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Strengths and Weaknesses in Perceptual Processing in Autism: An Investigation of Central Coherence.

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ABSTRACT

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The literature regarding Gestalt ideas about perceptual organisation is reviewed. The global/local paradigm has suggested that in typical development global properties of visual stimuli are processed first, followed by local properties. This Gestalt paradigm has been applied to explain the atypical perceptual abilities seen in autism. Clinical observations and empirical findings have suggested that individuals with autism take a more piecemeal approach to perceiving things within their environment. Perception of this kind has been explained by the suggestion that individuals with autism do not integrate information into meaningful representations, therefore showing weak central coherence. This cognitive account of autism can explain the weaknesses as well as the strengths displayed in autism. This study examined whether individuals with autism show weak central coherence, by processing information at a local, rather than a global level. Two perceptual tasks were used; one to identify a weakness and one to identify a strength of performance that would result from weak central coherence. For example, children with autism were predicted to show poor performance, compared to matched moderately learning disabled and typically developing controls, on a measure that had high Gestalt content, and where visual context was required to see the stimulus. This task required the participants to recognise biomechanical motions presented in point-light displays. Conversely, children with autism were predicted to show as good or better performance, compared to the control groups, on a task that involved disembedding the local properties of the stimulus. This task was the Children's Embedded Figures Test. The findings supported the hypotheses and were consistent with the central coherence account of autism. The central coherence account of autism needs further investigation. The biomechanical motion stimulus task could be used to extend the exploration of weak central coherence in autism.

Key Words: visual perception; autism; central coherence; biomechanical motion.

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Strengths and Weaknesses in Perceptual Processing in Autism: An Investigation of Central Coherence.

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Literature Review

Global/Local Processing in Perception and the Central Coherence Account of Autism.

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Global/Local Processing in Perception and the Central Coherence Account of Autism.

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Running Header

Perceptual Organisation and Autism

Global/Local Processing in Perception and the Central Coherence Account of Autism.

Abstract

Global/local processing in typical development has been one of the most investigated elements of perception. This review considers the empirical literature regarding these Gestalt ideas about perceptual organisation. These ideas have been applied to explain the atypical perceptual abilities seen in autism. Clinical observations and recent empirical findings have suggested that individuals with autism take a more piecemeal approach to perceiving things within their environment. Perception of this kind has been explained by the notion that individuals with autism do not show the drive for 'central coherence' or meaning, that characterises normal information-processing. Further research is needed to establish the central coherence account of autism. Possible directions for future research using point-light stimuli and habituation paradigms are discussed.

Key Words: perceptual organisation; autism; central coherence.

Global/Local Processing in Perception and the Central Coherence Account of Autism.

Introduction

Perceptual deficits have been suggested to be pervasive in autism. A recent account has suggested that these may be characterised by a deficit in global processing or 'weak central coherence' (Frith, 1989). One of the most enduring issues in the psychology of perception concerns the perceptual relations between wholes and their parts. The main focus of interest in part-whole processing has been whether processing of the overall structure precedes and determines the processing of the component parts or properties, or whether the parts are registered first and are then synthesized to form the objects of our awareness (Kimchi, 1992). An additional question has asked whether the ability to discriminate between parts and wholes is innate. These questions permeate many topics in psychology, both theoretical and applied. For example, are faces recognised by identifying facial features, such as eyes, nose, and mouth or by perceiving the overall configuration first? (see Bruce, 1988); which is the better method of learning to read, the whole word method or by phonics? (see Rayner & Pollatsek, 1989); and can perceptual or cognitive development be characterised by a move from a holistic to an analytic mode? (see Kemler, 1983; Werner, 1948). This review is separated into two main sections. The first section concentrates on theoretical ideas and empirical findings in the study of perception, including those of global/local processing and the organisation of perception in infants. To demonstrate the importance of perceptual processing in autism, it is necessary to turn to the literature that encompasses perceptual processing in typical development. The second section addresses the perceptual abilities of the clinical population of autism and the implications that the work on typical perceptual development has for better understanding autism. There is a large literature concerning both of these areas. Therefore, it is beyond the scope of this paper to provide a detailed review. The reader is directed to other comprehensive reviews of specific areas for more detailed discussions.

Perception

There has been a long tradition of research into perceptual processes of human beings. Understanding the components of perception in typically developing individuals has enlightened us about the components of atypical perceptual processing, by furthering our understanding of the differences and deficits seen in individuals with autism.

Constructivist versus Gestalt Perception

The debate about the acquisition and organisation of perceptual abilities has a long history. Two basic positions of perceptual organisation can be traced back to the controversy between two schools of perceptual thought: Constructivist and Gestalt. Constructivist psychologists (Titchener, 1909; Wundt, 1874) have emphasised that every sensory whole must be built up from a conglomerate of elementary sensations and the perception of segregated, organised units corresponding to objects in the physical world. This approach has suggested that the world is perceived in mosaic. In addition, it has proposed that much of perception is achieved only by associations learned through experience. This approach has been retained in some current models of perception, especially models of pattern and object recognition (see Treisman, 1986, for an extensive review). Such analytic models have assumed that objects are identified, recognised and classified by detecting combinations of elementary features.

In contrast, Gestalt psychologists (Wertheimer, 1923; Koffka, 1935; Kohler, 1929) have ascribed great importance to the tendency to perceive patterns as wholes rather than as collections of details. There have been a number of studies which have demonstrated that typically developing individuals respond more easily to the global structure of a stimulus, than to the constituent parts (see Kimchi 1992 for a review). According to Gestalt theory, these perceptual processes are innate. It has been suggested for example, that "perceptual organisation is the direct result of a perceptual system that is constrained to obey certain organisational principles such as proximity, similarity, good continuation and closure" (Quinn, Burke & Rush, 1993). Therefore, in this view, the perceptual world is biologically organised into patterns or configurations rather than a mosaic of sensations. This global processing conceptualisation has been tested experimentally by the global-precedence hypothesis (Navon, 1977).

The Global/Local Paradigm

The global-precedence hypothesis has claimed that the processing of a scene is global to local. That is, global properties of a visual object are processed first, followed by analysis of local properties. This hypothesis has been tested by studying the perception of hierarchically constructed patterns, in which a large letter is constructed from smaller letters of either the same kind (compatible condition) or a different kind (incompatible condition) (Figure 1). The large letter is considered a more global element, in relation to the small letters, which are local elements. This is in much the same way as the eyes, nose and mouth are local elements of a face (Navon, 1981). Therefore, by virtue of their position in the hierarchy, it has been hypothesised that the global properties are processed first, followed by the lower level units. Performance measures such as relative speed of identification and/or asymmetric interference have been used to infer the precedence of one level or the other (Navon, 1977).

Insert Figure 1 about here

In general, the research has shown that the detection of the global properties is faster, compared with local properties (Robertson & Lamb, 1991). The slowed detection of local stimuli has been referred to as the global interference effect, where the drive to see the whole outweighs the ability to look at the component parts (Lamb & Robertson, 1989). Therefore, processing at a global level is thought to precede, or at least dominate, processing of the local level. This has been described as a manifestation of central coherence, which appears to predominate in some aspects of perception (Kimchi, 1992) and may do so from the first months of life (Freedland & Dannemiller, 1996).

Perceptual Acquisition and Organisation in Infants

Studies of the neonatal period have greatly increased awareness of the 'competence' of the infant and have suggested that perceptual abilities may be relatively advanced at birth. It is clear that in the early months, infants have an ability to take in information from the material and social world around them. Therefore perceptual ability far outstrips the infant's limited capability to intervene in the world at this age (E.J. Gibson, 1988). Perception is related to the interpretation of sensory input. It is through active perception that infants gain knowledge about the events, objects and people around them (J.J. Gibson, 1966).

The sensory capacities of infants have long been studied to ascertain what infants can perceive and how early they begin to interpret stimuli around them. These are intriguing issues that have caused some debate between the Constructivist and Gestalt schools of thought in perception. Before these are discussed, it is important to identify the methods by which visual abilities in infants have been measured. There are obvious difficulties in using babies in research, but ingenious techniques for discovering the development of visual capacities in newborn infants have been devised. These include monitoring eye movements of babies (Salapatek, 1975), conditioning a head-turning response to particular visual stimuli (Siqueland & Lipsitt, 1966) and measuring response such as heart rate (Campos, Langer & Krowitz, 1970). Two other commonly used methods have examined which visual stimuli infants look at longest (Fantz, 1961) and their habituation to stimuli (Horowitz, 1974).

Preferential-looking techniques have been effective in exploring infant preferences for visual stimulation in the first few months of life (Fantz, 1961). This technique has involved presenting a pair of stimuli side-by-side, over a series of trials. For example, one screen displays patterned shapes, while another consists of unpatterned shapes. An observer records the length of time that the baby spends looking at each pattern. In this way, preferential-looking procedures have tested detection and discrimination simply by the ability of a stimulus to elicit a response. The preferential-looking technique has been useful for seeing what infant's like to look at. A preference must mean an ability to discriminate, but a lack of preference does not necessarily mean that the infant does not discriminate between them, but that the infant finds both equally interesting.

It has been possible to investigate discriminations by using habituation paradigms (Bornstein, 1985; Horowitz, 1974; Horowitz, Paden, Bhana & Self, 1972; Maurer & Barrera, 1981). This method has used a single stimulus and records how long an infant looks at it before turning away. The stimulus is presented repetitively until the infant gives a measurable decline in response. At this point, a different stimulus is presented and any recovery of responsiveness produced by the change is measured. While behavioural habituation has been harder to demonstrate in neonates than in older infants, the technique has been effectively used to study capabilities of infants around five- to six- weeks of age (Atkinson & Braddick, 1982).

Using these methods, pioneering research has demonstrated consistent and predictable tendencies for infants to look at certain patterns over others (i.e. visual preferences) shortly after birth (Banks & Ginsburg, 1985; Dannemiller & Stephens, 1988; Essock & Siqueland, 1981; Fantz, 1961; Maurer & Martello, 1980). These abilities have been used to explore the development of the visual system (see Freedland & Dannemiller, 1996 for a review). For example, to show a visual preference, newborns must be able to group the individual elements of a stimulus and form a global configuration (Farroni, Valenza, Simion & Umilta, 2000). Many studies on infant perception have been conducted to discover when human babies show the ability to perceive the global organisation of stimuli. Several investigations of young infants (but not newborns) have indicated that they group unconnected elements that are completely visible or partly occluded, in accord with the Gestalt principle of common fate (Bower, 1965; Kellman &

Spelke, 1983; Slater, Morison, Somers, Mattock, Brown & Taylor, 1990). More recently, the principle of common fate has been further investigated by Johnson and Aslin (1995), who have demonstrated that infants as young as two-months perceive object unity in partial-occlusion displays. In brief, most of the results reported in the literature have shown that by three- to four-months old, infants can perceive an overall configuration if the arrangement of the elements is well structured (for reviews see Dodwell, Humphrey & Muir, 1987; Quinn et al, 1993). The Constructivist and Gestalt perspectives of perception can both account for the onset of this ability.

The Constructivist view has maintained that the visual ability to detect patterns as whole entities, rather than sets of independent elements is the result of development in the first months of life. This development has been proposed to be dependent on the maturation of neural mechanisms in the central visual system and acquired knowledge derived from experiencing correlation in pattern visual stimulation (Quinn et al, 1993; Salapatek, 1975). The infant's visual behaviour and visual encoding would undergo a series of changes during the first year. These changes would reflect a shift from an emphasis on analysis of local details to a more holistic global strategy of visual intake. For example, visual scanning in one- to two-month old infants has been shown to be concentrated on specific local features (Haith, 1981; Salapatek, 1975) or on the boundary of a stimulus (Hainline, 1978; Milewski, 1976). After three to four months, the infant progresses to a more global concept of a stimulus, rather than just a collection of separate features (Cohen, 1979). In conclusion, some characteristics of the newborn's visual behaviour have indicated a remarkable preference for detecting the local features of a stimulus. Whereas older infants might engage in a global scan followed by a local visual inspection, in younger infants, looking might rely more heavily on a serial, feature-by-feature analysis of the visual stimulus.

Unlike the Constructivists, Gestalt psychologists have long argued that the visual system is biologically prewired to obey certain organisational principles from birth, and detect global configurations (E.J. Gibson, 1969; Kohler, 1929). Infant research has provided empirical evidence for the Gestalt view of perception. It has been suggested that a rudimentary form perception is present at birth, in the sense that infants have the capacity to perceive wholes rather than only separate parts of visual stimuli (see Slater, 1996 for a review). The findings that have suggested that form perception is present at birth have been very convincing. Face preference in newborn infants is a visual behaviour that has indicated the ability to perceive the global feature of a pattern. Morton and Johnson (1991) characterised as a template, an innate mechanism that seems sensitive to the relative spatial location of elements within the face. Global precedence (Kimchi, 1992; Navon, 1977, 1981) has also been found in early infancy. Young infants have demonstrated a pattern of responding in accordance with typical global to local processing sequences (Farroni et al., 2000; Freeseman, Colombo & Coldren, 1993; Ghim & Eimas, 1988).

Further investigation of the Gestalt view that newborn infants are inherently disposed to perceive the global properties of a visual stimulus, has used visually presented movement (e.g. an object moving across the field of view or a flickering light). Methods measuring perceptual abilities have shown that very young infants attend preferentially to visually presented movement. Active rather than passive visual experience is important for visually guided exploratory behaviour (E.J. Gibson, 1988). Using the habituation method, infants as young as three-months old have been shown to discriminate one form from another on the basis of kinetic information (Kaufmann- Hayoz, Kaufmann & Stucki, 1986). In this study, the outline of a 'form' was delineated by motion through a field of random dots. Habituated infants were shown to transfer recognition of the 'form's' outline to a static black and white drawing of it, by remaining habituated, and by dishabituating to the drawing of a different 'form'. Common motion of dots in the contours of the 'form' have therefore been suggested to serve to reveal structure and contribute to perceived unity of the figure. Investigation of the human perception of motion, using fairly simple and artificial dynamic displays has been undertaken to understand how the complex patterns of motion are interpreted.

Perception of Motion

Motion detection has been described as a fundamental property of the visual system that is thought to be rooted in early development (Bertenthal, Proffitt & Cutting, 1984; E.J. Gibson, 1988; Johansson, 1975). Movement serves to recruit attention and transformations are manifested in motion that specify different, persistent and changing properties of the environment (Haith, 1966; Volkman & Dobson, 1976; Milewski, 1979). One of the most basic and dramatic aspects of the environment revealed through motion, is figural coherence.

Elements moving together have been seen as forming a perceptual grouping (Wertheimer, 1923). Research has demonstrated that movement is analysed by the perceptual system into the two components of relative motions and common motions (Johansson, 1950). The relative motions of elements within an event, serve to specify the form or figural coherence of the objects involved. The common motions of these elements specify the object's displacement relative to the observer. The Gestalt psychologist Duncker (1929) has suggested that there was a 'separation of systems' in the perception of movement. The movement of any one part of a display is seen relative to its immediate surrounding frame, but is not affected by more remote influences. For example, if a light is placed on the rim of a wheel that is rolled along, the light is seen to trace out its actual path. It appears to bounce, but no cyclical wheel-like motion is perceived. If a second light is illuminated on the hub of the wheel, the light on the rim seems to trace out a path that revolves around the hub. There is a common motion component shared by the two lights, which corresponds to the direction in which the wheel is moving. The two lights now form a wheel-like configuration that translates across the field of view (Bruce, Green & Georgeson, 1996). The "rolling wheel" effect is one of a number of examples, where the perceived configuration of the motion of one element is affected by the presence of another. The perception of such displays has been shown to conform to a 'simplicity' or 'minimum' principle. Of many possible interpretations of a display of separately moving elements, the simplest is made; that is, the one in which the motion components are minimised (Cutting & Proffitt, 1982). This is an example of the visual system resolving simple dynamic displays into components of common and relative motions. These ideas have been applied to the complex patterns of motion given by events that are more natural. One of the best known and dramatic demonstrations of this phenomenon is the perception of human walkers from dynamic point-light displays (Johansson, 1973). Movement patterns obtained from humans have been referred to as biological or biomechanical motion.

Perception of Biomechanical Motion

Point-light displays of people have been created, where the only visible features are lights attached to the actors' joints. Lights attached to the head, shoulders, elbows, wrists, hips, knees and ankles form a total of fourteen moving lights in dynamic displays. Such displays have been produced either by placing flashlight bulbs or by wrapping reflective tape about the joints of a person and filming with a video camera set to pick up only high contrast (Johansson, 1973; Dittrich, 1993). The point-light displays remove the contour of the human form, but preserve motion. Therefore, accurate perception has to be due to sensitivity to motion. Any static frame from these sequences has appeared as a meaningless arrangement of dots (Kozlowski & Cutting, 1977).

Biomechanical motion displays are extremely complex since each joint allows for directional change and thus spatial relations among various joints are continuously changing. However, in spite of this apparent complexity, these moving displays have been shown to become rapidly perceptible as a human figure, by adult observers (Fox & McDaniel, 1982; Johansson, 1976). The perception of a moving person has been achieved with as little as 100msec of film, or with as few as six lights shown. Not only has the figure been clearly seen (with the invisible contours of arms and legs), but more rigorous analysis of this methodology has shown that the rudimentary information of these patterns is sufficient to convey more specific perceptions. For example, recognising people from their gait (Cutting & Kozlowski, 1977), differences in gender (Barclay, Cutting & Kozlowski, 1978; Kozlowski & Cutting, 1978; Kozlowski & Cutting, 1977), identifying emotional expression when recording facial motion (Bassili, 1978) and perceiving different actions (Dittrich, 1993). It is clear from the displays whether the person is walking, running, jumping, picking something up or dancing with a partner. Even when the lights have been placed inter-joint or when point-light displays have been inverted, human movement has still been perceived (Dittrich, 1993).

Point-light displays afford many different interpretations, depending on the notion of perceptual grouping. In the case of a point-light display of a person walking, an observer may not group all of the point-lights together, but may still perceive coherence. For example, among only the lights of the upper torso or of the arm. Although the form of a person will not be seen unless all of the point-lights are perceptually grouped together, figural coherence of a more limited portion of the display is still possible. Therefore, what is seen depends upon perceptual grouping abilities (Bertenthal, Proffitt & Cutting, 1984). The information, on which judgements of these displays are made, appears to be given by a global invariant, rather than by particular elements of the display.

Research has provided strong support for the suggestion that humans are adept at the perception of biological motion, even when given restricted information consisting only of points of light (Fox & McDaniel, 1982). The extraction of figural coherence or form is certainly a fundamental process in the perception of the visual world. When the salient nature of motion has been considered, it would seem highly adaptive for even young infants to be sensitive to figural coherence revealed through motion (Johansson, 1973). Interestingly, reviews of infant visual perception (e.g. Ruff, 1980) have suggested that sensitivity to motion-carried information is either innate or develops very early. Therefore, perception of biomechanical motion has been hypothesised, in line with

Gestalt theory, to be an intrinsic capacity of the visual system, rather than one acquired through experience (Johansson, 1975).

Bertenthal Proffitt and Cutting (1984) have found that three-and-five-month old infants were able to discriminate between upright and inverted walking point-light figures, though not between static frames from the upright and inverted conditions. Infants at this age have also been able to discriminate a "coherent" point-light display of a person walking a treadmill from a display with the dot motions scrambled to form what adults have judged to look like "a swarm of bees". Additionally, infants four- to-six-months old have been shown to exhibit a preference for biological motion patterns (Fox & McDaniel, 1982).

<u>Summary</u>

The question of whether global properties are perceived before component properties continues to be an enduring issue in psychology. The global/local paradigm (Navon, 1977) has been an elegant and controlled attempt to test this question experimentally. A review of the empirical findings obtained within the global/local paradigm has suggested that processing of the global level of hierarchical patterns dominates processing of the local level. A large body of research has been devoted to examine the locus and the source of this global-advantage effect. There has been evidence to suggest that a global advantage occurs at early perceptual processing. Early perceptual organisation has been investigated through the development of creative methodologies and the use varied stimuli.

The literature addressing perception in typical development has been used to look at aberrant patterns of perception in a clinical population. The autism population has been strongly suggested to show atypical perception. Looking at perceptual abilities in autism has received increasing interest in recent years. This review now focuses on this literature and suggests new directions that may be important for providing a better understanding of autism in the future.

Autism and Perception

Autism has defied all simple explanations. This lack of an all-encompassing explanation may be a reflection of the incomplete general understanding about cognition and its acquisition, in typical development.

The Diagnostic Criteria of Autism

Although biologically based with a strong genetic component, the diagnosis of autism has been based on behavioural criteria, that form the classical triad of deficits in reciprocal relationships, communication and imagination (American Psychiatric Association, 1994; Wing & Gould, 1979). As well as these core features there have been many other characteristics that are typical in autism (American Psychiatric Association, 1994, World Health Organisation, 1992). These include islets of ability on intelligence test batteries, where non-verbal skills often far exceed verbal abilities (Lockyer & Rutter, 1970). Some individuals with autism also show 'idiot savant' abilities of spectacular drawing, musical genius, rapid jigsaw construction and excellent rote memory (Rimland, 1978; Rimland & Hill, 1984). In addition, individuals with autism show repetitive behaviours. Repetitive behaviour has been a term used to refer to the broad and often disparate class of behaviours linked by repetition, rigidity and inappropriateness (Turner, 1999). These behaviours are often manifested in abnormal responses to sensory stimuli, preoccupations with parts of objects, other motor stereotypies, including rocking, hand-flapping, or flicking their fingers in front of their eyes and a desire for the preservation of sameness (Happe, 1994a).

Theoretical Accounts of Autism

There has been extensive progress in understanding many of the behavioural symptoms of autism. The most influential account of autism has been the cognitive hypothesis that individuals with autism lack 'theory-of-mind' skills (Baron-Cohen, 1995; Baron-Cohen, Leslie & Frith, 1985). The theory-of-mind account has been particularly influential in explaining the impaired social performance in many individuals with autism. Typically developing children, from around the age of four years old, understand that people have beliefs and desires about the world and these mental states determine a person's behaviour. The theory-of-mind explanation of autism has suggested that individuals with autism lack this ability to attribute independent mental states to self and others in order to explain and predict behaviour. It has been argued that social withdrawal is an understandable consequence of having theory-of-mind problems, as the ability to explain otherwise confusing behaviour in terms of underlying mental states is lacking (Frith, 1989). Similarly, having an understanding that others have mental states that differ from your own is necessary in order to be motivated to communicate (Happe, 1993). Finally, deficits in imagination have been argued to occur as a result of a theory-of-mind deficit, if imagination requires the same representational processes as attributing beliefs to others (Lillard, 1993). In addition, Baron-Cohen (1989) has suggested that repetitive and restricted behaviours may develop as a coping strategy that allows the individual with autism to reduce the high level of anxiety resulting from the primary impairment in the ability to understand and infer the mental states of others. These behaviours also allow the individual to withdraw from a social world that is unpredictable and frightening. A preference for stereotyped routines and sameness have been suggested to emerge as the individual attempts to gain control over their world (Carruthers, 1996).

Another cognitive theory, the executive function deficit account, has been proposed to address the presence of the restricted and repetitive behaviours seen in autism (Russell, 1997). Executive function deficits have been suggested to render the individual unable to disengage from an object or behaviour, to plan actions or display novel behaviour (Ridley, 1994). Individuals with autism have been shown to perform poorly on tests that are used to index executive problems in frontal lobe patients (Hughes, Russell & Robbins, 1994; Ozonoff, Pennington & Rogers, 1991; Prior & Hoffman, 1990). More directly, studies of executive control have indicated that individuals with autism have problems inhibiting their responses to external stimuli (Hughes, 1996; Ozonoff & Strayer, 1997; Russell, Mauthner, Sharpe & Tidswell, 1991). Clearly a deficit in self-control of action might well explain the breadth and diversity of repetitive and stereotyped behaviours in autism, the pervasive and enduring nature of these behaviours and their marked resistance to intervention (Turner, 1999).

These psychological theories of autism have focused on the impairments seen in autism. However, other features often seen in autism, suggest that people with autism show preserved and superior skills in certain areas. Therefore, the deficit accounts of autism (e.g. theory-of-mind and executive dysfunction) have struggled to explain these characteristic strengths. Therefore, it is important to provide an explanation that can account for both the strengths and weaknesses that are evident in autism.

Perceptual abnormalities have been a common feature of the autobiographical accounts of individuals with autism (Grandin, 1984, 1995; Jolliffe, Lansdown & Robinson, 1992; Williams, 1992; White & White, 1987). Fragmented and disorganised perception and intense experience of normally unnoticed aspects of the environment have been described. A number of early hypotheses posited to explain these aspects of autism were discounted for lack of empirical support and lack of specificity to autism (see Frith & Baron-Cohen, 1987 for a review). Nonetheless, some of these ideas have persisted, and, with some modification and refinement, have continued to inspire current research. These peculiarities are now being systematically explored, with the growing recognition that progress in understanding autism may come through exploration of not only the deficits identified in autism, but also the assets often displayed (Happe, 1999).

Islets of Ability

It has been well-documented that along with 'idiot savant' abilities, individuals with autism show an uneven distribution of cognitive skills, that is reflected in their pattern of scores on standardised intelligence tests (Ehlers et al., 1997; Prior, 1979). The pattern of psychological abilities is important if a cognitive dysfunction specific to autism is to be identified. Research on autism has, for the most part, concentrated on the performance impairments, indicating that individuals with autism are either deficient or delayed in the development of their information-processing abilities (Bryson, Wainwright-Sharp & Smith, 1990). However, the phenomenon of islets of ability has been noted (Hermelin & O'Connor, 1970). Until recently, this has only been regarded as an interesting but theoretically unimportant fact. Recently, there have been increasing numbers of empirical studies (Happe, 1994b; Shah & Frith, 1983, 1993) that have attempted to elucidate why islets of ability occur so frequently in autism. They have attempted to answer the questions that arise when good performance is achieved on certain IQ subtests of the Wechsler Intelligence scales (Wechsler, 1974, 1981), by individuals whose achievement on other subtests is poor. It has been suggested that it might be possible to explain both strengths and weaknesses of performance in terms of a single underlying cognitive dysfunction (Frith, 1989). This has led to the proposal that autism may be characterised by weak central coherence.

Central Coherence

Central coherence is a characteristic of normal information-processing, that has been described as the tendency to draw together diverse information to construct higher-level meaning in context (Frith, 1989). For example, the gist of a story is easily recalled, while the detail-by-detail form is quickly lost and is an effort to retain (Bartlett, 1932). Central coherence is also demonstrated in the ease with which contextually-appropriate sense is made of the ambiguous words used in everyday speech (son-sun, meet-meat, sew-so, pear-pair) (Happe, 1994a). The tendency to process information in context for global meaning is also seen in non-verbal material. For example, the tendency to misinterpret details in a jigsaw puzzle, according to the expected position in the whole picture (Happe, 2000). Frith (1989) has suggested that this universal feature of human information-processing is disturbed in autism and that weak central coherence can parsimoniously explain the assets and deficits seen in autism, within the context of cognitive processing or part-whole relationships. The phenomenon of perceiving the coherence of the whole is less striking in individuals with autism. They seem to have a superior ability to locate detail, noticing and retaining features, at the expense of global configuration and contextualised meaning (Fein, Lucci & Waterhouse, 1990; Prior & Hoffman, 1990).

The central coherence account of autism has proposed that autism is characterised by a specific imbalance in integration of information at different levels. Individuals may be deficient in integrating information at a local level of organisation to construct higher-level meaning in context (Frith, 1989; Frith & Happe, 1994). Instead of integrating low-level features into a coherent whole, they may process information in a more piecemeal way, giving more attention to detail, rather than global information. This notion is akin to Kanner's description of a universal feature of autism which consisted of an "inability to experience wholes without full attention to the constituent parts" (Kanner, 1943, p.38). On the basis of this theory, it has been predicted that individuals with autism would be relatively good at perceptual tasks where attention to local information - piecemeal processing - is advantageous, but poor at tasks requiring the recognition of global meaning or integration of stimuli in context.

Empirical Evidence - Strengths. The weak central coherence hypothesis can explain the idiosyncratic peaks in perceptual functioning seen in autism. This has been elegantly demonstrated using complex visuo-spatial constructional tasks. For example, individuals with autism have been shown to perform better (than control subjects matched for mental age) on the Block Design subtest of the Wechsler Intelligence Scales (Wechsler, 1974, 1981), than would be predicted by developmental level (Lockyer & Rutter, 1970; Shah & Frith, 1993; Tymchuk, Simmons & Neafsey, 1977). This has been stated as a robust finding in the research and has not been reported for moderately learning disabled individuals without autism. This visuo-spatial test requires segmentation abilities. The individual has to visually break up line drawings into logical units, so that individual blocks can be used to reconstruct the original design from its separate parts. This may indicate a perceptual orientation towards the constituent parts rather than the whole of a design (Shah & Frith, 1993). Indeed, when segmentation of the pattern is specified, the performance of the controls rises to the level of the individuals with autism, confirming that the benefit typically seen in autism is due to a predisposition to segment a whole Gestalt. Therefore, while the Block Design task may be hard for typically developing and learning disabled individuals, because the Gestalt of the design is hard to overcome, individuals with autism have no such difficulty. They do not succumb to the Gestalt, but instead, easily see the design in terms of its constituent blocks.

Individuals with autism have also been found to show superior performance on the Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971), compared with matched control subjects (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983). This involves finding a hidden shape within larger, more meaningful drawings. The difficulty of finding embedded figures is thought to be due to the competitive influence of the whole in detecting the hidden figure. Therefore, the superior performance is interpreted as an absence of global interference and a special facility in seeing parts in wholes (Shah & Frith, 1983).

Both block design and embedded figures tasks have strong Gestalt qualities and are accepted measures of central coherence. To perform well on these tasks, a piecemeal or "analytic" approach is advantageous, because they require attention to local information, rather than the global Gestalt. These findings have suggested that individuals with autism appear to process unconnected stimuli, outside a meaningful context, with remarkable efficiency.

This finding is in contrast with the ideas of the Gestalt psychologists, who have stated that in typical perceptual development, there is a "drive" to process the holistic properties of a stimulus prior to its constituent parts (Koffka, 1935; Kohler, 1929). Therefore, typically developing controls perform less well on these tasks as they respond more rapidly to the global structure of a stimulus and find it hard to overcome this drive to see the constituent parts.

Tasks with this requirement are unusual and are often found in the laboratory, rather than in real life. Information-processing in real life almost always involves interpretation of individual stimuli in terms of overall context and meaning. Laboratory tests and tests of academic skills are often difficult for typically developing children precisely because they do not involve global meaning. The opposite may be the case for individuals with autism, who may perform well on certain IQ subtests, but fail markedly in real life situations, by failing to extract meaning or notice context. These ideas are consistent with clinical observations of preoccupation with visual details and parts in individuals with autism (Wiltshire, 1991) and their abilities to locate tiny objects in the environment and detect changes in familiar layouts (Mottron, Burack, Stauder & Robaey, 1999).

Further evidence of the assets seen in autism has been shown in the "idiot savant" features of autism, which are often in visuo-spatial domains. Mottron and Belleville (1993), who have proposed an alternative account of local/global processing anomalies in autism (see Mottron, et al., 1999) have described fragmented perception and a bias towards local processing, in high-level individuals with autism who showed savant drawing skills. These findings of piecemeal drawing have also been found in a group of adolescents with high-functioning autism using impossible figures (Mottron, Belleville & Menard, 1999). The adolescents with autism were faster than typically developing controls at copying the 'impossible figures' (globally incompatible figures) than possible figures. This result reflected that the adolescents with autism were less affected by the global incoherence of the figures. Other savant skills, such as absolute pitch, that is unusually common in children with autism, may also reflect weak coherence in autism. (Heaton, Hermelin & Pring, 1998; Takeuchi & Hulse, 1993). Absolute pitch is a musical ability achieved by perceiving individual features. If individuals with autism show a pervasive and persistent local processing bias, this finding may explain the high frequency of absolute pitch in this population (Heaton et al., 1998).

In summary, these remarkable findings of superior areas of functioning can be explained by weak central coherence. The success of individuals with autism on various visuo-spatial tasks is due to a perceptual advantage that allows these individuals not to be captured by the global shape, but to focus on the components of the stimuli. However, having weak central coherence will more often be a disadvantage, as the missing context of visual information may lead to confusion and misunderstanding.

Empirical Evidence - Weaknesses. While weak central coherence confers significant advantages on tasks where preferential processing of parts over wholes is useful, it would be expected to confer marked disadvantages on tasks that involve interpretation of individual stimuli in terms of overall context and meaning. Some of the earliest research influential to the central coherence account of autism has been by Hermelin and O'Connor (1970), who founded the tradition of cognitive assessment of assets and deficits in autism and well-matched learning disabled comparison groups. Early findings used verbal-semantic studies to show that individuals with autism did not derive benefit from meaning in memory, suggesting that they did not make use of either semantic relations (words from the same category versus assorted words) or grammatical relations (sentences versus word lists) in memory. This work has been replicated by a number of authors (see Tager-Flusberg, 1991 for a review). Other studies have shown that individuals with autism fail to disambiguate homographs using surrounding word context (Frith & Snowling, 1983, Happe, 1997). In order to choose the correct (context-appropriate) pronunciation in the following sentences, the final word must be processed as part of the whole sentence meaning. For example "In her dress there was a big tear" or "He made a deep bow". The contextual disambiguation was problematic for individuals with autism, because of their piecemeal processing style. They were unable to integrate meaning across the sentence to allow context-dependent processing of the ambiguous information. This finding has supported the notion of weak central coherence.

The most recent studies investigating the weak central coherence hypothesis have used phenomena tapping fairly low-level perceptual processes. The notion that individuals with autism fail to integrate information has predicted difficulty in perceiving the environment in terms of coherent objects in context. Happe (1996) has investigated the phenomena of visual illusions. Visual illusions occur at an early stage of processing and are devoid of higher-level meaning. Nonetheless, they require the integration of perceptual features. Without cohesion, the perceptual features would remain as pieces that would be of limited use, when adapting them to the environment. The results of this study showed that participants with autism made more accurate judgements of illusory figures and less often succumbed to the typical misjudgements. Happe (1996) has argued that individuals with autism appear to resist the cohesive effect of illusions, by failing to integrate the induced lines and the inducing context. This ability appears to be related to a disembedding skill. When the figures were artificially disembedded, the control groups performed as accurately as the autism group. However, this artificial disembedding did not help the autism group. Another finding relating to low-level coherence has found that children with autism failed to enumerate canonical patterns in a counting task (Jarrold & Russell, 1997). The children with autism were found to show significantly less benefit than controls, for counting canonical dots (as on a die), as opposed to distributed stimuli, that consisted of different arrangements of dots with added distracter stimuli. Jarrold and Russell (1997) have interpreted these findings as implying that the autism group processed the visual array analytically (counting each dot separately) and without attention to the global configuration.

Other studies, though not intended to test the notion of central coherence, may relate to failures of integration in low-level processing. Individuals with autism have been shown to suffer less decrement in face recognition tests, when the faces are inverted (Hobson, Ouston & Lee, 1988; Langdell, 1978). Inverting faces is thought to affect primarily configural, (as opposed to featural) aspects of processing (Bartlett & Searcy, 1993; Rhodes, Brake & Atkinson, 1993). This featural processing style may also hamper emotion recognition (as opposed to identity), as emotions appear to be recognised from configural information (McKelvie, 1995). These findings are striking and have suggested that local processing in low-level perceptual tasks would appear to reflect a disruption of central coherence.

<u>Challenging Empirical Evidence.</u> Although weak central coherence has been fairly successful in explaining both the assets and the deficits seen in autism, there have been some findings that challenge this theory (e.g. Mottron et al., 1999). For example, one study using the Embedded Figures Test to assess superior performance, has reported findings directly counter to the idea of weak central coherence at the visuo-spatial level. Brian and Bryson (1996) have found that individuals with autism were no faster than controls on the Embedded Figures Test. Another study looking at the deficits caused by weak central coherence has also disputed this hypothesis (Ropar & Mitchell, 1999). This study failed to replicate Happe's (1996) study looking at the lack of susceptibility of people with autism to visual illusions. They reported that individuals with autism showed the same susceptibility to the illusions as controls.

In an attempt to identify the level at which central coherence may be weak in autism, other studies have tapped higher levels of processing, using the hierarchical Navon (1977) compound letters paradigm described earlier. There is a large literature of empirical findings using this task (see Plaisted, 2000 for a review). However, it is interesting to note that the results of these studies have provided discordant evidence of weak central coherence in perceptual tasks in autism and have challenged the idea that there is a global processing deficit in autism. Two studies using the Navon task have found a global advantage among individuals with autism (Mottron, et al, 1999; Ozonoff, Strayer, McMahon and Filloux (1994). Plaisted, Swettenham and Rees (1999) have also found inconsistent evidence for weak central coherence, using two variations of the Navon task, a selective attention task and a divided attention task. The selective attention task involved a large letter condition in which the participants were instructed to identify the letter at the global level and a small letter condition, in which the participants were instructed to identify the letter at the local level. On this task, children with autism performed like typically developing children and identified global letters more rapidly than local letters. On the divided attention task the target letter could appear at the local level only (incompatible/local conditions), the global level only (incompatible/global condition) or at both levels (compatible conditions). The participants were given no information regarding the level at which the target would appear. On this task, the children with autism detected local targets more rapidly. From this result, it has been suggested that the discrepancy in performance must lie in the different requirements for each task. One clear difference between the two procedures used was that participants were overtly primed by instruction in the selective attention procedure, about the level at which targets would appear. Therefore, the results have suggested that global processing is intact in autism, but operates only under conditions of overt priming. Plaisted et al. (1999) have suggested that these results support one of two ideas. Either that the inhibitory mechanisms that operate upon the output of local information processing channels do not operate automatically in autism, but must be primed, or that children with autism attend selectively to local information in the absence of overt instruction. This idea is consistent with the concept that central coherence processes in autism are "weak" rather than absent.

As a result of this study, it has been suggested that maybe the Navon task involves the use of other processes that are not specific to central coherence. Therefore, visual search paradigms, as tasks that explicitly require the integration of information for successful performance, have been used (Plaisted et al., 1999). In a series of studies, the performance of children with autism has been compared with typically developing children, on feature and conjunctive search tasks. Feature search tasks involve the target stimuli sharing one dimension e.g. colour, with one set of distracters and being unique in another dimension, such as form (e.g. searching for a red 'S' among red 'T' and green 'X' distracters). Conjunctive search tasks involve the target sharing one dimension with one set and another dimension with another set of distracters (e.g. searching for a red 'X' among red 'T' and green 'X' distracters). The weak central coherence hypothesis would predict that, due to a deficit to integrate features, the performance of children with autism would be slower on conjunctive tasks than the control group (Plaisted, O'Riordan & Baron-Cohen, 1998; O'Riordan & Plaisted, submitted, cited in Plaisted 2000; O'Riordan, Plaisted, Driver & Baron-Cohen, submitted, cited in Plaisted, 2000). The results have consistently found that children with autism show superior response time performance on conjunctive search tasks. Therefore, these results have demonstrated no deficit in autism in the integration of features into the coherent whole. However, again the stimuli used in this task may not tap weak central coherence, but instead focus on attentional mechanisms, which have been shown to be deficient in autism (Courchesne et al., 1994). Weak central coherence may only be apparent in tasks that employ stimuli that produce a global Gestalt, as well as being composed of individual features. The search tasks used in this study were unlikely to have produced a global pattern, since the letters were randomly placed on the screen (Plaisted et al., 1998).

Therefore, as far as the weak central coherence hypothesis is concerned, there has been robust empirical evidence suggesting that there are differences in perceptual processing in autism. However, there have also been contradictory empirical findings, which have given rise to a debate about the mechanisms underpinning the performance of individuals with autism on perceptual tasks (Mottron et al., 1999, Plaisted, 2000). Some reasons have been put forward to suggest why findings of weak central coherence in some studies have not been found. Differences in the nature and complexity of tasks used, how these tasks are processed and differences in levels of participants' functioning may have caused discrepant findings (Mottron et al., 1999). It is also possible that typical configural processing in autism has been identified in some studies because simple, highly familiar, configural stimuli were used. It has been suggested that using novel configural stimuli may show different results. Studies which manipulate stimulus parameters of novelty/familiarity and simplicity/complexity, therefore, need to be carried out (Plaisted, 2000).

Central Coherence as a Cognitive Style

The central coherence account of autism predicts both strengths and weaknesses in performance. Studies which have looked at individual, as well as group differences in performance on visual tasks, have found that group performance has significantly differed on experimental measures, but individual performance has not significantly differed across the groups (Jarrold & Russell, 1997). Therefore, weak central coherence may be best characterised in terms of a cognitive style (Happe 1999), rather than as a form of deficit or impairment. The notion of a balance between preferences for parts versus wholes may be a cognitive style that varies across the normal population (Happe, 1999), from weak central coherence (preferential processing of parts) to strong coherence (preferential processing of wholes). The wide range of scores commonly attained in normal samples on the Embedded Figures Test and Block Design task have supported this idea (Happe, 2000). There has also been existing evidence of normal individual differences in local-global processing, from infancy (Colombo, Freeseman, Coldren & Frick, 1995), through childhood (Chynn, Garrod, Demick & DeVos, 1991) and into adulthood (Marendaz, 1985). It could be hypothesised that individuals with autism fall at the extreme weak end of the continuum of cognitive style (Happe, 1999). Additionally, as a cognitive style, it could be hypothesised that this aspect of autism is genetically transmitted and may characterise other family members of individuals with autism on tasks where detail focus is an advantage (Baron-Cohen & Hammer, 1997; Happe, Briskman & Frith, in press, cited in Happe 2000). These studies have shown that parents, particularly fathers, of children with autism have shown superior performance on tasks favouring local processing.

Towards An Integrated Theory of Autism

A longstanding question has addressed the possibility of an integrated theory of autism, as all three of the psychological accounts of autism have been influential in explaining the behaviours displayed in autism. There has been some discussion as to whether executive deficits might be a fundamental cause of theory-of-mind problems in autism, or vice versa (Carruthers, 1996; Ozonoff et al., 1991). In addition, it might be necessary to consider the relation between the central coherence and executive function accounts of autism in the future. A central processing failure has been suggested to have implications for the repetitive behaviours seen in autism (Frith, 1989). If the ability to achieve central coherence or meaning is limited in autism, then detachment and fragmentation into meaningless activities is an inevitable consequence. It is understandable that individuals with autism might have difficulty planning and executing actions, because of their perception of fragmented forms. Therefore, as a result, fragmented behaviours might be displayed. Repetition and rigidity may occur because the central control processes are too weak to control them and switch them off appropriately (Frith, 1989). Most recently, empirical work has been applied to establishing a link between the central coherence and theory-of-mind accounts of autism.

Weak Central Coherence and Social Deficits. Recently, empirical research has proposed that the social deficits in autism are caused by deficits in perception (Happe, 2000; Jarrold, Butler, Cottington & Jimenez, 2000; Plaisted, 2000). A number of authors have suggested that early disruption in these primary processes can severely impact on the later emergence of social abilities exhibited by normal children (Bryson et al., 1990; Courchesne et al., 1994; Dawson & Lewy, 1989). Therefore, the social and asocial aspects of autism are starting to be regarded as being causally related (Happe, 2000; Jarrold et al., 2000; Plaisted, 2000). Jarrold et al. (2000) have shown that weak central coherence, assessed using the Embedded Figures Test, is correlated with worse performance on theory-of-mind tasks. This perspective makes a strong claim that social information-processing relies precisely on those mechanisms involved in processing non-social information. It is conceivable that integrative processing of the environment provides the input necessary for maturation of the theory-of-mind mechanism (Happe, 2000). According to this view, theory-of-mind deficits may occur when the individual is not exposed to a number of early experiences that rely on the primary processes of perception, learning and attention (Plaisted, 2000). This view has made the prediction that deficits in the primary processes are apparent from a very early age and possibly from birth. This account, of course, is a difficult prediction to test, because autism cannot be diagnosed until at least eighteen months of age. However, Gillberg and Coleman (1992) have highlighted studies which have addressed this question by documenting early symptoms of autism, many of which included abnormalities of perception. Alternatively, it might be important to directly assess perception in very young children with autism. Studies have started to address this area, by looking at the amount of attention directed towards objects and people (Joseph & Tager-Flusberg, 1997; Swettenham et al., 1998). The impression given by these two studies has been, for example, that children with autism show abnormalities in their attention to faces from a very early age. It is unclear whether this abnormality stems from deficits in processes specialised for face processing or from a more general abnormality in stimulus processing. One possibility has been that faces belong to a category of complex stimuli with spatial configurations and individuals with autism have a deficit at this level of processing (Plaisted, 2000). Some evidence for this has been found in a study that showed high-functioning children with autism were impaired in their ability to match random dot patterns on the basis of their spatial configurations (Davies, Bishop, Manstead & Tantam, 1994). This result is predicted by the weak central coherence hypothesis.

Summary

Gestalt psychologists have suggested that the balance between perception of parts and wholes is normally weighted towards wholes (Navon, 1977, 1981; Rock & Palmer, 1990). A universal feature of typical information-processing appears to be the coherence of the "whole" that develops with age (Frith & Happe, 1994; Witkin et al., 1971). When details of the parts need to be perceived, for example, when manipulating the constituent elements in the Block Design task, the tendency to see the whole has to be overcome and new structures (mapping onto the individual blocks) have to be mentally imposed. This step appears to require both time and effort, but in varying degrees for different individuals.

The central coherence hypothesis has drawn into focus many features of autism that have been neglected in other investigations and focuses on both the strengths and weaknesses evident in autism. There is a clear possibility that this explanation of autism could be integrated with the other proposed accounts of autism, to provide a unified theory of autism. In order for this to be considered, weak central coherence in autism needs to be empirically established.

Currently, a number of studies have provided evidence for a global deficit in autism. This evidence has been found in unique patterns of performance across various types of visual processing tasks that tap both local and global processing abilities. For example, individuals with autism have shown superiority on the Block Design task (Shah & Frith, 1993); facilitated performance on embedded figures tasks (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983); and impaired performance in identifying visual illusions (Happe, 1996) and impossible figures (Mottron, Belleville & Menard, 1999). However, there has also some evidence to suggest that this is not the case on representative tasks of visual processing (Brian & Bryson, 1996; Mottron et al., 1999, Plaisted et al., 1999; Ropar & Mitchell, 1999). These contradictory findings have indicated that the use of varied methodologies has not provided a consistent picture of central coherence in individuals with autism. Therefore, further research needs to be undertaken.

Future Research

There are many issues that need to be clarified if weak central coherence in autism is to become empirically established. One potential focus of research might aim to identify the mechanism responsible for central coherence and explore central coherence across a number of different domains. For example, the question as to whether the degree of central coherence in a verbal task predicts degree of coherence in a visuo-spatial task needs to be considered (Happe, 2000). In order to make cross-domain comparisons, it would first be important to explore and establish central coherence more thoroughly within one domain. For example, given the strengths and weaknesses seen in autism, it would be important to use two tasks, one that would predict weak performance and one that would predict strong performance, within the same domain, to identify whether weak central coherence is consistent within that performance domain. Surprisingly, there have been no studies to date that explicitly take this approach. Given the difficulty that individuals with autism appear to have with perception of a complete picture or a "whole", it is suggested that exploring weak central coherence in visuo-spatial skills should be furthered using this approach, to provide further evidence to substantiate this account of autism. For example, developing a study that incorporates tasks that tap both local and global processing would identify if there was a difference in performance that would be predicted if central coherence in autism is weak.

It has been suggested that individuals with autism fail to recognise human beings as different from other features of the environment (Wing, 1981). Failing to integrate visual information at low levels may account for this and have implications for how people with autism experience the social world (Jarrold et al., 2000). Weak central coherence may interact with or even cause deficits in theory-of-mind, as detail-focused perceptual processing may play a part in the social impairments seen in autism (Jarrold et al., 2000). Empirical support has suggested that children with autism may process faces in terms of individual features and not their overall configuration (Hobson, Ouston and Lee, 1998). In addition, they have been shown to have deficits in processing emotional information (McKelvie, 1995). Therefore, there may be further deficits in overall person perception that may be due to weak central coherence. If faces are processed by their features, then the whole person may also be processed as component parts. Therefore, basic recognition of the whole person warrants attention. One possibility for exploring this idea, could be the use of the established methodological paradigm using point-light displays (Johansson, 1973). A person depicted in point-light displays could represent a novel stimulus and complex spatial configuration that is argued to be important in investigating weak central coherence. A task representing biomechanical motion in point-light displays is argued to tap global processing. By using this novel approach it could be established whether individuals with autism were able to combine synchronised movement of apparently unconnected dots of light in order to see the "whole" person (Johansson, 1973). A recent study has successfully used this methodology with children with autism (Moore, Hobson & Lee, 1997). The perception of biomechanical motion in point-light displays would provide an essential step in the examination of how individuals with autism perceive stimuli which appear to present meaningful Gestalten to typically developing infants (Bertenthal, Proffitt & Cutting, 1984).

Using a standardised task that is an accepted measure of local processing would provide a control task that would predict enhanced performance in autism. The Embedded Figures Test and the Block Design task are accepted measures of central coherence bias that have been used extensively in many other studies (e.g.

Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983, 1993). The Embedded Figures Test was explicitly designed to test the "ability to break up an organised visual field in order to keep a part of it separate from that field" (Witkin et al., 1971, p.4). A local approach on the Embedded Figures Test has been shown to be related to enhanced ability to "disembed" items in tasks presented in non-visual modalities (Axelrod & Cohen, 1961; Lefever & Ehri, 1976; White, 1954). Similarly, Shah & Frith's (1993) study of block design performance provides direct evidence to show that success on this task is mediated by an ability to take a local visual approach. The fact that pre-segmenting the designs reduces the time taken to complete test items indicates that successful task performance requires the participant to ignore the global form and focus instead on the local constituent parts of the design. In addition, the relationships observed between performance on the Embedded Figures Test and Block Design task (Jarrold et al., 2000) lend support to the claim that these tap the same underlying process. Therefore, it is argued that the Embedded Figures Test provides a reasonable index of an individual's bias towards a local visual approach.

It would be predicted that individuals with autism would perform differently on a biomechanical motion stimulus task that taps global processing and an embedded figures task that taps local processing. This approach would take a further, crucial step in addressing weak central coherence. In addition, using a global task that uses point-light displays would be the first step towards developing a non-verbal perceptual paradigm. It is interesting to note that most of the existing studies looking at global/local processing in autism have been with high-functioning individuals and all have used language paradigms. It is important to establish the use of the point-light paradigm in autism as it could have implications for extending the investigation of weak central coherence in autism.

A point-light paradigm could be developed into a non-verbal measure that could be used with low-functioning individuals with autism and infants. This extends the recent work that has addressed the perceptual abnormalities in very young children with autism (Joseph & Tager-Flusberg, 1997; Swettenham et al., 1998). For example, further research using point-light displays of biomechanical motion, could measure global/local processing in infants with autism, based on the methodological preferential-looking and habituation paradigm procedures used in the perception literature (Fantz, 1961; Horowitz, 1974). Using this approach may have implications for identifying whether weak central coherence is present shortly after birth. If it is found that individuals with autism have different perceptual abilities from birth, based on the global/local paradigm, as suggested by the Gestaltists, this finding may be crucial in better understanding the development of autism. The implications of weak central coherence may be profound, suggesting that individuals with autism could be perceiving the world in a radically different way, from those with typical development. These differences may impact on the deficits shown in their social behaviour. If these notions can be established, they may have important implications for understanding autism and developing early clinical interventions.

This is an important direction for future research. However, firstly, it is important to establish the use of a point-light paradigm to investigate weak central coherence with older, high-functioning children with autism. If this is successful, then it could be considered as a methodology to be used with younger, non-verbal children with autism.

Conclusion

This review has addressed global/local processing in typical development and considered how this empirical literature has been applied to understand the perceptual abilities of individuals with autism, within a model of central coherence. The literature reviewed has confirmed a role for weak central coherence in explaining the strengths and weaknesses seen in autism. More specifically, the consideration of weak central coherence as a causal factor for theory-of-mind deficits has recently been investigated, in the drive to provide an integrated theory within which to understand autism.

This review has further discussed the need to extend the exploration of weak central coherence in autism to provide consistent evidence for this account to become empirically established. It has been suggested that this could take place by identifying both the strengths and weaknesses of perceptual abilities within one sample. This could be done by using a Gestalt stimulus that is perceived in everyday life, such as biomechanical motion in point-light displays and a standardised stimulus that involves disembedding the local properties, such as an embedded figures task. Further, developing a paradigm that could be used as with children of all developmental levels may provide important information about the development of autism and have implications for clinical interventions.

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Figure 1. Examples of the Compound Letters used in the Global/Local Paradigm (Navon, 1977).

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H       H          S      S
H       H          S      S
H       H          S      S
H H H H H          S S S S S
H       H          S      S
H       H          S      S
H       H          S      S

  H H H              S S S
H       H          S      S
H                  S
H H H H H          S S S S S
        H                 S
H       H          S      S
  H H H              S S S
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Empirical Paper

An Investigation of the Strengths and Weaknesses in Perceptual Processing in Autism: A Test of Central Coherence.

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Prepared as if for submission to the Journal of Child Psychology and Psychiatry

(see Appendix 5 for instructions for authors)

An Investigation of the Strengths and Weaknesses in Perceptual Processing in Autism: A Test of Central Coherence.

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Running Header:

Weak Central Coherence in Autism

An Investigation of the Strengths and Weaknesses in Perceptual Processing in Autism: A Test of Central Coherence

Abstract

Clinical observations have shown strong evidence of a dominant piecemeal processing style in autism. Empirical studies have assessed the processing of wholes versus parts in individuals with autism to address this perceptual style and explain both the strengths and weaknesses seen in visual performance. The central coherence account of autism has suggested that individuals with autism do not integrate information in context. The aim of the present study was to investigate weak central coherence in children with autism, using a task tapping global processing and a task tapping local processing. It was predicted that on a global task, children with autism would display weak performance, while on a task that involved local processing, they would show strong performance. Participants included matched groups of children with autism (n=17), children with moderate learning disabilities (without autism) (MLD) (n=20) and typically developing children (n=22). The global task required the participants to recognise representations of a person and their actions in moving point-light displays, presented on a computer. The local task was the Children's Embedded Figures Test (CEFT), which has been recognised as a measure of local processing bias. As predicted, the children with autism were less able to recognise the person and the action represented in point-light displays. In contrast, the children with autism were as good as the MLD and typically developing controls on the CEFT. The findings were consistent with the weak central coherence account of autism.

Key Words: autism; perception; central coherence; biomechanical motion.

An Investigation of the Strengths and Weaknesses in Perceptual Processing in Autism: A Test of Central Coherence

Introduction

The Diagnostic and Statistical Manual for Mental Disorders (DSM-IV) (American Psychiatric Association, 1994) and the International Classification of Diseases (ICD-10) (World Health Organisation, 1992) have highlighted three main diagnostic criteria for autism. The first criteria focus on qualitative impairments in social interaction. The second highlights qualitative impairments in communication and imagination. The third criteria focus on restricted and stereotyped patterns of behaviour, including adherence to routines, and stereotyped motor mannerisms. There are also other common signs in autism that may be related to these behaviours, and are now recognised to be essential to diagnosis (American Psychiatric Association, 1994). These include preoccupation with parts of objects.

There are two main cognitive theories that have been proposed to account for the behavioural symptoms of autism. The theory-of-mind deficit account of autism has been put forward to explain the social and communication problems in autism (Baron-Cohen, 1995; Baron-Cohen, Leslie & Frith, 1985). Theory-of-mind deficits have been defined as problems understanding social situations, resulting from an inability to understand that other people have a set of beliefs about the external world, which may be different to their own. The executive function account of autism has been proposed to explain the restricted and repetitive behaviours in autism (Russell, 1997; Turner, 1999). This theory has proposed that individuals with autism experience difficulties in essential tasks that reflect executive functions, for example, attention shifting, planning, flexible thinking and disengaging from reality (Ridley, 1994).

A further account of autism has been put forward to explain the non-social aspects of autism. Weak central coherence has been put forward to provide a framework for understanding the strengths and weaknesses seen in autism. In this respect, central coherence can explain patterns of behaviour that the theory-of-mind and executive function accounts do not address (Happe, 1999). Central coherence is described as a tendency to integrate information into meaningful representations (Frith, 1989). A number of researchers have proposed that autism can be characterised by weak central coherence, reflected in difficulties processing information in context (Happe, 2000) and a tendency to focus on parts of objects (Shah & Frith, 1983, Happe, 1996). Frith (1989) has proposed that weak central coherence can account for this pattern of behaviour in autism. Central coherence is described as the drive to process holistic properties. If this drive is weak, the result may be a difference in the perception of the global level of a stimulus. Therefore, the weak central coherence hypothesis in autism has suggested that individuals with autism fail to integrate information at a global level, within a visual context (Frith & Happe, 1994). This proposition has suggested they show a preference to process information locally rather than globally and tend to focus on parts rather than the whole (Frith, 1989). This type of processing gives individuals with autism an advantage on visuo-spatial tasks where attention to local information is required, but disadvantages them on tasks requiring recognition of global meaning or integration of stimuli in context.

There have been several clinical and anecdotal accounts that give a strong indication of perceptual differences in autism, when compared with typically developing individuals (Frith & Baron-Cohen, 1987). These observations have documented unusual experiences of perception that indicate heightened awareness of fine details in individuals with autism. Descriptions have included, for example, the fascination that individuals with autism have with small details of objects in the environment (Grandin, 1995; Jolliffe, Lansdown & Robinson, 1992; Williams, 1992). Although some common themes have emerged concerning the type of stimulation that provide interest, individuals with autism are seen to be fairly idiosyncratic with respect to the particular stimuli that they focus on (Frith & Baron-Cohen, 1987). Furthermore, once engaged, individuals with autism appear to process very little outside the object of interest. These features of autism have led researchers to suggest that individuals with autism have a general predisposition to process a limited part of the information available in the environment.

Recent research has tested the weak central coherence hypothesis, to see whether such a pattern of processing is evident in children with autism (Happe, 1996; Shah & Frith, 1983, 1993). Studies using visuo-spatial tasks that require local processing skills have demonstrated that individuals with autism are faster and/or more accurate than matched controls, on the Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971). This test involves the detection of a target figure embedded with a larger figure (Jolliffe & Baron-Cohen, 1997; Ozonoff, Pennington & Rogers, 1991; Shah & Frith, 1983). In addition, it has been well established that individuals with autism show superior performance on the Block Design subtest of the Wechsler Intelligence Scales (Wechsler, 1974; 1981; Shah & Frith, 1993), by assembling a shape from component parts faster than matched controls. Shah and Frith (1993) have hypothesised that this performance has reflected an ability to focus on the local parts, rather than on the global design. This enhanced performance has been successfully replicated in other studies (Allen, Lincoln & Kaufman, 1991; Happe, 1994).

This pattern of results stands in contrast to the perceptual processing of individuals with typical development, where global analysis has been shown to take precedence over local analysis (Navon, 1977). Gestalt psychologists have suggested that, in typically developing children, there is a "drive" to process the holistic properties of a stimulus prior to its constituent parts, and that this drive must be overcome in order to detect a part which is embedded within the holistic percept (Koffka, 1935; Kohler, 1929). There are a number of studies that have demonstrated that typically developing individuals respond more rapidly to the global structure of a stimulus (e.g. Robertson & Lamb, 1991; see Kimchi, 1992 for a review). With respect to the Embedded Figures Test, for example, the classic view in typical development, has been that accessing the local properties embedded in a holistic percept needs effort and impedes the detection of an embedded figure (Kimchi, 1992). According to the weak central coherence hypothesis, individuals with autism can immediately access the constituent parts of a stimulus and therefore, show superior performance on embedded figures and block design tasks.

Further evidence for weak central coherence has been seen in the "savant" features of autism, which are often in visuo-spatial domains. For example, graphic talent in individuals with autism, have been suggested to reflect a detail-focused processing style, as they often draw by detail, rather than the more usual sketching of the outline, followed by details (Mottron & Belleville, 1993; Mottron, Bellville & Menard, 1999; Pring, Hermelin & Heavey, 1995).

If children with autism have weak central coherence, then in contrast to their superior performance on visuo-spatial tasks that involve local processing, then they should show atypical performance on tasks that tap global processing. This has been shown in several studies. For example, children with autism have shown a failure to disambiguate homographs using surrounding word context (Frith & Snowling, 1983; Happe, 1997) and a failure to enumerate canonical patterns when counting (Jarrold & Russell, 1997). Additional supporting evidence for weak central coherence in autism has been reported by Happe (1996). The results of her study have suggested that individuals with autism may be less susceptible to visual illusions, compared with typically developing children. Here, participants inspected a variety of lines and shapes presented in a context that effected illusory distortion. Those with typical development were susceptible to the illusions and judged, for example, that two lines of physically identical length were different. In contrast, significantly more participants with autism made judgements about the stimuli in accordance with their physical properties. Further, typically developing participants benefited from having the stimuli pre-segmented with added colour and depth. In this case, they were less likely to succumb to the illusion. Individuals with autism gained no such benefit, because their judgements were already at or near ceiling in the condition without pre-segmentation.

Although weak central coherence has been fairly successful in explaining both the deficits as well as the assets found in autism, there have been some findings that do not give support to this theory (e.g. Mottron, Burack, Stauder & Robaey, 1999). Brian and Bryson (1996), for example, presented the Embedded Figures Test to participants and found that participants with autism were no faster then controls. More recently, Ropar & Mitchell (1999) failed to replicate Happe's

(1996) study looking at susceptibility of people with autism to visual illusions. They reported that individuals with autism showed the same susceptibility to the illusions as controls. Other studies have implemented the Navon hierarchy task (Navon, 1977) to test the weak central coherence hypothesis in individuals with autism (Mottron et al., 1999; Ozonoff, Strayer, McMahon & Filloux, 1994; Plaisted, Swettenham & Rees, 1999). This task has been utilised to assess contextual effects in pattern recognition. That is, the competition and reciprocal influences between recognisable parts in complex objects or arrays of objects. The results of these studies have provided no evidence that individuals with autism have a deficit in the ability to perceive a Gestalt. Plaisted et al. (1999) found evidence of local advantage when participants were required to divide their attention between local and global levels, but not in a selective attention task. As a result of these findings, it has been suggested that it is better to test the weak central coherence hypothesis using novel tasks that explicitly require the integration of information for successful performance (Plaisted, 2000).

Despite contradictory findings of weak central coherence, there has remained strong support, from both empirical work and clinical accounts that perceptual differences do exist in autism. Some explanations have been put forward to explain empirical discrepancies. These include, for example, differences in tasks, methodologies, and samples of participants. The weak central coherence hypothesis has been shown to be an account that can explain and predict some strengths and weaknesses in performance in autism. The aim of this paper was to continue the investigation of weak central coherence, by exploring further, the processing of perceptual stimuli in children with autism. More specifically, it aimed to compare two tasks, one that would predict a performance weakness, because it taps global processing and one that would predict a performance strength, because it taps local processing. It was predicted that children with autism would show different performance on these two measures, that would highlight both the strengths and weaknesses demonstrated in individuals with autism.

Firstly, this study investigated whether individuals with autism were impaired in recognising biomechanical motion, a task requiring global processing. Johansson (1973) pioneered the presentation of biomechanical motion in an unfamiliar form that appears to be easily recognised by young children and adults. This technique has involved filming a person with reflective patches attached to their joints. On playback, all that is displayed on the monitor are the points of light, with the person being invisible. It has been shown that typically developing adults can see a person in such displays, even when the displays are presented for very brief exposure times (Johansson, 1973). In addition, person-related features, such as the sex and identity of individuals, have been consistently recognised (Cutting & Kozlowski, 1977; Kozlowski & Cutting, 1977). Moreover, this capacity appears to be an early emerging ability. Five-month old infants have been reported to show preferential attentiveness to such displays, compared with randomly moving point-lights (Bertenthal, Proffitt & Cutting, 1984; Fox & McDaniel, 1982). These results have provided suggestive evidence that the visual system is picking up ecologically significant information from the biomechanical motion portrayed.

The perception of biomechanical motion under point-light conditions is entirely dependent on the ability to put together the disparate points of light and perceive the organised "whole" that exists. Therefore, this technique tested the ability to recognise Gestalt stimuli, by examining whether the participants have a perceptual processing preference for seeing parts over wholes. This method has taken a crucial step to look at how naturally occurring stimuli are processed by individuals with autism. Using this test on a population of children with autism has also provided a further critical test of whether they can perceive meaningful objects and events in point-light displays. From a methodological point-of-view, a point-light approach to perceiving bodily configurations is ecologically valid, but represents an unfamiliar and novel stimulus. This consideration has been suggested to be important when assessing weak central coherence in individuals with autism (Plaisted, 2000).

This study focused on how participants perceived a whole-body actions represented in point-light displays. A recent study has used this paradigm successfully with children with autism, although the focus of the study was to identify whether the perception of bodily configurations was distinct from the attribution of internal states, when the stimuli were presented in point-light displays (Moore, Hobson & Lee, 1997). Moore et al.'s (1997) study aimed to assess whether basic person-perceptual abilities underpin the ability to develop theory-of-mind. Firstly, they identified that children with autism did not differ in their ability to recognise that a person was represented in briefly appearing point-light displays of someone walking, compared with matched controls. Secondly, they found that children with autism were worse at identifying actions, compared with matched controls, but group differences were small and not significant. The autism group was, however, significantly worse at identifying emotional states displayed in body postures compared with matched controls.

In comparison, the methodology of the present study was adjusted to ensure that the paradigm addressed the issue of whether children with autism were able to perceive Gestalt stimuli. Previous work has shown that recognition of biomechanical motion is influenced by the type of action category used (Dittrich, 1993). Moore et al.'s (1997) study did not directly address this difference. When looking at the ability of children with autism to recognise a person in point-light display, they used only the action of walking. This action has been shown to be the easiest to identify in point-light display (Dittrich, 1993). Therefore, three categories of actions that differ in how easily they have been recognised in point-light displays were included in the present study. These were locomotory, instrumental and social actions (Dittrich, 1993). This approach is particularly important when working with the autism population, since it has been suggested that individuals with autism might have generalised deficits in perceiving Gestalten, or in integrating and interpreting meaningful perceptual input (Frith, 1989; Hermelin & O'Connor, 1970; Langdell, 1978). Secondly, when looking at the ability to label actions and emotions, Moore et al. (1997) told the participants that the stimuli was of a person doing something. Therefore, the task did not directly test Gestalt perception, but simply what was inferred in the person's movements.

The Children's Embedded Figures Test (CEFT) (Witkin et al., 1971), was also included in this study, as a comparative task. This task is an accepted measure of central coherence bias that has been used extensively in other studies (Brian & Bryson, 1996; Jolliffe & Baron-Cohen, 1997; Ozonoff, Pennington & Rogers, 1991; Shah & Frith, 1983). This task requires a piecemeal processing style for superior performance. By including this task, the present study tested both the strengths and weaknesses, seen in previous studies that address weak central coherence.

A computer programme was developed to illustrate biomechanical motion in point-light displays. This methodological approach was adopted to discover whether children with autism could apprehend a person and the more complex meaning of an action in fragmented displays. The performance of children with autism was compared with matched children with moderate learning disabilities (MLD) without autism and typically developing children. Based on the weak central coherence hypothesis of autism, it was predicted that firstly, the participants with autism would be less able to process the form (i.e. they would fail to integrate the dots into a whole), compared with the matched MLD and typically developing control participants. With respect to performance on the CEFT, a second hypothesis was constructed, predicting that the autism group would perform as well, or better than the control groups on this task.

Method

Design

This study employed a between-groups experimental design. There were three groups. One experimental group that consisted of children with autism, and two control groups. One control group consisted of MLD children and the other of typically developing children. Each child was assessed for cognitive ability using two measures: a verbal and non-verbal measure of ability. Each child was then given two experimental measures. Thus, the independent variable was the group they were assigned to. The dependent variables were the two experimental measures.

Participants

Fifty-nine boys (N=59) between the ages of 7-11 years old were recruited from three schools within one local education authority. These were two MLD schools and one mainstream school. Seventeen (n=17) boys (mean age: 8 years and 8 months) with a primary diagnosis of childhood autism (ICD-10, F84.0) made up the experimental group (World Health Organisation, 1992). All had received their diagnosis through a regional autism diagnostic centre. The autism cohort had a secondary diagnosis of moderate mental retardation (ICD-10, F71) (World Health Organisation, 1992) and attended MLD schools. All children had expressive language. The further forty-two boys made up the two control groups. The first control cohort consisted of twenty (n=20) children (mean age: 9 years and 4 months) with a primary diagnosis of moderate (non-specific) mental retardation (ICD-10, F71) (World Health Organisation, 1992), and attended MLD schools. The second control cohort consisted of twenty-two (n=22) typically developing children (mean age: 8 years and 3 months), who attended a mainstream school and had no clinical diagnosis. No child with known neurological problems (e.g. epilepsy, ADHD, impaired vision and motor co-ordination problems) was included in the study. Females were also not included, on the basis that there is a possibility of gender differences in weak central coherence and local/featural processing. Autism shows a very high male to female ratio, especially at the high-ability end of the spectrum (Kramer, Ellenberg, Leonard & Share, 1996; Maccoby & Jacklin, 1975).

The three cohorts were assessed for verbal and non-verbal ability using the short form of the British Picture Vocabulary Scale (BPVS: Dunn, Dunn, Whetton & Pintilie, 1982), and the Raven's Coloured Progressive Matrices (RCPM; Raven, 1965; Raven, Raven & Court, 1998) respectively. The BPVS (Dunn et al., 1982), is used to establish a receptive vocabulary (verbal ability) age equivalent. This test has been widely employed as a matching procedure for studies in autism (Happe, 1996; Moore et al., 1997). The short form has been standardised on a large sample of children between the ages of 3 and 19 years and has information on satisfactory reliability (0.75-0.86) (Dunn et al., 1982). The RCPM (Raven, 1965; Raven et al., 1998) is a non-verbal measure of ability. This is a standardised 36-item test of perceptual reasoning, which has information on good test-retest reliability (0.86-0.92) (Raven et al., 1998). In addition, it has norms for children in the 5-11 year old range. This test has also been used to match participants in previous studies (e.g. Shah & Frith, 1983).

Participant characteristics are shown in Table 1. In order to compare groups on chronological age, verbal ability and non-verbal ability, three oneway Analyses of Variance (ANOVA) were performed on each variable. A 3(group - autism, MLD and typically developing) by chronological age ANOVA showed that the groups did differ significantly in chronological age (F (2, 56) = 5.777, $p<.005$). A 3(group - autism, MLD and typically developing) by verbal ability (BPVS raw scores) ANOVA indicated significant differences between the three groups on this measure (F (2, 56) = 10.063, $p<.001$). A 3(group - autism, MLD and typically developing) by non-verbal ability (RCPM raw scores) ANOVA indicated that there were no significant differences between the three groups (F (2, 56) =1.764, NS, $p>.05$). Post hoc comparisons (Scheffe tests) revealed that the typically developing control group was significantly younger than the autism and MLD groups ($p<.005$). On the BPVS, the control group scored significantly better than the autism group ($p<.001$). There were no significant differences between the autism and MLD groups or between the MLD and typically developing control groups. On the RCPM, there were no significant differences between the groups. The autism group have been shown to perform as well as MLD and typically developing controls in other studies (Shah & Frith, 1983) and is likely to be due to good visuo-spatial skills that have often been demonstrated in autism. Overall, the autism and MLD cohorts did not differ significantly on any variable and were therefore, approximately matched for chronological age, verbal and non-verbal ability.

Insert Table 1 about here

Measures and Materials

There were two experimental measures. All participants in the three groups were administered a biomechanical motion stimulus task and the Children's Embedded Figures Test (CEFT), developed by Karp and Konstadt (Witkin et al., 1971). The administration of the experimental measures was counterbalanced to prevent order effects. Half of the children were administered the biomechanical motion stimulus task followed by the CEFT. The other half were administered the CEFT first, followed by the biomechanical motion stimulus task.

Biomechanical Motion Stimulus Task. A biomechanical motion stimulus task was produced in accordance with Dittrich (1993). A male and a female actor, of comparable heights, were filmed performing a series of eleven actions. A full description of all actions is shown in Table 2. These included three different categories of action; locomotory actions (e.g. walking, jumping and leaping), instrumental actions (e.g. hammering, stirring, box lifting and ball bouncing) and social actions (e.g. dancing, boxing, arguing and greeting). These actions were converted into point-light displays, by attaching fourteen one centimetre square green patches to the head, shoulders, elbows, wrists, hips, knees and ankles of each actor. The sequence of actions was recorded with a video camera using Colour Separation Overlay ®. This technique involved the video camera recording only one colour spectrum (i.e. green). On playback, this effect gave the impression of white dots on a black background. Therefore, all that was visible was the patches attached to the person, with the person themselves invisible.

Each action was choreographed and rehearsed twice before filming. All actions began in a neutral static position. For the locomotory and instrumental actions, recordings were taken from the side view. Where locomotion was involved, the actor moved from the right to left side of the screen and back again. During the performance of instrumental actions, the tools were not marked or visible. Two recordings were made of each action, one from each actor. In performing social actions, both actors participated together. Each action was edited to provide 50-60 seconds of stimulus presentation.

Insert Table 2 about here

Piloting Procedure. It was necessary to pilot the biomechanical motion stimulus task. Four adults and ten typically developing boys (mean age: 8 years 6 months; age range: 7 years 7 months - 10 years 1 month) were involved in the piloting study. These boys did not participate in, and were blind to, the experimental study. The pilot trial aimed to establish whether the point-light displays were representative of the actions and whether both the person and action could be identified. In addition, it aimed to determine whether the actions could be rank-ordered on a scale of easy to hard.

Firstly, the stimuli were presented to the adult pilot participants in a random order. They were asked to give spontaneous descriptions of the point-light displays. Data was collected on accuracy and latency of response. There was 100% accuracy in the judgements of the raters for all actions except one, the social action of greeting. This action was eliminated, since it could not be identified. The remaining ten point-light displays were then rank ordered on a scale of easy to hard, according to data regarding the time it had taken for each of the point-light displays to be identified. The locomotory actions were more easily identified than the social actions. The instrumental actions were the most difficult to identify. Therefore, the actions were ranked from easy to hard in the following order: walking, jumping, leaping, dancing, boxing, arguing, hammering, box lifting, stirring and ball bouncing. The stimuli were then presented to the ten children. This presentation was counterbalanced. Five children were presented the stimuli in the order from easy to hard and five children were presented the stimuli in the reverse order, from hard to easy. Again data was collected on the accuracy and latency of response. This method ensured that the stimuli were identifiable by children and identified any possible order effects.

On the basis of the data collected from this pilot study, all ten point-light displays were identifiable. However, piloting indicated that there was a priming effect according to which actions were displayed first. For example, the actions that involved locomotion (e.g. walking, jumping and leaping) appeared to have a priming effect, in that, once human movement was identified, this acted as a prompt for subsequent actions. To eliminate the priming effect, the presentation of the actions during the experimental condition would be pseudo-randomised (see below). It was also noted that there was some variation in the specific terms used to describe the actions (e.g. "running" and "jogging" for "leaping). This needed to be taken into account when scoring the data (see below).

Following piloting, the video was digitised and transferred into a computer programme. The programme was written to include a pseudo-random presentation. This involved the computer generating a random number between one and ten. For the first three consecutive trials, if the number generated corresponded to a simple stimulus (e.g. walking, jumping, leaping), the computer would then generate another random number. This ensured a pseudo-random presentation that would eliminate a priming effect.

Additionally, in order to prevent response bias, the ten point-light displays were integrated with ten distracter stimuli. These were taken from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 1997). They were basic line drawings of normative neutral pictures in the ability range of the children (e.g. book, fork, basket, truck, flower, carrot, cake, light bulb, umbrella and pencil). They were presented in a moving starburst form and were white against a black background. This display was similar to the biomechanical motion stimulus task.

The Children's Embedded Figures Test. The CEFT was designed to assess field dependence in young children. It has been standardised on a small sample of 160 children, ranging from 5-12 years. The authors have described the normative data as tentative and advise that it should only be used as a research tool. Data are available on validity for children 9-12 years (0.70-0.86) and test-retest reliability for children 5-12 years (0.87) (Witkin et al., 1971). The test materials from the

CEFT were used, in accordance with standardised procedures (Witkin et al., 1971). The test materials consisted of two cut-out shapes (a triangle or "TENT" and a rectangle with a triangle adjoined or "HOUSE"). There were thirteen complex figures with the TENT embedded in them (two practice and eleven test items) and fifteen complex figures with the HOUSE embedded in them (one practice and fourteen test items). The complex figures resembled meaningful forms (e.g. an umbrella), with the target shape incorporated in the item, but perceptually obscured by means of the line patterns and coloured sections. The items were administered in the standardised order, with the items graded in difficulty of disembedding.

Procedure

This study received appropriate ethical approval (see Appendix 1). Three schools (two MLD schools and one mainstream school) within one local education authority, were approached in order to identify participants. With the agreement of the Headteacher and all relevant teaching staff, an information sheet describing the proposed study and an appropriate consent form (see Appendix 2) was sent out to the parents of potential child participants. 100% of parents approached agreed for their child to be a potential participant. Each child was then asked if they would be willing to participate.

Each participant was tested in a small, quiet and familiar room in his school. All participants were seen on two occasions. Firstly, for administration of the BPVS and RCPM and secondly for administration of the experimental measures (biomechanical motion stimulus task and CEFT).

Biomechanical Motion Stimulus Task. The biomechanical motion stimulus task was presented on an IBM-PC compatible computer. The child was sat 60cm in front of a 15" monitor in a dimly lit room. The monitor was covered in a black fabric tent to prevent light reflection and to reduce environmental distraction. This set up aimed to provide consistent experimental conditions across all participants. Standardised instructions were used across all participants. The experimenter said "I am going to show you some pictures on the screen. I want you to tell me what you think you can see". The biomechanical motion stimulus task was then presented as a series. Before the first presentation (point-light display or distracter picture) appeared the experimenter said "Are you ready?" This phrase also appeared on the screen. When the participant responded positively, a blank was shown on the screen (5 seconds) before the series started. Between each of the following presentations (point-light display or distracter picture) appeared, "Are you ready?" appeared on the screen and was said by the experimenter. Each item was shown for a consistent length of time (50-60 seconds). At the end of the series, the words "Well done. You have finished" appeared on the screen and the experimenter concluded the task.

If the participant gave no response during any of the presentations, the participants were prompted with "What can you see?" For the point-light displays, if the participant gave only a partial answer, they were asked if they could see anything else. For example, if the participant reported seeing a person, but did not describe the action, they were prompted with "Can you tell me some more? ...What is the....<u>the participant's description of person</u>... doing?" In addition, if the participant identified the action only, the participant was prompted with "What is doing...<u>action stated by participant</u>...?". The experimenter recorded the participant's response verbatim.

The Children's Embedded Figures Test. For the CEFT, the standard testing procedure was used (Witkin et al., 1971). Firstly, the experimenter showed the participant the simple cut-out form of the TENT and asked "What does this look like to you?". When the participant had named the figure in an appropriate way, he was administered the two practice items and eleven test items, which had the TENT figure embedded in complex drawings. For each one, the participant was asked to "See if you can find another TENT that looks exactly like ours on this page". The participants were encouraged to place the cut-out target shapes on top of the hidden shapes, in order to leave no ambiguity in task understanding. The procedure was repeated for the items containing the HOUSE shape. No time limits were set for this task.

Results

Scoring

Biomechanical Motion Stimulus Task. Responses were scored on a three-point scale for each of the ten actions. If the participant accurately captured both the person and the action portrayed in the point-light display, then they scored two points (2). If the participant identified either the person or the action, but not both, they received a score of one (1). If they identified neither, they received no score (0). A total score was given to each participant, according to their correct responses in identifying a person and the action (maximum score = 20). For the actions, participants needed to provide the actual term or a close approximation to the specified action (e.g. 'running' for 'leaping', 'fighting' for 'boxing') (see Appendix 3).

The author firstly scored all the verbatim responses. The responses were transcribed and listed in random order so that there was no indication of which participants had made which responses. The author made a judgement about each response according to the scoring criteria. In addition, an independent rater scored the verbatim responses of 30 randomly selected participants (50%). This provided a measure of inter-rater reliability. Inter-rater reliability was calculated using the Kappa statistic, which gave an overall reliability of k=.99. For each discrepancy a final score was reached by consensus and the total scores for these participants amended, for use in the subsequent analysis.

The Children's Embedded Figures Test. Each child was scored for the total number of hidden figures correctly identified out of a total of twenty-five (maximum score = 25) (Witkin et al., 1971). Correct identification was defined during task administration, according to whether the child had correctly disembedded the target figure from the complex drawing.

Data Analysis

The mean score on the biomechanical motion stimulus task, and the mean number of correct responses on the CEFT are shown in Table 3.

Insert Table 3 about here

The data were reasonably normally distributed, indicated through inspection of histogram plots. Therefore, parametric analyses were used throughout.

Chronological Age, Cognitive Ability and Performance. It was hypothesised that the differences in chronological age and cognitive ability between the groups, may have affected performance on the experimental measures. For example, although the autism and MLD groups were approximately matched for these variables, slight differences in performance were observed. Additionally, the typically developing control group was seen to differ significantly on these variables. Therefore, Pearson's correlations were used to confirm whether chronological age and cognitive ability, (as assessed by the BPVS and RCPM), were related to performance on the experimental measures. These correlations are shown in Table 4.

Insert Table 4 about here

Scores on the biomechanical motion stimulus task were significantly positively correlated with performance on the BPVS and RCPM. Scores on the CEFT were significantly positively correlated with performance on the RCPM. However, the variable of chronological age was not significantly correlated with either the BPVS or RCPM. Therefore, it was necessary to statistically control for cognitive ability when running the analysis, by using Analyses of Co-Variance (ANCOVA). Two oneway ANCOVAs were performed, one on each dependent variable, to determine whether the three groups differed in performance on the biomechanical motion stimulus task and CEFT, when the potentially confounding effects of cognitive ability were controlled for. Simple contrasts, where the autism group was compared with the MLD and typically developing controls, were performed on adjusted scores, derived from the ANCOVA.

Biomechanical Motion Stimulus Task. A oneway 3(group - autism, MLD and typically developing) ANCOVA indicated that the pattern of performance on the biomechanical motion stimulus task differed significantly across the three groups (F (2, 54) = 3.573, p<.05). Further analysis, using simple contrasts, revealed that there was a significant difference between the autism and MLD groups (p<.05) and a significant difference between the autism and typically developing groups (p<.05). With cognitive ability controlled for, the autism group showed a significantly lower performance compared with the MLD or typically developing groups, that was not as a result of cognitive ability. The mean level of performance for the biomechanical motion stimulus task for each group is shown in Figure 1.

Insert Figure 1 about here

It can be suggested that the autism group might be performing at a lower level due to the different types of action used in the biomechanical motion stimulus task. In order to identify whether the types of action used in the biomechanical motion stimulus task (e.g. locomotory, instrumental and social) were affecting performance in the autism group, a 3(group - autism, MLD, typically developing) by 3(actions - locomotory, instrumental, social) split plot ANCOVA (SPANCOVA) was performed (group was between measures and type of action was repeated measures). Weighted means were calculated for each type of action, (total score for the type of action divided by the number of actions in that group). The SPANCOVA indicated that there was a significant main effect of group on the biomechanical motion stimulus task (F (2, 54) = 3.810, p<.05), as expected from the analysis above. In addition, there was a significant main effect of type of action (F (1, 54) = 9.145, p<.005). This effect can be seen in Figure 2. However, no significant interaction effect between group performance and type of action was found (F (2, 54) = .848, NS, p>.05). Therefore, there was no evidence to suggest that the autism group were performing worse for any one type of action used in this task. That is to say that, the type of actions presented did not affect individual group performances. This effect is shown in Figure 2.

Insert Figure 2 about here

The Children's Embedded Figures Test. In order to explore group differences on the CEFT, a oneway 3(group - autism, MLD and typically developing) ANCOVA was performed. This analysis showed that there was no significant difference in performance across the three groups (F (2, 54) = 1.570, NS, p>.05). The adjusted means (when cognitive ability is controlled for) showed a similar performance on the CEFT across all groups, as shown in Figure 3.

Insert Figure 3 about here

Discussion

The aim of this study was to explore Gestalt perception in children with autism. Following Frith's (1989) proposition that children with autism have weak central coherence, it aimed to show that they would perform less well, compared with matched control groups, on a task requiring global processing, but would show enhanced performance on a task requiring piecemeal or part-processing. The results showed that on a biomechanical motion stimulus task, a task requiring global processing, the autism group's performance was significantly impaired relative to the MLD and typically developing children. Moreover, this impairment was present even when controlling for verbal and non-verbal ability across the three groups. Although this task used three different types of action stimuli (locomotory, instrumental and social), children with autism were not specifically disadvantaged on any type of action. Analysis showed that all three groups were better at identifying locomotory actions, compared with instrumental and social actions. In contrast, the results showed that on the CEFT task, a task requiring piecemeal processing, children with autism did not show any impairment relative to control groups. Children with autism were as accurate on this task (identifying as many embedded figures). Group differences were small and not significant.

These findings, showing an autism-specific weakness in perceiving Gestalt input, and a strength in processing local stimuli in a sample of male children, are compatible with the theory that autism is characterised by weak central coherence (Frith, 1989). The results of the present study support previous findings showing weak central coherence in children with autism (e.g. Happe, 1996; Jolliffe & Baron-Cohen, 1997). Studies have reported that individuals with autism show weak performance on tasks that require global processing (e.g. Happe 1996). For example, children have shown impaired performance in reading for meaning (Frith & Snowling, 1983, Happe, 1997). They have also failed in visual counting tasks (Jarrold & Russell, 1997). Similarly, individuals with autism are less susceptible to visual illusions (Happe, 1996). Taken together, these findings suggest that individuals with autism are weak at processing information in context.

The results of the present study suggest that the poor performance on the biomechanical motion stimulus task, reflect a deficit in integrating the point-lights into the whole form. According to the Gestalt notion of perceptual grouping, children with autism may have differed in their interpretation of the stimuli by the process with which they group the point-lights together. For example, they may have perceived the display of moving point-lights as an unrelated swarm of randomly moving dots, or they may have detected parts of the configurations. For example, previous research (Bertenthal, Proffitt & Cutting, 1984) has suggested that figural coherence is not an all or nothing affair. The relative motions that are extracted from the biomechanical displays determine their interpretation. For example, it is possible for the observer to perceive something more than arrays of unrelated and randomly moving dots, but still not perceive any figural connectivity between individual point-lights. Specifically, in such complex phenomena as biomechanical motion in point-light displays, there is an indefinite number of possible configurations that could be perceived depending on what relative motions are extracted. For example, substructures, such as the upper and lower body, may be connected or remain apart. A host of other configurations that are consistent with the morphology of the human form, may be perceptually grouped, but not capture its holistic character. Therefore, the children with autism may have grouped the lights in a different way, due to processing the parts, rather than the whole. These ideas fit with the notion of weak central coherence in autism. This explanation for the performance of the autism group clearly needs more sophisticated research to identify how these individuals process point-light displays.

Featural processing has been shown to affect face recognition, as reflected in reduced decrement from inversion in face recognition tests (Hobson, Ouston & Lee, 1988) and hamper emotion recognition (McKelvie, 1995). This study further suggests that dominant processing of the parts hampers the recognition of whole-body actions. This finding appears inconsistent with those of Moore et al. (1997). They found no significant differences in the ability of children with autism and MLD controls, to recognise human actions, when presented in point-light displays. However, it was observed that the autism group did perform at a lower level compared with the MLD controls. The differences in the methodologies of Moore et al.'s (1997) study and the present study may account for the conflicting findings. For example, Moore et al. (1997) made their task easier by informing the participants that the stimulus was of a person. Participants were then only required to identify what the person was doing. The present study used biomechanical motion as a Gestalt task, that is argued to provide a reasonable index of individuals' relative bias toward either a global or local visual approach, by their ability to integrate the dots into a whole form. If the participants are provided with the information that the stimulus is a person, there is no requirement to integrate the dots, only a need to label the movement of the dots as a particular human action. Evidence of a weak drive for central coherence does not imply that an individual will never adopt a global approach. Therefore, the extent to which a local or global approach is implemented will depend on the interaction between an individual's bias and the requirements of the particular task (Jarrold & Russell, 1997; Plaisted et al., 1999). In addition, Moore et al. (1997) did not control for cognitive ability in their analysis. The present study indicated that both verbal and non-verbal ability related to performance. Moore et al.'s participants were a significantly older group of children (mean age: autism group: 14years and 9 months, MLD group: 14 years and 2 months, typically developing group: 7 years and 11 months) and higher in their verbal ability. This could contribute to the differences between their findings and the current study.

The results of the present study also support previous findings that have shown strong performance on tasks involving piecemeal processing (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983, 1993). The results specifically replicate previous findings using the Embedded Figures Test (Jolliffe & Baron-Cohen, 1997; Ozonoff et al., 1991), where individuals with autism are seen to perform as well as matched controls. However, the present finding did not replicate the finding of significantly superior performance on the CEFT by Shah and Frith (1983), when the participants were scored for accurate performance. Jolliffe and Baron-Cohen (1997) only found significantly superior performance on the Embedded Figures Test, when they collected response time data, rather than simply accuracy data. Therefore, it may be necessary to measure response time to find a significantly superior performance among the children with autism.

It is possible that the superior performance observed in some studies measuring piecemeal processing, may be related to the developmental age of the participants (Brian & Bryson, 1996). This suggestion is in line with weak central coherence theory, which argues that typically developing children develop control over high-level central force towards cohesion with age (Frith, 1989). Thus, the superior performance of children with autism on the CEFT, may be less apparent with increasing developmental age, because typically developing individuals may become more proficient at this task (Witkin et al, 1971).

The weak central coherence theory has been most useful in explaining the patterns of performance seen in autism. It has bridged the gap left by the deficit accounts of autism, theory-of-mind and executive function, in its ability to explain the strengths of autism. The question now is whether the deficit accounts can be linked with the central coherence account of autism. The present study provides important information about how children with autism process Gestalt stimuli of people. This finding may have important implications for linking the social deficits seen in autism, with perceptual processing. Frith (1989) proposed weak central coherence might be the root of social difficulties seen in autism. She argued that social interaction, including an ability to understand mental states, requires the ability to see things as a whole unit. Therefore, strong central coherence is important in theory-of-mind development, because it biases the individuals to take a global view of a situation and to integrate social information. Therefore, if individuals with autism show featural processing of faces (Hobson et al., 1988) and of whole-person stimuli, the present study suggests they may be unable to derive the necessary emotional information, emitted through facial expression (McKelvie, 1995) and body posture (Moore et al., 1997), for appropriate social interaction. In order to appreciate people's thoughts and feelings, it is necessary to integrate diverse information and take account of context. Therefore, individuals with weak central coherence and detail-focused processing are likely to be less successful in putting together the information necessary for sensitive social inference (Happe, 2000).

In support of the link between weak central coherence and theory-of-mind, recent work has been done to show that weak central coherence, assessed using the CEFT, is correlated with worse performance on theory-of-mind tasks (Jarrold, Butler, Cottington & Jimenez, 2000). In this study, it has been suggested that weak central coherence may lead to poor theory-of-mind, based on the premise that central coherence appears to be a lower level process than theory-of-mind. For example, the effects of central coherence bias have been seen in low-level tasks, such as counting visual stimuli (Jarrold & Russell, 1997), locating embedded figures (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983) and susceptibility to visual illusions (Happe, 1996). Future research needs to continue to explore this issue, using methodologies that are sensitive enough to reveal a true relation between the two. If a link is established, it may go some way to providing an integrated theory of autism. Research linking weak central coherence and executive dysfunction in autism may also be important. Therefore, it is important to continue exploring the perceptual abilities of individuals with autism and define whether weak central coherence may contribute to the difficulty that individuals' with autism have in understanding the world.

The present study used a male sample and therefore the results cannot be assumed to relate to all children with autism. Future research could establish whether this finding is also evident in a female sample. In addition, to extend the present study, future research could explore whether younger children and infants with autism, and indeed low-functioning children, have a weakness in perceiving Gestalt stimuli. Gestalt psychologists have provided evidence that global/local processing abilities are present at or shortly after birth (Slater, 1996). Therefore, it is important to trace the perceptual processes of individuals with autism back to earlier stages in life, to identify whether there are fundamental differences in biologically-based perceptual processes (Freedland & Dannemiller, 1996). Developing a non-verbal paradigm using point-light displays may provide important evidence of whether there is a cognitive difference in processing perceptual information from an early age. For example, preferential-looking paradigms (Fantz, 1961) that use random dot displays versus biomechanical motion presented in point-light displays and habituation paradigms (Horowitz, 1974) could be set up. These could provide crucial information about whether infants with autism discriminate between human form and random dots and therefore, whether they prefer to look at meaningful stimuli.

The development of such a procedure could have implications for the early identification of autism during infancy. Currently, early diagnosis of autism is impeded by the behavioural criteria. The types of behaviours that are impaired in autism (according to the diagnostic criteria) do not emerge reliably in normal children until the age of three or four years. Therefore, there is an increasing need for pinpointing earlier indicators of autism. This paradigm could provide a pre-verbal measure that looks at distinct perceptual processes, through preferential-looking and discriminative behaviour, that could be evident in early infancy. Hence, using point-light stimuli and habituation paradigms to track the perceptual development of infants could lead to an early and pre-verbal tool for diagnosis. This development would also have implications for early intervention in autism, which might have a strong remedial effect. Given that experience affects the development of perception (Plaisted, 2000), it could be important to identify the perceptual differences in autism as early as possible, in order to shape perceptual discrimination, using contingent learning paradigms (Siqueland & Lipsitt, 1966).

This could provide young children with autism with a more coherent experience of the world, which may reduce social impairments seen later in their development.

In summary, the present study provides further evidence to support the weak central coherence hypothesis in autism. It shows that children with autism show a weakness in processing Gestalt stimuli and a strength in processing local stimuli. Central coherence theory currently appears to be a useful framework for thinking about autism and enhancing understanding of whether the tendency to integrate details in order to see the bigger picture, is related to our need to make sense of those around us. The notion of weak central coherence will require further systematic research to become empirically established and to identify its core mechanism. This research could be crucial for the development of early and pre-verbal diagnostic tools and subsequent interventions that could have remarkable implications for the cognitive development of children with autism.

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Table 1. Participant Characteristics: Chronological Age, Scores on the British Picture Vocabulary Scale (BPVS), including Verbal Mental Age (VMA), and Scores on the Raven's Coloured Progressive Matrices (RCPM), including Non-Verbal Mental Age (NVMA).

Group	n		Chronological Age (Y:M)	BPVS		RCPM	
				VMA	Raw Score	NVMA	Raw Score
Autism	17	M	8:8	6:4	13.94	8:5	23.06
		SD	1.08	1.85	3.58	2.14	6.68
		Range	(7:0-10:10)	(3:7-10:11)	(8-22)	(5:6-11:6)	(13-32)
MLD	20	M	9:4	7:7	16.45	8:1	21.8
		SD	1.04	1.96	3.65	1.36	4.30
		Range	(8:1-11:3)	(4:0-11:6)	(9-23)	(1:6-11:6)	(15-33)
Typically Developing	22	M	8:3*	8:9	18.68**	8:10	24.68
		SD	1.06	1.52	2.61	1.09	3.96
		Range	(7:4-10:3)	(6:3-13:10)	(14-26)	(7:0-11:0)	(18-31)

* $p < .005$

** $p < .001$

Table 2. Descriptions of the Biomechanical Actions depicted in Point-Light Displays.

Type of Action	Labelled Action	Description of Action
Locomotory	Walking	Normal walking from left to right
	Jumping	Repeatedly jumping forwards with feet together
	Leaping	Leaping forwards on one leg
Instrumental	Hammering	Repeatedly hitting a nail with a hammer
	Stirring	Stirring a bowl
	Box Lifting	Lifting a box from the floor
	Ball Bouncing	Dribbling a basketball
Social	Dancing	A couple waltzing
	Boxing	A couple sparring
	Arguing	A couple vigorously shaking their fists at each other
	Greeting	A couple shaking hands

Table 3. Descriptive Statistics for the Biomechanical Motion Stimulus Task (BMM) and Children's Embedded Figures Test (CEFT) for the Three Groups.

Group	n		BMM (total=20)	CEFT (total=25)
Autism	17	M	7.53	17.35
		SD	6.44	5.01
		Range	(0-17)	(8-25)
MLD	20	M	11.45	15.65
		SD	4.66	4.13
		Range	(3-18)	(9-24)
Typically Developing	22	M	13.00	18.95
		SD	3.53	3.24
		Range	(2-17)	(13-25)

Table 4. Correlations between Chronological Age (CA), British Picture Vocabulary Scale (BPVS), Raven's Coloured Progressive Matrices (RCPM), Biomechanical Motion Stimulus (BMM) and Children's Embedded Figures Test (CEFT).

Variables	Chronological Age	BPVS	RCPM	BMM	CEFT
Chronological Age	-	.057	-.044	.026	-.100
BPVS		-	.267*	.347**	.216
RCPM			-	.316*	.509**
BMM				-	.131
CEFT					-

**$p<.01$

*$p<.05$

Figure 1. Adjusted Mean Scores of Group Performance on the Biomechanical Motion Stimulus Task.

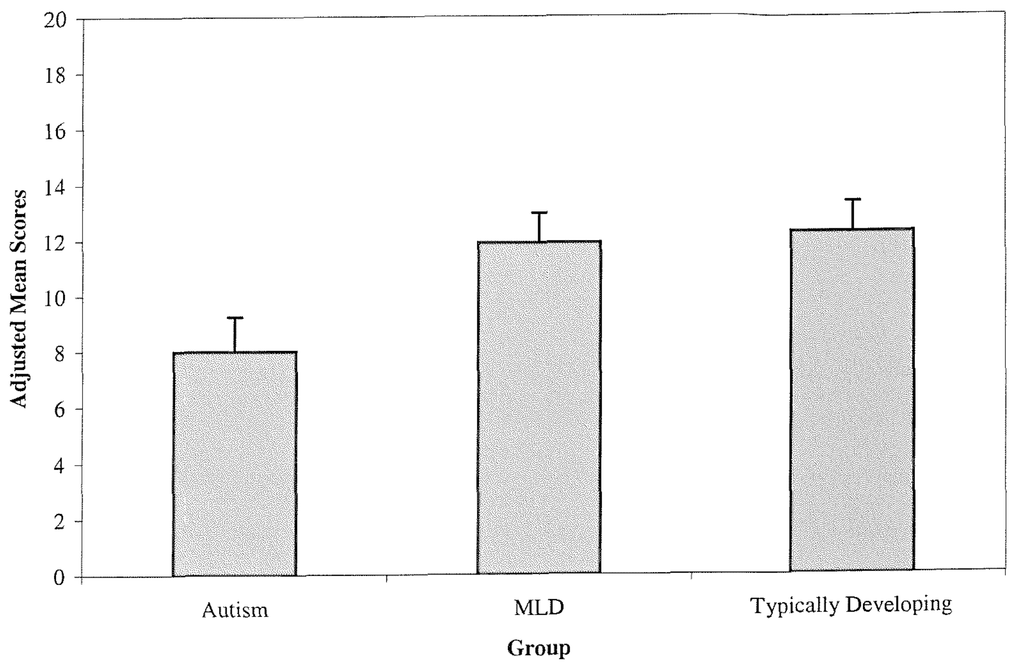


Figure 2

Interaction Effect Between Group Performance and Type of Action.

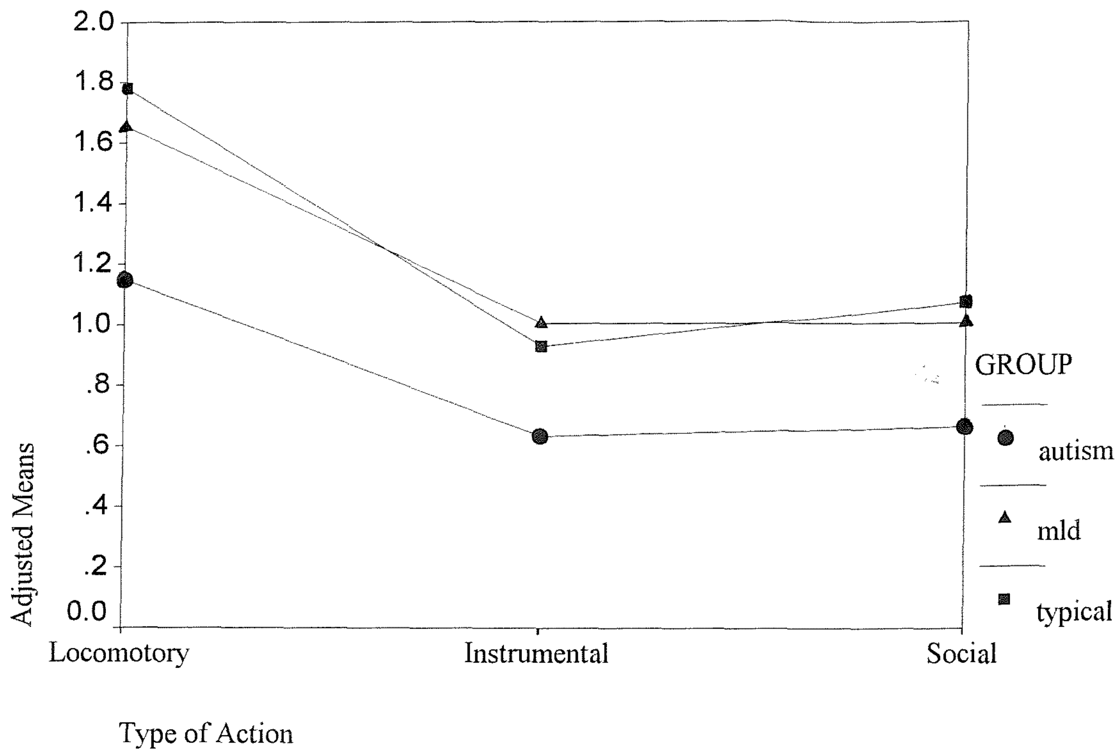
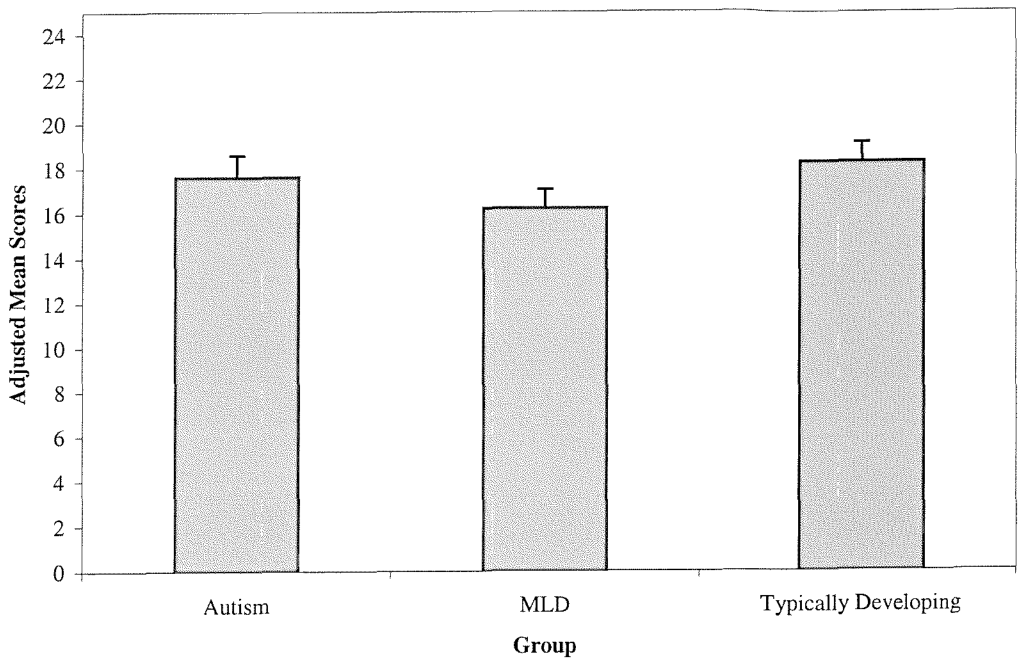


Figure 3. Adjusted Mean Scores of Group Performance on the Children's Embedded Figures Test



Strengths and Weaknesses in Perceptual Processing in Autism: An Investigation of Central Coherence.

Critical Overview

Working with children with autism has provided me with the inspiration for this study. In order to increase my understanding of the psychological deficits that are evident in autism, I was motivated to undertake a piece of research that could contribute to the expanding field of knowledge about autism. The cognitive accounts of autism have greatly increased understanding of autism, but there is still a long way to go before a complete and unified theory of autism can be presented. This experimental study has provided some new evidence that supports the weak central coherence account of autism, by providing a clear picture of the strengths and weaknesses shown on visual processing tasks that involve processing of parts and wholes.

The concept of this study was original and a unique strength. It provided the next logical step, within this field of research, by further exploring the notion of part-whole processing coherently and sufficiently. In order to achieve this aim two tasks were used, one that tapped the weaknesses seen in perceptual abilities in autism (e.g. global processing) and one which tapped the strengths (e.g. local processing). This study provided a clear and focused picture of the effects (i.e. the strengths and weaknesses) of central coherence.

Undertaking this piece of research has been a steep learning curve. The literature review provided a sufficient grasp of the background concepts of Gestalt theory in perception, within which the weak central coherence hypothesis has its origin. This understanding was important in thinking about further research in this area. The actual process of carrying out a substantial study was also enlightening. The planning and preparation of an experimental study was clearly critical to the actual running of the study. It informed me of the importance to think clearly and logically, be aware of the problems that might arise and be able to address these in the early stages, to the best of my ability, in order to produce a valid and reliable study. Although the actual data collection took some time, it involved much more time to design and develop the experimental measures, while taking account of possible problems. For example, using a novel stimulus of an everyday perceptual concept and one that may have clear implications for the social deficits seen in autism, was a clear strength. However, it was a newly developed concept and needed to be piloted. Including a pilot study of the biomechanical motion stimulus task was an important strength of this study. It was important to trial this task on a small sample of people to highlight possible problems or ambiguities and make adjustments before the actual data gathering began. This was particularly important to ensure that the stimuli were recognisable to typically developing children, before being used with a group of children with autism.

Using a point-light paradigm created an important step forward in developing a useful experimental measure that has the potential to be used with children of all developmental levels and abilities. This study aimed to establish the successful use of this paradigm with a sample of children with autism, before it can be used in the assessment of perceptual abilities in infants with autism. Therefore, using this methodological approach could possibly have exciting implications for the development of and early and pre-verbal diagnostic tool. This study could be regarded as the first in a series of experiments aimed to expand the test of weak central coherence in autism.

There were other methodological strengths of this study. The inclusion of both MLD and typically developing controls, and using a matching procedure to control for chronological age and cognitive ability was a clear strength. It was important to ensure that the observed group differences on task performance were specific to autism and not a reflection of the effects of general learning disabilities.

The experimental tasks involved the recognition and naming of visually presented materials. Therefore, this study used the BPVS, to ensure there was evidence that the tasks (which were language-related tasks) would not render the task incomprehensible to the participants with autism. Additionally, matching on the RCPM (a measure of 'non-verbal' ability) was rationalised as an appropriate task given the nature of the experimental tasks. It has been widely recognised that individuals with autism have a radically different profile of performance on intelligence tests. Therefore, matching on both of these measures was necessary, as children with autism are known to perform well on non-verbal tasks, but less well on verbal tasks. Therefore, a low estimate of ability on a verbal task, may have given a false impression of superior performance on a spatial task.

In addition, since there was a range of abilities within the groups, it was important to partial out cognitive ability in the analysis. Correlations were performed to assess the extent to which confounding factors may have affected performance on these tasks. The strength of this process tested individual group rather than developmental differences in performance. This is a distinction that is particularly relevant for the study of central coherence bias, as children are reported to become more competent at part-whole processing (e.g. perform better on the Embedded Figures Test) as they develop.

There were also weaknesses in the methodology of this study that need to be addressed in future studies. It was a disadvantage that the typically developing control group was not quite matched for cognitive ability. This difficulty could have been overcome by recruiting a chronologically younger group of typically developing children. This change would have led to them being better matched for cognitive ability and therefore, clearly illuminating the deficits and differences associated with autism. In addition, matching the groups on an individual basis, would have been useful, to keep participant variables to a minimum. This procedure was not carried out due to time constraints.

This study focused on group differences. However, it may be that individuals with autism vary among themselves in how weakly coherent their processing style is. Further research is needed to clarify whether weak central coherence is present within the autism population at differing levels or whether it is a subgroup of individuals with autism who show this processing style. It would have been useful to look at individual performances within the groups, although a matched-pairs design would have been important for this.

Other deficits in the autism group may have confounded the results. For example, although all the participants were assessed for verbal ability, given the language deficits and the social impairments often seen in autism, it would have been useful to check the ability of the children to understand what the person was doing and be able to name the action. Using pictures of the relevant actions and asking the participants to name what the person was doing could have done this.

Other improvements could have been made to this study. Firstly, accuracy in stimulus identification was measured with respect to the CEFT. It would have been useful to incorporate a time factor into this study. Including a measure of latency on the CEFT has been shown to find a significantly superior performance by the autism group in previous studies. In addition, measuring recognition time on the biomechanical motion stimulus task may have identified specific group differences in the time it takes to recognise the stimuli as a person. This methodological change could have added more experimental manipulation.

In addition, it would have been interesting to use inter-joint displays. These displays also give adequate representations of human motion. These displays have shown no evidence of impeded recognition in typically developing individuals. Using inverted stimuli would have degraded the biomechanical motion stimulus task further. This may have enhanced the picture of effects of weak central coherence, as individuals with autism would be predicted to show less decrement when the stimuli are inverted.

Gender differences have also been reported on tasks thought to tap local-global processing (Kramer, Ellenberg, Leonard & Share, 1996). The possibility of gender differences in coherence is intriguing in relation to autism, which shows a very high male to female ratio. This may suggest that the normal distribution of coherence in males may be shifted towards the weak coherence and local processing. At the weak extreme of the continuum may therefore, lay an area of increased risk for autism, particularly if the additional social deficits are also apparent. Future studies could extend this finding, by establishing gender differences in weak central coherence, using female sample. However, a totally female sample would be difficult to identify.

This study has been an important learning process in planning and executing a substantial piece of research and considering its importance in developing a clearer understanding of autism. The results are striking and provide further evidence for weak central coherence in autism. It has established the use of using a point-light paradigm with children with autism. This study should now be extended to infants with autism.

Appendices

Appendix 1	Ethical Approval from Southampton University
Appendix 2	Information Sheet and Consent Form
Appendix 3	Scoring Criteria
Appendix 4	Instructions for Authors (Psychological Bulletin)
Appendix 5	Instructions for Authors (Journal of Child Psychology and Psychiatry)

Appendix 1

Ethical Approval from Southampton University

University of Southampton

Department of Psychology

University of Southampton
Highfield
Southampton
SO17 1BJ
United Kingdom

Telephone +44 (0)23 8059 5000
Fax +44 (0)23 8059 4597
Email

Miss Beth Galliver
Children's Centre
Damers Road
Dorchester
Dorset

20th July 1999

Dear Beth,

Further to our telephone conversation earlier today, I am writing to confirm you that your ethical application titled, "Perception of biomechanical motion in children with autism", has been given approval by the department.

Should you require any further information, please do not hesitate in contacting me on (01703) 593995.

Yours sincerely,

Kathryn Smith
Academic Secretary

Appendix 2

Information Sheet and Consent Form

University of Southampton

Department of Psychology

Training Course in Clinical Psychology

University of Southampton
Highfield
Southampton
SO17 1BJ
United Kingdom

Telephone +44 (0)23 8059 5321
Fax +44 (0)23 8059 2588
Email

Dear Parent/Guardian, (of autism participants)

Information regarding a clinical research study investigating visual information processing in children with autism.

As part of my doctoral degree in Clinical Psychology, I am conducting a research study that looks at how children process visual information. This study is to look at whether children with autism approach these tasks in a different way from children without autism. Your son will enable us to look at how children with autism approach these tasks. This information will enable the Psychology service to evaluate whether such tests could be useful in the diagnosis of autism. This project will be supervised by Dr Tony Brown at the University of Southampton.

I am writing to inform you about this research study and ask if you would be prepared to give your permission for your child to be included in the study. If you allow your child to participate in this study, he will be given four short puzzles Three of these will involve looking at pictures on paper and one will be presented on a computer screen. It is anticipated that this will take 20-30 minutes to complete. However, your son is under no obligation to finish the puzzles.

Permission for involvement in this study can be withdrawn at any time. Withdrawal from the project would not require justification. Participation in this study would be anonymous and a copy of the findings would be available for your information.

I would be most grateful if you would give your permission for your child to participate in this study. Please indicate whether you are willing for your child to participate in this study by signing and returning the enclosed consent form.

If you require any further information or have any questions or queries, please do not hesitate to contact me.

Thankyou for your co-operation

Beth Galliver
Trainee Clinical Psychologist
University of Southampton

Dr Tony Brown
Chartered Clinical Psychologist
University of Southampton

University of Southampton

Department of Psychology

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SO17 1BJ
United Kingdom

Telephone +44 (0)23 8059 5321
Fax +44 (0)23 8059 2588
Email

Dear Parent/Guardian, (of control participants)

Information regarding a clinical research study investigating visual information processing in children with autism.

As part of my doctoral degree in Clinical Psychology, I am conducting a research study that looks at how children process visual information. This study is to look at whether children with autism approach these tasks in a different way from children without autism. Your son will enable us to look at how children who do not have autism approach these tasks. This information will enable the Psychology service to evaluate whether such tests could be useful in the diagnosis of autism. This project will be supervised by Dr Tony Brown at the University of Southampton.

I am writing to inform you about this research study and ask if you would be prepared to give your permission for your child to be included in the study. If you allow your child to participate in this study, he will be given four short puzzles Three of these will involve looking at pictures on paper and one will be presented on a computer screen. It is anticipated that this will take 20-30 minutes to complete. However, your son is under no obligation to finish the puzzles.

Permission for involvement in this study can be withdrawn at any time. Withdrawal from the project would not require justification. Participation in this study would be anonymous and a copy of the findings would be available for your information.

I would be most grateful if you would give your permission for your child to participate in this study. Please indicate whether you are willing for your child to participate in this study by signing and returning the enclosed consent form.

If you require any further information or have any questions or queries, please do not hesitate to contact me.

Thankyou for your co-operation

Beth Galliver
Trainee Clinical Psychologist
University of Southampton

Dr Tony Brown
Chartered Clinical Psychologist
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Email

CONSENT FORM

Visual Information Processing in Children with Autism

Participants full name:...

Parent/Guardian full name:...

Please complete the following:

	Please circle as necessary
Have you read the information sheet ?	Yes / No
Have you had an opportunity to ask questions and discuss this study ?	Yes / No
Have you received satisfactory answers to all your questions ?	Yes / No
Have you received enough information about the study ?	Yes / No
Who have you spoken to?	______________

Do you understand that you are free to withdraw from the study:

- At any time.
- Without having to give a reason for withdrawing.
- Without affecting your child's future education. Yes / No

Do you agree for your child to take part in this study ? Yes / No

I,......................................HEREBY CONSENT for my child, as named above, to take part in a clinical research investigation about which I have received written information.

Signed:______________________________ Date:____________

Appendix 3

Scoring Criteria

SCORING CRITERIA:

Each response is scored 2, 1, or 0. (Consult the general scoring principles and the sample responses that are provided below).

In general, the recognition of a person and the relevant action is acceptable, disregarding elegance of expression. However, *poverty of content* is penalised to some extent: indication of vague recognition of the stimuli does not earn full credit.

General Scoring Principles:

2 points

A good synopsis of what they see.

1. Recognition of a person (2 people for the social actions).
2. Verbs: a definitive example of action.
3. Correct descriptive features, which cumulatively indicate understanding of what they see.

1 point

In general, a response which is not incorrect but shows poverty of content. For example, recognition of a person or parts of the body, without reference to the relevant action (a general classification of movement), or recognition of the action without explicit recognition of the person after prompting. Additionally, the action may be shown rather than spoken, with or without recognition of the person.

0 points

Obviously wrong answers, with no reference to the person or action. Recognition of dots, stars, bees, flies etc.

Items and Sample Responses

Locomotory Actions

1.	WALKING	2 -	Recognition of the person and the action e.g. a person walking. No other accepted action responses.
		1 -	Recognition of either the person or the action. Recognition of person and wrong action. Recognition of correct action, but not explicit response about the person (e.g. dots walking).
		0 -	Saying something other than what it is.
2.	JUMPING	2 -	Recognition of the person and the action e.g. a person jumping. Other accepted action responses include: hopping, skipping.
		1 -	Recognition of either the person or the action. Recognition of person and wrong action. Recognition of correct action, but not explicit response about the person (e.g. dots jumping).
		0 -	Saying some thing other than what it is.
3.	LEAPING/ RUNNING	2 -	Recognition of a person and the action e.g. a person leaping. Other accepted action responses include running, jogging, skipping.
		1 -	Recognition of either the person or the action. Recognition of person and wrong action Recognition of correct action, but not explicit response about the person (e.g. dots running).
		0 -	Saying something other than what it is.

Instrumental Actions

1. HAMMERING

2 - Recognition of a person and the action e.g. a person hammering. Other accepted action responses include banging, thumping.

1 - Recognition of either a person or the action
Recognition of person and wrong action or a general classification of movement e.g. a person lifting arm up and down, doing exercises
Recognition of correct action, but not explicit response about the person (e.g. dots hammering).

0 - Saying something other than what it is.

2. BALL BOUNCING

2 - Recognition of a person and the action e.g. a person bouncing a ball. Other accepted action responses include patting something.

1 - Recognition of either a person or the action
Recognition of person and wrong action e.g. a person running/jumping etc.
Recognition of correct action, but not explicit response about the person (e.g. dots bouncing a ball).

0 - Saying something other than what it is.

3. STIRRING

2 - Recognition of a person and the action e.g. a person stirring. Other accepted action responses include baking, cooking, making something.

1 - Recognition of either a person or the action
Recognition of person and wrong action e.g. drawing a circle, or general classification of movement e.g. moving hand round and round.
Recognition of correct action, but not explicit response about the person (e.g. dots stirring).

0 - Saying something other than what it is.

4.	BOX LIFTING	2 -	Recognition of a person and the action e.g. a person picking up a box. Other accepted action responses include picking up something.
		1 -	Recognition of either a person or the action Recognition of person and general classification of movement e.g. sitting down, standing up/bending down. Recognition of correct action, but not explicit response about the person (e.g. dots picking something up).
		0 -	Saying something other than what it is.

Social Actions

1.	A COUPLE DANCING	2 -	Recognition of 2 persons and the action e.g. 2 people dancing. No other accepted action response.
		1 -	Recognition of either 2 persons or the action Recognition of 2 persons and wrong action e.g. jumping up and down. Recognition of correct action, but not explicit response about the people (e.g. dots dancing) Recognition of correct action, but only one person.
		0 -	Saying something other than what it is. Recognition of only one person and wrong action.

2.	A COUPLE BOXING	2 -	Recognition of 2 persons and the action e.g. 2 people boxing. Other accepted action responses include fighting, sparring, playfighting, wrestling, trying to punch one another, hitting.
		1 -	Recognition of either 2 persons or the action Recognition of 2 persons and wrong action e.g. jumping up and down. Recognition of correct action, but no explicit response about the people (e.g. dots fighting). Recognition of correct action, but only one person
		0 -	Saying something other than what it is. Recognition of only one person and the wrong action.
3.	A COUPLE ARGUING	2 -	Recognition of 2 persons and the action e.g. 2 people arguing. Other accepted action responses include fighting, shaking fists, talking, looking at each other and talking, telling someone off, hitting.
		1 -	Recognition of either 2 persons or the action Recognition of 2 persons and wrong action e.g. jumping up and down. Recognition of correct action, but no explicit response about the people (e.g. dots fighting). Recognition of correct action, but only one person.
		0 -	Saying something other than what it is. Recognition of only one person and wrong action.

Appendix 4

Instructions for Authors

(Psychological Bulletin)

Instructions to Authors

Psychological Bulletin

Authors should prepare manuscripts according to the *Publication Manual of the American Psychological Association* (4th ed.). All manuscripts must include an abstract containing a maximum of 960 characters and spaces (which is approximately 120 words) typed on a separate sheet of paper. Typing instructions (all copy must be double spaced) and instructions on preparing tables, figures, references, metrics, and abstracts appear in the manual. Also, all manuscripts are copyedited for bias-free language (see chap. 2 of the *Publication Manual*). Original color figures can be printed in color provided the author agrees to pay half of the associated production costs.

Masked review will be first an author's option. If masked review is not requested in a cover letter, it will become the prerogative of the processing editor. Authors requesting masked review are requested to include with each copy of the manuscript a cover sheet, which shows the title of the manuscript, the authors' names and institutional affiliations, and the date the manuscript is submitted. The first page of the manuscript should omit the author's name and affiliation but should include the title of the manuscript and the date it is submitted. Footnotes containing information pertaining to the authors' identity or affiliations should be on separate pages. Every effort should be made to see that the manuscript itself contains no clues to the authors' identity.

Information regarding the types of articles considered appropriate for *Psychological Bulletin* by the Editor was provided in an editorial in the July 1997 issue (pp. 3–4). In addition, guidelines for writing qualitative review articles and meta-analyses for the journal are available in a special section of the September 1995 issue, "Writing Articles for *Psychological Bulletin*" (pp. 171–198).

APA policy prohibits an author from submitting the same manuscript for concurrent consideration by two or more publications. In addition, it is a violation of APA Ethical Principles to publish "as original data, data that have been previously published" (Standard 6.24). As this journal is a primary journal that publishes original material only, APA policy prohibits as well publication of any manuscript that has already been published in whole or substantial part elsewhere. Authors have an obligation to consult journal editors concerning prior publication of any data upon which their article depends. In addition, APA Ethical Principles specify that "after research results are published, psychologists do not withhold the data on which their conclusions are based from other competent professionals who seek to verify the substantive claims through reanalysis and who intend to use such data only for that purpose, provided that the confidentiality of the participants can be protected and unless legal rights concerning proprietary data preclude their release" (Standard 6.25). APA expects authors submitting to this journal to adhere to these standards. Specifically, authors of manuscripts submitted to APA journals are expected to have available their data throughout the editorial review process and for at least 5 years after the date of publication.

Authors will be required to state in writing that they have complied with APA ethical standards in the treatment of their sample, human or animal, or to describe the details of treatment. A copy of the APA Ethical Principles may be obtained by writing the APA Ethics Office, 750 First Street, NE, Washington, DC 20002-4242.

Submit six copies of each manuscript. All copies should be clear, readable, and on paper of good quality. A dot matrix or unusual typeface is acceptable only if it is clear and legible. In addition to addresses and phone numbers, authors should supply electronic mail addresses and fax numbers, if available, for potential use by the editorial office and later by the production office. Authors should keep a copy of the manuscript to guard against loss. Mail manuscripts to the Editor, Nancy Eisenberg, *Psychological Bulletin*, Department of Psychology, Arizona State University, P.O. Box 871104, Tempe, AZ 85287-1104. Electronic mail may be sent to psychbul@asu.edu.

Appendix 5

Instructions for Authors

(Journal of Child Psychology and Psychiatry)

Notes for Contributors

GENERAL

1. Submission of a paper to the Journal will be held to imply that it represents an original contribution not previously published (except in the form of an abstract or preliminary report); that it is not being considered for publication elsewhere; and that, if accepted by the Journal, it will not be published elsewhere in the same form, in any language, without the consent of the Editors. When submitting a manuscript, authors should state in a covering letter whether they have currently in press, submitted or in preparation any other papers that are based on the same data set, and, if so, provide details for the Editors.
2. Authors are reminded that piecemeal publication of small amounts of data from the same study is not acceptable. Each publication should report enough new data to make a significant and meaningful contribution to the development of new knowledge or understanding.
3. Papers should be submitted to any Editor whose name appears on the first page of the Journal. Papers for the Joint Editors should be submitted care of:

The Journal Secretary,
JCPP/ACPP Office,
St Saviour's House,
39/41 Union Street,
London SE1 1SD, U.K.
Telephone: +44 (0)171 403 7458
Faxline: +44 (0)171 403 7081
E-Mail: jcpp@acpp.co.uk

Papers may be submitted directly to any of the Corresponding Editors whose addresses are shown on the first page.

MANUSCRIPT REQUIREMENTS

1. Manuscripts should be typewritten, **double spaced**, with wide margins, on good quality A4 paper, *using one side of the page only. Sheets should be* numbered consecutively. **Four** copies should be sent. The author should retain a copy of the manuscript for personal use. Fax and electronic mail should **not** be used for initial submission of manuscripts, except in exceptional circumstances when normal postal services are inoperative.
2. Authors whose papers have been given **final acceptance** are encouraged to submit a computer disk (5.25" or 3.5" HD/DD disk) containing the final version of the papers along with two printed copies to the editorial office: **do not** send disk with initial submission of paper. Please observe the following criteria:
   (a) Specify what software was used, including which release (e.g. WordPerfect 4.0).
   (b) Specify what computer was used (either IBM compatible PC or Apple Macintosh).
   (c) Include the text file and separate table and illustration files, if available.
   (d) The file should follow the general instructions on style/arrangement and, in particular, the reference style of this journal as given in the Notes for Contributors.
   (e) The file should be single-spaced and should use the wrap-around end-of-line feature (i.e. no returns at the end of each line). All textual elements should begin flush left, no paragraph indents. Place two returns after every element such as title, headings, paragraphs, figure and table callouts, etc.
   (f) Keep a back-up disk for reference and safety.
3. Papers should be concise and written in English in a readily understandable style. Care should be taken to avoid racist or sexist language, and statistical presentation should be clear and unambiguous. The Journal follows the style recommendations given in the *Publication manual of the American Psychological Association* (4th edition, 1994), available from the Order Department, APA, P.O. Box 2710, Hyattsville, MD 20784, USA.
4. The Journal is **not** able to offer a translation service, but, in order to help authors whose first language is not English, the Editors will be happy to arrange for accepted papers to be prepared for publication in English by a sub-editor.
5. *Title*
   The first page of the manuscript should give the title, name(s) and address(es) of author(s), and an abbreviated title (running head) of up to 80 characters. Specify the author to whom reprint requests should be directed. Authors requesting that their identity be withheld from referees should also provide a first page with the title only and adapt their manuscripts accordingly.
6. *Abstract*
   The abstract should not exceed three hundred words and should be typed **double spaced**. (In addition, a longer summary may, if desired, be included at the end of the main article.)
7. Original articles and research reports should, in general, follow the conventional form: Introduction and review of the literature, Materials and Methods, Results and Discussion. To conserve space, less important portions of the paper, such as description of methods, should be marked for printing in smaller type. Descriptions of techniques and methods should be given in *detail only when they are unfamiliar. In order to aid readers of the Journal,* we encourage authors who are using acronyms for tests or abbreviations not in common usage to provide a list of them which will be printed to follow on from the Abstract.
8. *Acknowledgements*
   These should appear on a separate sheet, **double spaced**, at the end of the body of the paper, before the References.
9. *Referencing*
   The Journal follows the text referencing style and reference list style detailed in the *Publication manual of the American Psychological Association.*
   (a) *References in text.*
   References in running text should be quoted as follows: Smith and Brown (1990), or (Smith, 1990), or (Smith, 1980, 1981a, b), or (Smith & Brown, 1982), or (Smith, 1982; Brown & Green, 1983).
   For up to five authors, all surnames should be cited the first time the reference occurs, e.g. Smith, Brown, Green, Rosen, and Jones (1981) or (Smith, Brown, & Jones, 1981). Subsequent citations should use "et al." (not underlined and with no period after the "et"), e.g. Smith et al. (1981) or (Smith et al., 1981).
   For six or more authors, cite only the surname of the first author followed by "et al." and the year for the first and subsequent citation. Note, however, that all authors are listed in the Reference List.
   Join the names in a multiple author citation in running text by the word "and". In parenthetical material, in tables, and in the References List, join the names by an ampersand (&).
   References to unpublished material should be avoided.
   (b) *Reference list.*
   Full references should be given at the end of the article in alphabetical order, and not in footnotes. **Double spacing** must be used.
   References to journals should include the authors' surnames and initials, the full title of the paper, the full name of the journal, the year of publication, the volume number, and inclusive page numbers. Titles of journals must not be abbreviated and should be italicised (underlined).
   References to books should include the authors' surnames and initials, the full title of the book, the place of publication, the publisher's name and the year of publication.
   References to articles, chapters and symposia contributions should be cited as per the examples below:
   Kiernan, C. (1981). Sign language in autistic children. *Journal of Child Psychology and Psychiatry*, *22*, 215–220.
   Jacob, G. (1983a). Development of coordination in children. *Developmental Studies*, *6*, 219–230.
   Jacob, G. (1983b). Disorders of communication. *Journal of Clinical Studies*, *20*, 60–65.
   Thompson, A. (1981). *Early experience: The new evidence.* Oxford: Pergamon Press.
   Jones, C. C., & Brown, A. (1981). Disorders of perception. In K. Thompson (Ed.), *Problems in early childhood* (pp. 23–84). Oxford: Pergamon Press.
   Use Ed.(s) for Editor(s); edn. for edition; p.(pp.) for page(s); Vol. 2 for Volume 2.
10. *Tables and Figures*
    These should be constructed so as to be intelligible without reference to the text. Tables should be **double spaced**. The approximate location of figures and tables should be clearly indicated in the text.
    Figures will be reproduced by photo-offset means directly from the author's original drawing and photographs, so it is essential that figures are of a professional standard. Line drawings, good photo prints and sharp copy from laser printers are acceptable. *Graphic work printed on a dot matrix printer is* **not** acceptable. Illustrations for reproduction should normally be about twice the final size required. Half-tones should be included only when they are essential and they should be glossy prints, mounted on separate sheets. All photographs, charts and diagrams should be referred to as "Figures" and numbered consecutively in the order in which they are first referred to in the text.
    Figure legends should be typed on a separate page.
11. *Nomenclature and symbols*
    No rigid rules are observed, but each paper should be consistent within itself as to nomenclature, symbols and units. When referring to drugs, give *generic names, not trade names. Greek characters should be clearly* indicated.

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The Journal has a policy of anonymous peer review and the initial refereeing process seldom requires more than three months. Authors may request that their identity be withheld from referees but it is their responsibility to ensure that any identifying material is removed from the manuscript. Most manuscripts accepted for publication require some revision, details of which are sent to authors.

Rejected manuscripts will not be returned to authors, unless a request for the return of one copy is made to the Journal Secretary within one month of receiving notice of rejection.

When a paper is accepted for publication, the authors will receive proofs for correction when the manuscript is first set. Authors should correct printers' errors but not introduce new or different material at this stage.

The original manuscript and figures will be discarded one month after publication unless the Publisher is requested (on submission of the manuscript) to return original material to the author.

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