WEAK CENTRAL COHERENCE IN AUTISM

OVER THE PRESCHOOL YEARS

By

Kelly K. Powell

Submitted to the

Faculty of the College of Arts and Sciences

of American University

in Partial Fulfillment of

the Requirements for the Degree of

Doctor of Philosophy

In

Clinical Psychology

Chair:

Michele M. Carter, Ph.D.

Laura G. Anthony, Ph.D

Emily Kuschner, Ph.D

Kathleen Gunthert, Ph.D

Dean of the College

August 15, 2012

Date

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ABSTRACT

This study investigated the developmental process of weak central coherence in preschoolers with autism by examining the longitudinal stability of their cognitive profiles utilizing the Brief IQ subtests of the Leiter-R. It was found that young preschoolers with autism (mean age=41.7 months) did not evidence specific strengths and weaknesses within their cognitive profile, suggesting a flat profile of comparable nonverbal abilities. In contrast, at Time 2 (18 months later), children with autism showed significant relative strengths on Form Completion and significant relative weaknesses on Sequential Order. Findings indicated that an uneven pattern of strengths and weaknesses in cognition found in previous research on individuals with autism, namely strengths in nonverbal perceptual versus nonverbal conceptual skills, which are proxies for WCC, are evident for older preschoolers (mean age= 59.7 months), but not yet present 18 months earlier. The results are interpreted as lending support for an important developmental process occurring over the preschool years for children with autism, which may have implications for intervention.

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CHAPTER 1

INTRODUCTION

Autism has become a public health crisis with rising estimates that one in 88 children in the United States have an autism spectrum disorder, meaning that approximately one million American children and teens have autism. The new figures are based on data collected in 2008 that indicate a 23 percent increase in autism diagnoses since the last estimates were reported in 2006. The previous prevalence was one in 110 children, which also signified an increase from the 2002 estimates that reported one in 150 children had an autism diagnosis. In essence, the occurrence of autism has increased almost twofold over the last decade. Federal health officials largely attribute the rise in incidence to increased surveillance and broadening of the definition of autism (CDC, 2012).

Early identification of autism and intervention is imperative. Children that receive services prior to the age of 3 years have shown better outcomes later in life (Rogers, 1996). However, many individuals with autism are not diagnosed until their 5th birthday or later. In particular, the median age of earliest autism diagnosis falls between 4.5 and 5.5 years with developmental concerns reported prior to the age of three for 51 to 91 percent of children with autism (CDC, 2007).

Much attention has been given to the role of early identification and intervention to combat the increasing prevalence of autism as well as its associated elevation in societal costs (CDC, 2009). The US government has also made autism an important initiative with the development of the US Department of Health and Human Services' Interagency Autism Coordinating Committee (IACC) to advise federal agencies and Congress on needs and opportunities for research investigating autism. One goal of the IACC is to discover how autism affects development in order to create targeted and personalized treatments. Specifically, the IACC has made the call for longitudinal research in multi-disciplinary settings to address the strengths and challenges of individuals with autism (IACC, 2010).

Autism is considered a developmental disorder that results in the delay of, and deviance from, the normal patterns of development, hallmarked by social-communication deficits. Autism Spectrum Disorders are typically used as an umbrella term for a wide spectrum of disorders also referred to as Pervasive Developmental Disorders. The terms Autism Spectrum Disorder and Autism, along with Autistic Disorder, Asperger's Syndrome and Pervasive Developmental Disorder- Not Otherwise Specified (PDD-NOS), are essentially describing disabilities with similar characteristics in which the individual demonstrates deficits in 3 core areas: 1) social interaction (i.e., impairment in the use of nonverbal behaviors such as eye contact and facial expressions, failure to develop appropriate peer relationships, lack of spontaneous seeking to share enjoyment, and/ or lack of social or emotional reciprocity), 2) verbal and non-verbal communication (i.e., delay in language development, inability to sustain a conversation, stereotyped and repetitive use of language and/or lack of make-believe or social imitative play), and 3) repetitive interests or behaviors (i.e., preoccupation with an overly focused interest, inflexible adherence to routines or rituals, hand or finger flapping or twisting, complex body movements, and/ or preoccupation with parts of objects) (American Psychiatric Association, 1994). The utilization of the nomenclature spectrum is important because it encompasses the broad range of skills and behavioral expressions of the syndrome. These primary symptoms of autism need to be present prior to the age of 3 years for a diagnosis of autism to be made.

When an individual evidences difficulties in these three domains of development, above and beyond the usual variation expected in typically developing children, the distinctive pattern of autism emerges. However, early identification and diagnosis in children with autism is difficult. Although it is likely that autism is present from birth, or very soon after, the nature of the disorder suggests that the developmental progression of autism may not necessarily be evident for months or even years. Identification of autism is further complicated by the variations found in the intellectual ability of children with autism, suggesting anywhere between 25 to 70% of children with autism also have a co-morbid intellectual disability (Dawson, Mottron, & Gernsbacher, 2008). Often times, a child with an intellectual disability may display unusual behavior patterns that may be attributed to an overall developmental delay, rather than autism. Conversely, autism may also be overlooked in children with average and above-average intellectual ability. Unusual behaviors or abnormalities in development in these children, especially in very young children, may be dismissed as mild or temporary. Additionally, many of the early markers or “red flags” of autism depend on the lack of appropriate developmental behaviors, such as joint attention and language. Diagnoses based on the absence of behaviors, instead of positive predictors, are more challenging for parents and practitioners.

Cognitive Theories of Autism

There are three main cognitive theories that have dominated psychological research in autism, including Theory of Mind, Executive Functioning, and Weak Central Coherence. Theory of Mind (ToM) describes a specific cognitive ability to understand others as intentional agents; such as interpreting another individual's mental state, including their beliefs and desires. By the age of four or five years, children begin to understand that other people have thoughts, knowledge, beliefs, and desires that influence their behavior (Crain, 2005). Many studies investigating theory of mind development in typically developing children have focused on 3 to 4 year olds and found a peak in theory of mind development emerging over these years (Welman, Cross, & Watson, 2001). The ToM hypothesis suggests that autism is caused primarily by a specific inability to "impute mental states to themselves and others" (Premack & Woodruff, 1978, p. 515). In essence, this theory manifests as inability to mentalise or a failure to take into account others' mental states (Pellicano, 2010), suggesting that individuals with autism have some difficulties conceptualizing and appreciating the thoughts and feelings of others. The fundamental clinical picture is that individuals with autism have difficulties understanding both their own and others' minds.

Executive functioning refers to the ability to maintain problem-solving sets for future goals when situational changes occur. Proponents of an executive functioning deficit in children with autism suggest that the theory of mind hypothesis does not easily account for common symptoms in autism such as a need for sameness, a difficulty switching attention, a tendency to perseverate, and a lack of impulse control, which are symptoms similar to those shown by individuals with Dysexecutive Syndrome (DES) (Pellicano, 2010). Individuals with DES have difficulties with executive functions, which are typically evidenced from frontal lobe damage. This led researchers to suggest that autism could be explained as deficits in executive functioning (Ozonoff, Pennington, and Rogers, 1991). Research suggests that both adults and children with autism exhibit difficulties in executive functioning, including planning (Hughes, Russell, and Robbins, 1994), mental flexibility (Prior & Hoffman, 1990; Ozonoff & Jensen, 1999), response inhibition (Robinson et al, 2009), and generativity (Hill, 2004), when compared to typically developing controls.

Frith (1989) describes central coherence as the "tendency to process incoming information in its context- that is, pulling information together for higher-level meaning- often at the expense of memory for detail." 'Weak' central coherence (CC) theory posits that inherent to autism is an unusual tendency to focus on individual, local elements rather than global wholes (Frith, 1989; Happé & Frith, 2006). One of the advantages of the weak central coherence account is that it describes an area of competence, rather than a deficit, which helps further explain the assets seen in autism, including advanced skills in math, music and drawing, visuospatial tests, and rote memory (Mitchell & Ropar, 2001). Happe (1999) further suggests that intact or superior functioning in certain domains cannot be explained by a general deficit. Rather, we should consider the distinctive cognitive styles of individuals with autism as an avenue to further understand the peaks and valleys in performance.

Although there is unequivocal support for general deficits in the area of theory of mind, executive functioning, and weak central coherence in individuals with autism, the developmental nature of these cognitive processes has received less attention. Among the three cognitive theories, the Theory of Mind hypothesis has received the greatest attention, examining early precursors of ToM using primarily eye tracking and joint attention tasks. This study aims to identify the earliest corollaries and/or appearance of weak central coherence via exploring the non-verbal cognitive profile of young children with autism. In particular, this study will examine the longitudinal stability of a visuo-spatial processing bias, a focus on details, which has been viewed as both a strength and weakness for individuals with autism. Understanding the developmental onset of this cognitive processing bias may help clinicians, educators, and therapists develop early interventions that target cognitive flexibility; helping children more flexibly shift between detail-focused and gestalt processing. This can lead to both earlier diagnosis and earlier treatment targeting this cognitive style.

Central Coherence Theory

In addition to the primary or core symptoms of autism that are necessary for diagnosis (i.e., communication, social interaction, repetitive interests or behaviors), other secondary symptoms or behaviors are commonly present, including a unique, detail-focused cognitive processing style (South, Ozonoff, & McMahon, 2007). *Weak* central coherence theory has described this perceptual-cognitive style as the limited ability to understand context, 'see the big picture,' or 'see the forest through the trees' (Happe´ & Frith, 2006). The theory tries to explain the abnormalities of individuals with autism on tasks involving local and global cognitive processes of visual information. For example, individuals with autism tend to focus on the details of a picture rather than see the gestalt. For many individuals with autism, their perceptual world is a collection of these many details. For example, an American flag lunchbox is processed as 13 red and white stripes, a blue rectangle with white stars, a metal box, a handle to carry it with, and a container usually containing lunch, etc., identifying each detail independently, and not an "American flag lunchbox." It is important to note that when many researchers discuss a '*weak* central coherence' or a difficulty seeing the gestalt, the inverse of this 'weakness' is enhanced local processing. Therefore, although weak central coherence is routinely described as a deficit, it is actually measured as strength, operationalized as a focus on visual details. More specifically, weak central coherence is observed when individuals show better performance on certain tasks that tap attention to details. Theories of weak central coherence in domains outside of the visual system have also been purported; however, the aim of the current study is on weak central coherence within the visual context.

Within the domain of visual perception, humans are able to identify and perceive wholes of objects, even when the relevant perceptual data are incomplete. One of the fundamental principles of gestalt perception is the law of pragnanz, which is the tendency to group features together into a "good form." This theory highlights that elements that are proximal to one another or that share a common property are subject to perceptual grouping. Sometimes the tendency to group visual features is so strong that it is often difficult to disambiguate constituent local features from a cluttered array (Mine & Szczerbinski, 2009). Despite research suggesting humans have a general bias towards perceptual grouping and a propensity to perceive the global or "big picture" before the local details, individual variation exists in the drive for global precedence. Subsequently, central coherence is a construct that accordingly varies on a continuum (Happe´ & Frith, 1994). Stronger coherence means greater capacity to understand context or to "see the big picture," as compared to the ability to process details. Weaker coherence means poorer capability to see the gestalt as compared to the ability to process details and individuals with autism reportedly lie at the weaker extreme. The concepts of weak central coherence along with local perceptual processing styles, as well as field-independence have been historically used to describe a locally, as compared to globally, dominated perceptual style. In 1962, Witkin and colleagues coined the terms field-dependence and field-independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). Someone who is characterized as field-dependent is greatly influenced by the context of the visual scene when processing stimuli. Conversely, someone who is field-independent is better able to perceive an element independently from its context.

Weak Central Coherence in Autism

Uta Frith has been a leader in conceptualizing and researching weak central coherence in autism and published a seminal paper in 1989. At that time, she proposed that contrary to typically developing people that processed the gestalt, often at the expense of attention to or memory for details, individuals with autism had a processing bias for detail and local information in conjunction with a failure to see the big picture or global information. Originally, weak central coherence was presumed to be a core deficit for individuals with autism. Over the past 20 years, researchers have modified this original conception. In particular, weak central coherence is now viewed as a common cognitive style rather than a primary problem with a greater focus on the possible *superiority* in local or detail focused processing (South, Ozonoff, & McMahon, 2007). For example, superiority in local processing, suggesting a *weak* drive for central coherence, facilitates an individual when engaging in activities whereby attention to detail results in greater success on a task, such as completion of jigsaw puzzles, block designs, and accounting. Additionally, weak central coherence is seen as a cognitive style or processing bias, in which the global or gestalt can be accurately seen by individuals with autism when explicitly asked to do so (Plaisted, Swettenham, & Rees, 1999; Happe´ & Frith, 2006). Moreover, weak central coherence may be seen as one aspect of cognition rather than causing or explaining other deficits including social cognition (Happe´ & Frith, 2006).

For some individuals with autism that have weak central coherence, this attention to detail may be related to their circumscribed interests or insistence on sameness. This overly focused attention can lead to amazing strengths and the acquisition of a wealth of knowledge in one particular area (e.g., becoming an expert on a specific topic) (Happe´ & Frith, 2006). For example, an individual with autism may be able to identify the sole clarinet that is out of tune amongst an entire orchestra. Though being able to locate the out of tune instrument may be an impressive perceptual strength, this focus and awareness of details can also cause much distress. The inability or difficulty to experience the "whole" of an object or entity without attention to each part can be overwhelming. These behaviors may stem from the notion that it is easier to make sense of the details while the big picture is more confusing (Happe´ & Frith, 2006). For example, Baron-Cohen and Belmonte (2005) have linked weak central coherence to the development of an aberrant tendency and/or skill for systemizing in autism (e.g., attending to rules that govern behavior of objects). They postulate that weak central coherence is either an early expression of the drive for systemizing, or that the attention to systemizing occurs because of the focus on detail. Baron-Cohen and Belmonte further propose that sensory hyperarousal or hypersensitivity is associated to the same neural causes as weak central coherence, suggesting that many individuals with autism are oversensitive to sensory information while also lacking the ability to selectively filter 'the trees from the forest' because of their abnormal attention to detail.

Many studies have investigated central coherence in autism. Happe´ and Frith (2006) reviewed over 50 empirical studies on weak central coherence in visuo-spatial, auditory, and verbal domains and found robust findings for an enhanced local bias in autism, with mixed findings regarding a global processing weakness. According to central coherence theory, the reciprocal side to superior local processing should be poor global processing. However, studies investigating this global processing weakness, characterized by difficulties integrating visual information in individuals with autism, have provided unclear results (Jolliffe & Baron-Cophen, 2001; Mottron, Burack, Iarocci, Belleville, and Enns, 2003; Plaisted, Saksida, Alcantara, & Weisblatt, 2003). More specifically, some studies support enhanced bottom-up processing, whereas others suggest reduced top-down feedback. Therefore, one possibility is that abilities pertaining to local and global processing may be somewhat independent of each other (Pellicano, Mayberry, & Durkin, 2005).

Research on weak central coherence in individuals with autism supports a deficit among school-aged children, adolescents and adults with autism as compared to a variety of controls (For a detailed review, see Happe´ & Frith, 2006). Additionally, researchers have recently examined tasks tapping into weak central coherence in preschoolers with autism and found enhanced local processing/ weak central coherence when compared to neurotypical and developmentally-delayed children (Kuschner, et al., 2007), suggesting a cognitive bias present during these early years. The purpose of the present study is to further delineate the developmental process of a weak central coherence visuo-perceptual processing style across the preschool ages in young children with autism. In what follows, I briefly describe various tasks used to measure central coherence and examine the ability for each task to identify difficulties in autism. Later, I review the research regarding the developmental process of central coherence in neurotypical children and argue for the need to further examine this unique cognitive processing bias in young children with autism.

Weak Central Coherence Operationalized as Strength on Tasks

Disembedding and Segmentation Tasks

While investigating weak central coherence, researchers have used a variety of experimental paradigms and tasks. Within the visuo-spatial domain, tasks such as the Embedded Figures Test (EFT; Witkin, Oltman, Raskin, & Karp, 1971), Figure-Ground, block design, and Form Completion have been employed. In each of these tasks, weak central coherence is operationalized as better performance on these tasks whereby the individual disregards the whole to attend to details.

Embedded Figures and Figure Ground Tasks

The Embedded Figures Test (EFT; Witkin, Oltman, Raskin, & Karp, 1971), Children's Embedded Figures Test (CEFT; Karp & Konstadt, 1971), and Preschool Embedded Figures Test (PEFT; Coates, 1972) have been extensively used to explore the notion of a weak central coherence bias among individuals, particularly those with autism. During an embedded figures test the participant is shown a simple shape (the target) and is asked to find it as quickly and as accurately as possible in a larger complex design in which it is embedded (See Figure 1.1). Finding the target more easily than the control group suggests a local processing bias, indicating weak central coherence.

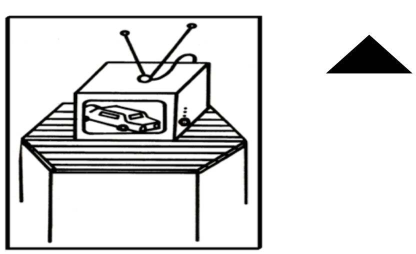

Figure 1.1 Embedded Figures Task

Shah and Frith (1983) used the CEFT with children with autism, mental age matched neurotypical children and mental age and chronological age matched intellectually disabled non- autistic children. Findings suggest that the children with autism performed significantly better than the other groups and employed qualitatively different search strategies on the CEFT. Stemming from Shah and Frith (1983), Brian and Bryson (1996) purported at least two explanations as to why comparison participants were relatively slower compared to individuals with autism. One hypothesis was that individuals without autism were more captivated by the meaning and therefore the global shape. As such, processing the picture in this way would 'blind' participants to the details. Another hypothesis was that regardless of how the stimulus is interpreted and classified, the comparison group participants might naturally process the stimulus as a whole, therefore making it more difficult to focus attention on the details. In an attempt to test these two hypotheses, Brian and Bryson (1996) presented children with autism and control participants with one kind of figure that resembled a familiar object and another that was an abstract line drawing. They proposed that if meaning were the important element, then the superior performance for individuals with autism would only be evident when stimuli were meaningful. However, if the superior ability to analyze parts were the important element, than individuals with autism would perform relatively well with both kinds of embedded figures. Unfortunately, Brian and Bryson failed to replicate the superior performance in individuals with autism when compared to controls on any of the embedded figures tasks. They did not find differences in accuracy between individuals with autism and a group of younger developmentally matched controls. Furthermore, they did not find differences in reaction time. No evidence was found for “less capture by meaning” or reduced “central coherence” in autism, raising the possibility that earlier findings reflect a developmental, rather than a stable autism-specific, phenomenon. However, other researchers have found support for enhanced performance on embedded figures tasks suggesting the utility of repeating Brian and Bryson’s procedures. Jolliffe and Baron-Cohen (1997) examined weak central coherence in 17 individuals with High Functioning Autism (HFA), seventeen individuals with Asperger’s Disorder and seventeen age and IQ matched neurotypical adults. Both clinical groups had faster response times on the EFT as compared to the control group; however, there were no group differences concerning accuracy. Moreover, Ropar and Mitchell (2001) compared 19 individuals with autism (mean chronological age of 14-years-2-months and verbal mental age of 11-years-6-months), 11 with Asperger’s Disorder (mean chronological age of 11-years-10-months and a verbal mental age of 9-years-11-months), 37 typically developing children (nineteen 8-year-olds and eighteen 11-year-olds), and twenty individuals with moderate learning difficulties in a battery of visuospatial tasks thought to measure weak central coherence. On the EFT task, the autism group outperformed their Verbal mental age-matched controls. However, those with Asperger’s syndrome performed similarly to typically developing 11-year-olds, but did not outperform them. Overall, findings have repeatedly shown children with autism to be more accurate, and faster, at finding embedded figures than control and comparison groups.

The Figure- Ground task from the Developmental Test of Visual Perception (DTVP; Hammill, Pearson, & Coress, 1993) and from the Leiter-R parallel the PEFT and require children to identify a number of stimulus figures (e.g., triangles, squares, circles) or items (e.g., picture of a hairbrush) embedded in a complex background (e.g., picture of cluttered garbage). On the DTVP, children are prompted to find as many of the figures as they can on a page where the figures are hidden on a complex confusing background. On the Leiter-R the children are provided various cards, presented one at a time, and prompted to find the item in a complex visual field (See Figure 1.2). The items increase in difficulty across the response set. The Figure-Ground task calls for perceptual analysis or the ability to disembed each image into its details. In order to perform well, it is necessary for children to disregard the global configuration and focus on local details, reflecting a bias towards a weak central coherence. Therefore, a weak drive for coherence should be operationalized as high scores on these Figure-Ground tasks.

Figure 1.2. Figure Ground Task

Kuschner, Bennetto, and Yost (2007) used the Figure-Ground task from the Leiter-R, among other subtests, to investigate nonverbal cognitive processing in preschoolers with autism, non-autism developmental delay, and neurotypical children.

They found strengths on tasks requiring visuospatial disembedding or detailed focused perceptual processing in children with autism, which were relative within their own profiles and specific when compared to other groups.

Block Design and Form Completion Tasks

Various block design tasks are used to assess central coherence. During these tasks, the individual is presented with a picture of a design and required to replicate the design using blocks. In the unsegmented version, the pictures of the designs do not reveal their internal parts and require mental segmentation of the design in order to reconstruct the pattern with blocks. In the segmented version, the parts are separated from one another spatially in the design and do not require mental segmentation to be recreated with the blocks (See Figure 1.3). In order to perform well on these tasks, the child is required to complete a number of these puzzles, which are generally timed. The faster and more accurate an individual is, the higher their score, suggesting a greater ability to segment and process the details.

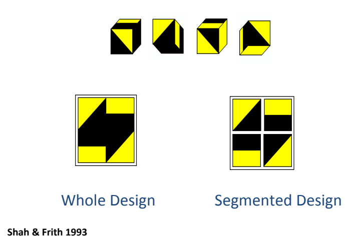

Figure 1.3 Block Design Task

Shah and Frith (1993) found that individuals with autism, regardless of age and ability, performed better than controls when presented with unsegmented designs. This suggests that individuals with autism require less effort to segment a gestalt and support the hypothesis of weak central coherence. Similarly, Happe´ (1994) found that a relative strength on the Block Design subtest was characteristic of 85% of their sample of individuals with autism regardless of theory of mind performance, further supporting the central coherence hypothesis. As previously mentioned, Ropar and Mitchell (2001) used a battery of visuo-spatial tasks including block design in their study. Similar to their findings using the EFT, the autism group outperformed their Verbal Mental Age-matched controls on the block design test. Additionally, children with Asperger's syndrome performed similarly to typically developing 11-year-olds, but did not outperform them.

During the Form Completion task on the Leiter-R participants are handed a single card with a picture broken into pieces (e.g., a horse divided into three sections) and are prompted to find the whole picture in a visual field (e.g., a completed horse on a farm) (See Figure 1.4). This task requires segmentation, mental manipulation, and synthesis of pieces of a pictured object analogous to the cognitive demands required to complete Block Design tasks.

In Kuschner and colleagues' (2007) study, the authors used the Form Completion subtests of the Leiter-R to further investigate patterns of cognitive performance in preschoolers with autism. Similar to their results using the Figure-Ground subtests, they found individuals with autism to have relative strengths on Form Completion within their own profiles and specific when compared to other groups.

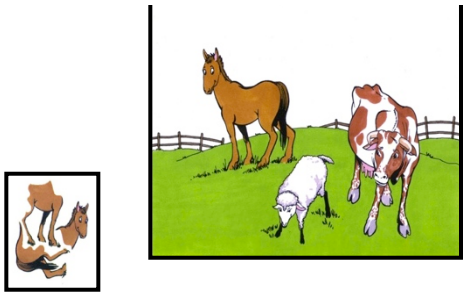

Figure 1.4. Form Completion Task

Weak Central Coherence Tasks
Operationalized as Weaknesses

The abovementioned tasks (Embedded Figures, Figure Ground, Block Design, and Form Completion) capture the strength in local processing as described in a cognitive profile of weak central coherence. As noted, this strength is captured as higher scores on these tasks for individuals with a weak drive for central coherence. As mentioned, according to Frith's original central coherence theory, the reciprocal side to superior local processing should be poor global processing. Yet, as mentioned, studies investigating this global processing weakness have provided mixed results (Jolliffe & Baron-Cohen, 2001; Mottron, Burack, Iarocci, Belleville, and Enns, 2003; Plaisted, Saksida, Alcantara, & Weisblatt, 2003), suggesting that abilities pertaining to local and global processing may be somewhat independent of each other (Pellicano, Mayberry, & Durkin, 2005).

Tasks such as Navon Hierarchical Figures Test and the copying strategy of the Rey-Osterrieth Complex Figure have been purported to measure a bias towards a more globally or more locally dominated perceptual style. In addition, there is some support for the notion that individuals with autism have greater difficulties on tasks involving abstraction or concept formation that require gestalt processing. The Repeated Pattern and Sequential Order tasks of the Leiter-R have recently been used to assess abstraction and concept formation abilities (Kuschner et al., 2007). These tasks tap abilities similar to those needed for measures of executive functioning or complex information processing, as well as tasks that measure abstraction abilities more directly. Poorer performance on these tasks may be consistent with a weak central coherence processing style. It is important to note that Kuschner and colleagues (2007) highlight that Repeated Patterns and Sequential Order may not tap these abilities (e.g., abstraction and concept formation) as clearly as Figure Ground and Form Completion tap disembedding abilities.

Hierarchical Figures

During hierarchical figures tasks participants are typically given the Navon Hierarchical Figures (a large letter (e.g., 'H') composed of smaller congruent letters (Hs) or incongruent letters (Ss)) and instructed to identify and respond to the local or global level in different blocks of trials (See Figure 1.5). In his 1977 paper, Navon theorized that visuo-perceptual processes proceed from global structuring towards more fine-grained analysis. When neurotypical participants were asked to state the smaller letters (Hs), they were slower if the global form was incongruent (S) than if it was congruent (H). Interestingly, response time was not affected by the incongruence of the smaller letter when participants were prompted to state the larger letter. He found that participants have an advantage at processing the global letters, and the global letters influence processing of the local letters.

Figure 1.5 Hierarchical Figures Task

Research using the Navon Hierarchical Figures with individuals with autism shows mixed results. Some research suggests that the performance of children with autism on the this task is similar to other control groups in their global advantage or interference (Oznoff, Strayer, McMahon & Filloux, 1994; Plaisted, Swettenham & Rees, 1999; Rinehart, Bradshaw, Moss, Brereton and Tonge, 2000). However, some studies found that controls did make fewer errors for targets at the global than local level and those individuals with HFA, but not Asperger's, showed more local interference than the control group (Plaisted, Swettenham & Rees, 1999; Reinhart, Bradshaw, Moss, Brereton, & Tonge, 2000). In a subsequent experiment, Reinhardt, Bradshaw, Moss, Brereton and Tonge (2001) found individuals with HFA, but not Asperger's, had a slower reaction time to global level targets when the previous target was at the local level, when compared to controls. These findings suggest a deficit shifting between local to global processing for individuals with HFA. Others have also found null effects when comparing individuals with autism and controls on the Navon Hierarchical Task (Mottron, Burack, Iarocci, Belleville & Enns, 2003).

Rey-Ostereith Complex Figure

On the Rey-Ostereith (Rey-O), an individual is asked to reproduce a complicated line drawing, first by copying and then from memory (See Figure 1.6). Many different cognitive abilities are needed to accurately recreate the design (e.g., visuospatial abilities, memory, attention, planning, and working memory). However, the approach to a copying task provides information regarding their local or global processing patterns. For example, an individual who approaches the task in an organized fashion is purported to take a gestalt approach, drawing the larger forms first (e.g., big rectangle) and then filling in the details or drawing from left to right. An example of a part-oriented or local processing approach would be an individual approaching the test in a disorganized fashion. Instead of working from left to right, or drawing the larger forms first (e.g., big rectangle), the individual would process the details of the design more readily than the big picture (e.g., first drawing the small diamond on the far right end of the design).

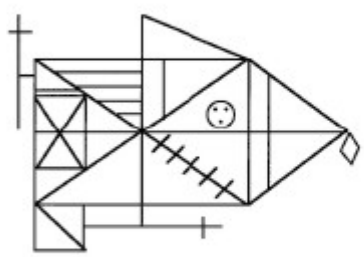

Figure 1.6. Rey-Ostereith Complex Figure Task

Studies using the Rey Complex Figure Test (Osterrieth, 1944) to assess drawing strategies have found mixed results. Some research suggests individuals with HFA and Asperger's syndrome perform significantly better than those with moderate learning difficulties group on the Rey-O copy but not on the Rey-O recall trial (Ropar & Mitchell, 2001). However, when compared to neurotypical controls, these differences disappear (Ropar & Mitchell, 2001; Joliffe & Baron-Cohen, 1997; Kuschner, Bodner, & Minshew, 2009). In addition, evidence does not support that individuals with autism or Asperger's have a distinctly local drawing strategy (Ropar & Mitchell, 2001, Kuschner, Bodner, & Minshew, 2009). However, controls tended to employ improved organizational and planning skills and a shift to global processing approaches with age, as seen by group differences between the control adolescents/adults group (ages 15-47) when compared to the control children (ages 8-14) (Kuschner, Bodner, & Minshew, 2009). Findings on these drawing tasks suggest that drawing and performance on visuospatial tasks may rely on different mechanisms making drawing tasks a poorer measure for weak central coherence.

Leiter-R Repeated Patterns and Sequential Order

During the Repeated Patterns task participants are shown the beginning of a pattern of items (blue square, yellow triangle, blue square, yellow triangle, blue square) and are given more than one card and required to complete the appropriate pattern (See Figure 1.7). On this task, individuals need to apply abstract concepts to the presented stimuli. During the Sequential Order tasks, participants are prompted to complete the sequence of items (finishing the sequence of small-medium-large or completing a set of concentric circles) (See Figure 1.8). This task also requires individuals to connect related concepts as a group.

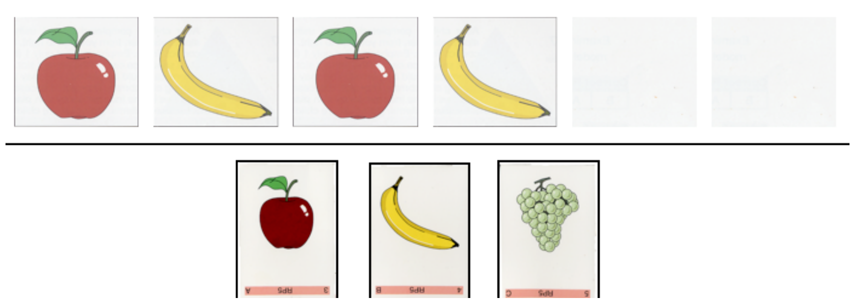

Figure 1.7 Repeated Patterns Task

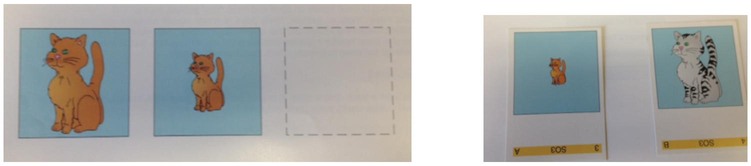

Figure 1.8 Sequential Order Task

As mentioned, Kuschner and colleagues (2007) used these tasks when investigating nonverbal cognitive profiles in preschoolers. They found Repeated Patterns to be a relative weakness for individuals with autism within their own profiles and specific when compared to developmentally delayed and neurotypical control groups. In addition, Sequential Order was found to be a relative weakness within their own profiles; however, it was not specific when compared to the neurotypical group.

Studies Comparing Central Coherence Measures

In summary, despite the abundance of research on central coherence, there has been less focus on the degree to which the numerous tests that are currently utilized really do measure the same construct. Pellicano, Maybery, and Durkin (2005) investigated the construct of central coherence in neurotypical children via examining their performance on several visuo-spatial coherence tasks including EFT, block design, Figure-Ground, and VMI. They did not arrive at a single construct of weak central coherence amongst their four weak central coherence measures. Instead, the analysis produced two factors; one received loadings from the Block Design Task and Visuo-Motor Integration, and the other received loadings from the Embedded Figures Test and the Figure-Ground Test. However, the loadings on this second factor were not in the anticipated direction as faster times on the Embedded Figures Test were associated with low scores on the Figure-

Ground Test. These data suggest that the four selected tasks do not represent a unitary construct or a coherent index of perceptual style. The authors posit that the Figure Ground task has good face validity, containing a strong local-global component. In addition, Figure-Ground requires the deconstruction of the global image into its individual elements and is similar to the PEFT. The task does involve more abstract figures, however central coherence theory would nonetheless predict that an individual's coherence bias would be apparent on this task. Additionally, both the VMI and Figure Ground measures loaded with one of the more frequently used central coherence measures (e.g., PEFT and Pattern Construction), which would indicate that the two new measures (VMI and Figure Ground) share variance with each of the accepted central coherence variables. The authors conclude that the four visuospatial measures used in their study, PEFT, Pattern Construction, VMI and Figure Ground, assessed local-global processing in preschool children.

Booth (2006) investigated cross-domain perceptual styles in 204 children and adolescents. Four visuo-spatial tasks were administered including Embedded Figures Test, Block Design, classification of possible and impossible figures, and a version of the Navon Hierarchical Figures Test. This analysis also produced two factors. The first factor, the Visual Segmentation Factor, received loadings from the Embedded Figures and Block Design tests. The second factor, the Visual Integration Factor, received loadings from the Impossible-Possible Figures Test and the Navon Hierarchical Figures. Other tasks including identification of fragmented pictures, picture memory and drawing style were also administered; however, these did not correlate with each other and were not entered into the factor analysis. Mine and Szczerbinski (2009) investigated the factor structure of weak central coherence by examining the relationships within a set of tasks that are commonly described in the literature as measuring weak central coherence/field-independence. They examined the factorial structure of visual perceptual styles and found the tasks that loaded most on a weak central coherence/field-independence factor involved the ability to disembed a simple stimulus from a more complex array. They generally found that individuals who show weak central coherence/field-independence processing styles could be considered as having a locally biased perceptual style. Conversely, those with a more globally biased perceptual style are more strongly influenced by the surrounding context and would be described as having strong central coherence/being field-dependent.

Taken together, it appears that tasks involving disembedding and segmentation such as embedded figures tasks and block design tasks, as well as those tapping similar skills such as Figure-Ground and Form Completion, materialize to have the most empirical support in measuring weak central coherence. This review also suggests there is robust support for the superiority of individuals with autism on these tasks (embedded figures, Figure-Ground, block designs, and Form Completion). Moreover, as previously discussed, there is less promising support for tasks assessing a more globally biased perceptual style. However, the Repeated Pattern and Sequential Order subtests of the Leiter-R appear to have promising results (Kuschner et. al, 2007). The noted inconsistencies among the weak central coherence research may stem from the operational definition of performance used (e.g., accuracy, reaction time, search strategies) as well as the differences that emerge when the autism group is collapsed to include both individuals with High Functioning Autism and Asperger's. One may speculate that results where the HFA group outperformed controls but the Asperger's group did not may suggest the weak central coherence effect is stronger for individuals with HFA as compared to Asperger's on measures of EFT. However, to my knowledge, no research has yet to investigate this phenomenon. Age related factors might also play a role in the discrepant findings. In addition, the difficulties assessing gestalt processing may be due to the notion that global processing involves a higher level processing involving additional executive functioning abilities.

Developmental Process of Central Coherence in Young Neurotypical Children

Presently, there is a dearth of research regarding neurotypical preschoolers' central coherence abilities because it was a construct developed to explain cognition in autism. Navon (1977) first argued that "perceptual processes are temporarily organized so that they proceed from global structuring toward more and more fine grained analysis," suggesting that we first process global properties of a visual scene and then process the local features. Early research on how children process the spatial properties of visually presented patterns; particularly how they perceive parts, wholes and the relations between these two pattern levels was weighted toward a more gestalt or holistic processing theory. That is, research in the 1960s, 1970s, and early 1980s generally supported a holistic processing approach in early development. Kemler Nelson has provided extensive data supporting this early research (Kemler, 1982, Kemler, 1983). As noted by Stiles, Delis and Tada (1991), "They do not generally attend to separate dimension but rather treat the stimulus as a comparatively undifferentiated whole," and that with development children gradually become more analytic. For an extensive review, see Prather and Bacon (1996).

Even more recently, Vinter, Puspitawati, and Witt (2010) studied the developmental nature of local and global processing in young neurotypical children and used perceptual as well as a constructional drawing task. On drawing tasks, they did not observe the use of global-only elements at any age; however, they did observe the use of local-only elements. These unidimensional local-only responses were primarily seen in 50% of the 3-year-old participants, were rare at 4 years of age, and completely disappeared between 5 and 6 years of age. However, they also found that integrated responses, either correct or incorrect, developed rapidly between 3 and 5 years of age. Even at three years of age, some children (40%) were capable to attend to both levels of pattern organization but their drawings were less integrated. By 6 years of age, children produced correct integrated responses in more than 70% of the cases, and this accuracy reached 100% by the age of 9 years. On perceptual tasks results suggested that when children had to decide whether a compound figure had more similarities with its global shape or with an arrangement made of its local elements, a local processing bias was evident for the youngest children (3 year olds). At 4 years of age, no significant differences appeared between the local and global responses, and at 5 years of age, the global responses were selected twice as often than the local responses.

In conclusion, recent studies show that from 3 years of age, children are able to attend to both levels of pattern organization, but separately. They also revealed that the local level tended to dominate as long as the two levels were not coordinated, inducing a phenomenon of local-to-global interference. When the coordination between the two levels was utilized, a global processing preference emerged, which tended to occur around 5 years of age. The question remains whether children with ASD follow a similar developmental pattern, but are delayed, or do they stay at the earlier developmental stage or do they follow another developmental trajectory.

The Development of Weak Central Coherence in Young Children with Autism

Except for one study, there is a dearth of research on weak central coherence in preschoolers with autism. As previously discussed, Kuschner, Bennetto and Yost (2007) investigated preschoolers with autism, non-autism developmental delay and neurotypical children and found strengths on tasks requiring visuospatial disembedding or detailed focused perceptual processing in children with autism, which were relative within their own profiles and specific when compared to other groups. They concluded that these results provided further support for the weak central coherence theory. In addition, they found relative weaknesses on nonverbal tasks that depend on abstract reasoning or concept formation. Kuschner and colleagues purported that one explanation for this weakness may be related to weak central coherence, as careful use of the whole of the item is necessary for success on abstract reasoning, tasks; ignoring the gestalt would have a negative impact on performance. Therefore, although they did not explicitly test weak central coherence, their data supports the presence of weak central coherence in their sample of children with autism as compared to other preschoolers. However, Kuschner and colleagues did not analyze the impact of age in their sample.

Though there are no other studies specifically looking at weak central coherence in preschoolers with ASD, some support from the theory can be extrapolated from research with other efforts. Tsatsanis et al. (2003) examined the concurrent validity of the Leiter-R in a sample of children with autism ranging from 4-years-0-months to 16-years-11-months. They graphically illustrated the profile of subtest scaled scores for their sample and found a roughly flat profile across the four BIQ subtests; however, based on visual inspection of the graph, Figure Ground appeared to be a relative strength. Additionally, in their entire sample, the most frequent area of significant strength was obtained on the Paper Folding subtest, which involves spatial reasoning.

In general, research suggests that nonverbal perceptual skills appear to be a strength for individuals with ASD, particularly those that are school-aged and older. As previously noted, weak central coherence, which is considered a secondary characteristic of autism, may develop after the core symptoms of ASD are present. Examining the development of weak central coherence longitudinally is an important step in further uncovering the role of a weak central coherence cognitive bias in young children with autism.

Longitudinal Investigation of Weak Central Coherence

Not much is known about the developmental nature of cognitive factors in autism in general (Pellicano, 2010), and only one study has investigated weak central coherence longitudinally. Pellicano (2010) studied weak central coherence in children with autism (mean age=5.6 years at time point 1 and 8.4 years at time point 2) and controls (mean age= 5.4 years at time point 1 and 8.16 years at time point 2), along with theory of mind and executive functioning. With the CEFT and a block design task as measures of central coherence, findings suggest that children with autism showed a significant advantage on the CEFT with faster times as compared to controls at both time point 1 and time point 2. However, within group analyses found that for the children with autism, the time taken to find a hidden picture did not change across the two time points. On the block design task, children with autism outperformed controls at time 1, but this was not maintained at time 2. Again, within group analyses found that children with ASD performed similarly across time 1 and time 2. In other words, children with ASD performed consistently across time points on the CEFT and block design tasks, while the neurotypical controls showed worsening detail-focused processing at time point 2 (i.e., poorer performance on CEFT and better performance on block design). The developmental change for the neurotypical controls drove the group differences. Findings suggest that children with autism do not show significant changes within the domain of central coherence across the early school aged years as compared to neurotypical controls. However, this study did not examine each child's relative strengths and weaknesses within their own profile.

Proposed Study

This study aims to further explore the developmental process of weak central coherence in preschoolers with autism and will extend work by Pellicano (2010) as well as Kuschner and colleagues (2007) to examine this proposed pattern of a relative strength in perceptual nonverbal cognitive abilities and relative weaknesses in conceptual nonverbal cognitive abilities. In particular, this study tests whether this pattern is evident at two time points across the preschool years in young children with autism. As previously noted, weak central coherence has both strengths and weaknesses associated with a local processing bias and examining this secondary symptom longitudinally in young children with autism will help elucidate when (or if) a local processing bias develops.

As previously discussed, weak central coherence is related to an increase in ability to process detail-oriented information, also referred to as a local processing bias (Frith, 1989, Happe´, 1994, 1996). Therefore consistent with Kuschner and colleagues' (2007) investigation of patterns of cognitive performance in preschoolers with autism using the Leiter-R, this study uses a relative strength in Figure Ground and Form Completion, in comparison to performance on Repeated Patterns and Sequential Order as a marker for weak central coherence.

Based on our knowledge, no previous study has investigated the cognitive profiles in children under 4 years of age using the Leiter-R, particularly those with autism. Therefore, time point 1 analyses are considered exploratory in nature. However, consistent with previous research, we predict at time point 2 the children will show a relative strength on Figure Ground and Form Completion with relative weakness on the Repeated Pattern and Sequential Order subtests.

CHAPTER 2

METHOD

Participants

Participants consisted of a sample of 27 children enrolled in a special education preschool program (n= 21 [75%] male) with an ASD or autism diagnosis based on the diagnostic algorithm on the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999) and clinical impression using DSM-IV criteria (American Psychiatric Association, 1994). Thirteen children met DSM-IV criteria for Autistic Disorder and 14 met criteria for Pervasive Developmental Disorder, Not Otherwise Specified. Demographics and sample characteristics are presented in Table 2.1 and 2.2. All data were collected during a comprehensive clinical diagnostic evaluation by an interdisciplinary team of clinical psychologists, social workers, special education teachers, and speech pathologists at a special education preschool at two time points (mean age=41.7 months and mean age=59.7 months).

Table 2.1 Demographics

	n	%
Diagnosis		
Autism	13	48.1%
PDD-NOS	14	51.8%
Sex	n	
Male	21	77.8%
Female	6	22.2%
Ethnicity		
Asian	3	11.1%
Black/ Afr. Am	1	3.7%
Hispanic	2	7.4%
White	18	66.6%
Other	3	11.1%

Table 2.2 Sample Characteristics

	Time 1	Time 2	*t*	*p*
Age in months	41.70 (2.97)	59.74 (3.57)		
Cognitive Abilities (Leiter-R)			*t*	*p*
Fluid Reasoning	86.85 (17.81)	75.30 (20.32)	3.72	.001
Fundamental Visualization	83.85 (20.70)	86.96 (20.77)	-1.023	.316

The Just Kids Autism Program (JKAP) is a center-based early childhood program for children with autism. The JKAP curriculum is a comprehensive intervention program that uses a multi-method, special education curriculum to individualize the program and meet the needs of each child and their family. The program follows the Early Start Denver Model and places great emphasis on developing socially interactive skills that help to foster the development of functional language and cognitive skills leading to independent learning. The program strives to find each child's personality and style of interaction. Great care is given to identify which strategies and methods of teaching and intervention help each child to communicate more effectively with children and adults.

Play skills and sensory social routines are emphasized to enhance functional learning skills and social engagement through intentional teaching in the JKAP curriculum. These components are designed to engage children in their environment, and support problem-solving abilities, social referencing and skills acquisition. These skills are critical to a child's ability to evaluate and compare their physical coordination, thoughts, perceptions and emotions with others. Importance is placed on reciprocal language and communication, developing friendships, self-confidence and self-reliance. Due to the intensive intervention these children receive, we do have some concern that this program may prevent the emergence of the pattern we are hypothesizing. However, a longitudinal investigation of weak central coherence still appears reasonable for this sample as it represents a common educational program for children with autism.

Participants completed a comprehensive medical and developmental history, diagnostic assessment and psychological/ educational evaluation at two time points (Time 1: prior to entry into JKAP (mean age=41.7) and Time 2: upon graduating from the program (mean age=59.7 months)). Participants with identified neurological or genetic syndromes (e.g., seizure disorders, Downs syndrome, etc.) were excluded from this study in order to formulate a more homogenous group when conducting analyses and drawing conclusions based on the findings. Children with hearing loss and those who do not have English as their first language were also excluded because many of the tests administered are only normed in English and therefore, those with a hearing loss or those who do not have English as their first language scores may be an underestimation of their true abilities (N= 2). For this human subjects IRB approved investigation of de-indentified archival data, parents of children whose clinical data were used in the study were informed via a center based informed consent.

Measures

Autism Diagnostic Observation Schedule (ADOS)

The Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999), which is considered the gold standard diagnostic instrument for individuals with autism, is a structured play and conversational interview that includes a series of social presses and other opportunities to elicit current symptoms of an ASD. Raw scores are aggregated into symptom clusters using specified algorithms that correspond to DSM-IV criteria for a diagnosis of autism. ADOS trained clinical psychologists administered the ADOS. The ADOS, along with the developmental history and clinical impression, were used in determining diagnosis.

Leiter International Performance Scale-Revised (Leiter-R)

The Leiter-R is an individually administered measure of nonverbal intelligence. The Fluid Reasoning Index is comprised of Classification, Sequential Order, and Repeated Patterns. The Fundamental Visualization Index is comprised of Matching, Picture Context, Figure-Ground, and Form Completion. The BIQ Screener is composed of four of these subtests including Figure Ground, Form Completion, Repeated Patterns, and Sequential Order (See Table 2.3 for subtest descriptions). These tasks are untimed and scaled scores are based on the number of trials the participant passes. Psychometric properties reveal good test-retest reliability for the BIQ Screening assessment (r=.88) and internal consistency with cronbach's alphas have routinely been found to be between 0.70 and 0.81 (Roid & Miller, 1997). During the Figure Ground task, participants were handed a single card with a picture and were required to find that same picture in a complex visual field (e.g., find a hairbrush amongst a picture of cluttered garbage) corresponding to the demands of the Embedded Figures Task (Kuschner et al., 2007). During the Form Completion tasks participants were handed a single card with a picture broken into pieces (e.g., a sun divided into four sections) and were prompted to find the whole picture in a visual field (e.g., a completed sun in a park). This task requires mental manipulation and synthesis of pieces of a pictured object parallel to the cognitive demands required to complete Block Design tasks. Conversely, the Repeated Pattern and Sequential Order tasks require more abstract reasoning or concept formulation as compared to the Figure Ground and From Completion tasks. In particular, during Repeated Patterns participants were shown the beginning of a pattern of items (blue square, yellow triangle, blue square, yellow triangle, blue square) and were given more than one card and prompted to complete the appropriate pattern. During the Sequential Order task, participants were required to complete the sequence of items (finishing the sequence of small-medium-large or completing a set of concentric circles).

Table 2.3. Description of Subtests

Subtest	Brief Description	Example	Measures
Figure Ground	Location of figures or designs within a complex stimulus	Find a hairbrush amongst a picture of cluttered garbage	Perceptual Processes/ Disembedding
Form Completion	Ability to recognize whole objects from its fragmented parts	Find a whole horse in a picture of a farm using a picture of a horse broken into pieces	Perceptual Processes/ Segmentation
Repeated Patterns	Identification of missing portion of a repeated pattern of pictorial or figural items	Continue a pattern of blue square, yellow triangle, blue square, yellow triangle, blue square	Concept Formation/ Abstract Reasoning
Sequential Order	Appreciation of logical progression of pictorial or figural items	Complete the sequence of small-medium-large	Concept Formation/ Abstract Reasoning

Central coherence estimation was calculated using a relative strength and weakness profile (discussed below) using the BIQ Screener subtests. A benefit of using the BIQ Screener as a measure of central coherence is that all central coherence measures come from one standardized assessment tool, allowing for more confidence when conducting comparisons. Central coherence was estimated using patterns of cognitive performance from the BIQ Screener from the Leiter-R. As mentioned, the Leiter-R is a nonverbal measure of intellectual functioning, comprised of four subtests (Figure Ground (FG), Form Completion (FC), Repeated Patterns (RP), and Sequential Order (SO).

Procedure

Clinical psychologists administered the ADOS and Leiter-R to participants at both time points. Participants were typically tested in two separate 45-minute sessions at each time point. As previous researchers have suggested, administering the Leiter-R to children with autism is often difficult when administered entirely nonverbally (Tsatsanis et al., 2003, Kuschner et al., 2007). Therefore, the current study compensated for this difficulty and at times provided simple verbal cues (e.g., “point”).

CHAPTER 3

RESULTS

To examine primary hypotheses, (Time 1: exploratory, Time 2: the children will show a relative strength on Figure Ground and Form Completion with relative weakness on the Repeated Pattern and Sequential Order subtests) the profile of nonverbal cognitive abilities in the autism group were examined via a two-stage series of analyses using both the Leiter-R BIQ subtest scaled scores and derived deviations scores. Deviation scores were computed by first calculating the mean subtest score for each individual child. Next, the child's overall mean score was subtracted from each of their subtest scores. First, we examined patterns of strengths and weaknesses within time points. Then, we tested patterns of strengths and weaknesses across time.

Within Group (Time) Analyses

To examine relative strengths and weaknesses within each individual's cognitive profile, all pairs of the four subtest scaled scores were compared within each group via six paired sample t-tests for Time point 1. This analysis was repeated for Time point 2. (See Table 3.1 for within group comparisons).

For Time point 1, within group analyses showed null effects, suggesting no differences in abilities across BIQ subtests ($ps \geq .5$) (see Table 3.1). This provides evidence against a weak central coherence profile at this earlier age.

In contrast, paired samples t-tests at Time 2 indicated differences between FC>FG=RP>SO (*ps*≤ .05); however, differences between FG-RP were not found (*p*≥.76) (see Table 3.1). Contrary to our prediction, we found significant differences between Figure Ground and Form Completion as well as Repeated Patterns and Sequential Order. In addition, we did not find differences between Figure Ground and Repeated Patterns. However, at Time 2, individuals with autism did best on a task that requires disembedding and segmentation (Form Completion) and most poorly on a task involving abstraction (Sequential Order), which is consistent with our prediction of a weak central coherence profile. Our results provide partial support for a weak central coherence profile at Time 2.

Table 3.1. Within-Groups Comparisons Between Subtest Scaled Scores

	Difference between scaled scores (SD)	t	p
Time 1			
Figure Ground-Form Completion	-.26 (2.74)	-.492	.627
Figure Ground- Repeated Patterns	.15 (4.00)	.193	.849
Figure Ground-Sequential Order	-.19 (4.27)	-.225	.823
Form Completion- Repeated Patterns	.41 (3.09)	.685	.500
Form Completion- Sequential Order	.07 (3.44)	.112	.912
Repeated Patterns- Sequential Order	-.33 (4.12)	-.420	.678
Time 2			
Figure Ground-Form Completion*	-1.81 (2.18)	-4.317	.000*
Figure Ground- Repeated Patterns	-.19 (3.08)	-.313	.757
Figure Ground-Sequential Order*	1.07 (2.37)	2.36	.026*
Form Completion- Repeated Patterns*	1.63 (3.42)	2.475	.020*
Form Completion- Sequential Order*	2.89 (3.04)	4.934	.000*
Repeated Patterns- Sequential Order*	1.26 (2.55)	2.565	.016*

*Significant at .05

Within Subject Analyses

The focus of this analysis was on strengths and weaknesses with respect to an individual's average ability instead of overall group differences in cognitive ability. Longitudinal analyses were performed to evaluate whether the pattern of relative strengths and weaknesses seen at Time 1 were maintained when directly compared to Time 2 profiles. We created ipsative subtest profiles relative to each participant's overall performance (Kuschner et. al, 2007 and Bennetto, Pennington, Porter, Taylor, & Hagerman, 2001). Deviation scores were calculated by first calculating the mean subtest standard score for each individual child. Next, the child's overall mean score was subtracted from each of their subtest scores. The same analyses were carried out for Time point 1 and Time point 2. Four paired sample t tests were performed using deviation scores for Figure Ground Time 1 compared to Time 2, Form Completion Time 1 compared to Time 2, Repeated Patterns Time 1 compared to Time 2, and Sequential Order Time 1 compared to Time 2 (See Table 3.2). Paired sample t-tests using deviation scores found significant differences between Form Completion Time 1 compared to Time 2 ($t=-3.172$, $p=.004$) and between Sequential Order Time 1 compared to Time 2 ($t= -1.31$, $p=.035$). Paired sample t-tests using deviation scores indicated no differences ($ps> .7$) between the Figure Ground Time 1 compared to Time 2 and Repeated Patterns Time 1 compared to Time 2. These results provide some evidence for an emerging pattern of relative strengths on a task measuring disembedding and segmentation (i.e., Form Completion) and a relative weakness on a task measuring abstraction and concept formation, (i.e., Sequential Order).

Table 3.2. Leiter-R Variables

	Time 1 M *(SD)*	Time 2 M *(SD)*		p
Scaled Scores				
Figure Ground*	7.78 (4.41)	5.96 (3.20)	2.833	.009
Form Completion	8.04 (3.57)	7.78 (3.70)	.470	.642
Repeated Patterns*	7.63 (3.21)	6.15 (3.87)	2.459	.021
Sequential Order*	7.96 (4.28)	4.89 (3.38)	3.519	.002
Deviation Scores				
Figure Ground	-.07 (2.33)	-.23 (1.42)	.364	.719
Form Completion*	.19(1.49)	1.58 (1.86)	-3.172	.004
Repeated Patterns	-.22 (2.37)	-.05 (1.99)	-.348	.731
Sequential Order*	.11 (2.60)	-1.31 (1.54)	2.231	.035

*Significant at p<.05

Taken together, the within-group analyses confirm that a developmental process is occurring across the preschool years wherein at Time 1, young preschoolers with autism are not showing specific strengths and weaknesses within their cognitive profiles, suggesting flat profiles of comparable nonverbal abilities. In contrast, at Time 2 (18 months later), children with autism are showing relative strengths on Form Completion and relative weaknesses on Sequential Order. Findings suggest that an uneven pattern of relative strengths on tasks tapping disembedding and segmentation with relative weaknesses on tasks requiring the need for abstraction and concept formation are evident for older preschoolers (on Specific Leiter-R subtests (i.e., Sequential Order)), but not present for younger preschoolers with autism. These results show promising support for the development of a weak central coherence processing style over the preschool years.

CHAPTER 4

DISCUSSION

Previous research examining the presence of weak central coherence in individuals with autism, as measured by strengths on disembedding and segmentation tasks, generally support this cognitive processing bias among school-aged children, adolescents, and adults with autism as compared to a variety of controls (Shah & Frith, 1983; Jolliffe & Baron-Cohen, 199; for a detailed review see Happe´ & Frith, 2006). Furthermore, findings from Pellicano (2010) suggest that between the ages of 5.7 and 8.4 years children with autism demonstrate changes in theory of mind and executive functioning; however, they do not exhibit changes in central coherence (Pellicano, 2010). This lack of change in performance on central coherence tasks is striking in contrast to the significant gains made by typically developing children on measures of central coherence during this three-year period. However, there is little to no research examining the developmental stability of central coherence in younger children with autism. Kuschner and colleagues (2007) found support for a weak central coherence processing bias in a younger sample (mean age= 4.7 years) of preschoolers with autism (Kuschner, et al. 2007); however, the question remains whether children younger than 4.7 years evidence a similar weak central coherence processing bias. Recent studies from the neurotypical literature show that at 3 years of age, neurotypical children are able to attend to both local and global levels of pattern organization, but separately. However, the local level tends to dominate as long as the two levels are not coordinated. When a neurotypical child is able to coordinate between the two levels, which tend to occur around the age of 5 years, a global processing preference emerges. The current study sought to further examine whether young children with autism evidence a local processing bias at an even earlier age (mean age= 3.5 years) and to evaluate the longitudinal stability of this cognitive profile as measured 18 months later.

The current study's findings extend previous research on the longitudinal stability of a weak central coherence processing bias by demonstrating a change in the nonverbal cognitive profiles of young children with autism across the preschool years. Within group analyses suggest that at Time 1, young preschoolers with autism are not showing specific strengths and weaknesses within their cognitive profile, suggesting comparable nonverbal abilities. In contrast, as predicted, at Time 2 (18 months later), children with autism are evidencing a unique cognitive profile characterized by a relative strength on a subtest that depended on detail-focused perceptual processes (i.e., Form Completion), compared to a relative weakness on a subtest that required abstract reasoning or concept formulation (i.e., Sequential Order). Consistent with hypotheses at Time 2, findings also confirm significant differences between Form Completion (a measure of detail-focused perceptual processing) and Repeated Patterns (a measure of abstract reasoning or concept formation). However, inconsistent with stated hypotheses, results indicated significant differences between Figure Ground and Form Completion (both purported to measure perceptual processes) as well as between Repeated Patterns and Sequential Order (both purported to measure conceptual processes). Additionally, I did not find predicted differences between Figure Ground and Repeated Patterns. Overall, these findings suggest a general pattern of better performance on detail-focused perceptual tasks and greater weaknesses on abstract reasoning or concept formation tasks as evidenced by Form Completion>Figure Ground=Repeated Patterns>Sequential Order. Longitudinal analyses were also conducted to evaluate the pattern of relative strengths and weaknesses as compared to each child's own average subtest performance across time. Findings suggest that at Time 2 children with autism performed significantly better than their own average subtest performances on Form Completion compared to Time 1. Results also indicated that at Time 2 children performed significantly worse than their own average subtest performances on Sequential Order compared to Time 1. However, relative strengths in performance on Figure Ground were not found. Additionally, relative weaknesses in performance on Repeated Patterns were not confirmed.

Taken together, the present study extends previous research by demonstrating the presence of this unique cognitive profile in older preschoolers but not younger preschooler with autism when using a specific subtest of the Leiter-R (i.e., Form Completion). However, this was not found while using another subtest purported to measure disembedding and segmentation, (i.e., Figure Ground). Additionally, the present study demonstrated the presence of a relative weakness on a task measuring abstraction and concept formation (i.e., Sequential Order) for older but not younger children with autism. However, this was not found while using another subtest hypothesized to measure abstraction and concept formation (i.e., Repeated Patterns). The partial support for the emergence of these unique strengths and weaknesses during the preschool years suggests that there may be an important process occurring during this crucial time in development for children with autism having implications for intervention, which will be later discussed. Although, future research comparing the developmental pattern of neurotypical children is necessary before drawing concrete conclusions, one may speculate that during the early preschool years (mean age=3.5 years), children with autism are evidencing similar cognitive profiles as the normative sample, which may lean towards a local processing bias. However, when typically developing children approach their 5th birthdays, they are more able to complete abstract reasoning and concept formation tasks, whereas the ASD group maintains their local processing abilities and those skills strengthen in response to weaker processes of higher order operations. One theory in support of this hypothesis suggests that the development of local to global processing may take disparate courses in autism and typical development wherein rather than existing from birth, superior local processing appears early on during the course of development in response to weaken processing of higher order operations in children with autism (Pellicano, 2010; Motrron & Burrack, 2001). In other words, early on in development children with autism may not evidence specific and relative strengths in detail-focused processing and be more comparable to their same age peers, both preferring local elements. As neurotypical children begin to process both the local and global components together they tend to develop a global processing preference around the age of 5. However, the children with autism may not be coordinating the local and global features as readily as their neurotypical peers and may maintain their local processing preference, therefore, evidencing weaknesses in processing higher order operations, such as abstraction reasoning and concept formation. Evidence supporting this hypothesis can be found via examining the consistency of the children with autism on the Form Completion task in which the average performance on this task remained relatively constant from Time 1 to Time 2 (scaled score of approximately 8), whereas the performance on the Sequential Order task worsened over time compared to the normative sample (scaled scores of approximately 8 and 5).

Kuschner and colleagues (2007) identified various potential explanations for relative weaknesses on nonverbal conceptual tasks such as Repeated Patterns and Sequential Order. They purport that weaknesses may arise due to difficulties with concept formation and the initiation of novel ideas or principles. In addition, they suggest that careful use of the whole of the item is necessary for success and ignoring the gestalt would have a negative effect on performance. An alternative consideration is that children with autism exhibited better performance on tasks where they were required to link two items (e.g., use one picture to identify another picture on Figure Ground and From Completion tasks) and evidenced greater difficulty when prompted to make connections between as many as six items (e.g., on Repeated Patterns and Sequential Order), suggesting that individuals with autism have greater difficulties with meaningful connections between multiple items. However, the current study found similar patterns of performance on Figure Ground and Repeated Patterns, suggesting that this second argument may not accurately explain these differences.

The differences found between Kuschner and colleagues (2007) and the present study's findings, as well as those from Tstatsanis et al. (2003), deserve further clarification (See Table 4.1).

Table 4.1. Across Study Comparisons

Scaled Scores	Present Study Time 1	Present Study Time 2	Kuschner et. al (2007)	Tsatsanis et al. (2003)
	3.5 years	4.9 years	4.7 years	9.13 years
Perceptual processes				
Figure Ground	7.78 (4.41)	5.96 (3.20)	9.19 (2.56)	~5
Form Completion	8.04 (3.57)	7.78 (3.70)	9.25 (1.69)	~7
Conceptual Processes				
Repeated Patterns	7.63 (3.21)	6.15 (3.87)	5.19 (3.15)	~5
Sequential Order	7.96 (4.28)	4.89 (3.38)	4.75 (4.34)	~5

Qualitative comparisons among the three studies suggest that at Time 1, the present study's mean scaled score is approximately 8 for all of the subtests. Whereas, Kuschner and colleagues (2007) findings suggest scaled scores of approximately 9 for Figure Ground and Form Completion and scaled scores of approximately 5 for Repeated Patterns and Form Completion. This indicates that the scores on the tasks measuring disembedding and segmentation (i.e., Figure Ground and Form Completion) are comparable between studies whereas the scores on abstraction and concept formation tasks (i.e., Repeated Patterns and Sequential Order) differ wherein Kuschner and colleagues (2007) sample performs more poorly. When examining the profiles of Tsatsanis et al. (2003), we find that their sample of children with autism (mean age=9.13) have Figure Ground and Form Completion subtest scaled score that are approximately 5 and 7, respectively, which are slightly lower than both the present study's and Kuschner et al.'s (2007) sample. However, their sample's performance on Repeated Patterns and

Sequential Order are more consistent with Kuschner and colleagues' (2007) findings, which are lower than those found at Time 1 of the present study.

At Time 2, when partial support for the emergence of the proposed unique cognitive profile was evident, the children in the present study exhibited more comparable scores to those found in Tstatsanis et al. (2003) on Figure Ground, (scaled scores of approximately 6 and 5), which were lower than those found in Kuschner et al.'s (2007) (scaled scores of approximately 9). On the Form Completion subtest, the three studies' findings were more comparable; however, some variability existed, with Kuschner and colleagues (2007) having the highest scores (scaled scores of approximately 9), followed by the current study (scaled scores of approximately 8), with Tstatsanis et al. (2003) having the lowest scores (scaled scores of approximately 7). On the Repeated Patterns subtest, the present study yielded generally commensurate yet slightly higher scores on Repeated Patterns (scaled score of approximately 6) when compared to Tstatsanis et al. (2003) and Kuschner et al. (2007) (both scaled scores of approximately 5). Lastly, on the Sequential Order subtest all three studies reported scaled scores of approximately 5. Taken together, when using Time 2 results, the performances on the Form Completion (mean scores of approximately 8, 9, and 7) and Sequential Order (mean scores of approximately 5, 5, and 5) subtests were the most robust across studies, which provides additional insight into the local processing bias. However, it is important to note that no statistical tests were used to compare the aforementioned studies' findings and instead visual inspection of the data was utilized.

Kuschner and colleagues (2007) argued that one explanation for the discrepancy between their findings and those of Tsatsanis et al. (2003) may be a product that relatively enhanced performance on nonverbal perceptual tasks is more evident in higher functioning children with ASD. In addition, more children in Tsantasis' study were diagnosed with classic autism (versus PDD-NOS), indicating that patterns of nonverbal condition may vary within subtypes. The present study examined the nonverbal cognitive profiles of children with a wide range of functioning, some of which would be considered more comparable to Tsatsanis et al.'s (2003) sample (i.e., lower functioning) and others more consistent with Kuschner et al.'s (2007) sample (i.e., higher functioning). These differences in level of cognitive functioning and diagnostic classification may contribute to the partially discrepant findings across studies. The notion that the level of functioning of the children may help explain the differences between presence and absence of the unique cognitive profile at Time 2 is noteworthy. Whereas previous findings indicate that the local processing bias is less strong for children with Asperger's as compared to HFA (Jolliffe & Baron-Cohen, 1997; Ropar & Mitchell, 2001), Kuschner and colleagues (2007) purport that the absence of this cognitive profile in Tsatsanis et al. (2003) may be a result of the lower levels of functioning in their sample, which seems contrary to previous findings. To examine this hypothesis, I performed post hoc analyses on the data and found comparable findings when comparing the autism group to the PDD-NOS group, indicating that diagnostic groupings did not explain the purported differences. However, a further examination of these findings is warranted to draw more confident conclusions. Beyond functioning level, language ability may be a potential means to explain group differences. At Time 2 in the present study, 60% of children had phrase speech, compared to 93% of Kuschner's sample. However, Tsantsais et al. (2003) did not report on the number of children they had that were considered to have phrase speech. Therefore, I hypothesize that language abilities may also be contributing to these discrepant findings; however, future research should investigate this more systematically. An examination of potential mediating and moderating variables will be fruitful in further understanding the contributing factors to the presence and/ or absence of a weak central coherence cognitive profile.

Kuschner and colleagues (2007) argued that upon replication of their findings with other samples of young children with autism, the unique patterns of relative and specific nonverbal cognitive strengths and weaknesses might signify a core component of autism. However, in order to be considered a core component of a disorder, the criterion of specificity (i.e., the core features of a disorder should distinguish an individual with that disorder from individuals with other disorders), universality (i.e., should be present in the majority if not all individuals with the disorder,) and primacy (should be apparent at early stages of development) must be met (Sigman, 1994, Kuschner et al., 2007). Previous research lends support to the notion of specificity as the visuospatial disembedding and detail-focused processing abilities are specific, relative strengths in children with ASD, when compared to control groups (Kuschner et al. 2007, Happe and Frith, 2006). Although the current study did not compare children with autism to other control groups, the relative strengths on Form Completion and relative weaknesses on Sequential Order lend partial support to the specificity of the cognitive bias in individuals with autism. However, the lack of these relative strengths and weaknesses in all individuals in the ASD group could argue against the universality of these features in autism; although, it may reflect the phenotypic heterogeneity of children with ASD suggesting cognitive subtypes within the population (Kuschner et al., 2007). The current study's Time 2 findings lend further support to this notion as 70% of children evidenced a relative strength on Form Completion and 89% of children evidenced a relative weakness on Sequential Order. Additionally, the current study's results argue against the support for the primacy of these non-verbal cognitive strengths and weaknesses, as this unique profile was not evident at Time 1. Replication of these findings is necessary to draw further conclusions.

Although the results of the current study appear to be robust and offer additional insights into the nonverbal cognitive profiles of young children with autism, limitations are present. First and foremost, the small sample size and lack of comparison groups limit the generalizability regarding the specificity of the emergence of the cognitive profiles purported. Another limitation of this study is that all children were enrolled in the same preschool program and therefore the specific educational programming used in the school may also impact the cognitive profile found at Time 2. However, I believe this is unlikely given the present results partial replication of previous findings using the Leiter-R. However, replication of these findings in other settings would be valuable.

Another factor to consider is the theoretical model underlying weak central coherence. As previously mentioned, weak central coherence theory was originally developed to further explain the cognitive processing bias seen in individuals with autism. Although local and global processing in neurotypical children are readily discussed, the nature of weak central coherence was specific to understanding children with autism. In addition, although the theory is explained as distinct from other cognitive theories of autism, namely executive functioning, many researchers purport that there is overlap between the constructs. As such, some of the weaknesses described by the central coherence theory may be explained by deficits in executive functioning. For example, the relative weaknesses seen on Sequential Order may be explained as a trouble with generativity or the initiation of novel ideas or principles (Klinger & Dawson, 2001; Plaisted, 2001), which are facets of the executive functioning theory.

When comparing the methodology used in the current study to previous research on central coherence we also find differences. Most importantly, many embedded figures and block design tasks utilize a timing component and the faster a child performs the task, the better the performance. Future research using the Letier-R as a proxy for central coherence may consider timing the children as they complete the various trials to help further understand not only the accuracy of their performance but also the completion time when compared to other groups.

Another limitation to consider is that the Leiter-R may not be sensitive enough to assess the local processing bias in the younger sample, suggesting that this cognitive bias may be present at this younger age, but is less pronounced and therefore more difficult to detect using the Leiter-R. Moreover, when using a measure that is intended for a wide age range (2 through 20), the examiner needs to caution against floor effects, which may have also contributed to the null findings at Time 1. The Sequential Order subtest of the

Leiter-R also presents with other difficulties when generalizing results. In particular, Kuschner and colleagues (2007) found this subtest to be a relative weakness for the neurotypical sample as well. Therefore, this weakness may not be specific to autism, which raises concerns. In addition, when inspecting raw scores for the children in the current study, although significant improvements were noted for the other BIQ subtests (e.g., Figure Ground, Form Completion, Repeated Patterns), the Sequential Order raw scores remained consistent from Time 1 to Time 2, suggesting that the children did not answer any additional questions correct over time. This plateau is a cause of concern and should be further examined. These concerns also bring to question the validity of the Leiter-R at younger ages, particularly for children under 4 years of age. However, to our knowledge, there are no studies investigating the validity of the Leiter-R with young children. Therefore, further examining the validity of the measure as well as using other measures of central coherence may be beneficial in further disambiguating the absence of the unique cognitive profile at Time 1 and the emergence at Time 2.

Future research should address these identified limitations as well as provide examination regarding the potential moderating and mediating factors attributing to the development of this local processing bias. Additionally, research should target the impact this cognitive profile has on other aspects of development including language, social behaviors, and restricted and repetitive interests and behaviors. If these findings are replicated, the use of the nonverbal perceptual strengths to help ameliorate abstract reasoning and concept formation vulnerabilities may be beneficial.

Various treatment options may be considered to address this local processing bias. As noted, this processing preference has been identified in numerous studies investigating older preschoolers, school aged children, adolescents, and adults with autism. Therefore, early intervention techniques targeting the ability to *flexibly* shift from local to global perceptual processing may be warranted. One such intervention involves cognitive flexibility, which is typically conceptualized under executive functioning theories (Cannon et al., 2011). Adapting these interventions for verbal preschoolers would be beneficial as it could offer preventative strategies to teach young children with autism to "see" the big picture in a visual scene. For example, children could be taught concretely to concretely to attend to the details of a picture (e.g., finding the birthday cake) while also probing them to "put the pieces together" and see the gestalt (e.g., all of the individual objects together depict a birthday party scene). Later, these perceptual flexibility exercises can target cognitive flexibility in other contexts, particularly social situations. For example, having a child locate the various details within a picture as well as describe the gestalt of the scene, whereby two children are having a conversation while one child is looking away, can offer creative opportunities to break down social situations into it's component parts. In addition, to further enhance cognitive flexibility, problem-solving techniques can be utilized whereby the child is prompted to identify other reasons for the children's behaviors. Additional interventions may include taking various individual pictures of a child while performing an activity and having the child narrate this experience with an emphasis on describing the details as well as the overall meaning. In this way, utilizing a child's local processing preference can help mitigate some vulnerabilities in other domains of flexibility, including executive functioning and theory of mind.

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