribution both of agency, and of covert states such as intentionality, may be based on perceived 'surface' features of a social interaction completely independently of whether or not the 'actors' have the perceived physical attributes of animate objects (i.e. are not recognisably human or animal):

Heider & Simmel (1944) showed adults a cartoon film in which two triangles of different sizes and a circle moved in relation to each other and a 'house' (two-dimensional rectangular outline), including going in and out of the door and having a 'fight' (see Bruce & Green, 1990, pp. 338-339, for a summary). The observers described the geometric shapes as people, attributing them with covert states such as intentions, desires and personality characteristics. Apparently they used the perceived dynamic relationships and contact/lack of contact to attribute animacy/inanimacy, as found with children in the above research on inanimate and animate physical causality. Such an interpretation is supported by Bassili (1976), who varied the spatiotemporal relationships in a similar event in which a white circle 'chased' a black circle. When their directions were tightly linked, observers spontaneously attributed the circles with agent/recipient roles and intentions, whereas when
their directions were random but still temporally linked, a unspecified interaction was reported between the circles. More recent work by Thommen (1991) has extended this work to the study of children. She showed Heider & Simmel's original (1944) film to children between the ages of four and twelve years. The youngest children tended to describe the movements (in French) as intentional inanimate actions (eg. "the triangle hits [casse] the rectangle"), or as interactions when the figures touched each other, with a minority using mental state causal expressions. Seven year-olds perceived causal relationships between the figures even if they were not close together and ten year-olds tended to give social interaction descriptions with more intentional, and fewer action, descriptions.

Dasser; Ulbaeck & Premack (1989) have also attempted to demonstrate the perception of intentionality within filmed events of a similar type to Bassili (1976; although with no reference to any of the above research), using a non-verbal, habituation/recovery, method. There were three types of event in which a larger and a smaller ball moved in relation to each other, their relative motions being designed to represent animate/social interactions, 'as if' carrying, touching, pushing, rubbing and hitting each other. Adults tended to use mental state vocabulary to describe the events (eg. 'helping', 'reassuring'). Three year-old children recovered their visual fixation more when such an event was repeated with the balls taking opposite roles, than when the habituation and recovery events were in a different, less 'understandable', order. Whilst one may tentatively conclude, from this 'irreversibility' of roles, that the children attributed the balls with different 'social' roles, it is difficult to see how Dasser, Ulbaeck & Premack felt justified in concluding that "intentionality" is the irreversible 'covert' element which was perceived in the events.
Summary:

These studies indicate clearly that the presence of interactive causal relationships may be perceived in 'social' events simply on the basis of the relative movements of the social 'objects', even where the objects do not have the surface features of animate objects (i.e. there are no other surface cues about the nature of the relationships). The relationships do not necessarily depend on perceived contact between the objects, but do depend on spatiotemporal contingencies in the relative patterns of the movements. When there is a 'tight' spatiotemporal relationship, then children as young as four years may spontaneously attribute intentional mental states to the objects, this tendency increasing through to adulthood.

7. Conclusions and Introduction to the Present Study

7.1 Summary of current Theorising and Evidence concerning early Social Development in Autism and in Normal Infancy

The preceding literature review has highlighted a variety of theories about social abnormalities in autism and their early origins, which are still at an early stage. There are two current theories which are most clearly articulated and supported by empirical evidence:

1) Hobson (Hobson, 1989; Moore, Hobson & Lee, 1995) proposes that abnormal visual perception causes autistic children not to notice, discriminate or 'understand the meaning' of emotional facial expressions and 'attitudes' (eg. gestures), and that this restricts their ability to respond to overtly recognisable affective behaviours.

2) Leslie, Baron-Cohen & Frith (Leslie & Happe, 1989; Baron-Cohen, 1992; Frith, 1992) propose that autistic children have a difficulty in developing the conceptual ability to infer the processes and contents of other people's minds (a 'metarepresentational' difficulty in developing 'theory of mind').
These theories illustrate, respectively, an 'overt/perceptual' and a 'covert/conceptual' approach to theorising about autism. Although the second group of researchers state that their ideas are unrelated to perceptually-based ('bottom-up') processes, in contrast Hobson suggests that perceptually-based processes may underlie later-developing 'top-down' conceptual difficulties. There are a number of empirical and theoretical objections to the second group's position, which will be discussed later. Hobson's ideas also may not give an account of the range of social difficulties in autism (as illustrated by the self reports of autistic people), and are not without controversy and contrary evidence. However, they are more consistent with the evidence on the early origins and nature of the social abnormalities in autism (particularly the difficulties in 'joint attention' - shared interest between child and onlooker), and with the abnormalities in sensory processing which are discussed earlier.

Hobson's position is used as starting point to explore two related proposals which may have promise in developing a complementary hypothesis. These are the suggestions of Mundy & Sigman (1989a, b) that the early joint attention difficulties represent difficulties in processing perceived social information. They relate this to Dawson & Lewy's suggestion (1989a, b) that it is the unpredictability of social information which autistic children have difficulty in processing. Further evidence is reviewed above which indicates that autistic children may not notice external events if they are unexpected and/or brief, and if they are in a visual or auditory, rather than a tactual, modality. Furthermore, autistic children may find it difficult to respond to a situation if visual cues are either brief or misleading. This evidence is based mainly on the results of habituation/recovery procedures, measuring primarily central and peripheral physiological responses to novel events or static stimuli.

A second line of theorising and evidence is drawn from the literature on normal infant social development, to operationalise Dawson & Lewy's proposal concerning social
unpredictability. Essentially, a major task during the first 18 months of infancy is for the child to build on an ability, which may be present at 6 months, to perceive causality in physical events, by discriminating between the types of movement of animate (humans & animals) versus inanimate objects. Three authors propose that animate objects are (at least partially) categorised on the basis of being 'self-propelled'. Shultz proposes that this is achieved by applying a 'discounting heuristic'; an object is perceived as self-propelled if it is seen not to have an external source of motion. Premack (Premack & Dasser, 1990) has widened the area of social interactions which may be considered on this developmental basis by suggesting that normal children may start to assign 'causal' social roles on the basis simply of the perceived relative movements of 'self-propelled objects'. This area had already been explored by Heider & Simmel (1944) and later researchers. Shultz further suggests that successful categorisation enables the development of intentional communication 'to' the animate object (person) and forms the basis for affective relationships, a proposal which brings us back to Hobson's idea (and that of Kanner, 1944) that autistic children's 'core' difficulty is in affective relatedness.

This theorising about normal infancy is generally supported by the available empirical evidence. The results from habituation/recovery procedures clearly indicate that normal infants have expectations about causal events in the physical world well within their first year. They also assign roles in inanimate/physical, animate/physical and 'social' causal events on the basis of the relative movements of objects, but it is less clear when this capability starts to develop. The evidence is consistent both with origins around the end of the first year, when intentional communication becomes evident (Poulin-Dubois & Shultz, 1989), or even earlier (Leslie, 1984), and with development continuing beyond the age of four years (Thommen, 1991).
The possible importance of the development of causal perception for affective relationships are outlined by Poulin-Dubois & Shultz (1988, p. 119); "From a concept of human beings as passive recipients of his or her own actions the child progresses to regarding them as independent actors. The infant's knowledge of others as independent agents manifests itself first in his differential emotional response (eg. interest) to human beings as performers of overt actions that cause observable events." We may conclude that difficulties in developing the perception of causal events, on the basis of perceived spatiotemporal contingencies between 'objects', whether physical or animate, may give rise both directly and indirectly to affective and functional difficulties within both dyadic and social relationships.

It is suggested here that it would not be surprising to find that autistic children have difficulties with causal perception, after considering the evidence on their abnormalities in processing dynamic visual information and the few first-hand reports available about the fearful properties of many moving objects for them. If this is the case, their abilities to initiate and respond within affective and social situations would be likely to be seriously compromised, and similarly some of the scope of their ongoing, minute-to-minute, wide-ranging difficulties with changing and unpredictable environments may be accounted for. Such wide-ranging difficulties may be only partially accounted for by current theorising about person-perception (Hobson, 1989), joint attention (Mundy & Sigman, 1989a, b) or mental inferencing (eg. Baron-Cohen, 1992, and others).

7.2 Methodology

Much of the evidence concerning the physiological responses of autistic children to unpredicted perceptual events, and concerning the perception of physical, animate and social causality in normal infancy, has come from the application of habituation/recovery methodology. Discrimination and underlying information processing is measured from the
presence and extent of a response (physiological or visual) to a novel stimulus after the child's attention has diminished to the 'habituated' stimulus. One weakness of research in autism has been its reliance on verbal and observational evidence. The former cannot be applied with very young and/or developmentally delayed children and interpretation may be complex, whilst the latter, although potentially ecologically valid, has limited potential to inform about information processing mechanisms. The hypothesis articulated below is tested using a visual habituation/recovery methodology. The results will partly represent a test of the utility of such an approach for future research about autism and other developmental difficulties.

7.3 Experimental Hypothesis and Predictions

Hypothesis:

It is proposed that autistic children have a tendency either not to notice, or not to process further, brief dynamic visual information in observed events unless it follows a simple predictable pattern, and that this restricts their early social development, out of keeping with the level predicted from their receptive language development. Areas of pre - 8 month (anticipatory and affective social responses) and pre - 12 month (joint attention) social development will be affected. In particular, autistic children may not apply a 'discounting heuristic' which states that animacy is attributed to a moving object if there is no observable external source of its motion (Shultz, 1990).

Predictions:

The first two predictions (1 & 2 below) are concerned with the hypothesised deficit in applying the 'discounting heuristic'. Recovery of visual fixation is measured, following habituation, to two moving images, one 'inanimate' ('Ball') and the other 'animate' ('Runner' [boy]). The novel element, common to both displays, is the introduction of a
time delay in the reversal of direction of travel on making contact with a 'wall' ('rebound'), so that the novel Ball display becomes 'impossible', in contrast with the 'possible' novel Runner display (see Method for full description). The next two predictions (3 & 4 below) are concerned with the hypothesised connection between discrimination of the 'impossible' display and early social abnormalities. The remaining predictions (5 - 10 below), based on the preceding literature review, are concerned with the application of the habituation/recovery methodology to dynamic displays with autistic and developmentally delayed children (upon which the above predictions are based).

1) Autistic children will have lower visual fixation recovery scores for the novel Ball display ('impossible' inanimate event) than developmentally delayed children of similar receptive verbal ability.

2) The autistic children will have lower recovery scores for the novel Ball display ('impossible' inanimate event) compared with recovery to the novel Runner display ('possible' animate event), than the developmentally delayed children.

3) A) The autistic children will have lower scores than the developmentally delayed children on seven of the pré - 8 month items from the Socialisation Domain of the Vineland Adaptive Behaviour Scales, which Klin et al (1992) found to be significantly reduced in autism.

   B) Total scores on the above Socialisation items will be associated, in the appropriate direction, with recovery scores (1 above) and recovery score differences (2 above), both across groups and within the autistic group.

4) A) The autistic children will tend not to have joint attention behaviours compared
with the developmentally delayed children, as indicated by caregiver questionnaire scores (Goodhart & Baron-Cohen, 1993).

B) Joint attention behaviours will be associated, in the appropriate direction, with recovery scores (1 above) and recovery score differences (2 above), both across groups and within the autistic group.

5) The autistic children will have lower total fixation times than the developmentally delayed children for both displays.

6) The autistic children will have increased total fixation times for the Ball compared with the Runner display, relative to the developmentally delayed children.

7) Both groups of children will habituate to both displays.

8) There will be no differences between the groups in rate of habituation (number of trials to habituation criterion), for either display.

9) The fixation times of both groups of children will recover to the novel displays following habituation.

10) Both groups of children will have shorter durations of fixation and recovery for both the habituation and the novel displays (respectively) when seen after a preceding habituation or novel display sequence.
CHAPTER 2. METHOD

1. Materials

1.1 Experimental Displays

The computer-animated displays were prepared using MacroMind Director animation software, run on an Apple Macintosh Quadra 610 microcomputer. There were two sets of two-dimensional dynamic graphic colour ('animated cartoon') images, each set consisting of a 23.5 x 17.5 cm habituation and novel display (see Figure 1). One set consisted of a 'boy' ('Runner' display; 2.2 cm high x 2.5 cm wide maximum) with red jacket, blue trousers and yellow hat, appearing from off-screen left, running with appropriate arm and leg movements towards a wall 18.5 cm from the left hand edge of the display, contacting it with his left hand, turning around and running back off-screen. This display was continuously repeated (as with a 'film-loop') so that the Runner was a changing and repeating dynamic element against the constant, static, background of the wall and the 'ground'. The other set ('Ball') was identical to the Runner display in the constant, static, background, but the dynamic image consisted of a two-dimensional red disc (2.5 cm diameter). Its directions of movement were identical to the Runner, appearing from off-screen left, moving along the 'ground', contacting the wall and returning off-screen.

The habituation and novel displays differed solely in the timings of the contact of the Runner and the Ball with the wall, and in the period each dynamic element was not visible (i.e. off-screen; see Table 1 for timings). Both of the novel displays extended the contact with the wall from instantaneous (i.e. 'rebound' in the case of the Ball) in the habituation displays to a 2s delay, and decreased the time off-screen by 2s (Runner) or 1s (Ball). The on/off screen time ratio for the dynamic elements increased 2.3 fold (Runner) and 1.7 fold
(Ball) from habituation to novel displays. In the case of the Runner, the 'boy' maintained contact with the wall with his left hand, facing the wall. After the delay he immediately turned around and ran back. The delay was designed, as discussed, to introduce an 'impossible' element in the inanimate Ball + Delay novel displays, as conservation of energy would not be apparent in the rebound, whereas the animate Runner + Delay novel display was designed to remain 'possible', as apparent conservation of energy would not be expected in the turnaround.

<table>
<thead>
<tr>
<th>Dynamic Element</th>
<th>Runner</th>
<th>Ball</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>No Delay</td>
<td>Delay</td>
</tr>
<tr>
<td>Total duration of display cycle</td>
<td>5.0s</td>
<td>5.0s</td>
</tr>
<tr>
<td>On screen (complete dynamic element)</td>
<td>1.5s</td>
<td>3.5s</td>
</tr>
<tr>
<td>Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On screen/Total</td>
<td>.30</td>
<td>.70</td>
</tr>
<tr>
<td>Contact with wall</td>
<td>0</td>
<td>2.0s</td>
</tr>
<tr>
<td>Off screen</td>
<td>3.5s</td>
<td>1.5s</td>
</tr>
</tbody>
</table>

Table 1. Duration of each display.
Figure 1     Experimental displays (top - Runner, bottom - Ball)
1.2 Inter-Trial Display

This was a dynamic, relatively abstract computer-generated colour image ('Leaves'; *After Dark Screen Saver*, Berkeley Systems Inc.) with constantly transforming elements changing between blue and green, described informally either as "shapes" or "leaves" by adults. It was designed to maintain the interest of the children in the experimental situation and hold attention for the display screen, without interacting with the representational and dynamic information content of the experimental displays.

2. Piloting

There is little literature evident about habituation/recovery procedures with this age group or with autistic children. The use of this type of dynamic cartoon display also appeared to be novel. Piloting was therefore carried out, with one child who had autistic tendencies and two developmentally delayed children, of similar ages and verbal abilities to the potential experimental groups. The results indicated that the displays were of an appropriate level of interest, likely to give both reliable habituation within 6 - 10 trials and reliable recovery scores. However, the piloting also revealed two potential problems; 1), restlessness and lack of attention of the children between trials and over the duration of the session; and 2), wide individual differences in duration of visual fixation per trial, the autistic child looking for up to around two minutes on many trials. It was necessary for each child to see both sets of habituation/recovery displays within one continuous session, in view of the shortage of autistic children meeting the diagnostic, age and ability criteria and in view of potential within-participant variance between sessions in visual fixation due to changes in state.

The following procedures were designed to alleviate these two problems: The inter-trial dynamic 'screensaver' display was introduced, and a maximum trial length of one minute
was adopted (Kellman, Hofstein & Soares, 1987) to facilitate the habituation procedure. The number of novel trials was restricted to two and additional trials were no longer included to measure fatigue or to control for spontaneous regression (artifactual recovery as a result of chance variations in looking, boredom or frustration; Bertenthal, Haith & Campos, 1983), issues which are evaluated in the Discussion.

3. Selection of Participants

Staff were consulted at the specialist nursery and school facilities taking part in the study, to draw up a list with the experimenter of autistic children, and of developmentally delayed children of similar verbal abilities to each of the autistic children. The initial criteria were that the 'diagnostic' categories were likely to be correct and that each child was no older than 10 years. Parents were then contacted by letter, via the establishment, for consent (see Appendix K), ethics approval having been obtained for the project from Plymouth Local Research Ethics Committee. The criterion for including the results of any child in the final data analysis was that he or she achieved a minimum age score of 13 months (i.e. a minimum Raw score of 7 including four of the directly tested items) for verbal comprehension on the Reynell Developmental Language Scale A (RDLS age score; Reynell & Huntley, 1981), thus having a higher equivalent age score than the proposed normal age of onset of causal perception of animate versus inanimate movements (Poulin-Dubois & Shultz, 1989). See Table 2 for a summary of the characteristics of the seven autistic and seven developmentally delayed children whose results were included in the data analysis.

All 14 children had been referred to a consultant paediatrician for developmental difficulties and all except one autistic child had been assessed by a pre-school multi-disciplinary assessment team including clinical psychologist, consultant paediatrician, speech therapist,
pre-school advisory teacher, specialist health visitor and specialist nursery staff.

3.1 Autistic Children

A total of 16 autistic children took part in the habituation and recovery procedure from whom 10 complete records were obtained. Six children did not complete the procedure due one or more of; failure to settle or restlessness (5 children), fixation times increasing to the 60s cut-off after 9 habituation trials (1 child), and equipment failure (1 child). A further three children were eliminated due to their RDLS scores falling below the 13 month cut-off. The final seven children had all been diagnosed by a consultant paediatrician, the majority also having been assessed by a specialist clinical psychologist, as suffering from a disorder on the autistic continuum, and they were all in receipt of nursery or primary school provision for autistic children. In all cases, onset was before 30 months and the children conformed both to Rutter's 'triad' of impaired social development, delayed or deviant language development and insistence on sameness (Rutter, 1978) and to DSM-III-R criteria. Classification was confirmed by an overall score ≥ 33 on the Childhood Autism Rating Scale (CARS), above the cut-off (CARS = 30) validated for a psychiatric diagnosis of 'autistic' (Schopler, Reichler & Renner, 1988). The scores of three children were within the 'mildly-moderately autistic' category (≥ 30, < 37), the remaining scores being within the 'severely autistic' category (≥ 37).

Six of the children had clinically significant global cognitive delay, including receptive and expressive language, indicated, in formal testing, by a specialist clinical psychologist and speech therapist, and by a consultant paediatrician. Three children did not use words functionally, two children used single words functionally and one child also used up to three word phrases functionally; of these six children, four were also echolalic for words or phrases. One further boy was not significantly delayed in receptive or expressive language
but had some abnormal language usage, expressing himself in the third person (his first name), and had difficulties identifying and expressing gender.

3.2 Developmentally Delayed Children

A total of 14 developmentally delayed children took part in the habituation and recovery procedure from whom seven complete records were obtained. Seven children did not complete the procedure due to: failure to settle or restlessness (3 children), inattentiveness or sleepiness (2 children), fixation times increasing to the 60 s cut-off after 9 habituation trials (1 child), and distraction (1 child). Absence of autistic features and differential classification from the autistic group were confirmed by a score of < 24 (below the cut-off for 'autistic', < 30) on the CARS.

The final seven children had all been diagnosed as having a clinically significant global cognitive delay, including receptive and expressive language, from formal testing by a specialist clinical psychologist and speech therapist, and by a consultant paediatrician. The causes were neurodevelopmental delay (3 children) or unknown (4 children). One child did not expressive himself verbally, four children used single words, one child also used occasional two-word phrases, and one child used grammatical phrases.

4. Participant Matching

Autistic and developmentally delayed children were matched pairwise on RDLS age scores and order of display presentation; three pairs in one order condition and four in the other (see 5. below). It is now current practice to match autistic and control participants on receptive language age scores from a test such as the RDLS which includes more complex semantic and syntactical linguistic demands than simple vocabulary pointing tests (Lewis &
Boucher, 1988; Hobson, 1991; Morris, 1992b). If a relative 'deficit' is predicted, relative to other abilities, for the autistic participants from the hypothesis (as here), this procedure provides a conservative test, minimising Type I errors, due to the tendency of autistic children to achieve relatively reduced verbal, versus non-verbal, ability scores.

<table>
<thead>
<tr>
<th></th>
<th>Autistic N = 7</th>
<th>Dev. Delayed N = 7</th>
<th>F(1,5) p</th>
<th>r</th>
<th>p(1tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDLS age score (mo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mean (SD)</td>
<td>31.3 (15.7)</td>
<td>28.4 (10.9)</td>
<td>0.45</td>
<td>n.s.</td>
<td>.028</td>
</tr>
<tr>
<td>Range</td>
<td>19 - 66</td>
<td>13 - 48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronological age (mo)</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Mean (SD)</td>
<td>75.4 (25.4)</td>
<td>50.1 (16.9)</td>
<td>10.58</td>
<td>.023</td>
<td>.66</td>
</tr>
<tr>
<td>Range</td>
<td>50 - 121</td>
<td>35 - 84</td>
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<td></td>
<td>.106</td>
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<tr>
<td>RDLS quotient</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>46.3 (28.5)</td>
<td>57.8 (18.6)</td>
<td>3.83</td>
<td>.108</td>
<td>.66</td>
</tr>
<tr>
<td>Range</td>
<td>23 - 101</td>
<td>37 - 86</td>
<td></td>
<td></td>
<td>.108</td>
</tr>
</tbody>
</table>

Table 2. Means (standard deviations), ranges, and pairwise statistics of the participants

4.1 RDLS Age Scores

There were no significant group differences in RDLS age scores (see Table 2). The mean scores of both groups were greater for the Runner First (M = 32.7 mo) than for the Ball First (M = 26.0 mo) order condition, but there was no significant effect of Order (F(1,5) = 0.45, n.s.), and no significant Order by Group interaction (F(1,5) = 3.01, p = .143). The correlation of scores between group pairs was high and significant (see Table 2).

4.2 Chronological Age

The mean chronological age of the autistic group was significantly greater than that of the developmentally delayed group in both the Runner First and the Ball First conditions (see
There was no significant effect of Order (F(1,5) = 0.13, n.s.), and no significant Group by Order interaction (F(1,5) = 0.11, n.s.). The correlation between group pairs was moderate and not significant (see Table 2).

### 4.3 RDLS Quotient

In view of the group differences in age, RDLS quotients (100 x [RDLS age score/chronological age]) were calculated to assess differences in developmental delay of verbal comprehension. Quotients were calculated rather than standard scores as the latter are unreliable below -2 SD in the RDLS and are not tabulated above 84 months chronological age (Reynell & Huntley, 1981). However, it is important to note that such quotients are not tabulated for the RDLS and are only approximately comparable between age groups, as the quotient standard deviation varies between 18 and 28 points according to age. Such quotients are also not comparable with other quotient scores based on SD = 15 (eg. IQ).

The mean quotient of the autistic group was less than that of the developmentally delayed group, but the difference was not significant (see Table 2). This trend was stronger within the Runner First condition, whereas the group quotients were similar within the Ball First condition, although there was no significant effect of Order (F(1,6) = 0.05, n.s.) or Order by Group interaction (F(1,5) = 3.62, p = .115). The correlation between group pairs was moderate and not significant (see Table 2).

### 4.4 Gender

No attempt was made to match children by sex. There was the expected minority of girls within both groups, there being two autistic girls and one developmentally delayed girl within the Runner First condition (one matched pair), and two developmentally delayed girls
within the Ball First condition.

5. Apparatus and Procedure for the Habituation/Recovery Displays

The children viewed the displays in a room in the nursery or school. Each child sat on the lap of a caregiver familiar to him or her (nursery staff, teacher or classroom assistant), within an approximately 200 x 200 x 200 cm area. The child was 130 cm distance from a 26 x 20 cm VDU computer monitor, placed at the child's eye level on a table at one apex of the triangle, the opposite 'side' of the triangle being open to the door and rear wall of the room. Two brown corrugated 260 x 160 cm card sheets were 'concertina'-folded, each to form a 200 cm x 160 cm high side panel and a 46 cm front panel in the plane of the VDU display screen. A further folded 200 x 160 cm corrugated card panel was placed immediately behind the VDU monitor. This portable arrangement provided a homogeneous cubicle that occluded the experimental room from the child's view. The level of daylight in the room was reduced to a minimal level by blackout over the windows and low-level illumination was provided from a 40 W bulb in a diffuse reflector behind one side screen and aimed at the ceiling.

The experimenter operated the displays by computer keyboard-from behind one of the side screens. The display VDU screen was viewed by him, when changing the displays, through a 14 x 2 cm horizontal slit in the side panel near the VDU screen, unobserved by the child. The direction of the child's visual fixation was monitored by a Panasonic X16 Camcorder with low light functioning, the lens of the Camcorder being placed at the child's eye level, 5 cm behind a 9 x 8 cm aperture in the front panel of one of the side screens and 16 cm from one edge of the display VDU screen. The Camcorder drove an additional 20 x 14 cm VDU screen for real-time monitoring by the experimenter (behind the side screens) of the
child's visual fixation, which was timed using an electronic stopwatch.

Each child viewed both display sets, the order of the sets being counterbalanced so that three pairs of children saw the Ball first and the Runner second, and four pairs saw the sets in the reverse order. Analysis of unweighted means was used to give equal weight to the two conditions (see Appendix E). The overall duration of the session varied between children, lasting usually 8 - 15 min, occasionally up to 20 min due to a child control procedure being used (Cohen & Gelber, 1975): When the child was observed to be settled and to orient towards the 'screensaver' display, the experimental display was started, commencing a trial. When the child looked away from the display for two seconds or more, or after a maximum cumulative fixation time of 60s, the trial was then ended when the target image (Runner or Ball) moved 'off screen', the inter-trial screen-saver display being re-started. The cumulative fixation time was noted, the habituation criterion calculated and, as necessary, the display changed between habituation and novel trials (the latter procedure added approximately 1 s to the total inter-trial period between habituation and novel trials). The inter-trial period lasted usually 15 - 25 s, the upper limit depending on the child again being settled and oriented towards the display screen.

After the first three trials, the mean cumulative trial fixation time was calculated. For this purpose only, 'first trial' was defined as the first trial to accumulate a fixation time of at least 10s, to ensure that the child had the opportunity to see the 'rebound' event in the display. The trials then continued until the habituation criterion was reached, this constituting cumulative fixation times of at least 0.5s less than the mean on each of three consecutive trials, following the procedure of Leslie & Keeble (1987) for dynamic event-displays of this nature. Thus each child had a minimum of six trials.
Visual fixation was re-assessed from the videotape by the experimenter and also, independently, by a second observer who was blind to the experimental displays and group membership of the children. The experimenter's re-scored fixation times were used in the calculations. The correlations between the real-time measurements and the experimenter's re-scored timings, and between the experimenter's and the observer's re-scored timings, were all very high, \( r(30) \geq .99 \), for both groups of children. The observations were from either five autistic or five developmentally delayed children (randomly selected), scoring the first two habituation, last two habituation and the two novel trials, over the first display set. The mean recorded fixation times were \( M = 17.9 \) s (real-time), \( M = 17.4 \) s (experimenter re-score) and \( M = 18.5 \) (observer re-score) for the five autistic children, and \( M = 19.5 \) s, \( M = 19.4 \) s and \( M = 20.1 \) s, respectively, for the developmentally delayed children. Such high reliability correlations in a child-control procedure may be sometimes be an artefactual consequence of the experimenter having curtailed some of the trials, when this was assessed from videotape, yet not being able to time how long the trial would have lasted if allowed to run. In this case, no instances of curtailment were reported for the 60 re-scored observations.

6. Verbal Tests

6.1 Reynell Developmental Language Scales, Verbal Comprehension Test A (RDLS; Appendix A)

This was administered within six weeks of the experimental displays, seven of the children being tested by a speech therapist, the remainder by the author. The standard test protocol was followed (Reynell & Huntley, 1981).
6.2 Identification Test (Appendix B)

This test was administered to all the developmentally delayed and six of the autistic children up to one week after the experimental trials. The remaining autistic child spontaneously named the displays during the trial; "ball" and "boy". The identification test was a pointing test for comprehension of an appropriate verbal label for these two images; "ball" and "boy". The protocol and materials were based on the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1981), which consists of a developmental sequence of sets of four black and white line drawings. One drawing of each set (or each of the four drawings, in the case of the Training Plates) represents a target word named by the examiner. The child was shown PPVT Training Plate A and asked to "Put your finger on the doll". If there was no appropriate response, the child's finger was gently placed on the picture of the doll after repeating the request, the experimenter saying "There's the doll". This procedure was repeated for each of the four pictures in the Training Plate, the child’s responses being noted. Training Plate B was now used as a test plate by placing a line drawing of the 'boy', from the experimental Runner display as a substitute for the 'man' depicted in the plate, it being assumed that 'man' was of a similar developmental level of difficulty to 'boy'. The child was asked "Now put your finger on the boy". Finally, identification of the 'ball' in Plate 2 was tested, as per the PPVT protocol. This was made a conservative test for recognition of the two-dimensional experimental Ball display, by obscuring the internal, three-dimensional, detail in the PPVT line drawing to retain the outline only.

7. Caregiver Rating Scales

These were all administered by semi-structured interview, in one session, to the member of staff in each establishment who worked most closely with the child.
7.1 Childhood Autism Rating Scale (CARS; Appendix C)

This scale was administered as described in the Manual (Schopler, Reichler & Renner, 1988).

7.2 Pretend Play and Shared Attention

The presence or absence of pretend play was tested using Item 5 from Section A of the CHAT Scale proposed for early identification of autism, (Baron-Cohen, Allen & Gillberg, 1992), adapted for administration to staff rather than to parents: "Does (John) ever pretend, for example, to make a cup of tea using a toycup and teapot, or pretend other things?". Shared attention was assessed using Items 7 and 9 from Section A of the CHAT, similarly adapted: "Does (John) ever use his index finger to point, to indicate interest in something?"; "Does (John) ever bring objects over to you, to show you something?". The responses (yes/no) to Items 7 & 9 were analysed separately, and also together as equally weighted items on a three-point scale.

7.3 Early Social Behaviours (Socialisation; Appendix D)

These were assessed using Items 6, 7, 8, 9, 11, 13, & 14 from the Socialization Domain of the Vineland Adaptive Behaviour Scales (Sparrow, Balla & Cicchetti, 1984), scored, as described in the Manual, as 'usually performed'/'sometimes or partially performed'/'never performed' to give an item score of 2/1/0 and a total score range of 0 - 14 for the seven unweighted items. These items were selected on the criteria of having a median age norm of no greater than 8 months (in the original standardisation sample), of having an unambiguous content validity for social behaviours, and of a dichotomous score = 2 (versus score = 1/0) being obtained significantly less frequently by the autistic children than by matched learning disabled children in the study of Klin, Volkmar & Sparrow (1992).
CHAPTER 3. RESULTS

1. Descriptions of the Variables and Methods of Analysis

The primary variables, their descriptive statistical properties, the methods of analysis and the implications of the descriptive statistics for the reliability of the conclusions drawn from the analyses, are all fully discussed in Appendix E.

In summary, it was considered, where parametric analyses such as ANOVA and partial correlation/multiple regression were applied, that the few significant deviations from normality or homogeneity of variance were not sufficiently numerous or extreme to weaken the reported significance levels, taking account of the robustness of the tests and the directions of the relevant 'outliers' in the data (the latter being mostly biased against the experimental predictions). In the cases of a minority of the secondary (transformed or control) variables, there were significant deviations from normality and/or homogeneity of variance which may have affected the reported significance levels, taking account of unequal and small cell sizes. These are discussed, as they occurred, in the main body of the Results.

2. Differences in Total Fixation Times During Habituation

2.1 Group and Display Differences

Prediction 5 stated that the autistic children will have lower total fixation times than the developmentally delayed children for both displays. Prediction 6 stated that the autistic children will have increased total fixation times for the Ball compared with the Runner display, relative to the developmentally delayed children.
Figure 2  Time course of individual habituation and novel trials, by group and display.

HF = First habituation trial
HL = Last habituation trial
N = Novel trials
The time course of habituation (Figure 2) and the mean total durations of fixation (see Figure 3 & Table 3) indicate that the autistic children had consistently longer fixation times for the Ball than for the Runner, with the developmentally delayed children consistently having the reverse pattern (Display by Group interaction), consistent with Prediction 6. However, the means for the total fixation times during habituation were in the reverse order from that predicted (Prediction 5), the autistic children looking for longer durations than the developmentally delayed children.

<table>
<thead>
<tr>
<th>Group</th>
<th>Autistic (N = 7)</th>
<th>Dev. Delayed (N = 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Runner</td>
<td>Ball</td>
</tr>
<tr>
<td>Total mean fixation (s)</td>
<td>145.7</td>
<td>182.0</td>
</tr>
<tr>
<td>(Standard deviation)</td>
<td>(122.1)</td>
<td>(126.1)</td>
</tr>
<tr>
<td>Range</td>
<td>49-370</td>
<td>60-426</td>
</tr>
</tbody>
</table>

Table 3. Means (standard deviations) and ranges of the total durations of fixation during habituation, by group and display.

The significances of these differences were tested, entering total fixation times into a 2 x 2 x 2 (Order x Display x Group) mixed design ANOVA, with Display entered as a repeated measure variable and Group entered as a related pairs variable (see Appendix F for summary table). The Display by Group interaction was not significant \(F(1,5) = 3.63, p = .115\). However, a Display simple effects analysis for Group showed that the autistic children had significantly longer fixation times for the Ball compared with the Runner, consistent with the prediction \(F(1,5) = 9.26, p = .029\), although there was no significant difference in fixation times between the displays for the developmentally delayed children \(F(1,5) = 1.66, \text{n.s.}\). The main effect of Group was not significant \(F(1,5) = 0.32, \text{n.s.}\),
Figure 3  Mean total durations of fixation during habituation, by group and display
and similarly a Group simple effects analysis for Display did not reveal significant differences between the groups \((Runner; F(1,5) = 0.00, \text{n.s.}; Ball; F(1,5) = 1.48, \text{n.s.})\).

In summary, \textit{Prediction 6} was partially supported. The autistic children tended to look longer at the Ball than at the Runner display, compared with the opposite tendency of the developmentally delayed children but the predicted overall group by display interaction did not reach significance. However, the autistic children looked significantly longer at the Ball than at the Runner, consistent with the prediction. \textit{Prediction 5} was not supported, as the autistic children looked longer at the displays, taken together, than the developmentally delayed children, contrary to prediction, but this tendency was not significant.

\subsection*{2.2 Order and 'Carry-over' Effects}

\textit{Prediction 10} stated that both groups of children will have shorter durations of fixation (and recovery) for both displays when seen second rather than first.

Consistent with \textit{Prediction 10}, the children spent more time looking at both displays, considered together, if presented first rather than second (First display, \(M = 168.3\) s; Second display, \(M = 130.6\) s) and this Order by Display interaction was significant \((F(1,5) = 21.12, p = .006)\); thus there was an apparent fatigue effect. The autistic children appeared to have a lesser 'fatigue' effect than the developmentally children, their mean fixation time for the second display being 92\% of that for the first display, compared with 62\% for the developmentally delayed children, but this Order by Display by Group interaction was not significant \((F(1,5) = 1.56, \text{n.s.})\). However, due to the combined effect of their low fatigue effect and their significantly longer fixation times for the Ball than for the Runner, the fixation times of the autistic children increased, rather than decreased, between first and second displays when the Ball was seen second.
For either group, it was possible that which display was seen first affected their degree of fatigue on seeing the second display. For instance, the children might be 'disappointed' by the Ball after seeing the Runner, but not vice versa; they would then be expected to look at the Ball-Runner sequence for a shorter duration than the Runner-Ball sequence (differential 'carry-over'). The absence of a main effect of Order ($F(1.5) = 0.40$, n.s.) indicates that there was no differential carry-over shared by the groups and there was no difference between groups (no significant Order x Group interaction; $F(1.5) = 0.02$, n.s.).

In summary, Prediction 10 was supported, as both groups had significantly shorter fixation times for the second display.

2.3 Group differences in Variance and Consistency of the Total Fixation Times

Table 3 shows that the autistic children had a greater variability than the developmentally delayed children in fixation times for both displays, as indicated by the ranges and standard deviations of their fixation times. The group differences in variance were significant for the Ball ($t(5) = 2.60$, $p < .05$, two-tailed test) but not for the Runner ($t(5) = 1.64$, $p > .10$, two-tailed test).

It was also found that the autistic children's fixation times for the Runner and the Ball were strongly correlated with each other ($r(7) = .96$, $p < .001$, two tailed test), unlike the developmentally delayed children ($r(7) = -.25$, n.s.). This group difference in correlation was significant ($z = 3.17$, $p < .002$; two tailed test). A portion of the difference in correlation between the two groups may be artefactual, due simply to the greater variance in the autistic children's fixation times.
2.4 Conclusions

Although, contrary to Prediction 6, the Display by Group interaction was not significant (p = .115), the autistic children looked significantly longer at the Ball compared with the Runner (2.1), which is consonant with prediction. The autistic children did not have shorter fixation times than the developmentally delayed children, contrary to Prediction 5.

There was a significant 'fatigue' effect for the second display, consistent with Prediction 10. The fatigue effect was less for the autistic than for the developmentally delayed children, but the difference was not significant. The relatively low fatigue effect of the autistic children and their significant preference for the Ball, resulted in an increase in fixation by them when this was presented as the second display. There was no evidence for any differential carry-over effect between the two displays (2.2).

The autistic children had a wider variance in fixation times than the developmentally delayed children, significant for the Ball display. The autistic children were also significantly more consistent in their fixation times between the two habituation displays, although this may partly be artefactual, due to their greater variance in fixation times (2.3).

3. Habituation

3.1 Rate of Habituation; Number of Trials to Criterion

Prediction 8 stated that there will be no differences between the groups in number of trials to habituation criterion, for either display.

Consistent with the prediction, there were no differences in the number of trials to habituation criterion either between groups for the same display or between displays within
Figure 4  Number of trials to habituation criterion, by display and group
the same group (see Figure 4: z ≤ .41, n.s., two tailed Wilcoxon signed ranks tests). The majority of both groups reached criterion for both displays within eight trials and many within the minimum of six, the remainder taking up to 12 or, in the case of one autistic child viewing the Runner display, 15 trials.

3.2 Time Course of Habituation

Figure 2 shows a generally smooth 'monotonic' continuous decrease in trial fixation times for both groups and displays. Differences in fixation times between groups and displays by trials were therefore analysed in blocks of two trials; First trials and Last trials.

3.3. Fixation Times during Habituation by Trial Blocks

Figure 5 shows the mean fixation times on First and Last habituation trials. The primary results were analysed by 2 x 2 x 2 x 2 (Order by Display by Trials by Group) mixed design ANOVA, with Trials and Display entered as repeated measures variables, and Group entered as a related pairs variable (see Appendix G for summary table).

Differences between Groups and Displays:

There were no significant main effects of either Group (F(1,5) = 0.65, n.s.) or Display (F(1,5) = 0.02, n.s.).

Consistent with the predicted group and display differences reported above in Total fixation times, the autistic children had longer fixation times for the Ball relative to the Runner, on First and Last trials combined, and this was significant when compared with the opposite tendency of the developmentally delayed children (Display x Group interaction; F(1,5) = 7.38, p = .042). The strength of the interaction depended on whether First or the Last trials were considered, although this effect was of borderline significance (Trials x Display
Figure 5  Mean durations of fixation during first and last habituation trial blocks, and during novel trial block, by group and display.
First Trials Block:

A Display by Group interaction effects analysis for Trials showed that, during the First trials, the autistic children had significantly longer fixation times for the Ball relative to the Runner when compared with the developmentally delayed children, as predicted (See Figure 5: Display x Group interaction; \( F(1,5) = 9.20, p = .029 \)). However, a Display simple effects analysis for Trials and Group did not reveal significant differences in fixation times between the two displays during the First trials for either the autistic (\( F(1,5) = 3.97, p = .103 \)) or the developmentally delayed children (\( F(1,5) = 1.57, p = .266 \)). Similarly, a Group simple effects analysis for Trials and Display failed to reveal significant differences in fixation times between the two groups for either the Runner (\( F(1,5) = 0.03, \text{n.s.} \)) or the Ball (\( F(1,5) = 4.01, p = .102, \text{n.s.} \)).

Last Trials Block:

The Display by Group interaction effects analysis for Trials did not indicate any significant differences in fixation times during the Last trials block (See Figure 5: Group x Display interaction, \( F(1,5) = 2.07, p = .210 \)), although the developmentally delayed children's mean fixation time for the Ball was around half that for the other three conditions (see Table 4, p. 70). A simple Display effects analysis for Trials and Group confirmed that the developmentally delayed children had significantly shorter fixation times for the Ball relative to the Runner (\( F(1,5) = 10.92, p = .021 \)), whereas there was no significant effect of Display for the autistic children (\( F(1,5) = 0.15 \)). A simple Group effects analysis for Trials and Display did not show any significant differences between the groups in fixation times for either display (Runner; \( F(1,5) = 0.04, \text{n.s.} \); Ball; \( F(1,5) = 1.69, p = .250 \)).
3.4 Group and Display Differences in Magnitude of Habituation

There were no significant differences between the displays, across the two groups, in magnitude of habituation (decrease in fixation times from First to Last trials: Trials x Display interaction, F(1,5) = 0.29, n.s.). The Trials by Display by Group interaction (p = .066) outlined earlier (Section 3.3, p. 65) was analysed for differences in habituation between both groups and displays. A Trials by Display interaction effects analysis for Groups, showed that the fixation times of the autistic children decreased more for the Ball than for the Runner (Trials x Display interaction, F(1,5) = 15.17, p = .011). The fixation times of the developmentally delayed children were not significantly different between the displays (Trials x Display interaction, F(1,5) = 0.42, n.s.).

3.5 Reliability of Habituation

Prediction 7 stated that both groups of children will habituate to both displays.

Due to the above interactions, it cannot be reliably concluded from the expected main effects of Trials (F(1,5) = 42.46, p = .001) and the absence of a significant Group by Trials interaction (F(1,5) = 0.50, n.s.), that both groups habituated reliably to both displays. However, individual paired t-tests confirmed that the decreases in fixation times from First to Last trials were significant for both displays and groups, as predicted (Autistic: Runner, t(6) = 3.73, p = .005; Ball, t(6) = 4.28, p < .003; Dev. Delayed: Runner, t(6) = 3.06, p = .011; Ball, t(6) = 4.68, p < .002; one-tailed tests).

3.6 Order Effects and Carryover between Display Presentations

The Trials by Display by Group interaction (Section 3.3) depended on the order of display presentation, an effect of borderline significance (Order x Trials x Display x Group interaction, F(1,5) = 6.04, p = .057). This was primarily due to the developmentally
delayed children tending to habituate more to the first display compared with the second, relative to the autistic children.

In contrast to the developmentally delayed children, the autistic children habituated more to the Ball when it was presented second than when presented first, which is also the opposite pattern to their own fixation times for the Runner (this being similar to that of the developmentally delayed children). If this effect is significant, it may be due to the autistic children having a combination of increased fixation times for the Ball (versus the Runner) and a lesser fatigue effect, when compared with the developmentally delayed children, which may have resulted in relatively enhanced fixation times for the Ball, as second display, during the first trial block.

The presence of such a group difference in interaction pattern has support from a Trials by Display by Group interaction effects analysis for Order. The interaction was significant for the Runner First/Ball Second condition (F(1,2) = 10.33, p = .049) but not for the Ball First/Runner Second condition (F(1,1) = 0.01, n.s.). There is also limited support from the Order by Group by Trials by Display interaction effects analysis for Group. This failed to reveal an interaction for the autistic children (F(1,5) = 0.06, p = .815), unlike the developmentally delayed children, although the latter effect did not reach significance (F(1,5) = 4.61, p = .085).

There were no significant carryover effects between display presentations for either First or Last trials, groups or displays, as indicated by the lack of further significant order effects: Order (F(1,5) = 0.42); Order x Trials (F(1,5) = 1.68); Order x Group (F(1,5) = .21); Order x Trials x Group (F(1,5) = 0.05); Order x Group x Display (F(1,5) = 0.60).
3.7 Group differences in Variance and Consistency of the Fixation Times during First and Last Habituation Trial Blocks

The autistic children had significantly greater variance than the developmentally delayed children in their Last trials fixation times for both displays (See Table 4: Runner; t(5) = 6.95, p < .001: Ball; t(5) = 6.17, p < .01; two-tailed tests), but there were no significant group differences in variance for the First trials (Runner; t(5) = 0.25, p > .20: Ball; t(5) = 2.49, p > .05; two-tailed tests).

<table>
<thead>
<tr>
<th>Group</th>
<th>Autistic (N = 7)</th>
<th>Dev. Delayed (N = 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Runner</td>
<td>Ball</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Trials mean fixation (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>58.3</td>
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<td>Last Trials mean fixation (s)</td>
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<td>Range</td>
<td>5.7-64</td>
<td>3.0-64</td>
</tr>
</tbody>
</table>

Table 4  Means (standard deviations) and ranges of the durations of fixation during first and last habituation trial blocks, by group and display

The autistic children were significantly consistent, as indicated by a strong significant correlation, in their First trials fixation times between the Ball and the Runner displays (r(7) = .82, p = .022, two-tailed test), in contrast to the developmentally delayed children (r(7) = -.28, n.s.). There were no significant correlations, for either group, for the Last trials (Autistic; r(7) = .47, p = .286, two-tailed test: Developmentally Delayed; r(7) = -.026, n.s.).
3.8 Conclusions

Both groups habituated reliably to both displays (3.5), consistent with Prediction 7, following a smooth 'monotonic' decline in fixation times over individual trials (3.2). Consistent with Prediction 8, there were no significant differences in number of trials to habituation criterion, with the majority of children habituating within eight trials (3.1). The autistic children's fixation times decreased significantly more for the Ball than for the Runner, whereas there was no difference between the displays for the developmentally delayed children (3.4). The autistic children also tended to habituate more to the Ball when it was presented second, although there were no 'fatigue' effects evident when considering the First and Last trials (3.6).

The greater magnitude of habituation of the autistic children for the Ball and their tendency to habituate to the Ball more when it was the second display may be related to their relatively enhanced fixation times for the Ball, when presented second, during the First trials: There was a significant interaction between Display and Group with the autistic children tending to have greater fixation times for the Ball relative to the Runner, compared with the developmentally delayed children, but no significant Display or Group simple effects were evident (3.3). During the Last trials, there was no significant Display by Group interaction, but the developmentally delayed children had significantly shorter fixation times for the Ball relative to the Runner (3.3).

The autistic children had greater variance in their fixation times than the developmentally delayed children during the last trials. The autistic children were also more consistent in their fixation times between the two displays, although this may be partly an artefact of their greater variance in fixation times (3.7).
4. Group Differences in Response to the Novel Displays

4.1 Group & Display Differences in Duration of Fixation for the two Novel Trials

Figure 2 (p. 58) shows that fixation times decreased between the first and second novel trial for the autistic children and for the developmentally delayed children looking at the novel Runner display, in contrast to the fixation times increasing for the developmentally delayed children looking at the novel Ball display. However, this Trials by Display by Group interaction was not significant when the fixation times were entered into a 2 x 2 x 2 x 2 (Order x Trials x Display x Group) mixed design ANOVA, with Trials and Display entered as repeated measures variables and Group entered as a related pairs variable (F(1,5) = 3.57, p = .117; see Appendix H for summary table). Similarly, a Trials by Display interaction effects analysis for Groups did not reveal any such significant interaction for the developmentally delayed children (F(1,5) = 2.86, p = .151) or for the autistic children (F(1,5) = 0.73, n.s.). There were no other significant main effects or interactions (p > .10).

As there was no significant effect of Trial (F(1,5) = 3.55, p = .118), and there were no other significant first, second or third order Trials interactions (F(1,5) ≤ 3.28, p ≥ .130), analysis now considered both novel trials together as a block.

5.2 Reliability of Recovery & Individual Differences

Prediction 9 stated that both groups of children will recover to the novel displays following habituation.

The Constant effect was significant in the ANOVA for the Recovery scores (Novel minus Last trials fixation times; F(1,5) = 39.95, p = .001) and as there were no significant
interactions, this indicates that Recovery was reliable between Order, Display and Group, as predicted. This conclusion was confirmed for each Group and Display by paired t-tests: 

Autistic; Runner, t(6) = 2.27, p = .032; Ball, t(6) = 2.32, p = .030; Developmentally Delayed; Runner, t(6) = 2.39, p = .027; Ball, t(6) = 3.34, p = .008; one-tailed tests).

Not all participants recovered their fixation times to both displays, when this was (arbitrarily) defined as an increase in fixation time from Last habituation trial block to Novel trial block of at least 20 percent. One autistic child failed to recover to either display, another autistic child failed to recover to the novel Ball display when presented as the second display and one developmentally delayed child failed to recover to the same display when presented first.

4.3 Group & Display Differences in Recovery for the Novel Trials Block

Prediction 1 stated that the autistic children will have lower recovery scores for the novel Ball display than the developmentally delayed children. Prediction 2 stated that the autistic children will have lower recovery scores for the novel Ball display compared with recovery to the novel Runner display, than the developmentally delayed children. Prediction 10 stated that both groups will have lower recovery scores for both novel displays when seen second, after a preceding novel display.

Figure 6 shows that the autistic children had lower Recovery scores for both displays than the developmentally delayed children, consistent with Prediction 1. Also, their Recovery scores for the Ball were less than those for the Runner, unlike the developmentally delayed children whose scores were similar for both displays, consistent with Prediction 2. The significances of these effects were tested by entering Recovery scores into a 2 x 2 x 2 (Order by Display by Group) mixed design ANOVA, with Display entered as a repeated
Figure 6  Mean recovery to novel displays, by group and display.
measure variable and Group entered as a related pairs variable (see Appendix I for summary table). There were no significant main effects or interactions ($F(1,5) \leq 3.58, p > .10$). A planned Group simple effect analysis for the Ball Display (Prediction 1) similarly did not reveal a significant difference in mean Recovery between the groups ($F(1,5) = 1.58, p = .264$). Thus, none of the three predictions were confirmed by this analysis.

The predicted interactions during habituation in fixation times between groups and displays make it difficult to interpret the absence of significant differences in Recovery scores, as anticipated. The following analyses are concerned with elucidating whether this lack of statistical significance in the predicted score differences is 'real', or whether it is rather due to differences between the groups, and between individuals, in overall relative interest for the displays, as indicated by differences in their fixation times during habituation. In particular, the autistic children had a relatively high 'interest' for the Ball display during habituation, so their predicted relatively reduced recovery to the Ball may be confounded with their generally enhanced interest for this display. Similarly, the relatively enhanced 'interest' of the developmentally delayed children for the Runner display is in the contrary direction to the predicted recovery differences.

4.4. Relationship between Recovery Scores and Fixation Times during Habituation; Adjustment of Recovery Scores

It was hypothesised that Recovery was related both to the child's representation of the novelty per se and to his or her state during the preceding habituation trials (i.e. the general level of 'interest' for the habituation display), as the novel display was identical to the habituation display in every respect except the time delay in rebound.

Positive correlations between Recovery and fixation times during habituation would be taken
as support for the hypothesis and enable Recovery scores to be adjusted for fixation times during habituation. Such correlations were found, being stronger for Total than for First trial fixation times (Total; Runner, $r_{0.12} = .85$; Ball, $r_{0.12} = .89$. First Trials; Runner, $r_{0.12} = .64$; Ball, $r_{0.12} = .42$. Pooled within-groups partial correlation coefficients, partialling out Order of display presentation). Partial regression plots for each group, controlling for Order, indicate an approximately linear relationship between residual Recovery scores and Total fixation times (see Appendix J).

Group differences in the novelty element of recovery could now be tested by analysing Recovery scores separately by Group for each display, after partialling out Total fixation times and Order.

4.5 Group Differences in Recovery to each Display, controlling for Total Fixation Times and Order

Recovery to the Novel Ball display:

Prediction 1 stated that the autistic children will have lower recovery scores for the novel Ball display than the developmentally delayed children.

As predicted, Group was significantly correlated with Recovery to the novel Ball display, after partialling out Order and Total fixation times ($r_{0.1350} = .50$, $t(10) = 1.83$, $p = .049$, one tailed test), the developmentally delayed children having the greater residual Recovery scores. The residual scores are the differences between the observed and the predicted scores, the predicted scores being calculated in the multiple regression equation from each child's Total fixation time and Order of display. The significance of the effect was confirmed by t-test for the Group difference in mean residual scores (see Figure 7; $t(12) = 1.79$, $p = .050$, one tailed test). The reliability of this result is supported by the adherence
Residual recovery = Observed minus predicted recovery scores.
Predicted recovery = Recovery score predicted from Total fixation times during habituation and Order of display.

Figure 7  Mean recovery to novel displays by group and display, partialling out duration of fixation during habituation and order of display presentation.
of the data to the parametric assumptions of the analysis; 1), the lack of significant deviation from normality of the residual scores (Skewness = .84, z = 1.408, p = .139; Kurtosis = .03, z = 0.023, p = .980, two tailed tests); and 2), the homogeneity of variance in the residual scores by Group (Bartlett-Box F(1,432) = 1.01, p = .317).

Recovery to the Novel Runner display:

Group was not significantly correlated with Recovery for the Runner, after entering Order and Total fixation times (r_{0.23} = .11, t(10) = 0.73, n.s.).

Group and Display differences in residual Recovery scores:

Prediction 2 stated that the autistic children will have lower recovery scores for the novel Ball display compared with recovery to the novel Runner display, than the developmentally delayed children.

Residual Recovery scores (observed minus predicted Recovery scores, as outlined) were analysed by both Group and Display for the predicted Group by Display interaction. Order effects had been controlled for in the multiple regression, so residual scores were compared by t-test. The Group mean display difference scores (i.e. the means of individual Runner minus Ball residual Recovery scores) were compared, and the Group by Display interaction revealed was significant (t(12) = 1.83, p = .046, one tailed test, see Figure 7). Consistent with Prediction 2, the developmentally delayed children had greater residual Recovery scores for the Ball than for the Runner, when compared with the autistic children.

The residual display difference scores did not deviate significantly from normality (Skewness = -.23, z = 0.39, p = .69; Kurtosis = .48, z = 0.42, p = .68, two tailed tests) and were not significantly heterogeneous by Group (Bartlett-Box F(1,432) = 0.06,
4.6 Conclusions

Both groups recovered their fixation reliably to both novel displays (i.e. Display + Delay), consistent with Prediction 9, although one developmentally delayed and two autistic children did not recover their fixation to either one or both of the novel displays (4.2). There was a non-significant tendency for the developmentally delayed children to maintain their Recovery to the novel Ball display over the two novel trials, unlike the decrease found for the Runner, and with the autistic children for both displays (4.1).

Considering the two novel trials as a block, the developmentally delayed children recovered significantly more to the Ball display than did the autistic children, consistent with Prediction 1, when the positive correlation between Recovery and Total fixation times during habituation was partialled out. In contrast, there was no significant difference between the groups for Recovery to the Runner, about which no prediction had been made. Consistent with Prediction 2, there was a Group by Display interaction between the residual Recovery scores (observed minus predicted scores, when scores were predicted from Order and Total fixation times in the multiple regression), the developmentally delayed children having a stronger residual Recovery towards to Ball relative to the Runner, compared with the autistic children (4.4 & 4.5). There was no tendency for the children to recover less to the second novel display, contrary to Prediction 10 (4.5).
5. Group and Individual Differences in Early Social Behaviours: Relationship with Group Differences in Recovery

5.1 Group and Individual Differences in Socialisation Scores

*Prediction 3A* stated that the autistic children will have lower scores than the developmentally delayed children on the 7-item Socialisation scale.

As predicted, the autistic children had significantly lower Socialisation scores than the developmentally delayed children, (see Figure 8; Wilcoxon matched pairs signed rank test, T(7) = 1, p = .016, one tailed test). When the scores were dichotomised (0-7/8-14), a strong and significant association with group membership was found (see Table 5).

<table>
<thead>
<tr>
<th></th>
<th>Strength of association</th>
<th>p (two tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socialisation (0/1)</td>
<td>.87</td>
<td>&lt; .005</td>
</tr>
<tr>
<td>Joint attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pointing (0/1)</td>
<td>1.00</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Showing (0/1)</td>
<td>.71</td>
<td>.029</td>
</tr>
<tr>
<td>Total score (0/1/2)</td>
<td>.93</td>
<td>&lt; .003</td>
</tr>
<tr>
<td>Pretend play (0/1)</td>
<td>.32</td>
<td>n.s.</td>
</tr>
<tr>
<td>Display Identification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runner (0/1)</td>
<td>.29</td>
<td>n.s.</td>
</tr>
<tr>
<td>Ball (0/1)</td>
<td>.63</td>
<td>.070</td>
</tr>
<tr>
<td>Both displays (0/1)</td>
<td>.43</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Table 5 Associations between Group membership (Autistic = 1, Dev. Delayed = 2), Social Behaviours (caregiver report) or Identification of the dynamic Displays (Runner/Ball)

1Phi, or Cramer's V (Joint attention, total score)

2Fisher's exact test, or Chi-square (Joint attention, total score).
Figure 8  Socialisation scores, by group
Only one autistic child 'Show(ed) anticipation of being picked up by a caregiver' (Item 6), only two 'Show(ed) interest in children...other than siblings' (Item 8) or 'Play(ed) very simple interaction games with others' (Item 11) and none of them 'Show(ed) an interest in activities of others' (Item 13). None of these items were scored as 'Yes, usually' (2 points) for any of the autistic children. However, between four and five autistic children obtained at least one point for 'Shows affection.' (Item 7), 'Reaches for familiar person' (Item 9) or 'Imitates simple adult movements..' (Item 14).

Only one of the developmentally delayed children 'failed' any item or obtained a score as low as any of the autistic children. This child 'failed' on three items; Item 6 (anticipation of being picked up), Item 8 (showing interest in other children) and Item 11 (playing very simple interaction games).

5.2 Association between Socialisation Scores and Recovery to the Novel Displays

Prediction 3B stated that Socialisation scores will be associated with Recovery scores for the novel Ball display and with Recovery score differences between the displays.

As predicted, for all 14 children, those with greater Socialisation scores (> 7) had greater mean residual Recovery scores for the Ball display than those with lower scores (M = 4.4 s versus M = -3.3 s), but this difference was not significant (t(12) = 0.47, n.s.). Prediction 3B was, however, supported by the significant tendency of the children with the greater Socialisation scores to have greater mean residual Recovery scores for the Ball compared with the Runner (M = 13.4 s versus M = -10.0 s; t(12) = 2.32, p = .019, one tailed test).

Within the autistic group, raw Socialisation scores were weakly, and non-significantly,
associated with residual Recovery scores for the Ball in the predicted direction ($r_{01.23} = .28$, $t(3) = 0.50$, n.s.). Similarly, there was a weak, non-significant, correlation in the predicted direction between the Socialisation scores and the residual recovery Display difference scores ($r_{01.23} = .22$, n.s.).

5.3 Conclusions

The autistic children obtained substantially, and significantly, lower Socialisation scores than the developmentally delayed children, consistent with Prediction 3A (5.1). Considering all 14 children, there was a significant tendency, consistent with Prediction 3B, for children with greater Socialisation scores to have greater residual recovery scores for the Ball, compared with the Runner. A similar tendency in favour of residual recovery to the Ball, considered alone, was not significant (5.2).

Although there was a tendency for the autistic children's Socialisation scores to be positively associated both with recovery to the Ball, and with recovery to the Ball display compared with the Runner, consistent with Prediction 3B, this was weak and not significant (5.2).

6. Group Differences in Joint Attention: Relationship with Group Differences in Recovery

6.1 Group Differences in Joint Attention

Prediction 4A stated that the autistic children will tend not to have joint attention behaviours compared with the developmentally delayed children, as indicated by the caregiver questionnaire scores.

Prediction 4A was supported; Table 5 (p. 80) shows that there was a strong and significant
tendency for the autistic children to be less likely than the developmentally delayed children to show joint attention behaviours, as indicated by both the two individual measures and the combined measure. There was a 1:1 correspondence between group membership and the presence or absence of use of a finger point to indicate interest. One of the autistic children was reported to bring objects over to show the caregiver and one of the developmentally delayed children was reported not do this.

6.2 Association between Joint Attention and Recovery to the Novel Displays

Prediction 4B stated that joint attention behaviours will be associated with recovery to the Ball display, and with the differences in recovery between the Ball and the Runner displays, across the groups and within the autistic group.

As described, there was a 1:1 correspondence between membership of the autistic group and referential pointing, and only one autistic child was reported with joint attention showing behaviour. The results were not therefore analysed for within-group associations between joint attention and recovery scores.

For all 14 children, consistent with Prediction 4B, there was a strong, significant association between joint attention showing behaviour and residual recovery scores for the novel Ball display, after partialling out Order of display and Total fixation times during habituation ($r_{0.23pb} = .67$, $t(10) = 2.83$, $p = .009$, one tailed test). The difference in residual scores was confirmed by t-test for the means ($M = 18.4$ s versus $M = -18.4$ s; $t(7.8) = 2.96$, $p < .010$, one tailed test). Increased total joint attention scores were also associated with increased residual recovery scores for the novel Ball display ($\tau-c(14) = .55$, $z = 2.74$, $p = .003$, 1-tailed test). Similarly, both joint attention showing and total joint attention scores were associated with greater residual recovery for the novel Ball display compared
with the Runner. However, these tendencies did not reach significance for showing behaviour (M = 6.6 s versus M = -6.6 s; t(12) = 1.16, p = .136, one tailed test) or for the overall joint attention measure. In the latter case, the mean residual recovery display differences score was greater for a total joint attention score = 1 (M = 21.95 s, N = 2) than for joint attention = 2 (M = 5.84 s, N = 6), compared with joint attention = 0 (M = -13.16, N = 6; tau-c(14) = .31, z = 1.52, p = .064, one tailed test).

6.3 Conclusions

Significantly fewer of the autistic than the developmentally delayed children had joint attention behaviours, consistent with Prediction 4A, and there was a 1:1 correspondence between referential pointing and group membership (6.1). Considering the whole group of 14 children, there was a moderately strong and significant tendency for children who had joint attention behaviours to have greater residual recovery scores for the novel Ball display, consistent with Prediction 4B. There was also a moderate, predicted, tendency for joint attention to be associated with residual recovery in favour of the novel Ball display, relative to the Runner (6.2); this only reached significance for referential pointing (as for group membership; see Section 5.5, p. 78).

As only one autistic child was reported as showing either of the joint attention behaviours, Prediction 4B could not be assessed for within-group associations with recovery scores.

7. Group Differences in Pretend Play: Relationship with Group Differences in Recovery

Table 5 (p. 80) shows that fewer of the autistic than the developmentally delayed children were reported as showing pretend play, but the group difference was relatively weak and
not significant. As only one autistic child showed pretend play, no analysis was made of any association within the autistic group between pretend play and the residual recovery scores.

Considering all 14 children, there was a moderate and significant association between pretend play and residual recovery scores for the novel Ball display ($r_{pb} = .54$, $t(10) = 2.03$, $p = .035$, one tailed test); the difference in residual score means was also close to significance when compared by t-test ($M = 20.1$ s versus $M = -8.0$ s; $t(12) = 1.74$, $p = .054$, one tailed test). Similarly, the children with pretend play tended to have greater residual recovery scores for the Ball compared with the Runner novel display, but this tendency did not reach significance ($M = 12.1$ s versus $M = -4.8$ s; $t(12) = 1.37$, $p = .097$, one tailed test).

8. Group Differences in Identification of the Displays

The identification tests were intended to assess whether the children's recovery responses to the experimental novel displays were related to, or confounded with, their abilities to identify a named line drawing of the two dynamic display elements; "boy" (Runner) and "ball". It was possible that failure to give an appropriate identification response may have represented one or more of three factors; 1), lack of recognition of the verbal label; 2), lack of visual recognition of the display; 3) task-related factors such as general absence of a pointing or touching response or motivation. Different factors may have been evident for the two groups and this section is concerned with evaluating these factors, to aid interpretation of the relationship between identification and recovery responses to the experimental displays.
8.1 Group Differences in Identification of the Displays; Relationship with Verbal Abilities and Joint Attention Pointing

As indicated in Table 5 (p. 80), fewer of the autistic than the developmentally delayed children successfully identified the dynamic display elements, but, of the three identification measures, this group difference only approached significance for Identification of the Ball (two tailed tests). The association of group membership with Identification of the Runner was weak. Only two of the autistic children identified both displays, with one more child identifying the Ball and another identifying the Runner ("boy"). In contrast, only two of the developmentally delayed children failed to identify the Runner and all identified the Ball.

Considering the developmentally delayed children, these results suggest that the identification test for the Ball was generally easier than identification of the Runner, so the 'failure' of the two developmentally delayed children to identify the Runner may have represented lack of either verbal or visual recognition. However, this apparent difference in difficulty between the two identification tests was not significant (binomial p = .500, N = 7; two tailed McNemar test) and 'success' in the Runner identification test may not have depended on verbal comprehension level or developmental delay alone as it was not significantly associated with greater RDLS age scores or quotients for these children (see Table 6).

Considering the autistic children, the presence of differences in identification rate between them and the developmentally delayed children, despite matching of participants on RDLS comprehension age scores, suggests that their responding to the identification tests may have primarily represented task-related factors such as their ability, or willingness, to point at, or place a finger on, any named picture, rather than verbal or visual recognition. Against this suggestion is the association between identification for the Runner, and RDLS age
scores and quotients (the latter significant; see Table 6). Also, any task-related factors were probably not necessarily dependent on joint attention pointing, as none of the autistic children were reported by their caregivers as having referential pointing behaviours to indicate interest (as outlined in Section 6.2, p. 84). Nevertheless, the suggestion that task-related factors were important is supported from two related lines of evidence: 1) None of the four autistic children who failed to identify the Ball display 'passed' the four items on the Training Plate ($\phi = 1.00, p = .029$, one tailed Fisher's exact test). Of these four children, just one pointed appropriately at any of the four training items ("Car"). 2) All seven autistic children were able to respond appropriately in the RDLS comprehension test by picking up at least 10 named objects, including two of those depicted on the Training Plate used in the identification test ("doll" and "car").

<table>
<thead>
<tr>
<th></th>
<th>RDLS age score</th>
<th>Chron. age</th>
<th>RDLS quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autistic (N = 7)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean score, 'identifiers'</td>
<td>41.3</td>
<td>55.3</td>
<td>72.0</td>
</tr>
<tr>
<td>Mean score, 'non-identifiers'</td>
<td>23.7</td>
<td>90.5</td>
<td>27.0</td>
</tr>
<tr>
<td>$t$ (df)</td>
<td>1.41 (2.1)</td>
<td>2.46 (5)</td>
<td>3.06 (2.1)</td>
</tr>
<tr>
<td>$p$ (directionality)</td>
<td>.145 (one tailed)</td>
<td>.057 (two tailed)</td>
<td>.043 (one tailed)</td>
</tr>
<tr>
<td><strong>Developmentally delayed (N = 7)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean score, 'identifiers'</td>
<td>29.8</td>
<td>42.0</td>
<td>59.0</td>
</tr>
<tr>
<td>Mean score, 'non-identifiers'</td>
<td>25.0</td>
<td>53.4</td>
<td>57.0</td>
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<td>$t$ (df)</td>
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<td>0.78 (5)</td>
<td>0.12 (5)</td>
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<tr>
<td>$p$</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

**Table 6**  Mean RDLS age scores & quotients, and chronological ages, of children 'passing' and 'failing' the identification tests for the Runner display
8.2 Conclusions
There was evidence to suggest that the autistic children were generally less 'successful' in the identification tests, compared with the verbal ability-matched developmentally delayed children. This may have been primarily due to factors related to the nature of the task, rather than necessarily due to lack of verbal or visual recognition. These factors were significantly associated, for the autistic children, with developmental delay in performance on the RDLS verbal comprehension test (RDLS quotients). It is, nevertheless, also possible that, for both groups, the 'boy' was a more difficult picture to recognise than the 'ball'.

9. Relationship between Identification and Recovery to the Novel Displays: Interactions with Group Membership

As outlined earlier (Section 8. p. 86), the identification tests were intended to assess whether the children's recovery responses to the experimental novel displays were related to, or confounded with, their abilities to identify a named line drawing of the two dynamic display elements; "boy" (Runner) and "ball". Partial correlation was used to analyse this possibility and to assess any interactions with group membership.

9.1 Recovery to the Novel Ball Display
Identification of the Ball was weakly correlated with residual recovery to the novel Ball display, partialling out Order of display and Total fixation times during habituation, but this effect was not significant (t(10) = 0.74, n.s.; see Table 7). Similarly, there was no interaction with the effect of Group in the residual recovery scores, as there was no reduction in the partial correlation coefficient between Group and the residual scores, after additionally partialling out the identification scores for the Ball (Table 7).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Partial correlation of the variable with recovery scores (RS)</th>
<th>Group/RS partial correlation, after additionally partialling out the variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group membership¹</td>
<td>.50</td>
<td>(.50)</td>
</tr>
<tr>
<td>Identify the Ball display¹</td>
<td>.23</td>
<td>.51</td>
</tr>
<tr>
<td>RDLS age score</td>
<td>.00</td>
<td>.50</td>
</tr>
<tr>
<td>Chronological age</td>
<td>-.29</td>
<td>.44</td>
</tr>
<tr>
<td>RDLS quotient</td>
<td>.13</td>
<td>.51</td>
</tr>
</tbody>
</table>

Table 7  Partial correlations between control measures, group membership and recovery scores for the novel Ball display, after partialling out Order of display presentation and Total fixation times during habituation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation of the variable with residual recovery display difference scores (RDS)</th>
<th>Group/RDS partial correlation, after partialling out the variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group membership¹</td>
<td>.47</td>
<td>(.47)</td>
</tr>
<tr>
<td>Identify the Runner display¹</td>
<td>.01</td>
<td>.49</td>
</tr>
<tr>
<td>Identify the Ball display¹</td>
<td>.13</td>
<td>.50</td>
</tr>
<tr>
<td>Identify both displays¹</td>
<td>-.07</td>
<td>.55</td>
</tr>
<tr>
<td>RDLS age score</td>
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<td>.47</td>
</tr>
<tr>
<td>Chronological age</td>
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<td>.30</td>
</tr>
<tr>
<td>RDLS quotient</td>
<td>-.11</td>
<td>.51</td>
</tr>
</tbody>
</table>

Table 8  Correlations between control measures, group membership and residual recovery display difference scores, after partialling out Order of display presentation and Total fixation times during habituation

¹Point biserial correlations
9.2 Recovery Score Differences between the Novel Ball and Runner Displays

There were no associations between any of the three Identification scores and residual display recovery score differences \( (p > .20) \), and similarly no interactions between Identification and Group effects on residual recovery score differences (Table 8).

10. Relationship between RDLS Age Scores & Quotients, and Chronological Ages, and Recovery to the Novel Displays: Interactions with Group Membership

As the groups were not matched with respect to either chronological age or, as a result, RDLS quotients, it was important to establish whether there were any interactions between these two variables and the residual recovery scores, and whether there were any second order interactions between these and the Group effects on recovery, which may have confounded the results outlined in earlier Sections. It was also of interest whether there were any interactions between RDLS age scores (the group matching variable) and the residual recovery scores.

10.1 Recovery to the Novel Ball Display

There were no substantial or significant correlations \( (t(10) < 1.40, p > .20) \) between RDLS age scores or quotients, or chronological ages, and residual recovery scores for the novel Ball display, after partialling out Order of display and Total fixation times during habituation (Table 7). The only interaction between these control variables and Group effects on residual recovery to the Ball was in the case of chronological age, where there was a small decrease in the partial correlation between Group and the residual score after additionally partialling out chronological age (from \( r_{0.23} = .50 \) to \( r_{0.23} = .44 \); see Table 7).
10.2 Recovery Score Differences between the Novel Ball and Runner Displays

There were negative correlations between both RDLS age scores and chronological ages, and residual display difference recovery scores, after partialling out Order of display and Total fixation times during habituation. There was no substantial association between RDLS quotients and the residual difference scores (Table 8). The only interaction between these control variables and Group effects on the residual score differences was in the case of chronological age, where there was a reduction in the partial correlation between Group and the residual score differences after additionally partialling out chronological ages (from $r_{0.234p} = .47$ to $r_{0.234p} = .30$; see Table 8).

10.3 Conclusions

**Effects of RDLS age scores:**

There was a negative association between increased RDLS age scores and residual recovery score differences between the novel Ball and Runner displays, in the opposite direction to membership of the developmentally delayed group. As the groups were matched on RDLS age scores, there was no interaction between the RDLS age score effect and the Group effect on residual recovery score differences.

**Effects of RDLS quotients and chronological ages in recovery to the novel Ball display:**

The only interaction of note between RDLS quotients or chronological ages and the residual recovery scores, was in the case of chronological age. When considering recovery to the novel Ball display, the weak effect of increased chronological age was in the same direction as membership of the autistic group and in the opposite direction to the weak effect of increased RDLS quotients. There was little interaction between the Group effect and the chronological age effect in the residual scores. Thus the chronological age effect is likely to be independent of group membership, as well as independent of group differences in
Effects of RDLS quotients and chronological ages in differences in recovery between the novel displays:

When considering recovery score differences between the novel Ball and Runner displays, a more substantial interaction was found between chronological ages and the Group effect in the score differences. Again, the effect of increasing chronological age was in the same direction as that of membership of the autistic group, but this time it was confounded, to some extent, with the Group effect, the autistic children being mostly older than the developmentally delayed children. The chronological age effect was not a result of the relatively lower RDLS quotients of the autistic children, as there were no interactions between the quotients, recovery score differences and group membership.
CHAPTER 4. DISCUSSION AND CONCLUSIONS

This discussion reviews the reliability of the results and the methods which were used to obtain them (Section 1). It then proceeds to evaluate the conclusions which may be made from the results, and their validity (Sections 2, 3 & 4). Relevant future directions for research are outlined (Section 5), the clinical and practical implications of the results are then considered (Section 6), and finally the overall conclusions are summarised (Section 7).

1. Application of Habituation/Recovery Methodology with Autistic and Developmentally Delayed Children

The results reported here indicate that the use of a habituation/recovery procedure can give rise to reliable, valid, information, for testing hypotheses about the perception of movement by autistic and developmentally delayed children. This claim will be examined in this Discussion. The reliability and validity of the tests used for identification of the displays, and for assessment of early social behaviours and pretend play, will also be assessed.

1.1 Reliability of the Methodology

The inter-observer reliability was high for both groups of children. The real-time measurements and timings of the experimenter were also highly reliable, so that trials were neither curtailed nor extended due to difficulties in monitoring visual fixation (Method, 5). However, although the recorded observations were reliable (accurate), three main practical difficulties led to a high degree of 'error' variance in fixation durations both between trials and between participants. This appeared to represent factors other than the child's 'interest' in the displays:
1) Some of the autistic children did not always clearly direct their gaze towards the display, appearing to use peripheral visual fixation.

2) There were wide individual differences in durations of fixation, particularly for some of the autistic children, as reported (Results, 2.3 & 3.7). When eye contact for the display was relatively fleeting (circa 2 s or less), the child was also likely frequently to look away from the display for periods of more than one second. Thus the two second criterion for ending the trial could often be approached during habituation, so the timing of this was potentially critical for the reliability of the results. Occasionally, such a child would make an initial fleeting glance at the screen at the start of a trial, look away for up to two seconds and then revert to looking at the screen for upwards of 20 seconds. If the last novel trial was allowed to run on, occasionally such a child would appear to have been 'curtailed' in his or her voluntary fixation by application of the two second 'look-away' criterion. This problem contributed to an overall unreliability of the method when used with small numbers of participants, as such large differences in voluntary fixation lead to the high variance found in fixation times between trials and participants.

3) There was a 30 - 35 percent loss of participants due to participant curtailment of the trials or lack of attention for the displays, the loss being similar for both autistic and developmentally delayed children. This attrition rate is comparable to infant studies, where the infants may be described as 'fussing'. However, it raised particular problems in a study of this nature, where participants were 'valuable' due to belonging to a minority group in the population. This led to logistical, and potential experimental, problems in carrying out the experiment in a number of widely different environments (although the consistent experimental arrangement and lighting levels minimised variance from this source). There was also the necessity of maintaining an ability match between the two groups. In this case, the match was pairwise and there was also a match in order of display presentation. For the last few participants, the matching had to take place before the experimental procedure.
Thus, it is relevant to evaluate the reason for the attrition of participants.

Some of the children became restless during the sessions, as discussed earlier (Method, 2), leading to predicted variations in fixation between trials and to a fatigue effect between display sets, which was greater for the developmentally delayed children than the autistic children (Results, 2.2 & 3.6). Unfortunately for this methodology (unlike the infants usually studied in this way), children of the age range studied here are mobile and free to curtail the sessions by either asking to leave or by getting up to examine the experimental arrangements more directly. Key determining factors in maintaining levels of interest during the sessions may have been the attractiveness of both the experimental and inter-trial displays, the duration of the habituation trials and the necessity of habituating each participant to two sets of habituation/recovery trials in one session (the latter again being a restriction due to the restricted participant population and to difficulties in matching participant groups). A dilemma in the habituation procedure is that a reliable habituation criterion must be set to ensure that recovery to the novel display is also reliable. As habituation essentially consists of the child becoming reliably bored, it is not surprising if his or her behaviour starts to conflict with the experimental demands.

Future research using this methodology with such special groups of children may need to address the above problems. Reliable results and avoidance of wastage may be achieved as follows: 1) A paired comparison procedure may be adopted (see Introduction, Section 5.3) which does not necessitate a stringent habituation criterion. This procedure was not adopted here due to the difficulty of running two contrasting dynamic displays side by side. It is also difficult, with such a procedure, to measure degree of discrimination between the displays, which was achieved here. Furthermore, Berthenthal et al (1987) argue that such an approach confounds the measurement of encoding with that of discrimination (see below,
2.1 & 3.1). 2) Experiments may be designed so that one set of habituation trials only need be used.

2. Habituation Responses of the Children

2.1 Reliability of Habituation

The results show, as predicted (Prediction 7), that both groups of children habituated reliably to both displays. As will become clear, 'reliable' here simply means that there was a 'real', statistically significant, difference in fixation times between first and last trials, not necessarily that this decrease represented anything other than chance variations in looking behaviour. As discussed in the Introduction (5.4), experiments measuring physiological responses have not always found habituation (i.e a reliable change in response over trials) among autistic participants, whereas visual habituation may take place where physiological habituation does not (Barry & James, 1988; Verbaten et al, 1991). Further literature was discussed, forming a basis for the experimental hypothesis, which also suggests that there is a relative lack of 'depth' of information processing in autism, despite appropriate behavioural responding. Thus, as discussed, the changes in visual fixation for autistic children may not represent 'deeper' information processing (Courchesne, 1987), such as conceptual processing or memory formation.

It is possible also that the developmentally delayed children here may have had a relatively low level of information processing during habituation and that recovery simply represented spontaneous regression to the mean. Cohen (1981) proposed that the apparent visual habituation of younger, 19 week old, infants with Down's syndrome, in contrast to normal infants and older infants with Down's, did not appear to represent significant information processing, as the younger infants 'spontaneously' recovered their fixation to the habituated
display on seeing one trial of a novel stimulus, after having reliably reached habituation criterion. However, apparent spontaneous regression may represent processes other than chance variations around a mean, such as a frustration response to boredom, having 'genuinely' habituated.

A child control procedure, as used here, makes it possible that children may reach habituation criterion by chance variations in looking. Then, recovery simply represents spontaneous regression to the mean, as discussed in the Method (Section 2). For practical reasons, this study did not include a control for the extent of information processing during habituation, such as repeating the habituation stimulus after criterion was reached (as described above in the study of Cohen, 1981, and advocated by others, eg. Berthenthal, Haith & Campos, 1983). As a result, it is possible that the 'reliable' decrease in visual fixation observed here for both groups represents one of three different possibilities: 1) It signifies simply chance variations in fixation levels which do not represent any significant information processing. 2) It signifies 'real' habituation (i.e. information processing), but without significant 'depth' of conceptual processing or memory formation. 3) It signifies conceptual-level representation and memory formation.

Both possibilities 2) and 3), but not 1), above are consistent with the experimental hypothesis (7.3, p. 40); as it is proposed that the autistic children do not process aspects of dynamic causal events, as depicted in either the habituation or the novel displays. As the discrimination of the novel from the habituated event (recovery) is what is measured here, rather than either event alone, it will be difficult to establish, if the hypothesis is supported, whether such a state of affairs is due to lack of processing of the habituation or of the novel stimulus event.
It will now be shown that possibility 1) above (i.e. habituation merely represents chance variations in looking), can be excluded, from two lines of evidence in the results:

1) If there were significantly different rates, or extents, of habituation between the two displays for either of the groups, then it may be concluded that information processing ('encoding') occurred to a greater extent for the display which was habituated faster or to the greater extent (Berthenthal, et al, 1987). Although there were no differences between displays or groups in the rate of habituation, as predicted (Prediction 8), the autistic children did habituate to a significantly greater extent to the Ball than to the Runner display. Also, these children habituated more to the Ball when presented as the second, rather than the first, display, unlike the Runner and unlike both displays when considering the developmentally delayed children (Results, 3.8). Therefore it is concluded that the autistic children processed information about the the Ball display during habituation.

2) If it can be shown that habituation and recovery were separate processes (Berthenthal et al, 1987), or if there was a differential recovery response between any of the conditions (Kellman & Spelke, 1983), then there was information processing during habituation, rather than chance variations around a mean level of looking. It was found here that there was a significant effect of order of display presentation during habituation (fatigue effect; Results, 2.2), whereas there was no significant effect of order on recovery scores for any of the group and display conditions (Results, 4.3). Also, the developmentally delayed children recovered significantly more to the novel Ball display, both relative to the novel Runner display and when compared with the autistic children, when group differences in levels of fixation during habituation were partialled out (Results, 4.6). Therefore it is concluded that information processing occurred during habituation for all four group and display conditions.

Overall, it is concluded that the significant decreases in fixation times between first and last
habituation trials were not due to chance variations in looking, but rather were due to information processing. Thus, the results presented here are concerned with group differences in information processing.

2.2 Group and Display Differences in Habituation

It was predicted that there would be no differences in rate of habituation between the groups (Prediction 8), that the autistic children would have lower total fixation times during habituation than the developmentally delayed children for both displays (Prediction 5), and that they would have increased total fixation times during habituation for the Ball compared with the Runner display, relative to the developmentally delayed children (Prediction 6).

Prediction 8 was made on the basis of the literature, reviewed earlier, concerning habituation by autistic individuals, and was supported by the results (Results, 3.1). This suggests that, in any one trial, the autistic children did not have a specific difficulty in remembering the information seen during the preceding trial, relative to the developmentally delayed children (Cohen, 1981).

Prediction 5 was made on the basis of the reported reduced central physiological responses (eg. Courchesne, 1987) in autism, and from the decreased fixation times for single presentations of photographs (Boucher & Lewis, 1992), evidence reviewed in the Introduction (Section 5.4). However, it was not supported here, as there were no significant group differences in total fixation times during habituation, considering both displays together, both for the first two trials and considering total fixation times for all the trials. There were also no significant differences for the developmentally delayed children in total fixation times between the Ball and the Runner, although the means were in the predicted direction, but the autistic children had significantly greater fixation times for the
Ball than the Runner (see Results, 2.4 & 3.8).

The latter results were, to an extent, consonant with Prediction 6. This prediction was made on the basis of previous research which found that autistic children tended not to respond differentially in their central neural responses to increased complexity of a visual stimulus (Strandburg et al, 1984; Verbaten et al, 1991). Further, it was predicted here that the autistic children would tend to process dynamic information to a relatively diminished extent. These group differences in fixation times between the two displays were predicted despite contrary evidence indicating that autistic children, like other children, have greater visual fixation times for more complex static visual images (Hermelin & O'Connor, 1970; Verbaten et al, 1991). The rationale for the predicted result is as follows: The Runner display was more complex than the Ball display in three ways. Firstly, considered as a static display, it had more elements (hat/head, arms, legs), giving a complex outline, and greater complexity of colours which provided greater internal complexity. Secondly, as discussed, it had internal movements which were lacking in the Ball display. Thirdly, it had a more complex categorical significance, being a representation of an animate, rather than inanimate, object.

If total fixation times during habituation are taken to measure stimulus encoding (Cohen, 1981, Berthental et al, 1987), then the first consideration would predict greater fixation times by the autistic children, whereas the second and third considerations would predict decreased fixation times by these children. The third consideration is discussed further below (Section 3); briefly, decreased fixation times would be expected for the Runner relative to the developmentally delayed children, if the autistic children tended to encode less information about it as an animate object. This aspect of the 'complexity' of the Runner may not be as salient for them due either to its abstract cartoon nature, or to wider
real-life difficulties with animate/inanimate categorisation.

There is also a fourth consideration which may have affected relative overall fixation times; that of the sensory properties of the red 'ball'. As discussed in the Introduction (Section 5), there are various differences in sensory processing between autistic and matched control children. It is possible that there was some sensory property of the ball, not necessarily related to lack of complexity, for instance its red colour, which was more salient, or attractive, for the autistic children.

2.3 Group Differences in Variance and Consistency of Visual Fixation during Habituation

It was found that the autistic children were both more consistent than the developmentally delayed children in their durations of visual fixation between the Runner and the Ball habituation displays (both seen within one continuous session), and that they had greater individual differences in the range of their durations of fixation. The former conclusion is consistent with the finding here that the autistic children had a relatively reduced fatigue effect between the displays (Results, 2.2, 3.6), although this finding did not reach significance. The latter finding is consistent with that of Boucher & Lewis (1992) for single presentations of photographs of faces and buildings. Thus, autistic children appear to vary greatly from each other in the durations of their gaze for graphic images, yet, in this study, they were also similar to each other, as a group, in the consistency with which each child looked at two different repeatedly presented displays.

It is difficult to come to any more definite conclusion from these results, other than that they substantiate one of the postulates underlying of the experimental hypothesis here - that autistic children differ significantly from matched developmentally delayed children in their
looking behaviour. However, an additional conclusion is suggested: Perhaps the autistic children habituated to the experimental environment (as against the experimental displays) more slowly than the developmentally delayed children (i.e. they became 'bored' more slowly). If this were the case, then it may have been a function of the 'desire for sameness' which is a diagnostic characteristic of autistic children (Introduction, 2 & 4.2).

3. Recovery Responses to the Novel Displays

3.1 Reliability of Recovery, and the Relationship between Recovery and Habituation

Prediction 9 stated that both groups of children would recover to the novel displays (habituation display + time delay on contact with the 'wall'), following habituation. Prediction 10 stated that both groups of children would have lower recovery scores for both the novel displays when seen after a preceding novel display.

Prediction 9 was supported, as recovery scores were significant for all four group and display conditions. There was no significant effect of order of display presentation, indicating that there was no overall fatigue effect for recovery, contrary to Prediction 10 and unlike the fatigue effect found for the habituation displays. As discussed above (2.1), the absence of a significant fatigue effect in recovery, unlike habituation, indicates that fixation durations during habituation and recovery are, to some extent, measuring different perceptual/cognitive processes, as emphasised by Berenthal et al (1987). These authors state that fixation during habituation measures encoding (as discussed earlier) whereas recovery measures discrimination between the habituation and the novel stimulus.

However, again as discussed earlier, it is suggested here that habituation and recovery cannot be measured completely independently, as discrimination can only be measured
relative to the encoded habituation stimulus. Furthermore, as discussed below, there were positive correlations in this study between fixation during habituation and recovery. These correlations probably were due to a part of the dynamic habituation displays containing an identical dynamic display element to the novel displays, and to this proportion increasing between the habituation and novel displays (2.3 fold for the Runner and 1.7 fold for the Ball display elements; see Method, 1.1). Berthenthal et al (1987) did not find any such correlations when habituation and recovery were to dynamic point light displays, varying in coherence, depicting the biomechanical motions of a person walking, where there were no visually identical elements in the habituation and novel displays.

3.2 Interpretation of the Group Differences in Recovery to the two Novel Displays

Prediction 1 stated that the autistic children would have lower recovery scores for the novel Ball display than the developmentally delayed children. Prediction 2 stated that the autistic children would have lower recovery scores for the novel Ball display compared with the novel Runner display, relative to the developmentally delayed children.

Both Predictions 1 and 2 were supported by the results here. Thus, the autistic children recovered less to the novel Ball display than to the novel Runner display, whereas the developmentally delayed children recovered to a similar extent to both displays. When raw recovery scores were considered, these predicted differences did not reach significance, but when the correlations discussed above, between recovery and fixation times during habituation, were partialled out, the mean group and display effects increased slightly and were significant. Essentially, both individual and group differences in durations of fixation were controlled for by this method, the group differences in habituation being in the opposite direction to the group differences in recovery. The partialling out removed that portion of each recovery score which was attributable to levels of visual fixation (encoding).
The interpretation of these group differences in recovery to the two novel displays essentially depends on what conclusions may be drawn about how the children in both groups mentally represented, or encoded, both the habituation and the novel displays.

*Mental representation of the novel displays by the two groups of children:*

The most parsimonious interpretation of the recovery patterns of the two groups to the two novel displays, is that the autistic children did not notice the anomalous, 'impossible', element of the Ball + Delay event. It cannot be decided, on the basis of the information presented here, whether this was; A), due to the autistic children expecting inanimate objects to move independently (i.e. not applying the 'discounting' heuristic; Shultz, 1988), or; B), whether it was a more situation-specific response to these particular displays, so that the children simply did not notice the anomalous significance of the two second event within the ongoing, repeated dynamic pattern of the displays. Both these possibilities are consistent with the experimental hypothesis, it being suggested, essentially, that a lack of access to conceptual-level processing may result in the child noticing the delay (as indicated by the presence of reliable recovery), but not responding to the conceptual significance of the delay in the case of the Ball (i.e. "impossible event").

The second explanation, B) above, would be consistent, to an extent, with the research discussed in the Introduction (Section 5.4, where autistic children did not appear to respond at a central, 'conceptual', neural level to changes in repetitive ongoing stimuli, but did respond at a behavioural, 'categorical'. Similarly, even though a 800 ms visual cue was sufficient (unlike a 100 ms cue) to facilitate autistic men to respond more quickly in a target location task, the men had difficulty in discounting the cue if it was invalid (i.e. if it
contained information that was contrary to expectations; see Introduction, 5.4; Wainwright-Sharp & Bryson, 1993). However, information which indicates, rather, that autistic children have difficulties in identifying specific real-life animate movements (human non-verbal expressions and actions) is provided by recent research of Moore, Hobson & Lee (1995). These authors have found that the time durations required for autistic children to reliably verbally identify moving point light displays as a "person", are similar to those reported for adults and for ability-matched children, i.e. 200 ms or less. In contrast, given 5 s exposures, the same autistic children had great difficulty identifying affective states (eg. happy, angry, cold, itchy) in the movements of a person with point light displays attached; but not in identifying actions (eg. jumping, kicking, digging). Thus, it may be possible that autistic children have specific difficulties in learning, or perceiving, 'real world' information about people (animate objects) in dynamic events, but that this difficulty is likely to be relatively domain-specific.

The above possibilities are not however, the only possible interpretations of the results here. There are two further possibilities to be considered: One possibility is that the autistic children had a general difficulty, in the real world, in categorising animate versus inanimate 'objects', and therefore that their recovery responses here were a result of a similar difficulty in categorising the cartoon images. This possibility appears unlikely: The results of the identification test indicated that at least three of the autistic children identified the Runner and three identified the Ball, and there were no significant effects of identification on the recovery scores (Results, 8.2 & 9.2). It would appear unlikely for autistic children to have a difficulty in assigning humans to a similar category to each other, in comparison with balls. As Shultz (1990) discusses, there are many properties of animate objects which distinguish them from inanimate objects apart from their causal movements, such as noise (speech), in addition to all the obvious surface features which are similar in humans versus
inanimate objects and which were shared by the cartoon 'boy' - arms, legs, head, clothes and hat. Tager-Flusberg (1985) found, as discussed in the Introduction (Section 5.2), that autistic children were able to sort items into biological and artifactual domains. Furthermore, autistic children identify adults as agents capable of independent actions, as at least a minority communicate intentionally, and many more use non-verbal behaviours or words to gain another's aid in obtaining objects or to create events (see Introduction, 3.4).

A second, further, possibility is that the autistic children did not have 'real-life' expectations of the movements of the two display images, due to failing to form the same expectations of the movements of cartoon images as for the real-life objects they represented. As discussed in the Introduction, autistic children tend to be relatively lacking in pretend play and imagination, and it may need an act of imagination to form real-life expectations of cartoon images. The identification test did not control for this possibility, as it did not measure the children's spontaneous response to the images. However, this 'lack of imagination' possibility has some limited support from the information collected from caregivers about the presence or absence of pretend play. If the group and display differences in recovery were due to 'lack of imagination' about the cartoon figures, then an association may be expected both between pretend play and group membership, and between pretend play and the residual recovery scores to the novel displays. It was found that there was a weak and non-significant association between reported pretend play and group membership, whereas there was a moderate, significant, association between pretend play and residual recovery to the novel Ball, but a slightly weaker, non-significant association between residual recovery score differences between the displays (Results, 7).
Conclusion:

The experimental hypothesis stated "...autistic children have a tendency either not to notice, or not to process further, brief dynamic visual information...unless it follows a simple predictable pattern". The information presented in this study supports this hypothesis and the two predictions made from it: The two groups of children discriminated the novel Ball display in a different way from each other, the developmentally delayed children responding more strongly to it, as indicated by their recovery scores. A similar result was obtained when recovery to the novel Ball display was compared with recovery to the novel Runner display, indicating that the response of the autistic children to the former was not simply a group-specific preference for a stationary display.

As outlined above, it is likely, from these results, that the autistic children failed to notice the anomalous appearance of the Ball starting to move independently after the stationary delay. It cannot be decided, from the information here, whether this was due to a general expectation of independent movements by inanimate objects (not applying a 'discounting' heuristic), or to a situation-specific difficulty in perceiving the altered significance which the delay introduced within the context of the repetitive dynamic displays. Both interpretations are consistent with recent research, as discussed here and in the Introduction (Section 5.4). However, there is also an alternative possibility that the autistic children lacked the 'imagination' to invest the cartoon images with the expectations they would have of their real-life counterparts. If this were the case, it would not be surprising to them if the cartoon 'ball' moved in a way not expected of real-life inanimate objects. This possibility is perhaps supported by the presence of an association between the reported presence of pretend play and residual recovery to the Ball. However, the associations between pretend play and both group membership, and the residual recovery differences between the displays, were weak and non-significant.
4 Relationship between the Present Results and Existing Research and Theories concerning Early Social Abnormalities in Autism

4.1 Differences between the Autistic and the Developmentally Delayed Children in Early Social Behaviours

The results here confirmed previous findings about a relative absence of early social behaviours in autism. As predicted from the work of Klin et al. (1992) reviewed in the Introduction (Section 3.2; Prediction 3A), there was a strong, significant, association between group membership and total scores on seven of the pre-8 month items from the Socialization Domain of the Vineland Adaptive Behaviour Scales (Results, 5.3). The items which discriminated the developmentally delayed children most frequently from the autistic children were: showing an interest in others’ activities; showing anticipation of being picked up; showing interest in other children; and playing very simple interaction games with others. However, the autistic children obtained scores more frequently on the following items than on the others: showing affection; reaching for a familiar person; and imitating simple adult movements. There was a similarly strong significant tendency (Prediction 4A) for the autistic children to score less frequently on the two joint attention measures, as predicted from the work of Mundy and co-workers and later researchers (e.g. Mundy et al., 1986; see Introduction, 3.4). There was a 1:1 correspondence between group membership and joint attention referential pointing to indicate interest, and a slightly weaker but significant association between group membership and joint attention showing (bringing objects to show the person). As discussed earlier, both these behaviours are normally evident before 11-12 months.

4.2 Relationship between the Recovery Responses of the Children and Early Social Behaviours
Authors have recently emphasised the need to relate theorising and research in autism directly to such primary social/affective abnormalities; Klin et al (1992) have discussed how the recent 'cognitive primacy' of theories in autism tends to avoid relating theory directly to observed early social abnormalities, or attempting to measure the hypothesised relationships. Of critical importance to this study is the work of both Mundy & Sigman (1989a) and Klin et al (1992), who emphasise that theories postulating difficulties in relatively advanced conceptual abilities, such as 'metarepresentation' (theory of mind’), fail to account for such early abnormalities. These views, and the evidence for them, were reviewed in the Introduction (Section 4.1). As discussed there, although Baron-Cohen (1989) has argued that joint attention requires a 'rudimentary' metarepresentation ability, there is no evidence that children as young as 11 months can exercise such ability. Mundy & Sigman (1989a) suggest that a deficit in joint attention is due to diminished expression of positive affect, but, again as discussed earlier, they present no theory about its origins.

This study aimed to relate group differences in visual responses to dynamic events to the presence, absence or extent of early social behaviours. Inferences may then be drawn about a possible role of perceptual mechanisms in the developmental origins of the social abnormalities in autism.

It was predicted that both Socialisation scores (pre-8 month social behaviours; Prediction 3B), and joint attention behaviours (pre-12 month; Prediction 4B), would be associated with recovery scores for the novel Ball display and with recovery score differences between the Ball and the Runner displays, both across groups and within the autistic group. Both these predictions were supported in different ways by the results. Considering Prediction 4B for all 14 children (Results, 5.3), those children who had the greater residual recovery score differences between the two novel displays also had significantly greater Socialisation
scores, but this predicted relationship was weaker and not significant when considering the recovery scores for the Ball display alone. Considering the autistic children alone, the associations were both in the predicted direction but were weak and not significant. Considering Prediction 3B for all 14 children (Results, 6.3), the associations with joint attention were as predicted, but their relative strength and significance were in the reverse order from those for the Socialisation scale. Thus, there were strong significant associations with residual recovery to the novel Ball display. There was a weaker, non-significant, association between the residual recovery score differences and joint attention showing, but this association was stronger and statistically significant for joint attention pointing, as for group membership (given the 1:1 correspondence between pointing and group membership). Considering the autistic children alone, there was no significant association between joint attention and differences in residual recovery scores, as there was only one autistic child who showed either of the measured joint attention behaviours.

As discussed in the preceding section (3.2), it is difficult to choose whether differences in recovery to the novel Ball alone, or differences in recovery between the novel Ball and the novel Runner, are the most reliable measure of response to the anomalous content of the novel Ball + Delay event. Possible confounding group differences in responsiveness to the introduction of the delay per se, are controlled by measurement of the residual recovery score differences between the displays, as against responsiveness to the anomalous significance of the delay in the context of the Ball as an inanimate object. However, it is possible that differential recovery responses to the novel Runner signify differences in the degree to which the children 'successfully' sought a conceptual-level mental state 'explanation' for the delay of the 'boy' on contacting the 'wall'. Whilst there were no group differences in residual recovery to the Runner, the chronological age interactions possibly might represent such an effect. Similarly, although the differences in association
between socialisation or joint attention scores and residual recovery scores may be interpreted as representing an influence of differences in visual responsiveness on social behaviours, it is possible that there is also a causal effect in the reverse direction. For instance, increased social behaviours may signify a willingness or ability to 'seek explanations' about the delay in the novel Runner display, or differences in how the cartoon images are mentally represented. This might lead to the observed differences in association between the social behaviour or joint attention scores, and the two different recovery measures.

4.3 Conclusion

The results indicate an overall association between early social behaviours, including joint attention, and responsiveness to the novel Ball display. The strength and significance of the associations between the individual social measures and the two modes of measuring recovery varied according to measure and mode. Joint attention pointing (referential pointing) was significantly associated with both recovery measures, a necessary consequence of its 1:1 association with group membership.

It is concluded that early social behaviours, particularly joint attention pointing, were associated with recovery to the novel Ball display, as predicted. Given the strong and significant associations between the social measures and group membership, this means that there was a relationship between not noticing the 'impossible' element of the delay in the the Ball display, the social behaviours and a diagnosis of autism. Thus, there may be a relationship between how children literally see the 'world' of moving animate and inanimate objects and how they develop socially within their first year.

As indicated by both Wing and Rutter (as discussed in the Introduction, 3), there is a
spectrum of social behaviours among autistic children and adults. This study was unable to investigate this spectrum: There were no significant associations within the autistic group between the social measures and recovery to the novel Ball display. This is explained by the extremely low levels of social behaviours, on the measure used, among the autistic children, and the small number of autistic participants. However, this leaves open the question of whether differences between autistic children in 'socialisation' (as against considering differences between autistic and other children) may be related to differences in responding to the kind of experimental displays used here.

5. Implications of the Results for Future Research

The hypothesised relationship between a diagnosis of autism, early (pre-8 & pre-12 month) characteristic social abnormalities and responsiveness to changes in dynamic causal relationships was investigated. A statistically significant positive association was found between each of these three factors. However, the experimental records from only a small group of participants were able to be used. To obtain statistical significance of the primary results concerning group differences in recovery to the two novel displays, a computation was needed to partial out the confounding factor of differential levels of visual fixation during habituation. As the results were only just significant at the 5% level, they may have been critically dependent on the selection and matching of participants; to some extent the participants were self-selecting by attrition due lack of attention or restlessness during the experiment. Fortunately, the children were matched adequately on verbal comprehension scores and the results indicated that any interaction between the comprehension scores and the experimental results was negligible. However, there was a mismatch on chronological age and on degree of developmental delay (i.e. verbal comprehension quotient). Again, whilst there were no significant interactions between the experimental results and the
quotients, there was an interaction with chronological age (Results, 10.3).

For the results to be regarded as reliably valid, the above considerations indicate that the study should be replicated using a larger number of participants, matched on age as well as verbal ability to control for both age and degree of developmental delay. It would also be appropriate to introduce a control procedure to measure spontaneous regression (as discussed above, Section 2.1), if this can be made compatible with the practical requirement to reduce attrition of participants. As discussed, a paired comparison procedure may be more practical than the habituation/recovery procedure used here, although Berthethal at al (1987) argue that such a procedure confounds measurement of encoding with discrimination. A further factor which made the results difficult to interpret was the abstract nature of the cartoon images. Whilst it was valuable to have a lack of contextual clues (which have undermined other studies using real-life 'impossible' events; Baillargeon, 1994), it was difficult to elucidate, as discussed (Section 3.2 above), whether the autistic children failed to represent the displays as 'real-life' and hence respond less strongly than the developmentally delayed children to the novel Ball stimulus.

Further research using habituation/recovery, or paired comparison, methods with autistic children still may have to overcome the problem of group differences in habituation behaviour potentially confounding the variable of interest - recovery to the novel stimulus. Nevertheless, it is suggested that both the general application of this methodology with autistic and developmentally delayed children, and the investigation of the perception of dynamic events, are research areas of potential value in autism. A number of important areas of research in autism may be usefully investigated using this method, such as the causal perception of social events and processes of person perception (eg. emotion and gesture recognition).
The theory underlying this research was based on research on the perception of physical, animate and social causality by normal infants and children. This is still a little researched area. For related results from autistic children to be interpreted with greater validity, more normative data is required in this area.

6. Clinical and Practical Implications of the Results

It was the aim of this study to investigate autistic children’s causal perceptions of the movements of animate versus inanimate objects. The primary ‘clinical’ significance for autistic children of these results is likely to lie in the relationship found here between perceptual abnormalities and early social abnormalities. A common element in three of the four first hand accounts of autistic adults cited in the Introduction (Section 4.2), is the unpredictability, incomprehension, emotional isolation and fear which they experienced when children, particularly for moving animate objects and when in social environments. The hypothesis developed here goes some way in accounting for the minute-to-minute nature of the social difficulties described for social environments and moving objects.

As discussed in the Introduction, an account of the nature and causes of the early social abnormalities of autistic children is central to understanding the psychological mechanisms underlying their disabilities and their social distress (Klin et al, 1992; Ungerer, 1989; Mundy & Sigman, 1989a). The results here suggest that early in infancy, such children may fail to notice critical aspects of their changing environment, such as the causal movements of people, animals and inanimate objects. As a result, movements may appear incomprehensible and unpredictable and there may appear to be little to distinguish the patterns of movement engaged in by these categories of objects. As Dawson & Lewy (1989a) propose, it may be the unpredictable nature of social relationships which is a key
area of difficulty for autistic children.

It would premature to claim that these results are a sufficient basis on which to formulate relevant early interventions with autistic children. However, it is suggested that the results are sufficient to highlight relevant areas to consider. What Klin et al (1992) have termed the 'cognitive primacy' in current autism research has tended to emphasise the acquisition of verbally-based social skills by autistic individuals, to compensate for their postulated difficulties in understanding the mental processes of others. The results here suggest that attention should be directed to work with young autistic children, addressing their need for predictability and its interaction with their difficulties in forming affective relationships.

If affective interactions between parents, other caregivers and autistic children consist of simple, consistent patterns of behaviours, they may be potentially comprehensible and predictable, and thereby less aversive. As discussed, autistic children appear to learn more about their environment when presented with concrete materials, rather than abstract-visual materials (such as used in this study). Dawson & Lewy (1989a) propose that the use of imitative play may be beneficial for autistic children in facilitating their social responsiveness. This consists of the caregiver imitating "...virtually every behaviour of the child". They propose that it "...simplifies, exaggerates and distills many important features of social interactions...provides a highly salient and predictable contingent response for the child, and thereby may facilitate a sense of social effectiveness" (op cit, p. 63). Using toys as the 'concrete' imitation play medium, these researchers found that shared attention and eye contact by the autistic child increased under such conditions.
7. Overall Conclusions

The results show that the use of a habituation/recovery procedure can give rise to reliable, valid, information, for testing hypotheses about the perception of movement by autistic and developmentally delayed children. The reliability and validity of the methodology was demonstrated by the inter-scorer reliability of the measurements, by the reliability of habituation and recovery, by the evidence that habituation represented information processing (encoding) and by the evidence that recovery represented, to an extent, a different process (discrimination) from habituation. Nevertheless, there were difficulties specific to the application of the methodology with these special groups of children, such as the wide variance in visual fixation durations of the autistic children and their sometimes relatively reduced degree of directed gaze for the displays. Further difficulties originate in the particular 'cost' of participant attrition when researching such minority populations.

The experimental results showed that that the autistic children had relatively low levels of visual fixation ('encoding') during habituation for the Runner display, as predicted, although, contrary to prediction, their overall levels of fixation for the two displays, considered together, were not less than those of the developmentally delayed children. It was suggested that the autistic children's relatively low levels of fixation for the Runner display may have been due either to them tending to process less information, in real life, about animate moving objects, or people, or to them not representing the animate cartoon image as 'equivalent' to a real life (animate) person. Alternatively, it may have signified an autism-specific response to the sensory properties of the red Ball compared with the Runner display. The autistic children were also significantly more consistent than the developmentally delayed children in their levels of fixation for the two displays, Runner and Ball, yet they were also more individually variable than the developmentally delayed
children in their levels of fixation, a finding which is consistent with previous research. The latter results confirm that the autistic and the developmentally delayed children differed in their encoding of the dynamic visual displays. One possible interpretation of the results concerning group differences in consistency of looking is that the autistic children habituated more slowly to the experimental setting, reflecting their characteristic 'desire for sameness'.

There were predicted group differences in recovery responses to the novel displays (Runner + Delay; Ball + Delay), the autistic children recovering relatively less to the Ball display than the developmentally delayed children. The statistical significance of the effect depended on partialling out the correlations between habituation fixation levels and recovery scores, the group differences between the displays being in opposite directions for habituation and recovery. These results were consistent with the experimental hypothesis, which proposed that the autistic children had a tendency either not to notice, or not to process further, brief dynamic information, unless it follows a simple predictable pattern. It is likely that the autistic children did not notice the anomalous ('impossible') appearance of the Ball starting to move independently after the stationary delay. This may have been due either to a general expectation that all inanimate objects can move independently, or to a situation-specific difficulty in perceiving the altered significance which the delay introduced into the Ball display. There is also, however, an alternative possibility that the autistic children did not imaginatively invest the cartoon images with the expectations they would have of their real life counterparts. There was some relatively weak evidence consistent with the latter possibility, which cannot be completely excluded.

A further aspect of the hypothesis was investigated, which proposed that the relative absence of pre-12 and pre-8 month social behaviours by autistic children is due to a difficulty in processing dynamic causal information about animate versus inanimate objects. Associations
were predicted between the presence or absence of such early social behaviours, a diagnosis of autism, and the responsiveness of the children in recovery to the novel Ball display. As predicted, and consistent with recent published research, the autistic children were reported as engaging very infrequently in many of the measured early social behaviours, including joint attention, showing interest in others, and anticipating being picked up by a caregiver, although they were more frequently described as showing affection and imitating simple adult movements. The scores for early social behaviours by the autistic and developmentally delayed children, considered together, were associated with responsiveness to the novel Ball display, the significance levels depending on the measures used. Thus, there may be a relationship between how children literally see the 'world' of moving animate and inanimate objects and how they develop socially within their first year.

It is suggested that the results need replicating for the interpretations to be secure. In particular, it will be important to use a greater number of participants and to use dynamic displays which are closer analogues to real life, although previous research has found it problematic to create credible 'impossible' events in this way. Further research is also needed to extend current knowledge about the visual perception of social, and of animate versus inanimate, causal events, and its relationship to social development in normal infancy.

The results are of too preliminary a nature to suggest therapeutic interventions. However, they serve the purpose of drawing attention to the likely importance of early interventions with autistic children, and to interventions based on creating simple, predictable social interactions in which an autistic child may develop an experience of social effectiveness (Dawson & Lewy, 1989a).
APPENDIX A.

Reynell Developmental Language Scales, Verbal Comprehension Test A (RDLS 2nd Revision; Reynell & Huntley, 1981)
### Verbal Comprehension Scale A

<table>
<thead>
<tr>
<th>SCORE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 Selective recognition of word or phrase</td>
</tr>
<tr>
<td></td>
<td>2 Adaptive response to familiar word or phrase</td>
</tr>
<tr>
<td></td>
<td>3 Looking at one familiar object or person in response to naming</td>
</tr>
<tr>
<td>2</td>
<td>4 Where is the ball?</td>
</tr>
<tr>
<td></td>
<td>5 Where is the spoon?</td>
</tr>
<tr>
<td></td>
<td>6 Where is the brush?</td>
</tr>
<tr>
<td></td>
<td>7 Where is the doll?</td>
</tr>
<tr>
<td></td>
<td>8 Where is the car?</td>
</tr>
<tr>
<td></td>
<td>9 Where is the cup?</td>
</tr>
<tr>
<td></td>
<td>10 Where is the sock?</td>
</tr>
<tr>
<td></td>
<td>11 Where is the brick (block)?</td>
</tr>
<tr>
<td>3</td>
<td>12 Where is the chair?</td>
</tr>
<tr>
<td></td>
<td>13 Where is the bath?</td>
</tr>
<tr>
<td></td>
<td>14 Where is the table?</td>
</tr>
<tr>
<td></td>
<td>15 Where is the bed?</td>
</tr>
<tr>
<td></td>
<td>16 Where is the knife?</td>
</tr>
<tr>
<td>4</td>
<td>17 Where is the horse (gee-gee)?</td>
</tr>
<tr>
<td></td>
<td>18 Where is the dog (doggie)?</td>
</tr>
<tr>
<td></td>
<td>19 Where is the baby?</td>
</tr>
<tr>
<td></td>
<td>20 Where is the man (father, Daddy)?</td>
</tr>
<tr>
<td></td>
<td>21 Where is the lady (mother, Mummy)?</td>
</tr>
<tr>
<td>5</td>
<td>22 Put the doll on the chair</td>
</tr>
<tr>
<td></td>
<td>23 Put the spoon in the cup</td>
</tr>
<tr>
<td></td>
<td>24 Put the knife on the plate</td>
</tr>
<tr>
<td></td>
<td>25 Put the brick in the box</td>
</tr>
<tr>
<td>6</td>
<td>26 Which one do we sleep in?</td>
</tr>
<tr>
<td></td>
<td>27 Which one do we write with (draw with)?</td>
</tr>
<tr>
<td></td>
<td>28 Which one do we cut with?</td>
</tr>
<tr>
<td></td>
<td>29 Which one do we cook with?</td>
</tr>
<tr>
<td></td>
<td>30 Which one do we sweep the floor with?</td>
</tr>
<tr>
<td>7</td>
<td>31 Which one barks?</td>
</tr>
<tr>
<td></td>
<td>32 Which one cooks the dinner?</td>
</tr>
<tr>
<td></td>
<td>33 Which one is sitting down?</td>
</tr>
<tr>
<td></td>
<td>34 Which one shoots the rabbit?</td>
</tr>
<tr>
<td></td>
<td>35 Which one is carrying something?</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td>(Max. 35)</td>
</tr>
<tr>
<td>SCORE</td>
<td>8</td>
</tr>
<tr>
<td>-------</td>
<td>---</td>
</tr>
<tr>
<td>36</td>
<td>Find a yellow pencil</td>
</tr>
<tr>
<td>37</td>
<td>Show me the smallest button</td>
</tr>
<tr>
<td>38</td>
<td>Give me the longest red pencil</td>
</tr>
<tr>
<td>39</td>
<td>Put all the white buttons in the cup</td>
</tr>
<tr>
<td>40</td>
<td>Put the black button underneath the cup</td>
</tr>
<tr>
<td>41</td>
<td>Put the three short pencils in the box</td>
</tr>
<tr>
<td>42</td>
<td>Which button is not in the cup?</td>
</tr>
<tr>
<td>43</td>
<td>Take two buttons out of the cup</td>
</tr>
<tr>
<td>44</td>
<td>Which pencils have been put away?</td>
</tr>
<tr>
<td>45</td>
<td>Which red pencil has not been put away?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Which horse is eating the grass?</td>
</tr>
<tr>
<td>47</td>
<td>Put one of the pigs behind the man</td>
</tr>
<tr>
<td>48</td>
<td>Put one of the small pigs beside the black pig</td>
</tr>
<tr>
<td>49</td>
<td>Pick up the biggest white pig and show me his eyes</td>
</tr>
<tr>
<td>50</td>
<td>Put the farmer and one of the pigs in the field</td>
</tr>
<tr>
<td>51</td>
<td>Put all the pigs behind the brown horse</td>
</tr>
<tr>
<td>52</td>
<td>Put two of the horses together</td>
</tr>
<tr>
<td>53</td>
<td>Put all the white pigs round the outside of the field</td>
</tr>
<tr>
<td>54</td>
<td>Put all the other animals and the farmer into the field</td>
</tr>
<tr>
<td>55</td>
<td>Which pig is not outside the field?</td>
</tr>
<tr>
<td>56</td>
<td>Put one small pig beside the farmer</td>
</tr>
<tr>
<td>57</td>
<td>Which small pig has not been put in the field?</td>
</tr>
<tr>
<td>58</td>
<td>Which pigs are furthest away from the farmer?</td>
</tr>
<tr>
<td>59</td>
<td>Put all the animals except the black pig into the box</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Four dolls. 'Here is Bobby, here is Mary, here is mother and here is the baby.'</td>
</tr>
<tr>
<td>60</td>
<td>Bobby pushes the baby over. Who is naughty?</td>
</tr>
<tr>
<td>61</td>
<td>Who does mother pick up and comfort?</td>
</tr>
<tr>
<td>62</td>
<td>Mary and Bobby go to school. Who stays with mother?</td>
</tr>
<tr>
<td>63</td>
<td>Who goes to the shops while Mary and Bobby are at school?</td>
</tr>
<tr>
<td>64</td>
<td>Who goes to school with Bobby?</td>
</tr>
<tr>
<td>65</td>
<td>Who is younger than the school children?</td>
</tr>
<tr>
<td>66</td>
<td>Who used to go to school but doesn't now?</td>
</tr>
<tr>
<td>67</td>
<td>Who will go to school later but doesn't yet?</td>
</tr>
</tbody>
</table>

**Total Score**
(Max. 67)

* 'Pink pig' may be substituted for 'white pig' in either of the above directions if this seems more appropriate to the examiner.
Identification Test Materials (Plate A, and Plates B & 2 adapted as described in the Method, 6.2, from the Peabody Picture Vocabulary Test; Dunn & Dunn, 1981)
APPENDIX C.

Childhood Autism Rating Scale (CARS; Schopler, Reichler & Renner, 1988)
### I. RELATING TO PEOPLE

**1. No evidence of difficulty or abnormality in relating to people**  
- The child behaves appropriately for his or her age. Some shyness, fussiness, or annoyance at being talked to do may be observed, but not to an unusual degree.

**1.5**

**2. Mildly abnormal relationships**  
- The child may avoid looking at the adult in the eye, avoid the adult or become busy if interaction is forced, be excessively shy, fail to be responsive to the adult as a typical, or cling to parents somewhat more than most children of the same age.

**2.5**

**3. Moderately abnormal relationships**  
- The child shows aloofness (seems unaware of adult) at times. Persuasive and forceful attempts are necessary to get the child's attention. Minimal contact is initiated by the child.

**3.5**

**4. Severely abnormal relationships**  
- The child is consistently aloof or unaware of who the adult is, or is almost never responsive or initiates contact with the adult. Only the most persistent attempts to get the child's attention have any effect.

**Observations:**

### II. IMITATION

**1. Appropriate imitation**  
- The child can imitate sounds, words, and movements which are appropriate for his or her skill level.

**1.5**

**2. Mildly abnormal imitation**  
- The child imitates simple behaviors such as clapping, single verbal sounds most of the time; occasionally, imitates only after preceding or prior delay.

**2.5**

**3. Moderately abnormal imitation**  
- The child imitates only part of the sound and requires a great deal of persistence and help from the adult; frequently imitates only after a delay.

**3.5**

**4. Severely abnormal imitation**  
- The child never or almost never imitates sounds, words, or movements even with prompting and assistance from the adult.

**Observations:**

### III. EMOTIONAL RESPONSE

**1. Age-appropriate and situation-appropriate emotional response**  
- The child shows the appropriate type and degree of emotional response as indicated by a change in facial expression, posture, and manner.

**1.5**

**2. Mildly abnormal emotional responses**  
- The child偶尔 displays a tone what inappropriate type or degree of emotional reaction. Reactions may be quiet or fussy at times. Some minor or unrelated to the object or event are occurring.

**2.5**

**3. Moderately abnormal emotional responses**  
- The child shows definite signs of inappropriate type or degree of emotional response. Reactions may be quiet or fussy at times. Some minor are present, unrelated to the object or event are occurring.

**3.5**

**4. Severely abnormal emotional responses**  
- Responses are always inappropriate to the situation; once the child gets on a certain mood, it is very difficult to change the mood. Conversely, the child may also show extremely different emotions when nothing has occurred.

**Observations:**

### IV. BODY USE

**1. Age-appropriate body use**  
- The child moves in the same ease, agility, and coordination as a normal child of the same age.

**1.5**

**2. Mildly abnormal body use**  
- Some minor peculiarities may be present, such as clumsiness, repetitive movements, poor coordination, or the rare appearance of more unusual movements.

**2.5**

**3. Moderately abnormal body use**  
- Behaviors that are clearly strange or unusual to a child of this age may include strange finger movements, peculiar finger or body posturing, sitting or picking in the air, self-directed aggression, rocking, spinning, fidgeting, or walking.

**3.5**

**4. Severely abnormal body use**  
- Incense or frequent movements of the type listed above are signs of severely abnormal body use. These behaviors may persist despite attempts to discourage them or involve the child in other activities.

**Observations:**

---

128
### V. OBJECT USE

<table>
<thead>
<tr>
<th>1</th>
<th>Age appropriate use of, and interest in, toys and other objects • The child shows normal interest in toys and other objects appropriate for his or her skill level and uses these toys in an appropriate manner.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>Mildly inappropriate interest in, or use of, toys and other objects • The child may show delayed interest in a toy or play with it in an inappropriately chthonic way (e.g., banging or sucking on the toy).</td>
</tr>
<tr>
<td>2</td>
<td>Moderately inappropriate interest in, or use of, toys and other objects • The child may show little interest in toys or may be preoccupied with using an object or toy in some strange way. He or she may focus on some inadquate part of a toy, become fascinated with light reflecting off the object, repetitively move active part of the object, or play with one object exclusively.</td>
</tr>
<tr>
<td>3</td>
<td>Severely inappropriate interest in, or use of, toys or other objects • The child may engage in the same behavior at home, with greater frequency and intensity. The child is difficult to distract when engaged in these inappropriate activities.</td>
</tr>
</tbody>
</table>

**Observations:**

### VI. ADAPTATION TO CHANGE

<table>
<thead>
<tr>
<th>1</th>
<th>Age appropriate response to change • The child may notice or comment on changes in routine, but he or she accepts these changes without undue distress.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>Mildly abnormal adaptation to change • When an adult tries to change the child's activity, he or she may continue the same activity or use the same materials.</td>
</tr>
<tr>
<td>2</td>
<td>Moderately abnormal adaptation to change • The child actively resists changes in routine, tries to continue the old activity, and is difficult to distract. When he or she has become angry and upset when an established routine is altered.</td>
</tr>
<tr>
<td>3</td>
<td>Severely abnormal adaptation to change • The child shows severe resistance to change. If a change is forced, he or she may become extremely stressed or overreactive and may resist with anger.</td>
</tr>
</tbody>
</table>

**Observations:**

### VII. VISUAL RESPONSE

<table>
<thead>
<tr>
<th>1</th>
<th>Age appropriate visual response • The child's visual behavior is normal and appropriate for his age. Vision is used together with other senses as a way to explore a new object.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>Mildly abnormal visual response • The child must be occasionally reminded to look at objects. The child may be more interested in looking at mirrors or lighting than peers or may occasionally stare off into space, or may avoid looking people in the eye.</td>
</tr>
<tr>
<td>2</td>
<td>Moderately abnormal visual response • The child must be reminded frequently to look at what he or she is doing. He or she may stare into space, avoid looking people in the eye, look at objects from an unusual angle, or hold objects very close to the eyes.</td>
</tr>
<tr>
<td>3</td>
<td>Severely abnormal visual response • The child consistently avoids looking at people or certain objects and may show extreme forms of all visual peculiarities described above.</td>
</tr>
</tbody>
</table>

**Observations:**

### VIII. LISTENING RESPONSE

<table>
<thead>
<tr>
<th>1</th>
<th>Age appropriate listening response • The child's listening behavior is normal and appropriate for his age. Listening is used together with other senses.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>Mildly abnormal listening response • There may be some lack of response, or mild overreaction to certain sounds. Responses to sounds may be delayed, and sounds may be more easily overheard.</td>
</tr>
<tr>
<td>2</td>
<td>Moderately abnormal listening response • The child's responses to sounds vary; often ignores the sound the first time it is made, may be startled or cover ears when hearing some everyday sounds.</td>
</tr>
<tr>
<td>3</td>
<td>Severely abnormal listening response • The child overreacts and/or underreacts to sounds in an extremely marked degree, regardless of the type of sound.</td>
</tr>
</tbody>
</table>

**Observations:**

### IX. TASTE, SMELL, AND TOUCH RESPONSE AND USE

<table>
<thead>
<tr>
<th>1</th>
<th>Normal use of, and response to, taste, smell, and touch • The child explores new objects in an appropriate manner, generally by feeling and looking. Taste or smell may be used when appropriate. When reaching to touch, everyday past, the child experiences discomfort but does not overreact.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>Mildly abnormal use of, and response to, taste, smell, and touch • The child may be preoccupied with smelling, tasting, or using objects or people. The child may react too much or too little.</td>
</tr>
<tr>
<td>2</td>
<td>Moderately abnormal use of, and response to, taste, smell, and touch • The child may be more preoccupied with touching, smelling, or using objects or people. The child may ignore or avoid objects. He or she may ignore or avoid the smell of certain objects, or may ignore or avoid the taste of certain objects.</td>
</tr>
<tr>
<td>3</td>
<td>Severely abnormal use of, and response to, taste, smell, and touch • The child is preoccupied with smelling, tasting, or using objects. More for the situation than for the situation itself. The child is often too slow to react, or very strongly to slight discomfort.</td>
</tr>
</tbody>
</table>

**Observations:**

### X. FEAR OR NERVOUSNESS

<table>
<thead>
<tr>
<th>1</th>
<th>Normal fear or nervousness • The child's behavior is appropriate both to the situation and to his or her age.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>Mildly abnormal fear or nervousness • The child occasionally shows too much anxiety or nervousness as compared to the reaction of normal children of the same age in a similar situation.</td>
</tr>
<tr>
<td>2</td>
<td>Moderately abnormal fear or nervousness • The child shows either quite a bit more or quite a bit less fear than a typical child in a similar situation.</td>
</tr>
<tr>
<td>3</td>
<td>Severely abnormal fear or nervousness • Fears persist even after repeated experience with harmless events or objects. It is extremely difficult to calm or comfort the child. The child may, conversely, fail to show appropriate regard for hazards that other children of the same age avoid.</td>
</tr>
</tbody>
</table>

**Observations:**
<table>
<thead>
<tr>
<th>XI. VERBAL COMMUNICATION</th>
<th>XIII. ACTIVITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Normal verbal communication, age and situation appropriate.</td>
<td>1 Normal activity level for age and circumstances. The child is neither more active nor less active than a normal child of the same age in a similar situation.</td>
</tr>
<tr>
<td>1.5 Mildly abnormal verbal communication. Speech shows overall retardation. Most speech is meaningful, however, some echolalia or prepositional reversal may occur. Some peculiar words or jargon may be used occasionally.</td>
<td>1.5 Mildly abnormal activity level. The child may either be mildly restless or seem what &quot;lazy&quot; and slow moving at times. The child's activity level interferes only slightly with his or her performance.</td>
</tr>
<tr>
<td>2 Moderately abnormal verbal communication. Speech may be absent. When present, verbal communication may be a mixture of some meaningful speech and some peculiar speech such as jargon, echolalia, or prepositional reversal. Peculiarities in meaningful speech include excessive questioning or preoccupation with particular topics.</td>
<td>2.5 Moderately abnormal activity level. The child may be quite active and difficult to restrain. He or she may have boundless energy and may have a hard time getting to sleep, even at night. Occasionally, the child may be quite lethargic, and need a great deal of prodding to get him or her to move about.</td>
</tr>
<tr>
<td>3 Severely abnormal verbal communication. Meaningful speech is not used. The child may make incoherent sounds, words or animal-like sounds, complex noises approximating speech, or may show pretense, bizarre use of some recognizable words or phrases.</td>
<td>3.5 Severely abnormal activity level. The child exhibits extremes of activity or may be totally unresponsive and may even shift from one extreme to the other.</td>
</tr>
</tbody>
</table>

**Observations:**

<table>
<thead>
<tr>
<th>XII. NONVERBAL COMMUNICATION</th>
<th>XIV. LEVEL AND CONSISTENCY OF INTELLIGENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Normal use of nonverbal communication, age and situation appropriate.</td>
<td>Intelligence is normal and reasonably consistent across various areas. The child behaves typically of a normal child of the same age and does not have any unstable affective or behavioral problems.</td>
</tr>
<tr>
<td>1.5 Mildly abnormal use of nonverbal communication. The child may point vaguely, or reach for what he or she wants, in situations where same age child may point or gesture more specifically to indicate what he or she wants.</td>
<td>Mildly abnormal intellectual functioning. The child is not as smart as typical children of the same age and does not have any intellectual or behavioral problems.</td>
</tr>
<tr>
<td>2 Moderately abnormal use of nonverbal communication. The child is usually unable to express needs or desire nonverbally, and cannot understand nonverbal communication of others.</td>
<td>Moderately abnormal intellectual functioning. In general, the child is not as smart as typical children of the same age and may have difficulty learning across all areas.</td>
</tr>
<tr>
<td>3 Severely abnormal use of nonverbal communication. The child uses few or no gestures which have no apparent meaning, shows the awareness of the meaning associated with the gestures or facial expressions of others.</td>
<td>Severely abnormal intellectual functioning. While the child generally is not as smart as the typical child of her age, he or she may function better than the normal child of the same age in one or more areas.</td>
</tr>
</tbody>
</table>

**Observations:**

<table>
<thead>
<tr>
<th>XV. GENERAL IMPRESSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 No autism. The child shows none of the symptoms characteristic of autism.</td>
</tr>
<tr>
<td>1.5 Mild autism. The child shows only a few symptoms or only a mild degree of autism.</td>
</tr>
<tr>
<td>2 Moderate autism. The child shows a number of symptoms or a moderate degree of autism.</td>
</tr>
<tr>
<td>3.5 Severe autism. The child shows many symptoms or an extreme degree of autism.</td>
</tr>
</tbody>
</table>

**Observations:**
APPENDIX D.

Socialisation Scale (Items 6, 7, 8, 9, 11, 13, & 14 from the Socialization Domain of the Vineland Adaptive Behaviour Scales (Sparrow, Balla & Cicchetti, 1984)
1. Looks at face of caregiver.
2. Responds to voice of caregiver or another person.
3. Distinguishes caregiver from others.
4. Shows interest in novel objects or new people.
5. Expresses two or more recognizable emotions such as pleasure, sadness, fear, or distress.
6. Shows anticipation of being picked up by caregiver.
7. Shows affection toward familiar people.
8. Shows interest in children or peers other than siblings.
10. Plays with toy or other object alone or with others.
11. Plays very simple interaction games with others.
12. Uses common household objects for play.
13. Shows interest in activities of others.
14. Imitates simple adult movements, such as clapping hands or waving good-bye, in response to a model.
15. Laughs or smiles appropriately in response to positive statements.
16. Addresses at least two familiar people by name.
17. Shows desire to please caregiver.
18. Participates in at least one game or activity with others.
19. Imitates a relatively complex task several hours after it was performed by another.
20. Imitates adult phrases heard on previous occasions.
21. Engages in elaborate make-believe activities, alone or with others.
22. Shows a preference for some friends over others.
23. Says "please" when asking for something.
24. Labels happiness, sadness, fear, and anger in self.
25. Identifies people by characteristics other than name, when asked.
26. Shares toys or possessions without being told to do so.
27. Names one or more favorite television programs when asked, and tells on what days and channels the programs are shown.
28. Follows rules in simple games without being reminded.
29. Has a preferred friend of either sex.
30. Follows school or facility rules.
31. Responds verbally and positively to good fortune of others.
32. Apologizes for unintentional mistakes.
33. Has a group of friends.
34. Follows community rules.
35. Plays more than one board or card game requiring skill and decision making.
36. Does not talk with food in mouth.
37. Has a best friend of the same sex.

Count items before basal as 2, items after ceiling as 0.

INTERPERSONAL RELATIONSHIPS
PLAY & LEISURE TIME

Sum of 2s, 1s, 0s page 7
APPENDIX E.

Descriptions of the Variables & Methods of Analysis

1. Number of Trials to Habituation Criterion
There was a floor effect due to many of the children reaching habituation criterion within
the minimum six trials (see Figure 4), so the data were analysed using non-parametric
statistics.

2. Fixation Times and Recovery Scores

Observations, Levels of Factors & Methods of Analysis:
There were four classes of observations: Habituation Trials; Total fixation times, First trial
block fixation times ('First trials'), Last trial block fixation times ('Last trials'); Novel
Trials; Recovery scores (Novel minus Last trials fixation times; 'Recovery'). There were
two levels of each of three primary factors: Group membership (autistic/developmentally
delayed); Display ('Runner'/ 'Ball'); Order of display presentation (Runner First/Ball First);
Trials (First/Last habituation trial pairs).

The primary method of analysis was mixed design ANOVA with Group entered as a related
participant pairs variable (i.e a 'repeated measure' for computational purposes), Display and
Trials as a repeated measure variable and Order as the between participants variable. The
unweighted means/regression approach (unique sums of squares) was used in SPSS/PC+,
which assigns equal weight to all cells, so that main effects and interactions are independent,
regardless of unequal between-samples sizes (as here for Order). In view of the unequal
sample sizes by Order, differences between individual related means were tested with F tests
controlling for order effects, rather than paired t-tests within which effects of Order would
not have been counterbalanced:

Thus, there were 16 (4 x 4) variables for which normality needed to be considered, by one variable (Order) for which homogeneity of variance needed to be considered.

Normality:

The following three variables had significant skewness or kurtosis (z \( \geq 1.96 \), p < .05, two tailed tests):

1) Total fixation times during habituation by the developmentally delayed children for the Runner display (Skewness = 1.92, z = 2.42, p < .05; Kurtosis = 4.28, z = 2.70, p < .01).

2) Fixation times during the Last trial block by the autistic children for the Runner display (Skewness = 2.34, z = 2.94, p < .005; Kurtosis = 5.71, z = 3.60, p < .0001).

3) Recovery of the developmentally delayed children for the Runner display (Skewness = 1.82, z = 2.30, p = .021; Kurtosis = , z = 2.13, p = .027). In all four cases, the positive skewness was primarily due to one high 'outlier', the remaining values showing a central tendency.

In all cases except that of 1), the outliers had the potential to bias the results against, rather than in favour of, the experimental hypotheses and none of the significant results reported here were based solely on the total fixation times (1)).

Homogeneity of Variance:

The following two variables had significant heterogeneity of variance by Order (p < .05):

1) First trials fixation times by the developmentally delayed children for the Ball (Bartlett-Box F(1,67) = 4.06, p = .048). 2) Recovery by the developmentally delayed children to
the Runner (Bartlett-Box $F(1,67) = 4.26, p = .043$).

*Group and Identification as between variables:*

Group was also used as a between participants variable in multiple regression analysis and ANOVA. Additionally, ANOVA was used to examine differences between means by dichotomous Identification scores (which were unbalanced between related group pairs). These analyses were justified by the absence of significant correlations for any of the variables analysed between the autistic/developmentally delayed group pairs ($0.28 \geq r \geq -0.54$, $p > .20$, two tailed tests). These ANOVA results were consistent with those calculated using Group as a related participants variable. Normality and homogeneity of variance concerning these variables are considered in the body of the Results.

3. **Vineland Socialisation Scores**

As reported, most of the developmentally delayed children achieved a ceiling score on this scale. Group differences in scores were therefore analysed using non-parametric statistics. Associations with the observation variables were analysed using multiple regression/partial correlation, the consequences of violation of the parametric assumptions are considered. In contrast, the socialisation scores for the autistic children alone did not deviate significantly from normality ($p > .05$), no score being near to ceiling or at the floor value.

4. **RDLS Age Scores & Quotients, and Chronological Ages**

The RDLS age scores had significant ($p \leq .05$) skewness and kurtosis (Skewness = 1.83, $z = 3.05, p < .002$; Kurtosis = 4.11, $z = 3.57, p < .001$; two tailed tests). This was due to two children with high 'extreme' age scores; an autistic and a developmentally child who were matched in the related samples analysis. RDLS age scores were not involved in the calculations for the main conclusions of the study, but rather were used to control for
possible confounding variables. As the aim was to use any significant results to qualify the main results if necessary (i.e. avoid Type I errors), the use of parametric statistics was felt justified.
APPENDIX F

Summary table of Analysis of Variance to test for differences in Total fixation duration during habituation between Order of display presentation, Groups (autistic/developmentally delayed) and Displays (Runner/Ball)

Tests of Significance using UNIQUE sums of squares

Tests of Between-Subjects Effects.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>66977.21</td>
<td>5</td>
<td>13395.44</td>
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<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>612883.39</td>
<td>1</td>
<td>612883.39</td>
<td>45.75</td>
<td>.001</td>
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<td>ORDER</td>
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<td>5355.06</td>
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Tests involving 'GROUP' Within-Subject Effect.

<table>
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<th>Source of Variation</th>
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<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>124016.73</td>
<td>5</td>
<td>24803.35</td>
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<td></td>
</tr>
<tr>
<td>GROUP</td>
<td>7865.78</td>
<td>1</td>
<td>7865.78</td>
<td>.32</td>
<td>.598</td>
</tr>
<tr>
<td>ORDER BY GROUP</td>
<td>409.34</td>
<td>1</td>
<td>409.34</td>
<td>.02</td>
<td>.903</td>
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</tbody>
</table>

Tests involving 'DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>2301.15</td>
<td>5</td>
<td>460.63</td>
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<td></td>
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<tr>
<td>DISPLAY</td>
<td>32.07</td>
<td>1</td>
<td>32.07</td>
<td>.07</td>
<td>.802</td>
</tr>
<tr>
<td>ORDER BY DISPLAY</td>
<td>9726.61</td>
<td>1</td>
<td>9726.61</td>
<td>21.12</td>
<td>.006</td>
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</table>

Tests involving 'GROUP BY DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>MS</th>
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<th>Sig of F</th>
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</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>12362.73</td>
<td>5</td>
<td>2472.55</td>
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</tr>
<tr>
<td>GROUP BY DISPLAY</td>
<td>8968.09</td>
<td>1</td>
<td>8968.09</td>
<td>3.63</td>
<td>.115</td>
</tr>
<tr>
<td>ORDER BY GROUP BY DISPLAY</td>
<td>3853.49</td>
<td>1</td>
<td>3853.49</td>
<td>1.56</td>
<td>.267</td>
</tr>
</tbody>
</table>
APPENDIX G

Summary table of Analysis of Variance to test for differences in fixation duration during habituation Trial Blocks between Order of display presentation, Groups (autistic/developmentally delayed), Trials (First and Last Trials Blocks) and Displays(Runner/Ball)

Tests of Significance using UNIQUE sums of squares

Tests of Between-Subjects Effects.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>9777.00</td>
<td>5</td>
<td>1955.40</td>
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</tr>
<tr>
<td>CONSTANT</td>
<td>79685.61</td>
<td>1</td>
<td>79685.61</td>
<td>40.75</td>
<td>.001</td>
</tr>
<tr>
<td>ORDER</td>
<td>828.55</td>
<td>1</td>
<td>828.55</td>
<td>.42</td>
<td>.544</td>
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</table>

Tests involving 'TRIALS' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>2667.37</td>
<td>5</td>
<td>533.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRIALS</td>
<td>22651.57</td>
<td>1</td>
<td>22651.57</td>
<td>42.46</td>
<td>.001</td>
</tr>
<tr>
<td>ORDER BY TRIALS</td>
<td>895.17</td>
<td>1</td>
<td>895.17</td>
<td>1.68</td>
<td>.252</td>
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</table>

Tests involving 'GROUP' Within-Subject Effect.

<table>
<thead>
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<th>Source of Variation</th>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>10403.14</td>
<td>5</td>
<td>2080.63</td>
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<td></td>
</tr>
<tr>
<td>GROUP</td>
<td>1342.27</td>
<td>1</td>
<td>1342.27</td>
<td>.65</td>
<td>.458</td>
</tr>
<tr>
<td>ORDER BY GROUP</td>
<td>442.94</td>
<td>1</td>
<td>442.94</td>
<td>.21</td>
<td>.664</td>
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</table>

Tests involving 'DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>3457.94</td>
<td>5</td>
<td>691.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISPLAY</td>
<td>11.63</td>
<td>1</td>
<td>11.63</td>
<td>.02</td>
<td>.902</td>
</tr>
<tr>
<td>ORDER BY DISPLAY</td>
<td>1891.08</td>
<td>1</td>
<td>1891.08</td>
<td>2.73</td>
<td>.159</td>
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Tests involving 'TRIALS BY GROUP' Within-Subject Effect.

<table>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
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</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>4177.20</td>
<td>5</td>
<td>835.44</td>
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</tr>
<tr>
<td>TRIALS BY GROUP</td>
<td>416.87</td>
<td>1</td>
<td>416.87</td>
<td>.50</td>
<td>.511</td>
</tr>
<tr>
<td>ORDER BY TRIALS BY</td>
<td>41.12</td>
<td>1</td>
<td>41.12</td>
<td>.05</td>
<td>.833</td>
</tr>
<tr>
<td>GROUP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>
Tests involving 'TRIALS BY DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>1113.10</td>
<td>5</td>
<td>222.62</td>
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</tr>
<tr>
<td>TRIALS BY DISPLAY</td>
<td>64.85</td>
<td>1</td>
<td>64.85</td>
<td>.29</td>
<td>.613</td>
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<tr>
<td>ORDER BY TRIALS BY DISPLAY</td>
<td>727.25</td>
<td>1</td>
<td>727.25</td>
<td>3.27</td>
<td>.131</td>
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Tests involving 'GROUP BY DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>1496.58</td>
<td>5</td>
<td>299.32</td>
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<td>GROUP BY DISPLAY</td>
<td>2208.13</td>
<td>1</td>
<td>2208.13</td>
<td>7.38</td>
<td>.042</td>
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<tr>
<td>ORDER BY GROUP BY DISPLAY</td>
<td>94.67</td>
<td>1</td>
<td>94.67</td>
<td>.32</td>
<td>.598</td>
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</table>

Tests involving 'TRIALS BY GROUP BY DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>515.37</td>
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<td>1</td>
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<td>622.24</td>
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</table>
**Summary table of Analysis of Variance to test for differences in duration of fixation during novel trials between Order of display presentation, Groups (autistic/developmentally delayed), Trials (first and second novel trials) and Displays (Runner/Ball)**

Tests of Significance using UNIQUE sums of squares

### Tests of Between-Subjects Effects.

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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<td>ORDER</td>
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<td>896.81</td>
<td>1.84</td>
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### Tests involving 'GROUP' Within-Subject Effect.

<table>
<thead>
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<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>15651.58</td>
<td>5</td>
<td>3130.32</td>
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</tr>
<tr>
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<td>517.04</td>
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<td>.701</td>
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<td>ORDER BY GROUP</td>
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<td>800.65</td>
<td>.26</td>
<td>.635</td>
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### Tests involving 'TRIAL' Within-Subject Effect.

<table>
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<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>2261.28</td>
<td>5</td>
<td>452.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRIAL</td>
<td>1603.43</td>
<td>1</td>
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<td>3.55</td>
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<td>185.19</td>
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<td>185.19</td>
<td>.41</td>
<td>.550</td>
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</table>

### Tests involving 'DISPLAY' Within-Subject Effect.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig of F</th>
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<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>1001.47</td>
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<td>200.29</td>
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<tr>
<td>DISPLAY</td>
<td>435.23</td>
<td>1</td>
<td>435.23</td>
<td>2.17</td>
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<td>333.87</td>
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### Tests involving 'GROUP BY TRIAL' Within-Subject Effect.

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<tbody>
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<td>WITHIN CELLS</td>
<td>2554.91</td>
<td>5</td>
<td>510.98</td>
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<tr>
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<td>1676.48</td>
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Tests involving 'GROUP BY DISPLAY' Within-Subject Effect.

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<th>Sig of F</th>
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<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>692.94</td>
<td>5</td>
<td>138.59</td>
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<td>GROUP BY DISPLAY</td>
<td>.12</td>
<td>1</td>
<td>.12</td>
<td>.00</td>
<td>.978</td>
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<tr>
<td>ORDER BY GROUP BY</td>
<td>276.78</td>
<td>1</td>
<td>276.78</td>
<td>2.00</td>
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Tests involving 'TRIAL BY DISPLAY' Within-Subject Effect.

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<th>F</th>
<th>Sig of F</th>
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<tr>
<td>WITHIN CELLS</td>
<td>2104.80</td>
<td>5</td>
<td>420.96</td>
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<td>TRIAL BY DISPLAY</td>
<td>287.09</td>
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<td>ORDER BY TRIAL BY</td>
<td>97.93</td>
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<td>97.93</td>
<td>.23</td>
<td>.650</td>
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Tests involving 'GROUP BY TRIAL BY DISPLAY' Within-Subject Effect.

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<th>Sig of F</th>
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<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>2003.53</td>
<td>5</td>
<td>400.71</td>
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<td>GROUP BY TRIAL BY</td>
<td>1432.29</td>
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<td>1432.29</td>
<td>3.57</td>
<td>.117</td>
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<td>245.55</td>
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<td>245.55</td>
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TRIAL BY DISPLAY
APPENDIX I

Summary table of Analysis of Variance to test for differences in recovery scores between Order of display presentation, Groups (autistic/developmentally delayed) and Displays (Runner/Ball).

Tests of Significance using UNIQUE sums of squares

<table>
<thead>
<tr>
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<th>Sig of F</th>
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<td>WITHIN CELLS</td>
<td>4349.77</td>
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<td>869.95</td>
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<td>CONSTANT</td>
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<td>1.98</td>
<td>.218</td>
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Tests involving 'GROUP' Within-Subject Effect.

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<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>19671.59</td>
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<td>3934.32</td>
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<td>GROUP</td>
<td>1898.96</td>
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<td>1898.96</td>
<td>.48</td>
<td>.518</td>
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<tr>
<td>ORDER BY GROUP</td>
<td>883.16</td>
<td>1</td>
<td>883.16</td>
<td>.22</td>
<td>.656</td>
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Tests involving 'DISPLAY' Within-Subject Effect.

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<tr>
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<th>F</th>
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</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>1973.54</td>
<td>5</td>
<td>394.71</td>
<td>1.15</td>
<td>.332</td>
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<tr>
<td>DISPLAY</td>
<td>455.75</td>
<td>1</td>
<td>455.75</td>
<td>3.58</td>
<td>.117</td>
</tr>
<tr>
<td>ORDER BY DISPLAY</td>
<td>1411.55</td>
<td>1</td>
<td>1411.55</td>
<td></td>
<td></td>
</tr>
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</table>

Tests involving 'GROUP BY DISPLAY' Within-Subject Effect.

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<th>MS</th>
<th>F</th>
<th>Sig of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHIN CELLS</td>
<td>1694.62</td>
<td>5</td>
<td>338.92</td>
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<tr>
<td>GROUP BY DISPLAY</td>
<td>251.61</td>
<td>1</td>
<td>251.61</td>
<td>.74</td>
<td>.428</td>
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<td>ORDER BY GROUP BY</td>
<td>161.80</td>
<td>1</td>
<td>161.80</td>
<td>.48</td>
<td>.520</td>
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| DISPLAY             |      |    |      |      |          |
APPENDIX J

Regression scatterplots of residual recovery scores against residual total fixation times during habituation, after partialling out Order of display presentation.

Total fixation, habituation (s)

Correlation .97686 Sig. .0002 Slope(S.E.)  .30656 (.03002)

Autistic children, Runner display, N = 7
Autistic children, Ball display

Developmentally delayed children, Runner display, N = 7
Developmentally delayed children, Runner display, excluding outlier Case 4; N = 6

Developmentally delayed children, Ball display, N = 7
APPENDIX K

Consent Form sent to Parents
CONSENT FORM

Dear Parent or Guardian,

I am planning to carry out research to study how children with autistic behaviours understand the behaviours of other people. I am a psychologist in the NHS, currently in postgraduate training. The project has been given ethical approval by the Ethics Committee of Plymouth Health Authority.

The children will take part individually. They will be asked to watch short videotapes of moving objects and simple human actions. They may also be asked some questions to assess their present word understanding. I will be measuring how long each child spends looking at each video. To help me with this, I would like to record the child using a discrete videocamera, while he or she watches the videotape. You may keep the videotape of your child. Otherwise I will rub out the tape after use. Each child will be asked if he or she wishes to watch the video and to answer the questions. If the child is unwilling, he or she will not take part.

The information from each child will be anonymous, so that only I will know which information belongs with which child. No name of any child will be revealed to other persons.

I do hope this you will allow your son or daughter to take part. Please complete and return the slip below. If you have any questions, please contact me via the Clinical Teaching Unit, Department of Psychology, University of Plymouth, 4/5 Rowe Street, Plymouth, Tel (0752) 233161. If you leave a message, I will contact you.

I thank you in anticipation of your help.

Your sincerely,

Martin Morris

I am/am not willing for my son/daughter to take part in the study. (Please delete accordingly)

I am/am not willing for my son/daughter to be videoed as part of the study. (Please delete accordingly)

Signed

Date
REFERENCES


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*Developmental Psychology, 11*, (2) 178-185.


