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Weak Central Coherence Theory Problem Solving in Adults with Asperger Syndrome

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The University of Southern Mississippi

Weak Central Coherence Theory
Problem Solving in Adults with Asperger Syndrome

By

Marie Ferderer

A Thesis

Submitted to the Honors College of
The University of Southern Mississippi
in Partial Fulfillment
of the Requirements for the Degree of Bachelor of Arts
in the Department of Speech and Hearing Sciences

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Abstract

This study examined the effect of Weak Central Coherence on problem solving strategies in adults with Asperger Syndrome. A group of adults with Asperger Syndrome and a group of Neurotypical adults were assessed using a riddle game. This game required participants to solve a riddle based on a cryptic language clue. The types of problem solving strategies employed by each group were recorded and compared in statistical analyses.

Significant differences in problem solving strategy were obtained for the two groups. The neurotypical group evidenced a strategy in which they considered the meaning of the language clue while attempting to solve the problem. The Asperger Syndrome group evidenced a strategy in which they considered the structure of the language clue while attempting to solve the problem. These findings support the theory of Weak Central Coherence.

Introduction

Autism is a neurodevelopmental disorder which currently affects 1 in 110 children born in the United States (Center for Disease Control and Prevention). First named by Leo Kanner (1943), autism has been the subject of much study. One major area of study concerns the cognitive underpinnings of the disorder. Researchers have attempted to identify the unique cognitive aspects of autism. Major cognitive theories of autism have included Theory of Mind theory (Baron-Cohen, Leslie, & Frith, 1985), Executive Dysfunction theory (Ozonoff, Pennington & Rogers, 1991), and Weak Central Coherence theory (Frith, 1989). Other cognitive theories have been suggested and studied (Hughes & Russell, 1993; Baron-Cohen, 1989b; Hobson, 1989), but they have not gained wide acceptance as viable explanations for the cognitive aspects of autism (Happe, 1998). None of the theories provide a unified account of autism; however, each provides some plausible explanations for the impairments in autism.

Frith (1989) postulated the Weak Central Coherence (WCC) theory. This theory holds that autistic individuals are impaired in their ability to form cognitive gestalts. Instead, they perceive the world as fragmented and process information on a primarily local cognitive level. Several studies have supported this theory (Shah & Frith, 1983; Hobson, Ouston, & Lee, 1988; Frith & Snowling, 1983), but other studies contradicted the Weak Central Coherence theory (Motttron, Burack, Stauder, & Robaey, 1999; Plaisted, Swettenham, & Rees, 1999). In 2002, Frith revised her original book to include the new findings on WCC theory.

Happe and Frith (2006) summarized the studies that have been conducted concerning WCC theory since 1983. The studies addressed three main areas of perceptual cognition: visuo-spatial ability, auditory processing, and verbal performance. Few studies have been conducted on higher order cognitive skills and whether they are affected by Weak Central Coherence.

Language based studies such as sentence completion tasks and reading comprehension have been conducted (Booth & Happe 2010; Saldana & Frith 2007). However, there have been no studies on the effects of Weak Central Coherence on higher order problem solving ability.

This study seeks to compare problem solving between a group of adults with Asperger Syndrome, a high functioning form of autism, and a group of neurotypical adults. Neurotypical refers to individuals with normal neurological development and functioning. If the cognitive mechanism which underlies autism is not confined to individual sensory systems, then higher levels of reasoning and problem solving may be affected. If this is the case, individuals on the autism spectrum will use different strategies to solve a problem, and their strategies will likely be less efficient than the strategies of neurotypical individuals.

This study compared the strategies that autistic and neurotypical adults use to solve a complex riddle. Each participant's problem solving process was measured and quantified according to types of reasoning used throughout each stage of the solution process. The number of steps each person needed to solve the riddle was recorded and compared on a group basis. The group with Asperger Syndrome is expected require more turns to solve the task and is expected to rely upon mathematical and memory based strategies to a greater degree than the neurotypical group. The neurotypical group is expected to consider more dimensions of the riddle and to solve the problem in fewer turns.

Understanding cognitive functioning in Asperger Syndrome can lead to a practical application of research concerning cognitive theories of autism. Research has already shown that autistic people typically have difficulty organizing information globally and that their cognitive style is detail focused (Happe & Frith, 2006; Navon, 1977; Plaisted et al. 1999). However, more research should be conducted to identify the effects of autistic cognition in everyday functioning.

Previous studies have gained useful information by studying isolated performances on specialized tasks (Pellicano, Gibson, Mayberry, Durkin & Badcock, 2005; Mottron et al. 1999). However, these tasks do not reflect activities necessary for everyday functioning. Higher order skills are vital to functioning effectively, and if they too are affected by Weak Central Coherence, then autistic people are at a disadvantage. Understanding how Weak Central Coherence affects functioning can lead to practical therapy for autistic individuals.

Review of the Literature

Rational Evidence

Autism can be specifically classified by what is known as “a triad of impairments.” These impairments are problems of socialization, communication, and imaginative interaction or play (Happe, 1998). A satisfactory cognitive theory of autism should account for the deficits in all three of these areas. Three major cognitive theories of autism and their evolution over the past thirty years are considered here. These theories include Theory of Mind, Executive Dysfunction, and Weak Central Coherence. Weak Central Coherence is the main focus of this study.

A. Theory of Mind:

Premack and Woodruff (1978) held that “an individual has a Theory of Mind if he imputes mental states to himself and others.” Theory of Mind allows individuals to understand another person’s point of view, and to adjust their behavior accordingly. In a broad sense, Theory of Mind is the ability to predict relationships between external reality and one’s own state of mind (Frith, 2003). The theory is closely related to the notion of role-taking. In role-taking, an individual combines his knowledge of people and their behavior with his perception of their

behavior in a given situation to determine an appropriate social response (Flavell, Botkin, Fry, Wright, & Jarvis, 1968).

The Theory of Mind hypothesis of autism, first suggested by Baron-Cohen, Leslie, and Frith (1985) has received much attention as a cognitive theory of autism. Baron-Cohen (1993) defined the *Theory of Mind hypothesis of autism* as “the idea that in autism there is a failure to develop a normal understanding that people have minds and mental states, and that a mental state relates to behavior.” The hypothesis holds that autistic children are unable to infer the mental states of others, and are therefore unable to comprehend the beliefs or predict the behavior of others. If autistic children lack Theory of Mind, they may also lack the ability to form second-order representations. Such representational ability is the cognitive precursor of both Theory of Mind and the emergence of pretend play, which is also impaired in autistic children (Leslie, 1987). With impaired Theory of Mind, autistic children cannot engage in normal social role-taking behavior, and are thus impaired in social interaction and communication. The inability to infer the mental states of others adversely affects socialization. A lack of role-taking ability interferes with appropriate communication. Limited second-order representation precludes the development of imaginative play. Thus, the Theory of Mind hypothesis of autism gives a satisfactory account for the triad of impairments.

Some researchers, however, question the validity of impaired Theory of Mind as an explanation for autism. If the Theory of Mind hypothesis claims to account for the triadic deficits in autism, it should be manifested universally in the autistic population. However some autistic children pass the Theory of Mind tasks, though they still evidence social deficits (Baron-Cohen et al, 1985; Happe, 1998). This would seem to indicate that Theory of Mind impairment is not a characteristic in all autistic individuals. Theory of Mind research has been influential, because it

has the potential to identify a unifying, causal account of autism. However, subsequent studies have identified dimensions of the theory that could limit its usefulness as the underlying account of autism (Frith & Happe, 1994). The theory also has not accounted for other non-social aspects of autism. Plaisted (2000) identified some of the non-social aspects of autism not explained by Theory of Mind, such as visuo-spatial processing differences and pattern processing, and suggested that other cognitive theories may aid in understanding autism.

B. Executive Dysfunction

Welsh & Pennington (1988) defined Executive function as “the ability to maintain an appropriate problem-solving set for attainment of a future goal (p. 201).” It includes a broad range of skills, such as inhibition, planning, flexibility, organization, self monitoring, goal setting, and working memory (Ozonoff, Cook, Coon, Dawson, Joseph, Klin, McMahon, Minshew, Munson, Pennington, Rogers, Spence, Tager-Flusberg, Volkmar, & Wrathall, 2004.) The Executive Dysfunction Theory of autism provides a possible explanation of the triad of impairments in autism. This theory holds that autistic individuals are impaired in their ability to engage in problem solving behavior to attain a future goal (Ozonoff, Pennington & Rogers, 1991).

Rumsey (1985) studied executive function in autism by using the *Wisconsin Card Sorting Task* (Heaton, 1981). She found that executive function in autism is impaired. Hughes (2001) reviewed studies of Executive Dysfunction in autism, and concluded that Executive Dysfunction in autistic individuals tends to be high-level and non-spatial in nature. Specifically, a review of recent studies has shown that autistic people have impaired flexibility, but their inhibitory functions and working memory are intact (Ozonoff et al., 2004). A study of executive function in

young children with autism revealed normal functioning in the areas of set-shifting, action monitoring, and spatial and object working memory. The study cast doubt as to whether Executive Dysfunction can be considered a true cognitive theory of autism, as its results indicated that executive functioning may be intact in very young autistic children, but that it may worsen as they age. If this is the case, Executive Dysfunction cannot cause autism, but must arise from a deeper cognitive deficit (Griffith, Pennington, Wehner, & Rogers, 1999).

Executive Dysfunction of autistic individuals could be the result of an underlying deficit in rule use. A study by Russell, Saltmarsh, and Hill, (1999) attempted to show that autistic children are capable of executive function tasks that are non-rule based, while they have difficulty with tasks that rely on arbitrary and novel rules.

C. Weak Central Coherence

The theory of Weak Central Coherence was originally developed by Frith (1989). She theorized that autistic individuals lack the high-level central cognitive control needed to perceive global, cohesive concepts. As a result, they may perceive the world as fragmented, and unorganized, a collection of unconnected details.

The theory of Weak Central Coherence is based on the view of a global versus local processing style. Before Weak Central Coherence can be fully understood, some clarification of terms is necessary. The distinction between global and local processing is rooted in the psychological debate over the relationship between wholes and parts. Global processing, also known as wholistic processing, refers to the hypothesis that the wholistic properties of an object are perceived before its component properties (Kimchi, 1992).

Navon (1977) coined the terms “local” and “global” when he tested global versus local processing bias in a visual task. He described every visual scene as a “hierarchy of subscenes interrelated by spatial relationships (p. 354).” Information at the top of the hierarchy is considered global, while the information at the bottom is considered local. He determined that humans process perceptual information at the global level initially, and that the local information is derived from a finer analysis of the global picture.

In normal central processing, an individual extracts and remembers meaningful information from the environment without needing to recall the information’s original form. Bartlett (1932) published a series of studies demonstrating the way neurotypical individuals assimilate information into memory. He showed, for example, that a person can listen to a story and recall the plot later, without remembering the entire story verbatim. In fact, recall of such local detail is burdensome if not impossible for most individuals. Even then, Bartlett noted that some individuals lacked the ability to comprehend things in a coherent fashion, and were instead reliant on analysis of details. He described people who “are unable to combine realms of interest not conventionally put together, until some reason that can be formulated has been found by themselves or by some different person” (pp. 223-224).

This preoccupation with detail, and inability to recognize “gist” is the basis of the Weak Central Coherence theory of autism (Frith, 1989). In the past twenty years, studies have revealed that autistic children have enhanced local processing abilities, but are deficient in global processing of information. These studies include the *Homograph Test* (Frith & Snowling, 1983), a *Prototype Formation Task* (Klinger & Dawson, 2001), and the *Embedded Figures Test* (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983). Each of these studies addressed a different area of cognitive processing affected by weak central control. The homograph test measured verbal-

semantic ability, the embedded figures test addressed visual-spatial ability, and the prototype formation test measured perceptual coherence.

A feature unique to weak central control theory is its explanation for the “islets of ability” that have been reported in autism (Happe, 1999; Frith, 1989). Even autistic individuals who score below average on an IQ test often evidence some form of exceptional skill in areas such as memory, calculation, art, or music. One parent talked of his grown son’s inability to order food for himself at restaurants. This same young man could remember every key he had ever seen, what it unlocked, and who it belonged to. Frith (1989) observed similar phenomena in the autistic individuals she encountered. She hypothesized that such phenomena could be the result of enhanced local processing at the expense of global coherence and incorporating details into meaning.

Since the Weak Central Coherence theory was first published, several studies have supported this theory (Shah & Frith, 1983; Hobson, Ouston, & Lee, 1988; Frith & Snowling, 1983). However, the results of some studies contradict this theory (Mottron, Burack, Stauder, & Robaey, 1999; Plaisted, Swettenham, & Rees, 1999; Plaisted, 2001).

Since the original theory was published, it has undergone several important revisions. The theory now emphasizes superior local processing as opposed to deficient global processing. In addition, its authors no longer claim that Weak Central Coherence is the sole explanation for deficits in social cognition, but that it is a contributing factor along with deficits in Theory of Mind (Happe & Frith, 2006). Some researchers now refer to local processing as a cognitive style that falls along a normal continuum, rather than as a cognitive deficit per se (Happe, 1999). If this is the case, autistic individuals simply fall at the extreme end of the continuum, while other

individuals may be impaired by their propensity to primarily process information on a global level.

Empirical Studies

Within the past two decades, there has been a significant increase in the number of empirical studies concerned with autism. This section reviews seminal studies supporting each of the three major theories of autism: Theory of Mind, Executive Dysfunction, and Weak Central Coherence. It specifically concentrates on major developments in Weak Central Coherence theory, by reviewing several landmark studies conducted over the course of the theory's development.

A. Theory of Mind:

Baron-Cohen et al. (1985) designed an empirical study to compare false beliefs in autistic children, children with Down's syndrome, and normal children. The children were matched for mental age, rather than chronological age, using the Leiter International Performance Scale (Leiter, 1936), and the British Picture Vocabulary Test (Dunn, Dunn, Whetton, & Pintilie, 1982). They hypothesized that autistic children in the study would not form false beliefs, while the other two groups would use false belief and respond to the task accordingly.

In the experiment, a child observed two dolls named Sally and Anne. The dolls were sitting on a stage, each holding a basket. The child watched as Sally placed a marble in her basket. Sally then exited the stage. While she was gone, Anne took Sally's marble, and placed it in her own basket. When Sally returned, the child was asked "Where will Sally look for her marble?", "Where is the marble really?", and "Where was the marble in the beginning?" The

second two questions were merely control questions, to ensure each child understood the basic scenario. The first question, however, measured false belief reasoning through Theory of Mind. If a child answered that Sally would look in her own basket, the child inferred Sally's mental process, realizing that her thoughts may not match with what the child knows is true. If the child answered that Sally would look in Anne's basket, he did not infer Sally's mental state, but instead answered the question based on his own knowledge.

The findings were consistent with the original hypothesis of the study. About 85% of both the normal group and the Down's syndrome group passed the false belief question. However, only 20% of the autistic group passed the false belief question. All participants correctly answered the control questions, indicating that the results were not influenced by extraneous variables such as comprehension or memory problems. The results of the study indicated that the autistic group had impaired Theory of Mind when compared to other groups of the same functional age.

B. Executive Dysfunction:

Rumsey (1985) tested a population of autistic adult males who had normal IQs. They were matched with a normal control group according to highest level of education completed. She used the *Wisconsin Card Sorting Task* (Heaton, 1981) as a measure of executive function. In this task, a subject was given four cards, each with a pattern of geometrical shapes, colors, and numbers. A control deck contained 64 cards, each displaying a variation of one of the four original cards. Subjects were directed to sort the 64 cards into categories based on the first four cards. They were told whether they categorized a card correctly or incorrectly based on a predetermined sorting rule. The experimenter knew the rule, but the subjects were required to

deduce the rule independently. After 10 correct responses, the rule was changed, and the subject was required to deduce the new rule. The task required inductive logic and hypothesis testing, and so was a good measure of problem solving ability. Each participant also completed the *Vinland Social Maturity Scale* (Doll, 1947) which measured social functioning.

Participants were scored according to ten different criteria, including number of categories completed, number of perseverative responses, number of perseverative errors, number of nonperseverative errors, total errors, percent of perseverative errors, number of trials to complete the first category, percent conceptual-level responses, failure to maintain set, and improvement or lack of it over categories (“learning to learn”).

The results of this study indicated that individuals with high functioning autism and normal IQs evidenced deficits in conceptual problem solving. These deficits seemed to result from a tendency to dwell on previous answers and hypotheses even when those are shown to be wrong. The study also evidenced significant heterogeneity within the autistic group. While their group scores fell consistently below the scores of the control group, the individual scores did not reflect a homogenous pattern. The study also showed that problem solving and social adaptivity were not correlated.

C. Weak Central Coherence:

Autistic individuals are known to have varying degrees of deficits in certain areas such as socialization, communication, and pretend or imaginative play. However, these impairments are often paired with “islets of ability,” which are specialized areas of cognitive functioning that do not match the autistic individual’s overall level of functioning. Shah and Frith (1983) constructed a study to explore these cognitive anomalies further by testing autistic children’s attention to

perceptual detail and visuo-spatial performance. They hypothesized that autistic children would have better perception of detail and would evidence higher visuo-spatial ability than their age matched peers.

Shah and Frith (1983) conducted an empirical study which compared autistic children, mentally retarded non-autistic children, and normally developing children. The groups were matched by mental age as determined by the *Raven's Coloured Progressive Matrices*.

The researchers used the standardized *Children's Embedded Figures Test* (CEFT) which was developed by Karp and Konstadt (Witkin, Oltman, Raskin, & Karp, 1971). A child was presented with a picture of a recognizable object, such as a baby carriage or a rocking horse. Easily recognizable geometric shapes were embedded throughout the larger picture, and the child was asked to find all the smaller shapes within the larger pictures. He was given a small cut-out of his target shape which he could use to aid his search. The speed and accuracy with which the child found the shapes determined his overall score. The researchers recorded one of three search patterns for each shape the child found: (a) immediate response, where the child found the shape with no noticeable effort; (b) visual search, where the child searched the picture but found the shape without the aid of the cut-out; and (c) concrete search, where the child used the cut-out by sliding it around the picture.

Shah and Frith (1983) found that the autistic group had higher overall accuracy than the other two test groups. They also found significantly more shapes through immediate recognition than the other two groups. However, unlike their neurotypical counterparts, the autistic group evidenced minimal visual search. Instead, they used concrete search to find any shapes they could not immediately recognize. The neurotypical also used concrete search, but with significantly lower accuracy than the autistic group.

The autistic group evidenced good immediate recognition, but poor visual search, showing that they did not have particularly enhanced visuo-spatial reasoning. Instead, the findings indicated that autistic children were not impaired by the picture as a whole. They did not need to mentally deconstruct the picture because their original perception of the picture was detailed oriented, or local, rather than Gestalt, or global.

Klinger and Dawson (2001) observed that autistic individuals often did not generalize information to contexts other than the one in which the information was first presented. This resulted in rigid thinking and behavior, and dependence on rules for functioning. They hypothesized that this inability to generalize resulted from an impairment of the cognitive process of categorization. Earlier studies had shown that autistic individuals categorized information, but that there were some deviations in their process of categorization.

Klinger and Dawson (2001) investigated autistic individuals' concept formation through categorization. The study compared concept formation among an autistic group, a group of people with Down's Syndrome, and a normally developing group. Each group was matched for language comprehension and mental age according to the *Peabody Picture Vocabulary Test* (Dunn, 1965).

This study used three different tasks in which a child was asked to categorize drawings of imaginary animals according to certain criteria. Before each task, the child was familiarized with the new animal. In the first task, a child was shown a prototype animal and given its name. The child was then shown the prototype picture and a picture of the same type of animal which had slight variations of physical features (for example, longer feet, thicker arms, a rounder mouth, etc.). Each child was asked to point to the animal, and could choose either the prototype or the variation. In the second task, the child was shown a different kind of imaginary animal, and was

told an explicit rule for categorization (For example, “This is a Sops, all Sops have two teeth.”). He was then shown three animals which were identical with the exception of the categorization characteristic. The child was asked to point to the correct animal. In the third task, the child was shown a third type of animal, and was expected to infer the categorization rule during the familiarization process.

The researchers found that the autistic and Down’s syndrome groups chose the prototype animal at chance levels in the first task, while the normally developing group chose the prototype animal the majority of the time. There was little variation among groups in the explicit and implicit rule tasks. These results indicated that the autistic individuals were not impaired in their ability to learn or follow rules. However, they evidenced an inability to form prototype information. The Down’s syndrome group had similar results, indicating that prototype formation deficit is not specific to autism. The researchers noted that the rule tested in the experiment was only based on one condition, and so the children were not required to integrate information. They speculated that, were more information integration required, autistic children may show a greater deficit in learning the rules.

Booth and Happe (2010) studied three major issues in Weak Central Coherence theory. They conducted three separate studies to determine: (a) individual differences of central coherence within a large neurotypical (NT) population, (b) the hypothesis of Weak Central Coherence within an ASD population, (c) the hypothesis that local processing is a cognitive style, rather than a deficit of inhibitory control as seen in populations affected by Executive Dysfunction. They used a sentence completion task, and scored the subjects’ responses in terms of local and global answers.

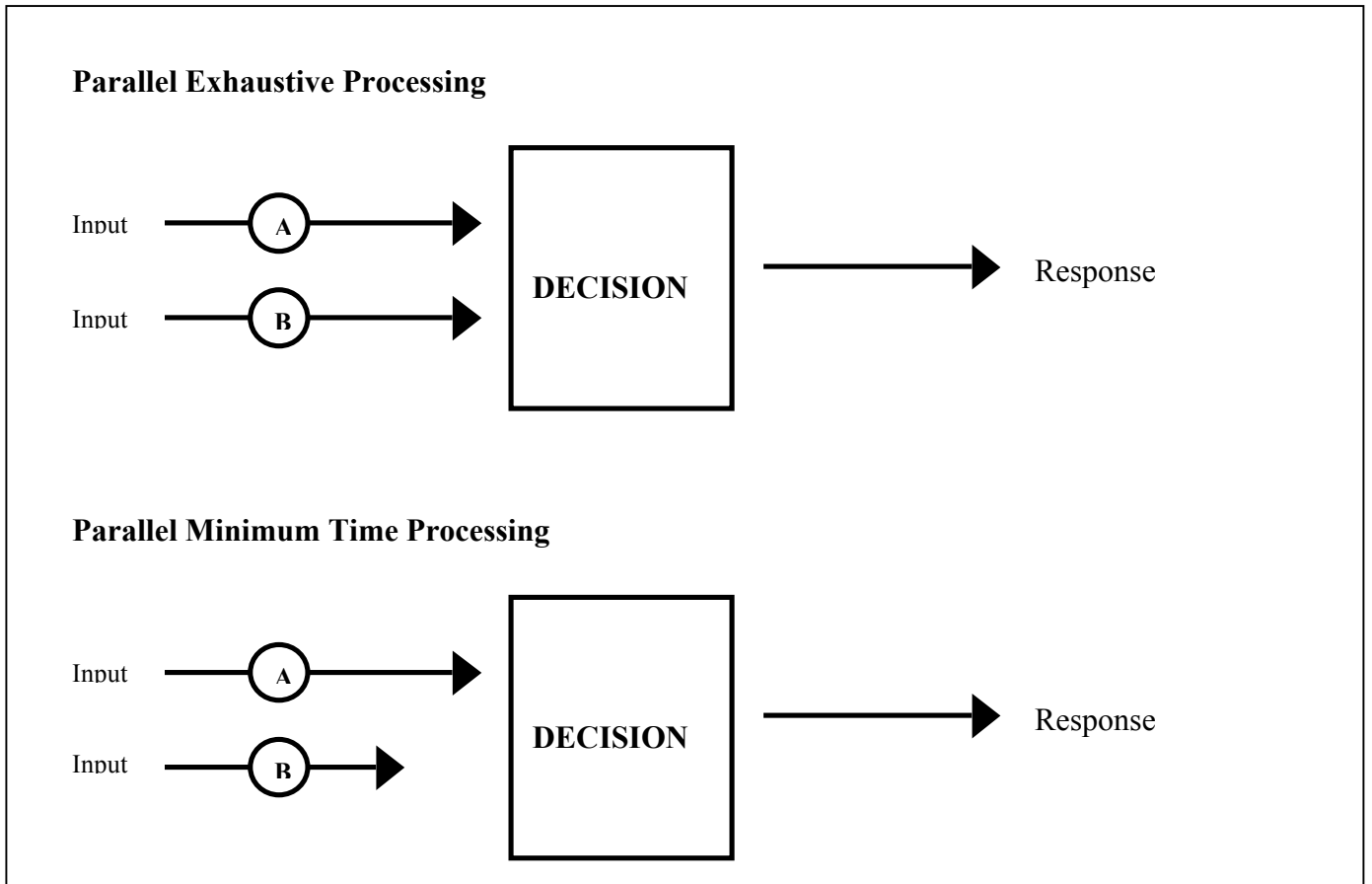
The first study showed little central coherence variation in the NT group. What variation there was correlated with age, but was not significant. There was no correlation between local-global processing and IQ. In the second study, the ASD group evidenced significantly more local processing than the NT population did. There was also a significant correlation between severity of autism and incidence of local answers as opposed to global answers. This indicated that high functioning autistic individuals were using compensatory strategies for deriving global answers, while lower functioning individuals did not implement such strategies. In the third and final study, the ASD group was compared to an ADHD group. Once again, the ASD population gave significantly more local answers than the ADHD group. If local processing was the result of impaired local inhibition, the ADHD group, who evidenced executive function deficits, particularly in the area of inhibition, should have given more local answers.

Johnson, Blaha, Houpt, and Townsend (2010) mathematically analyzed some of the underlying cognitive mechanisms which could account for Weak Central Coherence. The study used a well established mathematical empirical paradigm called *Systems Factorial Technology* (Townsend, 1984) to identify the differences in local-global processing between autistic and neurotypical groups.

The study compared a group of 10 adults or adolescents with High Functioning Autism and a control group of 11 typical adults and adolescents. In the task, the participants had to respond to the presence or absence of arrows on a computer screen. Each stimulus consisted of a global shape made of smaller local shapes. The global shape could be a high-salience arrow, a low-salience arrow, or a dash (no arrow present). The global shapes were constructed of smaller high-salience arrows, low-salience arrows, or dashes. Each participant was presented with the stimulus, and instructed to indicate the presence or absence of an arrow in either context by

clicking a mouse. Each participant completed 2,560 trials total. The reaction times for each participant were used to calculate selective influence using Systems Factorial Technology.

Figure 1. Processing Pathways



In contrast to the premise of Weak Central Coherence theory, both test groups evidenced global advantage in the task. There was no global impairment or local advantage for the autistic group. However, analysis of the data revealed significantly distinct information processing differences between the two groups. The autistic group evidenced coactive and facilitatory parallel exhaustive processing, while the neurotypical group evidenced inhibitory parallel minimum-time and inhibitory parallel exhaustive processing. These processing models are illustrated in figure 1.

These findings indicate that people with autism may process information in a fundamentally different way than neurotypical people. It seems that neurotypical people process information according to inhibitory parallel processing, meaning they process two channels of information simultaneously but arrive at the conclusion as soon as one channel provides the necessary threshold of information. This processing style pits the channels against one another, so that multiple channels impede processing time. Alternatively, autistic people use facilitatory exhaustive processing. They also process two channels of information simultaneously, but both channels must reach the threshold before a decision is made. In this processing style, the channels aid each other, leading to faster responses with more information. However, when more than two channels are needed, this exhaustive method takes much longer than an inhibitory one.

Asperger Syndrome is an autism spectrum disorder, and is not a distinct disorder apart from autism (Wing, 1998). Individuals with Asperger Syndrome are characterized by the autistic triad of impairments. Asperger Syndrome is distinguished from other autism spectrum disorders by the fact that symptoms are less severe. Individuals with Asperger Syndrome have normal to above average intelligence, and the cognitive and verbal ability to understand and respond to verbal instructions. (Charman, Jones, Pickles, Simonoff, Baird, & Happé, 2011). This study uses adults with Asperger Syndrome for the test group because, while they possess the cognitive phenotype of autism, they also function well enough to complete the required task (Chapman et al. 2011).

Hypothesis

Research Question

This study compares differences in higher order problem solving between a group of adults with Asperger Syndrome and a group of neurotypical adults. What are the differences, if any, between adults with Asperger Syndrome and neurotypical adults in solving a cognitively complex task? The independent variable is the presence or absence of autism in the participants. One dependent variable is the number of turns that each participant takes to solve the task. Another dependent variable is the cognitive strategy that each participant uses to solve the task.

Null Hypothesis

The group with Asperger Syndrome required a comparable number of turns to solve the task and their strategies did not differ significantly from the neurotypical group.

Directional Hypothesis

The group with Asperger Syndrome required more turns to solve the task and relied on mathematical and memory based strategies to a greater degree than the neurotypical group.

Procedures

Participants

This study compared a group of nineteen adults with a diagnosis of Asperger Syndrome to a group of twenty neurotypical adults on a problem solving task. The autistic adults volunteered through their membership in the Fort Wayne Aspergers Support Group, their

involvement with the Alabama Autism Resource Foundation, and through their participation in programs hosted by Together Enhancing Autism Awareness in Mississippi.

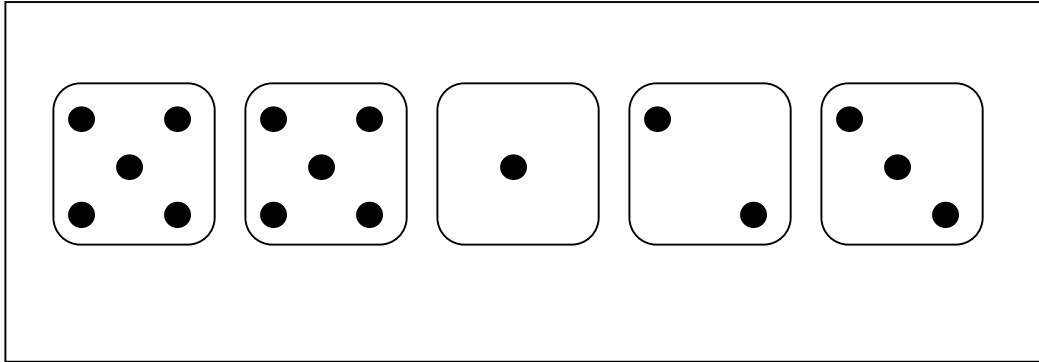
The neurotypical adults were a random selection of students at the University of Southern Mississippi. A request for participants was sent to university students via email, and participants were drawn from students who responded to the emails and who volunteered to participate in the study. Neurotypical individuals were required to have no diagnosis of an autism spectrum disorder, and no immediate family members with a diagnosis of an autism spectrum disorder.

Many published studies involving individuals with Asperger Syndrome use small sample sizes, ranging from seven to fifteen participants in any given test group. This study used a sample size of twenty participants in each group, a comparatively large number in the field of Aspergers research.

The Dice Task

The Dice Task, based on Robert Steinwachs' "Petals around the Rose" riddle (1993), measures the amount of information an individual needs to deduce a rule. The riddle uses a single rule to assign a numerical value to rolls of five dice. The rule itself is simple, but nearly impossible to derive without the language hint. The player must realize that the "rose" is the dot in the center of an odd dice, and that the "petals" are the dots surrounding the "rose." The answer to a roll is determined by counting the total number of "petals" shown on all five dice. Figure 2 is an example of a possible roll:

Figure 2. Dice Roll Example



In this roll, there are four dice displaying roses (dice with no center dot are disregarded). The fives each have four petals, and the three has two petals. The one has a rose, but no petals, so it adds nothing to the final answer. According to the rule, this roll equals ten.

A facilitator who already knows the rule conducts the game for the other players. A player is told the name of the game, and that the name of the game is important. After each roll of the dice, he is given the opportunity to guess the answer. The facilitator then provides the correct answer. The player can have as many rolls as needed to determine the answer. The player proves that he has solved the riddle by answering three consecutive rolls correctly.

In this study, the “Petals around the Rose” game has been converted into a measure of information integration. There are three dimensions of information that a player needs to consider to solve the problem. The first dimension is the title of the game-- the linguistic hint. The second dimension is the numerical solution assigned to each role of the dice-- the numerical hint. The third dimension is the numerical value displayed on each dice irrespective of the “petal” value. A player’s ability to integrate all three tiers into a solution will affect the number of turns required to derive the “petal” solution. The more efficiently the tiers can be related to one another in a coherent fashion, the fewer turns will be required to solve the riddle.

Methods

Each participant were given five pieces of information:

1. The name of the game is Petals around the Rose.
2. The name of the game is significant to the answer.
3. Every roll of the dice will have a numeric value that is either 0 or an even number.

The following pieces of information are derived from rolls of the dice that are shown to the participant:

4. A roll equals _____
5. A second roll equals _____

The participants subsequently observed dice rolls and were asked “what do you think the answer is?” After each response, they were asked “why do you think the answer is ___?” The researcher then told them what the correct answer was by saying “The answer to this roll is ____.” No other verbal prompts were given. The number of rolls was recorded. The experimenter recorded each answer as one of six categories of rule reasoning:

1. *Language function reasoning*- the participant used this when the answer was based on the language clue in some way
2. *Language structure reasoning*- the participant used the language rule as a mathematical formula based on structure rather than content.
3. *Numerical mathematical reasoning*- the participant used this when the answer was based on a mathematical operation or algorithm.

4. *Answer based reasoning*- the participant used this when the answer was based directly on an identical role, or when the answer was derived by the answer to the previous role
5. *Pure guess*- the participant used this when the answer was not reasoned but simply an attempt to illicit more information
6. *Spatial Reasoning*- The participant used this when the answer was based on the physical configuration of the dice.

Progression up the scale indicates movement to a higher tier of reasoning, and more effective integration of information.

Data

The data gathered from the participants was analyzed in two ways. First, group comparisons were calculated for the number of turns required to solve the problem. Second, the problem solving strategy sequence for each participant was recorded. These sequences were graphically displayed to ascertain any commonalities or differences between the groups.

Results

Data was collected for twenty adults with Asperger Syndrome and twenty Neurotypical adults. However, one of the adults with Aspergers solved the task in one dice roll, creating outlier data. Acting upon the recommendation of statistics expert, Dr. J.T. Johnson, data for this individual was not used in the final statistical analysis.

The raw frequency data from both test groups is listed in the table below. Table 1 records the frequency with which each participant in both groups used a given strategy when attempting to solve the dice roll problem. The number of trials varied for each participant, but a t-Test showed that there was no statistically significant variance in the average number of dice rolls in either group. There was also no significant difference between the groups in the number of participants who solved the problem.

Table 1. Strategy Frequencies for Both Groups

Asperger Syndrome Group Strategy Frequencies							Neurotypical Group Strategy Frequencies						
Participant	S1	S2	S3	S4	S5	S6	Participant	S1	S2	S3	S4	S5	S6
1-AS	0	1	2	2	4	2	1-NT	1	0	1	0	0	0
2-AS	4	0	10	9	0	7	2-NT	1	0	14	1	5	4
3-AS	2	0	2	0	0	2	3-NT	0	0	11	1	0	0
4-AS	0	0	9	10	4	0	4-NT	4	0	21	3	4	0
5-AS	1	3	3	4	0	0	5-NT	2	0	1	0	1	0
6-AS	2	0	12	4	4	0	6-NT	3	0	5	4	0	0
7-AS	5	0	1	1	0	0	7-NT	1	0	3	1	1	0
8-AS	0	0	9	0	6	0	8-NT	4	0	16	8	1	0
9-AS	0	5	3	3	3	0	9-NT	0	0	9	2	0	1
10-AS	0	0	2	6	4	0	10-NT	1	0	24	1	0	6
11-AS	0	1	9	3	6	0	11-NT	3	0	15	0	1	0
12-AS	1	0	8	9	1	1	12-NT	1	0	13	2	2	2
13-AS	0	0	22	6	2	0	13-NT	1	1	12	0	1	0
14-AS	2	3	9	1	2	0	14-NT	3	0	6	0	7	1
15-AS	1	0	4	1	1	1	15-NT	2	0	14	5	3	3
16-AS	0	0	15	0	2	1	16-NT	0	0	10	4	8	1
17-AS	1	0	9	0	0	1	17-NT	1	0	3	0	1	0
18-AS	0	0	11	6	11	0	18-NT	1	0	6	2	3	1
19-AS	0	1	11	2	4	1	19-NT	1	0	3	0	0	1
Average	1	0.74	7.95	3.53	2.84	0.84	20-NT	3	0	2	1	0	0
							Average	1.65	0.05	9.45	1.75	1.9	1

The raw frequency data were analyzed by a Kruskal-Wallis Test and by a Pearson Product-Moment Correlation. The Kruskal-Wallis Test (Table 2) was used to ascertain statistically significant differences in strategy usage between the groups. Such significance was found if $p \leq .05$ for any of the six problem solving strategies. The findings indicated that significant differences existed for Strategy 1 (S1), which was problem solving strategy based on the meaning of the language clue, and Strategy 2 (S2), which was problem solving strategy based on the structure of the language clue. The neurotypical group relied on S1 significantly more than the Asperger Syndrome group, with $p = .050$. The Asperger Syndrome group relied on S2 significantly more than the Neurotypical group, with $p = .029$. The results from the Kruskal-Wallis Test appear in Table 2.

Table 2. Kruskal-Wallis Test Ranks

	Participant Type	N	Mean Rank
S1	Asperger Syndrome	19	16.47
	Neurotypical	20	23.35
	Total	39	
S2	Asperger Syndrome	19	22.74
	Neurotypical	20	17.4
	Total	39	
S3	Asperger Syndrome	19	18.5
	Neurotypical	20	21.43
	Total	39	
S4	Asperger Syndrome	19	22.68
	Neurotypical	20	17.45
	Total	39	
S5	Asperger Syndrome	19	22.18
	Neurotypical	20	17.93
	Total	39	
S6	Asperger Syndrome	19	19.53
	Neurotypical	20	20.45
	Total	39	

Test Statistics^{a,b}

	S1	S2	S3	S4	S5	S6
Chi Square	3.84	4.779	0.646	2.135	1.42	0.08
df	1	1	1	1	1	1
Asymp. Sig.	0.05	0.029	0.421	0.144	0.233	0.778

a. Kruskal Wallis Test

b. Grouping Variable: Participant Type

Table 3. Pearson Product-Moment Correlations- Asperger Syndrome

Participant Type = Asperger Syndrome

		Correlations ^a						
		trials	S1	S2	S3	S4	S5	S6
trials	Pearson Correlation	1	-0.129	-0.167	0.786**	0.599**	0.392	0.223
	Sig. (2-tailed)		0.598	0.495	0	0.007	0.097	0.358
	N	19	19	19	19	19	19	19
S1	Pearson Correlation	-0.129	1	-0.136	-0.258	0.091	-0.544*	0.442
	Sig. (2-tailed)	0.598		0.579	0.286	0.71	0.016	0.058
	N	19	19	19	19	19	19	19
S2	Pearson Correlation	-0.167	-0.136	1	-0.283	-0.077	-0.067	-0.211
	Sig. (2-tailed)	0.495	0.579		0.24	0.754	0.785	0.385
	N	19	19	19	19	19	19	19
S3	Pearson Correlation	0.786**	-0.258	-0.283	1	0.199	0.211	-0.014
	Sig. (2-tailed)	0	0.286	0.24		0.414	0.387	0.956
	N	19	19	19	19	19	19	19
S4	Pearson Correlation	0.599**	0.091	-0.077	0.199	1	0.082	0.348
	Sig. (2-tailed)	0.007	0.71	0.754	0.414		0.739	0.145
	N	19	19	19	19	19	19	19
S5	Pearson Correlation	0.392	-0.544*	-0.067	0.211	0.082	1	-0.345
	Sig. (2-tailed)	0.097	0.016	0.785	0.387	0.739		0.137
	N	19	19	19	19	19	19	19
S6	Pearson Correlation	0.223	0.442	-0.211	-0.014	0.348	-0.345	1
	Sig. (2-tailed)	0.358	0.058	0.385	0.956	0.145	0.137	
	N	19	19	19	19	19	19	19

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

A Pearson Product-Moment Correlation was used to ascertain whether significant correlations existed between the number of trials and problem solving strategy. The results of this correlation for both groups are seen in Tables 3 and 4.

Table 3 shows the results for the Asperger Syndrome group. In this group, there was a significant positive correlation between number of trials and use of the S3 and S4 strategies. These were the mathematical based and memory based strategies, respectively. The Pearson

Correlation showed that the more trials a participant used, the higher the reliance on the S3 and S4 strategies.

Table 4. Pearson Product-Moment Correlations- Neurotypical

Participant Type = Neurotypical

		Correlations^a						
		trials	S1	S2	S3	S4	S5	S6
trials	Pearson Correlation	1	0.299	-0.019	0.93**	0.579**	0.419	0.55*
	Sig. (2-tailed)		0.2	0.936	0	0.007	0.066	0.012
	N	20	20	20	20	20	20	20
S1	Pearson Correlation	0.299	1	-0.121	0.181	0.357	0.04	-0.256
	Sig. (2-tailed)	0.2		0.612	0.445	0.123	0.868	0.276
	N	20	20	20	20	20	20	20
S2	Pearson Correlation	-0.019	-0.121	1	0.09	-0.194	-0.088	-0.145
	Sig. (2-tailed)	0.936	0.612		0.707	0.413	0.712	0.542
	N	20	20	20	20	20	20	20
S3	Pearson Correlation	0.93**	0.181	0.09	1	0.372	0.173	0.548*
	Sig. (2-tailed)	0	0.445	0.707		0.107	0.465	0.012
	N	20	20	20	20	20	20	20
S4	Pearson Correlation	0.579**	0.357	-0.194	0.372	1	0.17	0.031
	Sig. (2-tailed)	0.007	0.123	0.413	0.107		0.474	0.898
	N	20	20	20	20	20	20	20
S5	Pearson Correlation	0.419	0.04	-0.088	0.173	0.17	1	0.175
	Sig. (2-tailed)	0.066	0.868	0.712	0.465	0.474		0.459
	N	20	20	20	20	20	20	20
S6	Pearson Correlation	0.55*	-0.256	-0.145	0.548*	0.031	0.175	1
	Sig. (2-tailed)	0.012	0.276	0.542	0.012	0.898	0.459	
	N	20	20	20	20	20	20	20

** Correlation is significant at the 0.01 level (2- tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4 shows the results for the Neurotypical group. This group also evidenced a significant positive correlation between number of trials and reliance on the S3 and S4 strategies. They also evidenced a significant correlation between number of trials and use of the S6, which was the spatial reasoning strategy.

Discussion

Findings

The results of this study did not support the original hypothesis, but they did support the underlying premise of the hypothesis. The hypothesis stated that the Asperger Syndrome group would require more dice rolls than the Neurotypical group to complete the task, and that they would rely more upon mathematical and memory based strategies while solving the task. There were no statistically significant differences between the groups for mathematical or memory based strategies. There was also no statistically significant difference in the average number of rolls used by each group.

There was a significant difference in the way each group used the language clue. The Neurotypical group relied on the meaning of the language clue significantly more than the Asperger Syndrome group. However, the Asperger Syndrome group did not disregard the language clue, as this study hypothesized that they would. Instead, they attempted to find the answer using the structure of the language clue. In other words, the Asperger Syndromes group focused on features of the clue such as the number of words, the number of letters, and the sounds in each word. It is interesting to note that only one person in the Neurotypical group considered the structure of the language clue.

The results of the Pearson Product-Moment Correlation supported the premise that significantly more reliance upon mathematical and memory based strategies would hinder a participant's progress in solving the problem. Data for both groups indicated that participants who needed more rolls tended to rely significantly on these two strategies. Interestingly, the Neurotypical group needed significantly more rolls when they relied on spatial reasoning as well

as mathematical and memory based strategies. This was not true for the Asperger Syndromes group.

Further Research

This study used a subjective rating scale. Some of the participant's answers were vague, or could have been assigned two categories on the scale. The interviewer judged which problem solving category was most appropriate. This opened the possibility of unintended experimenter bias. The subjectivity issue could be reduced by having two or more interviewers judge the participants' responses. Ratings from each interviewer could be compared to ensure the most accurate data was used.

If the study was conducted again with a larger sample size, the problem solving disparity between the groups might become more readily apparent. Further studies might match participants for factors such as age, education, gender, and intelligence. This study could also be paired with another study of Weak Central Coherence, and results of each test could be compared for each participant. This would add cross testing validity. Controlling for these variables would help establish whether the results of this study were a true measure of Weak Central Coherence, or whether the results were influenced by extraneous variables.

Conclusion

The findings of this study support the Weak Central Coherence theory of autism (Frith, 2003). The Asperger Syndrome group evidenced a more detail focused, localized problem solving strategy than the Neurotypical group. The Asperger Syndrome group evidenced a tendency not to form a gestalt concept from the language clue. Instead, they looked at the

concrete details of the clue, searching for a hidden code within the pieces of the sentence. The Neurotypical group, however, formed a conceptual gestalt by looking beyond the letters and number of words, and by using the meaning of the sentence to aid their problem solving process. These results support the premise that autism is characterized by a detail oriented method of cognitive processing.

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Appendix A

IRB Approval

Pages 39-40



THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

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TO: Marie Holowach
118 College Drive #7403
Hattiesburg, MS 39406-0001

FROM: Lawrence A. Hosman, Ph.D.
HSPRC Chair

PROTOCOL NUMBER: 11051001
PROJECT TITLE: Problem Solving in Adults with Asperger's
Syndrome and Normal Adults

Enclosed is The University of Southern Mississippi Human Subjects Protection Review Committee Notice of Committee Action taken on the above referenced project proposal. If I can be of further assistance, contact me at (601) 266-4279, FAX at (601) 266-4275, or you can e-mail me at Lawrence.Hosman@usm.edu. Good luck with your research.



THE UNIVERSITY OF SOUTHERN MISSISSIPPI

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HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **11051001**

PROJECT TITLE: **Problem Solving in Adults with Asperger's Syndrome and Normal Adults**

PROPOSED PROJECT DATES: **09/15/2010 to 05/01/2012**

PROJECT TYPE: **Honors Thesis**

PRINCIPAL INVESTIGATORS: **Marie Holowach**

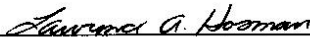
COLLEGE/DIVISION: **College of Health**

DEPARTMENT: **Speech & Hearing Sciences**

FUNDING AGENCY: **N/A**

HSPRC COMMITTEE ACTION: **Expedited Review Approval**

PERIOD OF APPROVAL: **05/10/2011 to 05/09/2012**



Lawrence A. Hosman, Ph.D.
HSPRC Chair

5-11-2011

Date

Appendix B

Consent Forms

Pages 42-43

ORAL PRESENTATION

- 1. Purpose:** This study seeks to examine differences in higher order problem solving between a group of adults with Asperger's Syndrome and a group of normal adults. It will determine the differences, if any, between adults with Asperger's Syndrome and normal adults in solving a cognitively complex task. The results of this study can give insight into the way people with Asperger's process information, and can be used for the development of useful treatment.
- 2. Description of Study:** Participation in this study requires the completion of a problem solving task. The task will be carried out in the presence of the experimenter. The task will last no longer than 30 minutes, and may be completed in less time. Subjects will participate in the problem solving task individually, having no contact with other participants.
- 3. Benefits:** There are no material benefits in this study. Participants will benefit from the knowing that they have helped further scientific research in the area of Asperger's Syndrome.
- 4. Risks:** There are no known physical, psychological, or social risks involved in this study. Inconveniences include the time required to complete the task. The test site will be in located in the participant's home or other convenient location, so that travel costs are minimal.
- 5. Confidentiality:** Participants will be assigned numbers, and only these numbers will be used in the published study. No personal identifying information will be published. Only the researcher and the thesis adviser will have access to personal data. Electronic data will be kept in a locked document for five years, and will then be deleted. Physical data such as paper forms will be kept in a locked file cabinet for five years and then shredded and disposed of.
- 7. Participant's Assurance:** This project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board at 601-266-6820. Participation in this project is completely voluntary, and participants may withdraw from this study at any time without penalty, prejudice, or loss of benefits. Any questions about the research should be directed to *Marie Holowach* at (601) 566- 5684.

Signature of presenter

Date

**THE UNIVERSITY OF SOUTHERN MISSISSIPPI
AUTHORIZATION TO PARTICIPATE IN RESEARCH PROJECT**

Participant's Name _____

Consent is hereby given to participate in the research project entitled *Problem Solving in Adults with Asperger's Syndrome and Normal Adults*. All procedures were explained by Marie Holowach. Information was given about all benefits, risks, inconveniences, or discomforts that might be expected.

The opportunity to ask questions regarding the research and procedures was given. Participation in the project is completely voluntary, and participants may withdraw at any time without penalty, prejudice, or loss of benefits. All personal information is strictly confidential, and no names will be disclosed. Any new information that develops during the project will be provided if that information may affect the willingness to continue participation in the project.

Questions concerning the research, at any time during or after the project, should be directed to Marie Holowach at telephone (601) 566-5684. This project and this consent form have been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-6820.

Signature of participant

Date

Signature of person explaining the study

Date