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OBJECT CATEGORIZATION IN CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

by

JAIME LAURA VITRANO

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2015

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The manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the Dissertation requirements for the degree of Doctor of Philosophy

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Abstract

OBJECT CATEGORIZATION IN CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

by

Jaime Laura Vitrano

Adviser: Dr. Laraine McDonough

The purpose of this study was to investigate hierarchical object categorization in children with

autism spectrum disorder (ASD), examining three levels of category inclusiveness

(superordinate, basic, subordinate) across three tasks (sequential touching task, generalized

imitation task, sorting task) in three domains (animals, tools, kitchen utensils) in the same group

of children with ASD. Previous research on the categorization abilities of children with ASD has

shown mixed results. This study was designed to clarify past discrepancies in the literature.

Ten children with ASD participated in this study (mean CA = 4 years, 10 months; range 3 to 6

years; mean VMA = 3 years, 3 months; range 9 months to 6 years, 5 months). In the sequential

touching task, children saw objects from two categories, and their spontaneous touching of those

objects was recorded. Results showed no differences between category levels. Within level,

participants differentiated between animate and inanimate domains on the superordinate level,

and categorized basic level animate categories, having more difficulty with subordinate level

categories. The generalized imitation task, in which the child must imitate the experimenter’s

modeled action with an appropriate exemplar, showed that participants generalized significantly

v better than chance on superordinate and basic level categories, but similar to chance on

subordinate level categories. The sorting task, in which the child must sort eight objects (from

two categories) into two separate boxes, also revealed no differences between level, but revealed

sorting better than chance on the subordinate level only. The proportion of correct sorting was

positively correlated with language. A positive correlation was found between the generalized

imitation and sorting tasks, suggesting that the tasks may be tapping similar background

knowledge. Overall, while children did not show significantly better performance on one level

over another, two of the three tasks revealed lowest performance on the subordinate level, a

finding that is consistent in typical development. The other task showed that it is possible that

children with ASD are showing a different pattern of categorization. The results emphasize the

importance of using multiple tasks, as well as multiple levels of category inclusiveness and

domains, to study categorization in ASD.

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1 **CHAPTER I. INTRODUCTION**

Autism is a complex spectrum disorder that has continued to perplex researchers since its

initial discovery over 70 years ago by Leo Kanner (1943). One question that has been repeatedly

asked but that lacks a definitive answer is how children with autism understand their world. How

do those with autism relate to objects around them and events that they experience in order to

make sense of their environments? If autism is as heterogeneous as it is believed, then it is

plausible that children with autism are learning in qualitatively different ways than typically

developing (TD) children, resulting in an understanding of objects and events that differs

considerably from their mental age matched counterparts. If children with autism have a

categorization impairment, then further study and better understanding of the issue are necessary

for developing appropriate interventions. First, however, it is necessary to define autism and to

understand how the concept of autism has changed over time.

What is autism? Though earlier accounts of autism are debated, the groundbreaking

description by Leo Kanner in 1943 is credited as the first official study of autism (Wolff, 2004).

Kanner listed the crucial symptoms as an extreme autistic aloneness; abnormal speech with

echolalia, pronomial reversal, literalness and inability to use language for communication; and

monotonous, repetitive behaviors with an anxiously obsessive desire for the maintenance of

sameness (Kanner, 1943). Only one year later, Viennese pediatrician Hans Asperger described

four cases of autistic psychopathy of childhood. His descriptions, similar to those of Kanner,

were of children often able, some with extraordinary gifts in mathematics or natural science with

creative and original modes of thinking. Their social and emotional relationships were often

poor, they were highly sensitive, they lacked feelings for others, had stereotypic behaviors as

well as pervasive special interests, and were clumsy. Language acquisition was not usually

2 delayed, but language use was idiosyncratic. Later work adjustment was often good but their

social handicaps endured (Wolff, 2004).

Although the first descriptions of autism occurred in the early 1940's, the disorder

appeared in both the DSM-I and II in the form of childhood schizophrenia, and not as a disorder

of its own (Volkmar, Cohen, & Paul, 1986). Subsequently after the DSM-II was published in

1974, much progress was made in characterizing and defining infantile autism (IA). The DSM-

III, published in 1980, incorporated many of these findings in its classificatory scheme for severe

disorders of early onset. The phrase, pervasive developmental disorder (PDD) was created to

encompass IA, childhood onset pervasive developmental disorder (COPDD), and atypical

pervasive developmental disorder (APDD).

The DSM-III change represented a major advance in the diagnosis of childhood

developmental disorders, making it possible to specify the related degree of intellectual disability

and medical symptoms on different axes. Though at the time this change seemed like a great

advance, the diagnostic categories and criteria for these disorders were not systematically

studied. For example, the comparison of IA and COPDD revealed weaknesses of the diagnostic

separation. IA was defined as an early onset disorder (prior to 30 months of age) characterized

by pervasive lack of responsiveness to others; gross deficits in language development; peculiar

speech patterns, if speech was present at all; bizarre responses to the environment; and an

absence of delusions, hallucinations, loosening of associations, and incoherence as in

schizophrenia. COPDD had an onset of after 30 months and before 12 years of age, and was

characterized by impaired social relatedness, an absence of delusions or hallucinations, and at

least three of the following: resistance to change; inappropriate or constricted affect; sudden,

3 excessive anxiety; peculiar movements; abnormal speech patterns (although not abnormal

language); under or oversensitivity to sensory stimuli; and self-mutilation.

When the DSM-IV was published in 1994, the diagnosis of autism changed yet again.

According to this manual, the major features of autism were represented in three domains: failure

to develop interpersonal relationships and a lack of responsiveness or interest in people,

impairment in communication and imaginative activity, and a markedly restrictive repertoire of

activities and interests (Tanguay, 2006). Because it is a categorical diagnosis, children had to

show a number of specific criteria, displaying symptoms from all three domains to receive the

diagnosis. In addition to changing infantile autism to autism, the DSM-IV also added Asperger’s

Syndrome (AS), first described by Hans Asperger fifty years earlier in 1944. AS was not

included in earlier manuals because it was not widely acknowledged until Lorna Wing's

innovative paper in 1981 (Wolff, 2004). The criteria in the DSM-IV for AS specified a profound

impairment in interpersonal relationships, but with normal language development. There has

been extensive controversy over whether AS is a qualitatively distinct form of autism, or whether

it is simply the upper boundary of the spectrum of autism (formally addressed in the latest

manual).

The DSM-5 was published in 2013 and major changes were made to the disorder. Four

previous disorders (Autistic Disorder, Asperger’s Disorder, Childhood Disintegrative Disorder,

and Pervasive Developmental Disorder Not Otherwise Specified), were combined to create one

new disorder, autism spectrum disorder (ASD). In addition to this overhaul, the latest manual

changed the three impairments (social impairments, language impairments, and restricted,

repetitive behaviors) to two domains; the primary impairment being social communicative, and

the secondary impairment remaining the restricted, repetitive behaviors. The DSM-5 also

4 specified three levels of severity for each of the two domains: level 1 (requiring very substantial

support), level 2 (requiring substantial support) and level 3 (requiring support; APA, 2013).

For some time, clinicians have recognized that a problem in the classification of ASD is

that the disorder does not seem to be a categorical, either/or disorder (Tanguay, 2006). Rather,

autism is a spectrum disorder, which was finally acknowledged in the DSM-5, and which makes

it extremely difficult to conduct research on this population. For instance, if one examines the

joint attention behaviors of children with ASD, the results will vary greatly depending on the part

of the autism spectrum from which one selects participants. If higher functioning children with

ASD take part in the study, their cognitive profiles might differ radically from others on the

spectrum. Likewise, if lower functioning children participate, intellectual disability often

accompanies autistic symptoms, creating a basic confound in the research. The heterogeneity of

ASD is one major reason why there are many confusing and inconsistent findings in this

literature base. Why is the history of the classification of ASD relevant? The early conceptualization of

the disorder has influenced not only how it is that one studies the disorder, but also who it is that

has been the focus of the study. Any empirical study with ASD as its focus must address its

history since the literature documenting ASD has drastically changed in the last several decades.

If, according to the DSM-I and DSM-II, children with ASD were grouped together with children

with childhood schizophrenia, then it is difficult to look objectively at studies that were

completed at that time, since "core" autistic symptoms were confounded with symptoms of other

disorders. Although we have learned much about the nature of ASD since its first discovery, its

turbulent and shifting history in the DSMs reminds us that there is still a great to deal to learn.

5 One area in which there is contradictory information in the literature is the study of

categorization in ASD. Do children with ASD categorize the world as do TD children? Do they

end up forming the same categories as others by using different processes? And is this

categorical knowledge (or lack of knowledge) related to any of their other abilities or lack of

abilities? Unfortunately, conclusions are mixed largely because the assumptions that researchers

have made about how categorization skills develop in children, widely differ. A more detailed

look into ASD and its many impairments will be presented later. First an analysis of

categorization in typical development is offered.

Categorization is an important skill to have in this world and yet it is not often explicitly

thought about in an everyday sense. Categorization is inextricably linked to our conceptual

understanding of everything in the world around us. The world is comprised of lots of things.

Aside from the billions of people who inhabit this planet, there are countless artifacts such as

vehicles, buildings, tools, furniture, technological gadgets, not to mention the many natural kinds

of animals, plants, and other living things with which we share the planet. Keeping track of all of

these things is certainly daunting, and what helps one manage the complex environment is the

ability to construct categories. These categories might not be exactly the same for all people

everywhere, since the world is an enormous place, but creating categories helps to make sense of

the environment. Even though there may be some differences from place to place, people

generally use categories for the similar purpose of providing structure and organization in their

representation of the world.

How do people come to categorize objects in the world? If one were to ask how it is that

one comes to understand that a maple tree is a certain kind of a tree, which is a certain kind of

living organism, realistically, it would be quite difficult to answer that question. And yet the

6 question is central to how we develop knowledge. The underlying answers to this fundamental

question can be addressed by studying how infants and young children develop knowledge of

object categories.

*Categorization: Traditional Views*

In 1976, Eleanor Rosch and her colleagues were interested in how people carve up the

world and find structure in the environment. They developed a theory of categorization that

featured a hierarchical structure with three levels: superordinate, basic, and subordinate (Rosch,

Mervis, Gray, Johnson, & Boyes-Braem, 1976). These levels are structured such that a

subordinate category is a member of a basic category, which is a member of a superordinate

category. An example of a superordinate category is animal, an example of a basic category is

cat, and an example of a subordinate category is Siamese cat. Rosch investigated which category

best matches the correlational structure of the environment and concluded that it was the basic

level category. Utilizing several experiments, Rosch and her colleagues found that basic level

categories are at the level of abstraction for which cue validity is maximized. Cue validity is the

validity of a given cue *x* as a predictor of a given category *y* which increases as the frequency

with which cue *x* is associated with category *y* increases, and decreases as the frequency with

which cue *x* is associated with other categories other than *y* increases (Rosch et al., 1976).

According to Rosch, categories at higher levels of abstraction (superordinate categories) have

lower cue validity since they have fewer attributes in common (e.g., cars and airplanes are not

very similar) and categories at lower levels of abstraction (subordinate categories) have lower

cue validity because they share most attributes with contrasting subordinate categories (e.g.,

electric guitars and acoustic guitars are very similar). In sum, basic level categories are the most

inclusive categories which optimize the correlational structure of features of the world (Rosch et

7 al., 1976). In this view, it is simply too much of a cognitive burden to consider cars, airplanes,

trucks, and motorcycles as the same thing because they actually look quite different from one

another, and have slightly different functions as well. Likewise, it would be quite burdensome to

create separate categories for a 747 jet and a 727 jet, since the similarities between them far

outweigh the differences.

This theory, which stressed the importance of basic level categories, claimed that the

process of category formation is universal, occurring in the same way for people everywhere.

Although universal, Rosch and her colleagues pointed out that expert knowledge might disrupt

these basic taxonomies, with their example being an airplane mechanic (Rosch et al, 1976). For

such a person, expert knowledge of airplanes will create a more differentiated taxonomy of

airplanes than that of an ordinary person. A mechanic might possess extraordinary knowledge of

different types and subtypes of airplanes, which would affect his categorical knowledge of

airplanes. Therefore, a person with expert knowledge in any field disrupts the tenet of this

theory. This example also demonstrates that defining the basic level can be difficult when

applied universally. Most domains have never even been studied; therefore, it is not clear what

the basic level may be for many categories, including artifacts such as buildings and toys

(Mandler, Bauer & McDonough, 1991).

What is important for categorization according to this theory? In other words, how do

people identify and categorize basic objects? Rosch and her colleagues asserted that people

categorize objects based on perceptual similarity and shape (1976). For example, dogs are all

perceptually similar, much more so than a dog is to a cat, bird, or rabbit. The first four

experiments investigated the aspects of basic objects that make them the most inclusive category:

the co-occurring attributes common to the category, sequences of motor movements common to

8 the object, similarity in the shape of an object, and identifiability of an average shape in the

category (Rosch et al., 1976). The conclusion of each of these four experiments was that basic

objects form the categories which are optimally inclusive. The next eight experiments examined

additional aspects of the concept of basic objects, with two experiments in this group studying 3–

10-year-old children on their ability to sort both basic level and superordinate level categories.

The authors, who employed both a simplified oddity problem format (which included the 3–4-

year-olds), and a simple sorting format, found evidence for their hypothesis that the basic level

categories were easier to sort than the superordinate level categories (Rosch et al., 1976).

Success on these experiments by the youngest children (3–5-year-olds) led to the conclusion that

children first develop knowledge of basic level objects, and then gradually come to understand

broader, superordinate level objects.

Despite the fact that this view of categorization was widely accepted at the time, there

were some weaknesses prevalent in Rosch’s argument, as evident in her own footnote. Rosch

stated that were the concept of cue validity a true probability, it would necessarily follow that the

superordinate level category would be the most inclusive category, since superordinate level

categories include basic level categories (Rosch et al., 1976). This important point, placed in a

footnote, disrupts the entire tenet of the theory, which is that the basic level category is the most

inclusive category. Also, in the latter eight experiments, the authors tested the hypothesis that

object names at the basic level should be the names most generally used by both adults and

children. These linguistic tasks were misleading, however, because one knows and expects a

child’s first learned words to be basic level nouns since they are present in adults’ everyday

language, particularly in child-directed speech (Anglin, 1977; Brown, 1958). For example, it is

convenient to say that I need to go to the *car* wash, not the *vehicle* wash, and not the place that

9 cleans my Jeep. Children often use first words that are spoken to them, a fact which does not

necessarily reflect children's underlying conceptual knowledge of those words. Finally, the

boundaries of basic level categories were often confounded with superordinate level categories

(Rosch et al., 1976). For instance, to categorize cars and dogs into exclusive categories and claim

such as evidence for basic level categorization is confounded because a car is a vehicle and a dog

is an animal. Therefore, it is unclear whether the differences between dogs and cars represent

boundaries between basic level or superordinate level categories. Actually, they represent both

(Mandler & Bauer, 1988).

This categorization theory, which was accepted for some time, was tested on three-year-

old children and older (Rosch et al., 1976). Within the last three decades, however, much

research has shown that infants, some as young as three months, are capable of categorizing

objects (Behl-Chadha, 1996; Eimas & Quinn, 1994; Mandler & McDonough, 1993, 2000). On

what bases are infants categorizing? Several studies have shown that very young infants can

categorize on perceptual bases, thus recognizing that two different kinds of mammals or pieces

of furniture look differently (Behl-Chadha, 1996; Eimas & Quinn, 1994). Though these findings

have departed greatly from earlier beliefs about infants' limited capabilities, they have not

addressed what it is that infants understand about objects in the world. Just because three-month-

olds differentially respond, indicating that a cat and dog are two different things (Quinn, Eimas,

& Rosenkrantz, 1993), does that mean that they understand that cats and dogs are indeed

different? At what point in development do infants and young children come to conceptually

understand what makes objects belong to one category and not another? Studies that focus on

perceptual differences are simply not sufficient in our understanding of infants' developing

10 knowledge of objects, since they only reflect infants' ability to detect that two objects look

differently.

*Conceptual Categorization*

Making the leap from noticing perceptual differences to understanding what makes up

kinds of things, has been a question at the heart of how humans develop knowledge. Yet,

studying the origin of knowledge in preverbal infants is not an easy task. By 3–4 years of age, it

is known that children are able to verbally explain what kinds things are (Gelman & Markman,

1986; Massey & Gelman, 1988). But what fosters the transition between the infant that is

capable of seeing differences among objects, and the toddler who can verbally explain why and

how objects are different kinds? Whereas Eleanor Rosch and other psychologists focused on how

and when young children and infants notice perceptual differences amongst objects and

categories, Mandler and McDonough (1993, 1998a, 1998b, 2000) took a more expanded,

developmentally-based approach because they were interested in determining when infants and

young children come to conceptually understand categories. They investigated the origins of

infants' conceptual knowledge by using a variety of different tasks that differ in structure, with

the goal of providing a comprehensive picture of infants' developing conceptual knowledge.

One of the tasks used to answer this question was the object examining task (Mandler &

McDonough, 1993, 1998), which was pioneered by Ruff (1986) and also used by Oakes,

Madole, & Cohen (1991). In this task, infants are familiarized to a set of objects within a

category. Following familiarization, they are given a new exemplar from the same category,

followed by a new exemplar from a contrasting category. If the infants increase their

examination time to the final test object compared to the exemplar from the same category, it can

be assumed that the infants differentiated the two categories. This task is well-suited for use with

11 infants, as there are no verbal demands on the infants, and the act of feeling, looking at, or

mouthing objects seems to be a lot more engaging than merely observing pictures or slides

(although examining time was the only measure used; Mandler & McDonough, 1993). Of

course, it should be noted that examination time, defined as concentrating on and inspecting the

object, does not necessarily imply a conceptual understanding of how two categories differ. If

infants examine a novel dog after seeing a series of cats, it is unclear if infants are categorizing

based on perceptual or conceptual differences. Mandler and McDonough (1993) found that both

9- and 11-month-old infants are capable of distinguishing airplanes from birds with outstretched

wings, two conceptually different categories that are perceptually quite similar. They

additionally found categorization of perceptually varied objects such as furniture vs. vehicles.

These results shed light on how this task can be used to speculate on the beginnings of

conceptual knowledge.

Another task that was used with slightly older infants (older than one-year-old) was the

sequential touching task (also referred to as the object manipulation task; Mandler et al., 1991,

Ricciuti, 1965; Sugarman, 1983). In this task, which is based loosely on a sorting task, the

experimenter places a collection of objects in front of the child, allowing the child to touch,

explore, and manipulate the objects. The eight objects consist of four objects from one category,

and four objects from a contrasting category. If children are sensitive to the categorical

distinction between the objects, they will tend to touch objects in the same category in sequence

more frequently than would be expected by chance (Mandler et al., 1991). As with the object

examination task, successively touching the objects within a category more frequently than the

contrasting category could be perceptual or conceptual categorization; the key to interpreting the

results lies in the contrasts used. Previous research by Mandler, Fivush, and Reznick (1987)

12 studied the categorization of "bathroom things" and "kitchen things" using this technique with

pictures rather than objects, and found that infants were able to differentiate these categories,

despite the fact that there were no perceptually similar attributes within each category.

Finally, the last task used by Mandler and McDonough was the generalized imitation task

(1996, 1998b, 2000). In this task, the experimenter models a simple event using small replicas of

real-world objects and encourages the infants to imitate what they have observed. The interesting

part of the task, however, is that the objects given to the infants are different than the ones used

to model the event. For example, the experimenter might demonstrate the event of sleeping by

showing a dog sleeping on a bed. The experimenter then takes away the dog, and gives the infant

another animal, along with a vehicle. The question is if the infants will imitate the event by

generalizing to the appropriate object. If the infants imitate that event with the animal but not

with the vehicle, this is taken as evidence that they understand that a property of being an animal

is sleeping, a property not shared by vehicles (Mandler & McDonough, 2000). This task

highlights knowledge of what objects are and how they function.

Using these three tasks on infants ranging from 7–30 months of age, Mandler and

McDonough uncovered a different developmental pattern of categorization than the one

proposed by Rosch and her colleagues (1976). Rather than learning first about basic level

categories, these studies revealed that infants from 7–18 months are categorizing between

animal, vehicle, plant, and furniture domains, and only from 9–11 months are infants *starting* to

categorize at the basic level, recognizing such distinctions as dog vs. cat and car vs. airplane

(Mandler, et al., 1991; Mandler & McDonough, 1993, 1998b; Pauen, 2002; Trauble & Pauen,

2007). In addition, 18–30 month-old infants are generalizing properties of animals, vehicles, and

household artifacts, and are becoming more successful at generalizing properties within basic

13 level categories at 24 months and older (Mandler & McDonough, 1998b, 2000). This evidence,

using more developmentally appropriate methods, has shown that infants are first distinguishing

between superordinate level categories and over time, are becoming more knowledgeable about

basic level domains within those categories. This developmental pattern is similar to patterns that

are evident when one gains expertise in a domain; namely, a differentiation process.

Much of the work of Mandler and McDonough was based on ideas about early

conceptual development as proposed by Katherine Nelson (1973, 1974). It should be noted that

historically speaking, the work of Katherine Nelson followed that of Eleanor Rosch and her

colleagues, followed by the work of Jean Mandler along with Laraine McDonough. The common

interpretation at the time was that according to Rosch’s theory, children were categorizing the

basic level according to perceptual similarity and shape. To her credit, Rosch and her colleagues

did include more varied aspects of categorization, but these studies were done primarily in adults

(Rosch et al., 1976). Rosch’s work on the functional basis of objects, was influential upon

Katherine Nelson, whose work very much influenced Mandler and McDonough. For the

purposes of the current study, Katherine Nelson is discussed after Mandler and McDonough, in

order to highlight how their theory contrasted directly with that of Rosch.

Nelson, who was interested in the relation between the young child's acquisition of

conceptual knowledge, learning of words, and production of first sentences, created a conceptual

model around what she termed a Functional Core Concept (FCC; Nelson, 1974). This theory is

based on the premise that children can categorize objects before they can name them, with the

assumption that a child has a concept of "ball" before labeling it as "ball". The FCC theory states

that a child develops the concept of an object by focusing attention on that object, identifying

how this object relates to surrounding persons and/or objects, identifying those characteristics

14 that are central to that object, and finally attaching a name to the object (Nelson, 1974). The

obvious, critical feature of this theory is that the object has functional value, leading to the

creation of the concept. Nelson's emphasis on the child's dynamic experiences with objects in the

world corresponds with the theories of Mandler and McDonough, who stressed that it is the

child's conceptual understanding of objects that is the basis of cognitive development.

Furthermore, the generalized imitation task used by Mandler and McDonough, (1993, 1996,

1998) tested infants' knowledge of what objects in different categories are and how they

function, and was based, in part, on the theoretical claims of Nelson and the FCC (Mandler &

McDonough, 2000).

Nelson also stated that children's knowledge is contextualized. Simply put, pieces of

reality are never experienced apart from their context, whether these pieces are concepts, words,

or objects (Nelson, 1983). Within this framework, it becomes clear that in understanding

conceptual development, it is necessary to not only analyze knowledge of objects, but to have

knowledge of events as well. Why? Because objects are embedded in events and cannot be

separated from them. For instance, a child develops the concept of ball by interacting with others

in the context of a ball, and learning the functional attributes of that ball (e.g., throwing, rolling,

bouncing, etc.).

One type of knowledge organization is a schema – a part-whole organization of elements

– for example, the temporal-spatial organization of scenes and events (Lucariello & Nelson,

1985; Mandler, 1979, 1983). Scripts are a type of schema representing event structures and are

organized in terms of temporal and causal relations between component acts (Nelson, 1978).

Nelson has demonstrated that the basis of many, or perhaps all, early categories of objects lies in

earlier acquisition of scripts, or representations of familiar routines (Lucariello & Nelson, 1985).

15 For example, a child learns the concept of food by figuring out that what happens at mealtime is

that mommy puts me in a highchair, puts a bib on me, and then I eat cheerios (or apples, or

carrots). Since a young child takes part of this mealtime event or activity, the child learns not

only appropriate actions (eating, drinking) but also appropriate objects associated with those

actions (cheerios, apples, or carrots). In this way, children learn these slot-filler categories, which

contain objects that can be substituted for one another (at mealtime I can eat x, y, or z just as at

the park, I can play with a, b, or c).

Nelson's theoretical framework for infant's concepts was based in part on explaining

toddler's first words, many of which are labels for objects (e.g., ball or dog; Nelson, 2008).

Though these objects differ for each child, their basis is functional within contexts. Nelson states

that the child's first language constructions are assumed to come directly from primitive

conceptual representations (Nelson, 1983). But how do language and the development of

concepts proceed together? The question is a complicated one. For one, it cannot be assumed that

infants are perceiving the world in the same way as are adults. McDonough and her colleagues

showed that preverbal infants are adept at forming various spatial categories (McDonough, Choi,

Mandler, & Bowerman 1999), and yet when the children are older (at around 20 months), the

categories onto which they extend early linguistic terms are specific to the language they are

learning (Choi, McDonough, Mandler, & Bowerman, 1999). Therefore, language can function as

both strengthening the salience of categories already formed, but also decreasing the salience for

those categories that are not present in the language being learned.

One idea about how children could be using rules to learn about objects and early words

has been postulated by Nelson and Nelson (1978). In the first two stages, a child moves from

idiosyncratic experiences to a few general rules. Often this is evidenced by children's early

16 preverbal behaviors (such as gestures or grunts) and proceeds to children naming first objects.

Children are using words to name those objects and describe the characteristics of those objects

(Nelson & Nelson, 1978). The third stage is comprised of the child learning many rules about

word names, all the while narrowing and acquiring more specific rules. It is at this stage where

children come to realize that as balls are round and bounce, bowls are round and hold food. The

fourth stage is integration and consolidation, such that a child has a basic, working vocabulary of

about 500 or so words, and can name most of the important objects in the child’s life (Nelson &

Nelson, 1978). Finally, the fifth stage is characterized by appropriate but flexible application.

Children in this stage are able to incorporate new words appropriately into their vocabularies.

This sequentially outlined theory highlights the importance of the two developing systems, of

learning words and objects, in the young child.

The link between language and conceptual development has been demonstrated

elsewhere as well (Balaban & Waxman, 1997; Booth & Waxman, 2002; Booth, Waxman, &

Huang, 2005; Gelman & Markman, 1987; Xu, 2002). This growing body of research has

provided evidence that early word learning supports the early acquisition and organization of

conceptual knowledge in infancy. Through three experiments, Booth and colleagues have shown

that infants as young as 20-months make extensions of novel words that vary systematically as a

function of the conceptual status of the named object (2005). For example, when objects were

named as artifacts, infants extended novel words primarily on the basis of shape, and when

objects were named as animate kinds, infants extended novel words on the basis of both shape

and texture. Giving infants conceptual information about objects had an effect on their word

learning, showing its importance as infants develop language. Perhaps a similar result could be

elicited by giving nonverbal information to infants? Not so. Balaban and Waxman (1997) found

17 that in nine-month-old infants, word phrases, but not tones, even those matched to the words for

amplitude, frequency, and duration, influenced object categorization. Additionally, Xu (2002)

found that in testing nine-month-olds on their ability to use labels to help establish a

representation of two distinct objects, the presence of two distinct labels facilitated object

individuation, while the presence of one label (for both objects), two tones, two sounds, or two

emotional expressions did not. The consensus from these studies is that in toddlers and young

children, conceptual knowledge and word-learning are two closely related and intertwined

processes.

*Categorization and ASD*

Now that categorization in typical development is understood, categorization in ASD will

be investigated. To start with, one needs to consider the possibility that people with ASD might

be experiencing the world differently than TD individuals. Anecdotal evidence comes from two

high-functioning individuals with ASD who have been successful at describing what it is like to

develop with ASD. Temple Grandin is one such individual who is on the higher end of the

spectrum. Not merely high-functioning, Grandin has a Ph.D. in animal science and has designed

one third of all livestock facilities in the United States (Grandin, 1995). She articulates in great

detail how she processes information, explaining that she is a "visual thinker" rather than a

language-based thinker (although she points out that other people with ASD think in other

sensory modalities besides vision).

Grandin states that her mind catalogs thoughts into visual images which she can

remember quite accurately for a long time. When describing what happens when she sees a

specific breed of dog, Grandin says that she accesses this catalog, remembering specific episodes

that she has had over her lifetime with that breed of dog. She states that her thoughts move from

18 specific visual images to generalization and concepts (Grandin, 1995). Contrasted with people

without ASD, who are able to generate images and prototypes rather quickly without necessarily

tapping episodes of memory, it is clear that this visual-based thought processing is quite taxing.

Moreover, it would seem that even though Grandin understands that a poodle is a type of dog,

which is a type of animal, her reflections reveal that perhaps *how* she obtained that information

might differ from how others obtain that information.

Donna Williams is another influential individual with ASD. Williams is an author from

Australia, who has written an autobiographical account of her life with ASD (1992). From a very

young age, Williams describes a world that captivated her, not because it contained people or

objects, but because it contained lights, colors, and sensations. In the first three years of her life,

she learned to lose herself in patterns on the wallpaper or carpet, or in repeated sounds. Williams

states that she heard the sounds of other people's voices, but did not actually listen to them, or

have any desire to communicate with them. There were relatives with whom she had a close

connection early on; however, those relationships were mediated through objects that she

associated with such people. For example, when remembering her grandmother, Williams

collected scraps of wool that were a reminder of her. She says, "For me, the people I liked *were*

their things, and those things (or things like them) were my protection from the things I didn’t

like–other people" (Williams, 1992, p.6).

These two accounts illustrate the firsthand experiences of an individual developing with

ASD. What is striking is the preference for objects over people in general, as well as each

person's experiences with those objects and concepts. Of course it should be noted that these are

two individual, introspective accounts, which are not likely to be indicative of ASD as a whole.

Nonetheless, these accounts are useful because they provide a window into the disorder, leading

19 one to ask more questions. How have researchers attempted to answer the question of how

children with ASD categorize objects and events? As stated before, due to both the complexity of

autism as a spectrum disorder, and the shifting definition of the disorder throughout history, there

is a great deal of contradictory evidence in the literature.

The earliest studies exploring concept formation revealed that children with ASD have

difficulty with perceptual categories (Fay & Schuler, 1980; Noach, 1974). One study looked at

how four children with ASD were able to classify blocks according to height and size, while

ignoring the other aspects (e.g., color, shape, and nonsense syllable). Qualitative analysis

revealed that the children with ASD showed an impairment, performing substantially lower as a

group than TD children (Noach, 1974). Another study by Schuler and Bormann (1977) used a

matching-to-sample paradigm and found that while children with ASD were able to match

identical objects, and match broken parts with their whole counterparts, they were unable to

match objects with their functional complements or equivalents. Also, some children had

difficulty with matching similar but non-identical objects (such as a red plastic toy car to a brown

metal car), as well as matching parts to wholes (such as the wheels of a car to the car),

suggesting that most of the children were able to use perceptual cues to match, but not

conceptual ones (see Fay & Schuler, 1980).

Three later studies examining categorization in ASD used control groups of children (TD

children and children with mental retardation [MR] now referred to as intellectual disability

[ID]) actually found no deficits at all in the group with ASD (Tager-Flusberg, 1985a, 1985b;

Ungerer & Sigman, 1987). In a study by Tager-Flusberg, knowledge of basic level and

superordinate level categories was assessed with a matching-to-sample task using pictures

(1985a). The first experiment within this study testing basic level categories (e.g., car, chair, and

20 dog), found no differences between children with ASD, children with MR, and TD children, who

were all matched on mental age. A second experiment within this study, utilizing the same task

with the same children, tested superordinate level concepts (e.g., vegetable, fruit, animal,

clothing, furniture, and vehicle). Again, no differences were found amongst any of the groups on

completion of the categorization tasks. However, as with the tasks that compared basic level and

superordinate level categories in Rosch's study, there was a major confound embedded within

these matching-to-sample tasks. When asked to point to the choice most like the target on each

trial (e.g., rocking chair), children were shown a picture of either another chair (e.g., ottoman) or

a category member from a different superordinate level category (e.g., an antique car). The fact

that children can match one type of chair with another type of chair, when compared with either

a car or a dog, does not provide specific information regarding their basic level categorization. A

more appropriate comparison would include basic level objects from the same superordinate

category (i.e., if the rocking chair is the target object, appropriate comparison objects might be

an ottoman and a bed for example).

A second study investigated another aspect of categorization, the acquisition and

organization of semantic concepts in the same three groups matched on verbal mental age

(Tager-Flusberg, 1985b). Since other studies revealed that children with ASD have difficulty

processing meaning in language and cognitive tasks (Hermelin & O'Connor, 1970; Tager-

Flusberg, 1991), it was hypothesized that there would be difficulties in concept formation as

well. The organization of both basic level (bird, boat) and superordinate level concepts (food,

tool) was assessed by showing each child 48 pictures and asking, "Is this a\_\_\_\_?” using the name

of the category for which picture was selected. Each category had central members of the

category, more peripheral members, related foils, and unrelated foils. Results indicated that there

21 were no significant differences between the three groups. Furthermore, the overextension and

underextension errors were comparable across groups as well, in that there were slightly higher

false positive responses to the unrelated foils for the superordinate level categories as compared

to the basic level categories (Tager-Flusberg, 1985b). In the second experiment, the child

selected a picture (a nonverbal response) that belonged to the named category from an array of

pictures, again using two basic level categories (house, fish) and two superordinate level

categories (musical instruments, tools). Again, the results showed no significant differences

across groups and a similar pattern of overextension and underextension errors. These results

showed that children with ASD have concepts; the methodology does not allow one to answer

the question of how or when these concepts were formed.

Finally, a third study assessed categorization skills on both functional and perceptual

grounds in children with ASD (Ungerer & Sigman, 1987). The methodology included a

spontaneous object sorting task, using stimuli that were geometric forms and miniatures of

objects representing four color (red, yellow, blue, and green), three form (square, triangular, and

circular shapes), and four function (animal, fruit, vehicle, and furniture) categories. Just as the

aforementioned studies demonstrated, no significant difference emerged between the children

with ASD, children with MR and TD children, who were all matched on mental age. There were

some problems with the sample of children, though, questioning the accuracy of the results. The

MR group was not homogenous (e.g., half of the sample had Down syndrome, others had

organic dysfunctions) and therefore, not an appropriate control group because it is unclear if the

results are attributable to intellectual disability or some other biological cause. In addition, it is

not clear what comparisons were made in the sorting task. For instance, the authors stated that on

each trial, the child was presented with two different sets of four objects (e.g., four red circles

22 and four red squares), both from the same superordinate category (e.g., form). This contrast

involves a change in one dimension with others held constant, therefore maximizing both high

contrast between categories and high similarity within categories. In the task involving four red

circles, it is not clear how discriminable one circle was from another. If they were not

discriminable, one might question whether any categorization strategy was required at all.

Even as these three studies demonstrated a lack of a categorization impairment specific to

children with ASD, there are some indications that a deeper look into categorization is necessary.

As stated before, there were potential confounds in two of the studies, compromising the

assertion that categorization skills are developing appropriately in children with ASD.

Additionally, in the previous spontaneous sorting task study which focused on the relationship

between categorization and receptive language, significant, positive correlations were found for

both TD and children with MR, whereas there was no such link in children with ASD (Ungerer

& Sigman, 1987). As a result, it is possible that children with ASD categorize by utilizing

different processes, with language processes playing a rather uncertain role if any.

Although the earliest studies looking at categorization did not find an impairment specific

to ASD, further studies looking at more complex aspects of categorization have shown mixed

results (Klinger & Dawson, 1995; Minshew, Meyer & Goldstein, 2002; Shulman, Yirmiya &

Greenbaum, 1995). One study by Shulman and colleagues tested children with ASD, children

with MR and TD children (all matched on mental age) on several Piagetian classification tasks

and found several group differences (1995). In this study, there were three different types of

tasks: two free-sorting tasks testing geometric shapes and representational objects, a matrix task

testing both perceptual and functional classification, and a class inclusion task. Results indicated

that on the free-sorting tasks, children with ASD performed similarly to the other groups on

23 sorting geometric shapes. However, children with ASD performed significantly worse than the

other groups on representational sorting, or placing objects that go together from six categories

(trees, beds, human figures, animals, tools, and vehicles). On the matrix task testing perceptual

classification, which is classifying according to two perceptual criteria (color and form)

simultaneously, those with ASD performed significantly better than those with MR and

significantly worse than TD children. The matrix task testing functional classification

(classifying things that fly, and things that give light) revealed that both children with ASD and

children with MR performed significantly worse than TD children. Finally, the class inclusion

task (testing color and shape) revealed that children with ASD performed significantly worse

than the other groups (Shulman, et al., 1995). These results provided a glimpse into differences

between perceptual and conceptual bases of categorizing. When utilizing individual perceptual

attributes alone, children with ASD do not seem to differ from TD children. However, when

more complex, functional attributes are tested, or when combinations of perceptual attributes are

used, children with ASD perform significantly worse than TD children, as well as children with

ID in certain contexts, suggesting that some aspect of the conceptual classification of objects

may be uniquely impaired in ASD.

Since early studies revealed that individuals with ASD were capable of rule-based

learning (Hermelin & O'Connor, 1986), several subsequent investigations focused on rule-based

and prototype-based categorization in children with ASD. What is a prototype? It has been

suggested that infants organize new information through the use of prototypes, or the best

representative member of a category, so that they are not overly cognitively burdened. Posner

and Keele (1968, 1970) have argued that a prototype is a mental representation created by

averaging all previously experienced category members. By utilizing prototypes, infants and

24 children are not constantly flipping through dozens of images of category members in order to

determine what something is (similar to Temple Grandin's descriptions of her concept

formation). Studies have shown that the ability to form a perceptually-based prototype is an

automatic process developing in the first year of life (Younger, 1990).

In ASD, the picture is not quite so clear. A study comparing prototype-based and rule-

based learning, found that children with ASD were just as accurate on rule-based categorization

as children with Down syndrome (DS) and TD children. However, on a task where the

participants had to select the category prototype, children with ASD and children with DS both

underperformed as compared with TD children (Klinger & Dawson, 2001). Although this study

and others have shown a possible prototype impairment in ASD (Klinger & Dawson, 1995,

2001; Plaisted, 2001), other studies have shown intact prototype formation in ASD (Molesworth,

Bowler, & Hampton, 2005; 2008), and still another found intact prototype formation but

impaired generalization (Froehlich, Anderson, Bigler, Miller, Lange, DuBray, Cooperrider,

Cariello, Nielsen, & Lainhart, 2012). These conflicting results could be due to the differing

functional levels of the participants, as well as methodological differences between the studies.

When Molesworth and colleagues (2008) employed the same methodology as Klinger and

Dawson (2001) but with higher functioning participants with ASD, they not only found overall

support for their earlier finding of intact prototype formation in ASD, but they also found that

there was great heterogeneity on task performance, with about a third of their participants failing

to show any prototype effect at all. This finding alludes to the problem of conducting research

within this population, since task performance depends on the functioning level of the

participants.

25 Another study looking at concept formation found evidence that high-functioning

individuals with ASD have difficulty abstracting information (Minshew et al., 2002). These

authors included measures of concept formation (the Stanford-Binet Absurdities Test, the 20

Questions task, and the Goldstein-Scheerer Object Sorting Test), measures of concept

identification (the Halstead Category Test and the Trail Making Test Part B) and a measure

testing both concept formation and identification (the Wisconsin Card Sorting Test; WCST) and

used factor analysis to find a dissociation between the concept formation and the concept

identification components of abstraction. In the ASD group, a three factor solution was obtained;

the first factor receiving salient loadings from the 20 Questions task, and the Stanford Binet

Picture Absurdities and Verbal Absurdities subtests; the second factor receiving loadings from

the WCST measures; and the third factor receiving high loadings from the Halstead Category

Test and the Trail Making Test Part B. In the control group, however, only a two factor solution

was obtained; the first factor including all of the tests except for the Halstead Category Test and

the Trail Making Test Part B, which loaded onto the second factor. Therefore, the authors found

evidence for their hypothesis that there is a dissociation between concept formation and concept

identification abilities that accurately describes the abstraction deficit in ASD.

All of the findings from these studies that have focused on more complex aspects of

categorization or concept formation point to the possibility that simple categorization tasks,

assessing perceptual constructs such as form, color, and shape, by utilizing sorting and matching-

to-sample methods are unable to capture the differences in how children with ASD are using

categories differently than others. Merely testing category skills may not be getting at how

children with ASD are processing this information differently.

26 It appears that the studies that have looked at categorization from one perspective only

(e.g., sorting, matching-to-sample, etc.) have found no deficits in children with ASD, while those

studies that have considered categorization as involving more than simple sorting or matching,

have found some differences in the way in which children with ASD categorize (Klinger &

Dawson, 1995, 2001; Shulman et al., 1995). Additional evidence that children with ASD may

categorize differently than TD children comes from a developmental study which examined

exemplar typicality on reaction time and accuracy of categorization (Gastgeb, Strauss, &

Minshew, 2006). Children, adolescents, and adults with ASD were shown pictures of objects that

were either the most typical, the least typical, or somewhat typical of their category. All of the

age groups (along with matched, typical controls) were then tested on their knowledge of

whether these objects did or did not belong to either natural (cat, dog) or artifact (couch, chair)

categories. The results showed that children, adolescents, and adults with ASD all responded

more slowly than typical controls to atypical category members, indicating slower processing of

categories that seem to persist through adulthood.

Another area in which individuals must use knowledge of whether or not something fits

into a typical category is in the perception of faces and facial expressions. Children and adults

are quite adept at perceiving different kinds of faces and facial expressions. People are so

proficient in this area that they can recognize faces and expressions in seconds, a skill that does

not require any explicit teaching. There are three aspects of processing faces: perceiving the

features that define faces (e.g., two eyes, a nose, and a mouth), assessing those features

holistically, and processing the second-order relations, or spacing among those features (Maurer,

Le Grand, & Mondloch, 2002). In this way, recognizing a face is more complex than one might

27 think. Are children with ASD able to process faces as are others, and are they able to categorize

expressions as happy, sad, or angry?

A study that focused on the second-order relations, or spacing of facial features, found a

deficit in individuals with AS (Katsyri, Saalasti, Tiipana, von Wendt, & Sams, 2008). Any image

can be broken down into spatial frequency components that represent different levels of details;

higher spatial frequencies represent more local or individual features and lower spatial

frequencies represent more global or holistic-level features. The authors evaluated the

recognition of four static and dynamic basic emotions (anger, disgust, fear, and happiness) from

varying levels of low-spatial frequencies (by using either slight, strong, or no filtering) in

participants with AS and matched controls. The results revealed that participants with AS did not

differ from the control group in identifying emotional expressions from the non-filtered or

slightly filtered displays. Only in the strongly filtered condition, individuals with AS displayed a

deficit in recognizing emotional expressions as compared with typically matched controls

(Katsyri et al., 2008). As a result, preliminary evidence indicates that at least one aspect of

processing faces may be impaired in individuals with ASD.

Another study assessed second-order processing and holistic processing in adults with

ASD as compared with TD controls (Wallace, Coleman & Bailey, 2008). For the holistic

processing task, 90 pictures of faces and 90 pictures of cars were flashed sequentially as pairs on

a computer screen for either 40, 70, or 100 milliseconds, afterwards which the participant was

asked whether the two images in the pair were the same or different. The second-order

processing task had 20 pictures of faces and 20 pictures of houses, which were each altered in the

same way; in the face pictures, alterations were made by both moving the eyes and cropping the

mouth a certain distance, and in the pictures of houses, the upstairs and downstairs windows

28 were shifted. The result was two test faces from one original face (and likewise for the house

pictures). After participants were shown sequential pairs of faces or houses (half being the same

and half being altered), they were asked again to identify whether the two images were the same

or different. Both of these tasks had similar results: participants with ASD performed

significantly worse than matched controls on the pictures of faces only (Wallace et al., 2008).

Another study using fMRI to map activation in the visual ventral cortex of adults with ASD in

response to faces, houses, and common objects, found group differences in adults with ASD only

in response to faces (on both an experimental and a more naturalistic paradigm; Humphreys,

Hasson, Avidan, Minshew, & Behrmann, 2008). Overall, these studies show an impairment of

processing faces in ASD.

Although there is ample evidence that individuals with ASD differ from others in their

perception of faces, what about facial expressions? Several studies assessing this ability found

varying deficits in individuals with ASD (Hobson, Ouston, & Lee, 1988; Teunisse & de Gelder,

2001). One study tested emotional facial expressions (happy, unhappy, angry, and scared) by

having participants with ASD match photographs of faces to the corresponding emotion, with

full-face oval photographs, photographs in which the mouth had been blanked out, and

photographs in which the mouth and forehead had been blanked out. The results suggested that

as the emotional cues (the mouth, forehead) were taken away, the participants with ASD were

less able (than matched controls) to infer emotion in the photographs, although they were just as

likely to identify the same person among the photographs (Hobson et al., 1988). Therefore, the

lack of the forehead and mouth had a detrimental effect on their ability to recognize emotion, but

not identity. The second experiment utilized the same procedure, except the photographs of the

faces were inverted (i.e., upside-down). The participants with ASD scored significantly better

29 than matched controls, showing that they were able to match emotion and identity using

photographs of inverted faces, while typical controls were not (Hobson et al., 1988). This finding

is of interest because it shows that when one disrupts facial configurations enough (by inverting

faces rather than blanking out certain features), typical individuals cannot use those emotional

cues to interpret faces. In contrast, individuals with ASD appear to be focusing more on

matching patterns of features, which is why they are more successful when faces are inverted,

than when specific features are blacked out. In a more recent study, it was found that on both a

discrimination and identification task using realistic photo stimuli of three expression continua,

adults with ASD were unable to perceive facial expressions categorically (Teunisse & de Gelder,

2001). From these studies it is clear that there are striking differences in the way that individuals

with ASD process and interpret or understand emotional facial expressions.

Is there any indication from the diagnostic criteria that there may be a categorization

deficit that is unique to ASD? Put differently, if we analyze each of the two impairments of

ASD, does it seem plausible that categorization may also be deficient, or at least developing

differently as compared with TD individuals? To answer this question, let us examine the

characteristics of ASD.

*Autism Spectrum Disorder: Two Impairments*

ASD is a pervasive developmental disorder that has two main impairments. The first core

impairment is in social communication and social interaction across multiple contexts and is

manifested by the following: deficits in social-emotional reciprocity, deficits in nonverbal

communicative behaviors used for social interaction, and deficits in developing, maintaining, and

understanding relationships. The second impairment is the presence of restricted, repetitive, and

stereotyped patterns of behavior, interests, and activities as manifested by: stereotyped or

30 repetitive motor movements, use of objects, or speech; insistence of sameness, inflexible

adherence to routines, or ritualized patterns of verbal or nonverbal behavior; highly restricted,

fixated interests that are abnormal in intensity or focus, and hyper- or hyporeactivity to sensory

input or unusual interest in sensory aspects of environment (American Psychiatric Association,

2013).

If one were to break down each of these impairments, it is apparent that categorization

impacts each of these abilities (or inabilities). The first impairment is a deficit in social behavior

and social communication. How do children with ASD interact with others? And how may these

behaviors affect categorization? Kanner stated that the fundamental disorder is the children's

"*inability to relate themselves* in the ordinary way to people and situations from the beginning of

life" (1943, p. 242). According to Kanner, the social impairment characterized the most

significant impairment of autism.

Social interaction is crucial for development from birth onwards and is linked with

various skills that one acquires throughout life. The few unfortunate examples of children who

managed to develop without substantive social interaction from an early age have proven that the

consequences of such an isolated life are dire. Arguably the most famous case documented was

that of Victor, who emerged out of a forest in France in 1800 as a young child. One of the

developmental outcomes of his early existence was an inability to develop communicative

language (Lane, 1979). Victor's upbringing and subsequent development, which fascinated

psychologists, philosophers, linguists, sociologists and countless others in many fields,

illuminated the importance of social interaction, especially on language development. Even if

Victor could not develop meaningful language, does this mean he could not categorize?

Certainly not. To some extent, his survival depended on his ability to categorize his

31 surroundings. For example, knowing what was edible was crucial. Had he been exposed to

people and developed social relationships, then this would have had beneficial consequences on

other aspects of his development. Unlike the circumstances of Victor and other feral children,

children with ASD have ample opportunities for social interaction and yet, they do not normally

interact with others either from a lack of desire or a lack of skills. What are the developmental

precursors to these social impairments?

It is apparent that from a very early age, TD infants are social creatures. Social

interactions influence categorization skills via observation, teaching, and cultural transmission.

From birth to six weeks of age, infants show a sensitivity towards social stimuli (Rochat &

Striano, 1999). Specifically, infants show an interest in people, looking at the features,

movements, and sounds of the human face (Maurer & Salapatek, 1976). Young children with

ASD are less likely (than both TD and developmentally delayed children) to orient to both social

and nonsocial auditory stimuli and this orienting impairment is more severe for social stimuli

(Dawson, Toth, Abbott, Osterling, Munson, Estes, & Liaw, 2004). If children with ASD do not

naturally orient towards people and faces, then it would seem that they might also have

difficulties using the gaze and attention of others to learn about objects and people in the world,

that is, joint attention.

Joint attention is defined as the simultaneous engagement of two or more individuals in

mental focus on the same external thing (Baldwin, 1995) and involves a number of social-

communicative acts on behalf of the infant: being able to follow its mother's gaze and gestures to

determine the mother's focus of attention, alternating gaze between an object or event and the

mother's gaze, and pointing to and showing objects to capture its mother's interest. These early

behaviors typically develop around 9–15 months of age and are an important social milestone in

32 the infants' understanding of objects and people (Siller & Sigman, 2008). It has been well

documented that children with ASD have significant deficits in joint attention, which in turn,

adversely affects their understanding of objects and people (Charman, Swettenham, Baron-

Cohen, Cox, Baird, & Drew, 2003; Dawson et al., 2003; Sigman & Ruskin, 1999).

There is a great deal of evidence that in addition to affecting knowledge of objects and

other people, joint attention is also linked with another important skill, the development of

communication. In typical development, it is through joint attention interactions that the infant

begins to link words and sentences with objects and events (Baldwin, 1995). Also, it has been

established that joint attention is a precursor to language development (Desrochers, Morissette,

& Ricard, 1995; Sigman and Kasari, 1995). Is the link between joint attention and language as

robust in ASD? Numerous studies have shown that in children with ASD, joint attention is

predictive of both current language ability and future gains in expressive language skills

(Charman, et al., 2003; Mundy, Sigman, Ungerer, & Sherman, 1987; Sigman & Ruskin, 1999).

How could these early social behaviors be linked with categorization? As stated earlier,

infants naturally look towards people, and specifically towards faces, very early on in

development. Orienting towards social beings is not only comforting for infants, but it is also

important in teaching infants about the myriad objects and events in the world. If infants and

young children with ASD are not inherently inclined to look towards others' faces, then they will

not follow others' gaze, nor share gaze focused on other objects, nor share attention of those

objects with others. And if they do not engage in these behaviors, then they are less likely to start

labeling those objects, using language to communicate about those happenings.

The other part of the core impairment of ASD is a delay, or lack of, spoken language.

Oftentimes, parents of children with ASD first become concerned about their children's

33 development when their speech is either delayed or absent (Wetherby, Woods, Allen, Cleary,

Dickinson & Lord, 2004). The picture is not so clear, however, across all children with ASD.

There is great heterogeneity in the language of children with ASD ranging from a complete lack

of verbal behaviors to idiosyncratic language use that can appear quite normal (Wetherby, 2006).

The proportion of children with ASD without any spoken language has been estimated anywhere

from 25% to 50% (Lord, Risi & Pickles, 2004). Yet those with ASD who are able to develop

language often find difficulty with the symbolic and communicative aspects of language,

expressing a range of problems including impaired or absent gesture-use, echolalia, and

difficulty following pragmatic and grammatical rules (Wetherby, 2006).

It is a momentous occasion when an infant or toddler begins to speak. Before one utters

one’s first words, one engages in a number of communicative acts, including coordinating

attention between people and objects, engaging in social exchanges, and communicating with

others by using gestures, such as pointing, that have common meanings (Bates, O'Connell, &

Shore, 1987). As stated earlier, these joint attention skills have been shown to be impaired in

ASD. Moreover, a number of longitudinal studies have shown a relationship between joint

attention abilities and later language outcomes, strongly suggesting that if a child is not looking

towards others nor using gaze to interact, then it is unlikely that this child will use language to

communicate as would a TD child.

What other early social-communicative behaviors are impaired in ASD? When a child

needs or wants something, one often directs one’s attention to others in order to relay this

information to them. Children with ASD often use gestures to communicate their wants or needs

(also called proto-imperative gestures), but they rarely use gestures to simply share information

with others (also called proto-declarative gestures; Tager-Flusberg, 1996). When children with

34 ASD start using spoken language, it seems that they do not use language functions (or speech

acts) in the same way as TD children. Children with ASD rarely use language to share

information with other people, nor do they ask information from others (Tager-Flusberg, 1996).

This link between social development and language development is strong in both typical and

atypical populations.

Children with ASD who go on to develop spoken language often acquire expressive

language between 2–6 years of age (Paul & Wilson, 2009). But even in this subgroup, there is

considerable heterogeneity. Some children with ASD who develop language may be extremely

delayed, with some cases of children developing language in adolescence (Paul & Wilson, 2009).

Others may have profiles similar to that of children with specific language disorders who are not

on the spectrum (Tager-Flusberg & Joseph, 2003), and still others may develop normal and even

precocious language (Tager-Flusberg, Paul & Lord, 2005).

One of the most salient aspects of the language impairment in ASD affects pragmatics

(Baltaxe, 1977), which are the rules for specifying how language is used appropriately in

different social contexts. Although they may have above average skills in language form (i.e.,

sound production, grammar) and/or content (i.e., vocabulary), children with ASD may have

difficulties with such pragmatic skills as taking turns, greeting others, and following along with

conversational rules (Paul & Wilson, 2009). Children with ASD are often unresponsive to the

conversational bids of others. When they do respond to others' initiations, they offer little to the

ongoing discourse, have difficulty sustaining the conversational topic, or offer irrelevant

comments (Tager-Flusberg & Anderson, 1991). The pragmatics impairment is useful in

illuminating categorization because it reveals the social nature of language. If children with ASD

have difficulty with joint attention, social-communication and pragmatics, then there could be an

35 intertwined categorization impairment as well, since it would appear that much of categorization

depends on social interactions and language.

How might the language impairment be related to categorization? If one does not have

language, or is developing abnormal language, then being able to categorize the world

effectively becomes a lot more difficult and tedious. As stated earlier, there is a link between

language and conceptual development in typical development (Balaban & Waxman, 1997; Booth

& Waxman, 2002; Booth, et al., 2005; Gelman & Markman, 1987; Xu, 2002), such that the two

systems are intertwined. If there were a categorization impairment, it might go hand-in-hand

with a language impairment. After all, one extends language to new situations based on

categorization skills, whether the categories are object, action, or event based.

The second impairment of ASD is the presence of repetitive and stereotyped behaviors

(RSBs). The first documented descriptions of these behaviors came from Kanner (1943), who

described both object and body stereotypies, including spinning, jumping, and other rhythmic

movements of the body. Despite the fact that RSBs are a core diagnostic feature of ASD, much

less is known about them as compared with the social and communication areas (Lewis &

Bodfish, 1998; Turner, 1999). There are several possible reasons for this lack of attention. First,

RSBs are not unique to ASD, being prevalent in a wide variety of developmental disabilities,

psychiatric disorders (e.g., schizophrenia), and neurological disorders (e.g., Parkinson's disease,

Tourette's syndrome; Lewis & Bodfish, 1998). Second, there is considerable heterogeneity in

RSBs in those with ASD, making it difficult to delineate how these behaviors function. Third,

there lacks a single, uniform measure of RSBs in the field, making comparisons among studies

complicated. Finally, there are few studies that explain how young, TD infants and children use

36 these behaviors, which differs from how they are used in ASD (Cuccaro, Shao, Grubber, Slifer,

Wolpert, Donnelly, Abramson, Ravan, Wright, DeLong, & Pericak-Vance, 2003; Turner, 1999).

Repetitive behaviors can vary widely in ASD and can include stereotypy, rituals,

compulsions, obsessions, insistence on sameness, echolalia, self-injury, tics, dyskinesia,

akathisia, and perseveration (Lewis & Bodfish, 1998). What are some possible implications for

the use of repetitive or stereotyped behaviors in early childhood? TD infants in the first year of

life engage in a number of repetitive behaviors including kicking, waving, banging, twirling,

bouncing and rocking (Thelen, 1979), with many of these behaviors relating to objects. At

around 3–4 months, TD infants begin to attend to, grasp, manipulate, and inspect distant objects

(Trevarthen, 1979, 1988). Infants' exploration of objects tends to get more advanced by about six

months, giving them information about the nature of different objects and the relationships

between them (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). This object exploration

is referred to as manipulative play, the first developmental step in children's play. Manipulative

play is sensorimotor in nature, allowing infants to handle objects by feeling, licking, sniffing,

turning them around, throwing them away, etc. (Williams, 2003). At 13–15 months, infants

begin to engage in the second developmental play skill, functional play, defined as using an

object in accordance with its socially designated function, for example, flying a toy airplane in

the air (McDonough, Stahmer, Schreibman, & Thompson, 1997; Williams, 2003). At this age,

the child understands what certain, common objects are and how they function, exhibiting this

knowledge through play. Finally, at around 24 months, spontaneous symbolic play develops in

which the child uses pretend play, for example, using a banana as a telephone. This advanced

type of play has been considered important by many theorists, including Piaget (1962), who

deemed pretend play (along with language and deferred imitation) the onset of children’s ability

37 to represent objects, events, and behaviors that are required but not available—indicating their

use of symbolic activity.

Due to the difficulty of testing very young infants with ASD, it is hard to assess play

behaviors at a young age. However, one study, which examined atypical object use in a group of

12-month-old infants (later diagnosed with autism), found that the autism group displayed a

number of atypical object use behaviors, especially unusual visual object exploration, defined as

either engaging in prolonged visual inspection (>10 seconds), examining objects from odd angles

or peripheral vision, or squinting/blinking repeatedly while examining the object (Ozonoff,

Macari, Young, Goldring, Thompson, & Rogers, 2008). Also, several of these indicators of

atypical object use at 12 months significantly predicted Autism Diagnostic Observation Schedule

(ADOS) scores, and four subscales of the Mullen Scales of Early Learning (fine motor, visual

reception, and expressive and receptive language) at 36 months, highlighting unusual visual

exploration as an early diagnostic indicator of ASD (Ozonoff et al., 2008). Another study

examined restricted object use, defined as action schemata and/or toy preferences that are

restricted in range and make up a large portion of the child's differentiated intentional actions

directed towards objects. The authors found that in children with ASD, the more time that is

spent in restricted object use, the less aware that children with ASD are of adult attentional

directives, adult prompts, and models to imitate (Bruckner & Yoder, 2007). These results show

that children with ASD who are inappropriately focused on objects are less likely to attend to

adults, thereby showing less coordinated attention between objects and people.

A number of studies have found deficits in the play behaviors of young children with

ASD. There is a lot of disagreement about functional play; several studies have shown no deficit

(Baron-Cohen, 1987; Charman & Baron-Cohen, 1997), while other studies have shown

38 differences in the functional play of children with ASD (Lewis & Boucher, 1988; Sigman &

Ungerer, 1984). Jarrold has reviewed the literature on symbolic play, concluding that

abnormalities in symbolic play among children with ASD are not restricted to delays in the

emergence of such play, nor can they be characterized as a straightforward inability to symbolize

(2003). The developmental picture is complex because it appears that children with ASD can

indeed demonstrate knowledge of pretend and symbolic events, even though they may rarely

spontaneously do so (Charman & Baron-Cohen, 1997; Hobson, Lee, & Hobson, 2009;

McDonough et al., 1997).

Overall, a presence of repetitive and stereotyped behaviors may be associated with an

impairment in categorization. As stated earlier, some evidence has shown that infants and young

children with ASD are interacting with objects differently than are TD children. Of course, all

young children engage in repetition during their development. One needs only spend an

afternoon with a toddler to appreciate how opening and closing a door over and over again is

leading to the child's understanding of how objects, and more specifically, doors, move and how

they function. Unfortunately, it seems that children with ASD get stuck in this developmental

course, and their fascination with certain parts of objects takes an abnormal course. If children

with ASD are busy spinning a top in the light of a window, flapping their hands at the sound of a

school bell, or obsessing over the school bus' route to school, then it is a wonder how they learn

about objects and how those objects function in the world. Being preoccupied with certain

objects does not necessarily imply a categorization impairment. However, it does lend evidence

that perhaps children with ASD are learning about objects and categorizing them quite

differently than are others. As can be seen, each of the two impairments has implications for

categorization.

39 *A Theoretical Account of ASD: Weak Central Coherence Theory*

Due to the heterogeneous nature of the disorder, it has been daunting for researchers to

explain the underlying cause of ASD. Besides the two main impairments, there are a host of

related impairments that are prevalent in ASD. There have been many psychological

explanations, but only one, weak central coherence theory, best explains the entire picture of

ASD. Central coherence is a term that Uta Frith first coined that describes how individuals

process incoming information (1989; Happe, 1999). TD children and adults tend to look for

meaning in global form, often at the expense of attention to or memory for details. Individuals

with ASD are hypothesized to show weak central coherence, exhibiting a processing bias for

featural and local information, along with a relative failure to see the big picture in everyday life.

Weak central coherence theory posits that this global processing feature that is typical of people

is disturbed in individuals with ASD, who show a more detailed-focused processing. This

different processing style leads to children and adults with ASD to show a preoccupation with

details and parts, while failing to extract the gist or meaning of a given situation. Kanner (1943)

also noted this weak central coherence, stating that a universal feature of ASD is the "inability to

experience wholes without full attention to the constituent parts" (p. 243).

How is this processing bias manifested in individuals with ASD? Children with ASD

have processing differences in a number of perceptual modalities, in addition to spatial and

verbal modalities (Happe, 1999; Happe & Frith, 2006). They perform faster than matched

controls on the Embedded Figures Test, in which individual shapes have to be found within a

larger pattern (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983). Additional strengths of

children with ASD include relatively good performance on certain subtests of the Wechsler

scales (Wechsler, 1974, 1981), such as Block Design and Object Assembly (Shah & Frith, 1993),

40 and good performance on the Figure Ground and Form Completion subtests of the Leiter

International Performance Scale-Revised (Kuschner, Bennetto, & Yost, 2007; Leiter-R; Roid &

Miller, 1997). Furthermore, individuals with ASD display a failure to disambiguate homographs

using surrounding word context (e.g., pronouncing tear in "In her eye/dress there was a big tear";

Happe, 1997), a difficulty in enumerating canonical patterns when counting (Jarrold & Russell,

1997), and a tendency not to perceive visual illusions (Happe, 1996). All of these cognitive

strengths and weaknesses seem to be best explained by a preference for processing at the local

level, at the expense of the larger, gestalt level. Weak central coherence theory also seems to best

explain savant skills (occurring in approximately 1 in 10 individuals with ASD; Happe, 1999), in

areas such as puzzles, music, art, calculation, and memory.

Other theories which attempt to explain the disorder include the theory of mind deficit

(Baron-Cohen, 1995; Baron-Cohen, Leslie, & Frith, 1985), which claims that individuals with

ASD are delayed in their ability to ascribe beliefs and desires to others in order to predict their

behavior, and the executive dysfunction hypothesis (Normal & Shallice, 1986; Ozonoff, 1995)

which states that people with ASD fail to guide their behavior with reference to internally

specified goals, as opposed to external stimulation. Both of these theories have explanations for

the main impairments, however, they fail to explain the various strengths of some individuals

with ASD. The notion of weak central coherence in favor of more detailed-focusing processing

is one of the only theoretical accounts accounting for strengths of those with ASD, and has been

received with enthusiasm and immediate recognition by the ASD community (Happe & Frith,

2006).

To summarize, children with ASD are not focusing on the global context in their

everyday lives, but on the smaller, more local details. This has been shown through various

41 studies in both the visual and auditory domains, with individuals with ASD demonstrating the

following: stable memory for exact pitches (Heaton, Hermelin, & Pring, 1998), enhanced local

processing of music stimuli (Heaton, 2003), raised thresholds for perceiving coherent motion

(Betrone, Mottron, Jelenic, & Faubert, 2003), and superior visual search (Plaisted, O'Riordan, &

Baron-Cohen, 1998). As compared with these perceptual domains, there is evidence in the

conceptual domain that children with ASD are less able to extract meaning from a given array of

information. One example comes from Tager-Flusberg (1991), who found that children with

ASD, as opposed to both TD and learning disabled children, were not facilitated in immediate

free recall by the semantic similarity in a list of nouns. Another study utilized a between-groups

analysis, concluding that children with ASD, as compared with TD and developmentally delayed

children, displayed an emerging pattern of relative strengths on Figure and Ground and Form

Completion and a relative weakness on the Repeated Patterns subtests of the Leiter-R (Kuschner

et al., 2007). This last study points to the differences in nonverbal cognitive functioning of

children with ASD, highlighting how certain perceptual tasks are a strength, while certain

conceptual tasks are a weakness for children with ASD.

If children with ASD are not attending to the same objects and events as are others, then

it may follow that they are not learning about object categories in the same way as are others. As

discussed earlier, TD infants and young children learn from a variety of different experiences,

constructing meaning along the way. They come to understand what constitutes food and what

constitutes a toy from attending to these different things in their environment and their

experiences with them. And yet, the evidence has shown that children with ASD have different

experiences; socially, communicatively, and with a reliance on repetitive actions/events in their

environment. It may be that in having these different experiences, they are relying more on

42 perceptual processes in developing knowledge of object categories. Ironically, it is possible that

Rosch's theory of category development may be more appropriate for children with ASD, with

their primary focus on perceptual similarity that allow basic level categories to have the highest

cue validity. If this were an accurate description of their categorization skills, then children with

ASD might show a different developmental pattern of categorization (as compared with TD

infants and children). In typical development, infants and young children first differentiate

superordinate level categories, and later come to differentiate basic level domains within those

categories, on the basis of conceptual knowledge. Perhaps children with ASD are so focused on

details that they differentiate categories in a more bottom-up process, first differentiating basic

level or even subordinate level categories, and later coming to differentiate more superordinate

level categories, by focusing more on perceptual differences. As compared with children with

ASD, TD infants and children have so many more advantages in their experiences with people

and objects in the world, developing categories as they develop themselves.

Overall, there are limitations with our current knowledge of categorization in ASD. It is

difficult to come to a consensus about how children with ASD form categories, since most

studies tend to regard categorization as a one-dimensional concept. The results from early studies

looking directly at categorization found no differences in ASD (Tager-Flusberg, 1985a, 1985b;

Ungerer & Sigman, 1987). Later studies, testing more complex aspects of categorization found

unique problems in children with ASD (with some problems shared with children with DS as

well; Klinger & Dawson, 1995; Minshew et al., 2002; Shulman et al., 1995). And yet, the results

seem to depend on which segment of the spectrum of autism is tested and which control groups

are used. This is problematic in that there is far from definitive evidence of whether children

with ASD have difficulty forming object categories. By considering categorization as a

43 developing multidimensional process, affected by other developing systems (language, social

development, repetitive behaviors), it appears that another look into categorization in ASD is

warranted.

Another limitation with the current literature is that the vast majority of studies have

utilized high-functioning children or adults with ASD at different developmental levels. What is

troubling is that ASD is a heterogeneous disorder. It is unclear if there are any meaningful

differences in the way in which different subgroups within ASD might be categorizing. Besides

having high and low functioning distinctions (related to IQ or developmental level), there are

also children who display a range of communicative abilities, from those that are nonverbal to

fairly precocious language speakers.

In studying object categorization in typical development, Bornstein and Arteberry (2010)

utilized the sequential touching methodology to assess superordinate, basic, and subordinate

categories within four domains (animals, vehicles, fruit, and furniture) in TD children from 12-

to 30-months of age. They found evidence of a clear developmental pattern of more inclusive

categorization (i.e., superordinate) developing prior to less inclusive categorization (i.e., basic

and subordinate). While not developmental in nature, the present research has a similar structure

to Bornstein and Arteberry, except that the present study used multiple tasks or methods.

Ultimately, this project will be expanded, mimicking the methodology of Bornstein and

Arteberry in utilizing several ages to assess categorization developmentally.

*Purpose of this Dissertation*

The goal of this research was to examine categorization abilities of young children with

ASD, across multiple levels, stimuli, and methods (or tasks). The pilot study was conducted first

to confirm if these categorization tasks were indeed appropriate for the population with ASD. In

44 the pilot study, only basic and superordinate level categorization were assessed in five

participants utilizing four categorization tasks: object examining, sequential touching,

generalized imitation, and sorting tasks. The object examining task was found to be inappropriate

for children with ASD, so the main experiment was conducted with three tasks: sequential

touching, generalized imitation, and sorting tasks. Within each task of the main experiment,

superordinate, basic, and subordinate categorization were tested in three domains (animals,

kitchen utensils, and tools) across children with ASD.

The main research question addressed in this research is how do children with ASD form

categories? Do they form categories in a top-down progression as do TD children, using

conceptual knowledge to distinguish superordinate level categories before basic level and

subordinate level categories (Mandler & McDonough, 1993, 1998a, 1998b, 2000)? Or are

children with ASD forming categories in a more bottom-up progression by using perceptual

differences to distinguish basic level and subordinate level categories before superordinate level

categories (Rosch et al., 1976)?

Another research question focuses on whether or not this categorization process differs

by domain. Do children with ASD categorize natural kinds and artifacts differently? In the

literature, there are mixed results concerning how children with ASD distinguish between

animate and non-animate objects. Several studies have found that individuals with ASD fail to

see social motion as do TD individuals (Blake, Turner, Smoski, Pozdol, & Stone, 2003; Klin,

2000; Moore, Hobson, & Lee, 1997). Other studies have found no difficulty in detecting animate

motion (Johnson & Rakison, 2006; Murphy, Brady, Fitzgerald & Troje, 2009). One study testing

whether children with ASD use motion to identify animacy found group differences (Rutherford,

Pennington, & Rogers, 2006). Using a novel paradigm involving geometric figures, the authors

45 found evidence only in the training phase that children with ASD take longer to consistently

distinguish animate from non-animate moving geometric figures, as compared with TD children

and children with developmental delay. In the testing phase, however, children with ASD

performed similarly as the two control groups once criterion was reached, suggesting that either

children with ASD are able to form quick, compensatory strategies, or that they need to be

primed in order to use such information.

Besides those main research questions which were the focus of the current study, the role

of language in developing categories was also assessed. Specifically, do language skills and

categorization abilities positively correlate in children with ASD?

46 **CHAPTER II. PILOT STUDY**

*Method*

*Participants*

Five children (3 males and 2 females) with ASD were assessed in this pilot study. Their

mean chronological age was 7.0 years, ranging from 5 to11 years. Having a wide range of ages

and abilities was thought to be useful in this initial study as there had been no systematic or

thorough analyses of categorization abilities in this population to date. The children attended a

school that was started for ASD and other developmental disabilities. Written parental consent

was obtained for each child. Due to experimenter error, one child’s date of birth is missing, so

age is approximated since only the birth year is known (see Tables 2 and 3).

*Stimuli* In each task, 3-dimensional miniature replicas of real objects in each of the categories

were used. The objects included animals, vehicles, musical instruments, tools, dogs, cats, cars,

and trucks. Stimuli are listed in Appendix A.

*Design and Procedure*

In this pilot study, the goal was to ascertain whether four different categorization tasks

were appropriate for children with ASD. Each task tested both a basic level and a superordinate

level contrast. The superordinate contrasts were between animals and vehicles, and musical

instruments and tools. The basic level contrasts were between cats and dogs, and cars and trucks.

Testing occurred in several sessions over the course of six months. Each session occurred at the

child’s school, during the school day. At each session, the child received a combination of the

object examining task, sequential touching task, generalized imitation task, and sorting task.

47 There were a total of eight tasks per child. Each session was videotaped for later scoring. During

each testing session, the child was seated at a table opposite the experimenter.

*Object examining task.*

In the object examining task, participants were familiarized to four of the five exemplars

from one category. Each of the four exemplars was placed on a table in front of the participant

one at a time. The participant was allowed to touch, examine, and/or explore the object for 20

seconds. After 20 seconds, the experimenter simultaneously took away the object, trading it with

another object from the same category for another 20 seconds. This pattern continued, with the

child examining four separate objects from the same category. The experimenter then repeated

this process, so that the child viewed the set of four objects twice (totaling eight trials). The

experimenter then gave the child a first test object, which was the fifth previously unseen object

from the familiarization category. Lastly, the second test object was presented, which was a

previously unseen exemplar from a contrasting category. All of the objects were counterbalanced

(as much as possible) across children.

*The sequential touching task.*

The sequential touching task was administered by placing eight objects in a random

fashion on a tray, four objects from one category and four objects from a different category. The

experimenter then pushed the tray in front of the child and said, “Play”. The child was then

allowed to play with all of the objects freely for two minutes. If the child dropped an object onto

the floor, the experimenter replaced the object within reach. After the two minutes elapsed, the

experimenter ended the task by retrieving the objects. This was done by having the child sort the

eight objects into two separate containers (see sorting task). The superordinate contrast was

musical instruments vs. tools and the basic contrast was cars vs. trucks.

48 *Sorting task.*

The experimenter administered the sorting task directly after the two minutes of the

sequential touching task had elapsed. The tray with eight objects (four from one category and

four from another category) was on the table in front of the participant. The experimenter then

placed two boxes on the table, one on either side of the tray, and then picked up an object from

the tray from one category and showed it to the child saying, “See this? It goes here”, as the

object was placed in one of the two boxes. The experimenter then showed the child another

object from the tray from a different category, saying the same thing while placing the object in

the second box. At this point the experimenter returned the objects to the tray, saying, “Your

turn. Put the objects away”. The superordinate contrast was musical instruments vs. tools and the

basic contrast was cars vs. trucks.

*Generalized imitation task.*

For the generalized imitation task, participants were first given a warm-up task, which

was stacking three soft blocks, and then knocking them over. Participants were encouraged to

imitate this action and were praised for doing so.

The experimenter then brought out a modeling exemplar and a prop and demonstrated an

action. There were two actions demonstrated typical of animals (sleeping and drinking) and two

actions performed typical of vehicles (keying and riding). For example, the action of sleeping

was demonstrated using a dog (modeled exemplar) and a bed (prop), by placing the dog into the

bed. The experimenter then patted the dog along with the appropriate vocalization of “night,

night”. This action was repeated three times in three different positions around the table to ensure

that the child was attending to the action. The experimenter then removed both objects from view

and placed three objects in the middle of the table. One item was the prop used in the

49 demonstration (bed) and it was placed in the middle of the table. The two new exemplars were

placed on either side of the object (with side counterbalanced), one of which was from the same

superordinate category as modeled (e.g., bird), and one from a different superordinate category

(e.g., airplane). After the three objects were placed on the table, the experimenter said, “Your

turn. Night, night”, in order to persuade the child to imitate the activity. In the example used, the

bird is a better selection than the airplane because birds sleep (a quality of being an animal) but

airplanes do not. In the basic level, a different kind of contrast was used. As before, the

experimenter would model sleeping with a dog (for example) but the test items were from the

same domain (e.g., a different dog and a cat). In this task, the focus was on if the child could

imitate the action, and which item the child would select first to demonstrate that action. Since

both dogs and cats sleep, either would be an appropriate choice. However, if the child noted the

modeling exemplar, the child would be more likely to choose the different dog rather than the

cat.

*Scoring* Two coders coded data across all four tasks and reliability exceeded 90%. For the object

examining task, the examining times were recorded for each of the objects. The dependent

measure was the child’s examining time with the hypothesis that the child would examine the

test item from the new category longer than the test item from the old category. It should be

noted that examining is not the same as merely looking at an object. Ruff (1984, 1986) found

different behavioral patterns between looking and examining that indicate different kinds of

‘attentive states.’ More recent research by Elsner, Pauen and Jeschonek (2006) showed that these

different states are also marked by physiological differences in heart rate.

50 For the sequential touching task, every object that the child contacted, either by hand or

with another object, and the order in which the objects were contacted, was coded. The

dependent measure was the order in which the child selected each of the items to touch, examine,

or manipulate. If the child noticed that there were items from two different categories, the child

should selectively examine items from one category and then move on to items from the

contrasting category in a sequential fashion (Ricciuti, 1965; Sugarman, 1983). The rationale

(based on extensive research with TD children) is that if the children touch the objects from a

given category in sequence more often than expected by chance, they must be doing this because

of their relatedness. There are two measures for analyzing their sequential touching. The first

measure of categorization was the mean run length (MRL), which was calculated by dividing the

total number of touches a child exhibits by the number of runs. Runs are sequences of touches to

objects from within one category; a run of three touches would indicate that the child touched

three items from one of the categories and then began touching an item from the other category.

The longest possible run is the total number of touches if a child touches items from only one

category. The MRLs were compared to chance (1.75; see Mandler, Fivush, & Reznick, 1987) to

establish whether the children responded to the category more than would be expected by

chance. When children as a group touched objects from the same category at run lengths greater

than chance, it follows that children as a group categorized.

The second measure is a more qualitative measure of individual categorization. To assess

individual categorization, the percentage of children in a group who are categorizers was

computed using a Monte Carlo program (Mandler et al., 1987). Individual children were

considered categorizers if their run lengths included three or four different objects from one of

the two domains presented. Because a run of touching multiple objects in a row can occur by

51 chance, especially when a child makes a lot of touches, the Monte Carlo program determines the

likelihood of such occurrences. The program computes how often categorizing runs occur in

10,000 random draws. Repetitions are allowed (excluding touches to the same item in immediate

succession) as long as the run includes three or four unique objects. This technique estimates the

probability of one or more categorizing runs occurring by chance, as a function of the total

number of items the child touched (Mandler, et al., 1987).

For the sorting task, coding consisted of the participants’ choice of stimuli to sort into the

two separate boxes. The dependent measure was the choice of stimuli used to sort the objects.

The results are expressed in terms of the proportion of correct sorting, out of eight trials.

For the generalized imitation task, coding included performance (or nonperformance) of

the properties and the exemplar used (Mandler & McDonough, 1996; 1998). The dependent

measure was the choice of stimuli used to imitate the properties that were demonstrated. First

and second choices were noted but only first choices were considered in the results.

*Results and Discussion*

The data allowed for both quantitative and qualitative analyses and were analyzed both

across and within participants. Since there were only five participants in this first study, the data

were analyzed mostly qualitatively and each task was evaluated in terms of success and failure.

*Object Examination Task*

The object examining task was the easiest and most structured task. The structure was

such that the first nine trials were composed of items from the same category and the tenth item

was from a different category. Thus the child only needed to derive the relatedness of the first

trials and note the novelty of the last. Success was measured as longer examining times at the

novel category member. For the superordinate level contrast, animals vs. vehicles, one out of five

52 children (20%) succeeded. After being shown a series of animals and then being shown a new

animal and a vehicle, 1 out of the 5 children looked longer at the vehicle than the new animal.

However, on this superordinate contrast, all five children performed close to ceiling. On the

basic level, one child’s data were not examined because of experimenter error. Two out of 4

children (50%) succeeded on the basic level contrast, dogs vs. cats. Therefore, after seeing

several dogs and then being shown a brand new dog and a cat, 2 out of the 4 children looked

longer at the cat than the brand new dog, with one child performing at ceiling (see Table 1).

This task, which is the simplest and most structured of the tasks, shows that children with

ASD are slightly more sensitive to the basic boundaries than the superordinate ones. However,

since this task has traditionally been used on TD infants (see Mandler & McDonough, 1993;

1998), and this population seems to be performing near ceiling, it appears that this task is not

appropriate for older children. It could be that children’s repetitive behaviors are interfering with

this task, making them selectively attend to parts of the object. It also could be that this task is

not appropriate for older children.

**Table 1**: Mean Amount of Time (in Seconds) Attending to Objects in Object Examining Task

Object Basic Superordinate

Object 4 15.6 19.0

Novel Object (from same category) 16.0 19.2

Novel Category 18.4 17.8

53 *Sequential Touching Task*

The sequential touching task is not as structured as the object examining task because the

child is shown a collection of eight objects at once arranged randomly on a tray. In order to

succeed on this task, the child must impose structure on the task, pulling out the differences

between the two categories. To determine whether the participants responded to the category

differences more than would be expected by chance, two-tailed *t-*tests were conducted,

comparing MRLs to chance. Results of the Monte Carlo task were also calculated and are

discussed below. Neither the superordinate level: *t*(4)=1.02, p > .10, n.s., nor the basic level: *t*(4)

= 0.37, p > .10, n.s. were statistically significant. Therefore, the children did not systematically

respond to the categories greater than would be expected by chance. Since there were only five

participants, though, and this measure is used for group performance, this is not that surprising.

The Monte Carlo analyses assessing individual categorization are shown in Table 2. As can be

seen, on the superordinate level contrast, musical instruments vs. tools, four out of five children

(80%) succeeded, while on the basic level contrast, cars vs. trucks, two out of five children

(40%) succeeded (with one of those children categorizing at a marginally significant level). This

result shows better performance on the superordinate level than on the basic level, a finding that

replicates research with younger TD children.

54 **Table 2**: Mean Run Length (MRL), P-values Comparing MRLs to Chance on the Sequential Touching Task across the Superordinate and Basic Levels

Participant

Chronological Age (CA)

MRL (Super) P (Super) MRL (Basic) P (Basic)

MM 6, 6 2.15 **p=.01** 2.83 **p=.00**

KB 7, 7 2.56 **p=.00** 1.50 p>.05

JC 6, 0 2.31 **p=.00** 1.76 **p=.06**

MB 6, 6\* 1.76 **p=.05** 1.38 p>.05

BH 10, 7 1.18 p>.05 1.76 p>.05

\*Approximation

*Sorting Task*

The sorting task has traditionally been considered a difficult task because it is relatively

unstructured and requires the child to shift focus. And yet, it has been used with success in this

population (Kaland, Smith, & Mortensen, 2008; Liss, Harel, Fein, Allen, Dun, Feinstein, Morris,

Waterhouse & Rapin, 2001; Ropar & Peebles, 2007; Ungerer & Sigman, 1987). Success is

measured by the placement of each of the two sets of objects in their correct, respective boxes.

One reason why the sorting task is difficult is because play activities sometimes interfere.

Children often ignore the instructions (that are both demonstrated and verbalized) to separate the

objects into two piles because they merely want to play with all of the objects. In the

superordinate level contrast, musical instruments vs. tools, two out of five children (40%) were

able to categorize correctly and in the basic level contrast, cars vs. trucks, the same two out of

the five children (40%) were able to categorize correctly. The other three children (60%) sorted

according to chance levels (50%).

55 These results do not support or refute the hypothesis either way, as it is difficult to

interpret the finding. Several of the children were unable to sort the objects because their

repetitive and stereotyped behaviors were impeding on the task. It is tough to say that these

children therefore lack knowledge of the two separate categories, just as it would be hard to say

that TD children lack that knowledge because they are playing with the objects.

*Generalized Imitation Task*

The generalized imitation task tested four actions (sleeping, drinking, keying, and riding)

for each of the superordinate and basic contrasts. For the superordinate level contrasts, all five

children (100%) were able to generalize to the appropriate superordinate category (see Table 3).

For the basic level contrasts, every action was again demonstrated (on a different test

day), but two different exemplars were presented to the child; one from the same basic category

as modeled (e.g., another dog) and one from a different basic category but the same

superordinate category (e.g., a horse). In this way, both objects would be appropriate since both

exemplars are animals. For this basic level contrast, all five children (100%) were again able to

generalize to both appropriate categories. Also, the order in which the objects were chosen was

also analyzed. Four out of the five children (80%) did not show a preference to either the object

from the same basic category or the object from the different basic category. One out of the five

children (20%) chose the object from the different basic category for all four actions (see Table

3). This task shows that the children are all demonstrating conceptual knowledge of these

objects. This finding should not be so surprising, since the ages of the participants were 5-11.

Though the other tasks have not revealed this pattern, these children have shown the ability to

imitate and generalize, just as TD children do.

56 **Table 3**: Results from the Generalized Imitation Task across the Superordinate and Basic Levels

Participant CA App. – Inapp. Same – Different

MM 6, 6 100 – 0 50 – 50

KB 7, 7 100 – 0 50 – 50

JC 6, 0 100 – 0 0 – 100

MB 6, 6\* 100 – 0 43 – 57

BH 10, 7 100 – 0 50 – 50

\*Approximation

Overall, it appears from the data that the results are mixed across tasks. The participants

show slightly more sensitivity to superordinate categories over basic ones, using knowledge of

what the categories are over how perceptually similar they are. When breaking down each task,

however, it is clear that this is not the whole story.

The object examining task revealed near ceiling performance, so this task was removed in

the main experiment. In the sequential touching task, it appears that the children were showing

more sensitivity to superordinate categories over basic categories. Why is there a discrepancy

between the object examining and sequential touching tasks? The answer lies in the differences

between the tasks. In the highly structured object examining task, the participants are focusing on

the objects one at a time. In the sequential touching task, the child must impose the structure on

the task, seeing all the items together. Here the children are more sensitive to the boundaries

between domains. The results of this task do not support the traditional categorization view or

weak central coherence theory (Happe & Frith, 2006).

The sorting task revealed that most of the children sorted according to chance. The

generalized imitation task results revealed that children with ASD were able to generalize, and

57 that they conceptually understood what the objects are and how they function. It is also

interesting that for the basic level contrast, when both exemplars given to the child were

appropriate, most of the children recognized this by generalizing to both exemplars. Traditionally

it has been thought that children generalize based on similarity; therefore, based on this view,

one would expect the participants to generalize to the different dog before generalizing to

another kind of animal. But, if they are categorizing based on conceptual knowledge, then one

would expect them to choose either exemplar about 50% of the time since they are both

appropriate. This is exactly what the data reveal. But across tasks, the generalized imitation task

showed that all five of the children possessed knowledge of the object categories, while in the

sorting task, three of the children were unable to demonstrate that knowledge.

In conclusion, no single task tells the entire story. Importantly, results from this first

experiment show that these tasks, with the exception of the object examining task, are

appropriate for children with ASD. Additionally, the main experiment included younger children

to determine the pattern of these emerging categories. Finally, in order to more clearly test the

possibility that children may be categorizing in a bottom-up way, the main experiment also

included the subordinate level.

58 **CHAPTER III. MAIN EXPERIMENT**

The purpose of the main experiment was to more systematically test the possibility that

children with ASD may be categorizing in different way than are TD children. In order to get at

differences between levels, the subordinate level was added to the research design of the main

experiment. The pilot study showed that the object examining task may not be appropriate for

children with ASD. Therefore, three categorization tasks (sequential touching, generalized

imitation, sorting) were used in the main experiment. Also, younger children were used in the

main experiment, and their language comprehension was assessed in order to delineate the

relationship between children’s categorization and their language comprehension.

Bornstein and Arteberry (2010) also analyzed three levels of categorization with the

sequential touching task in TD children across ages 12-, 18-, 24-, and 30-months. One of the

only studies to assess three levels of categorization across multiple domains (animals, vehicles,

fruit, and furniture), they found that more inclusive levels of categorization emerged earlier than

less inclusive levels. Using a similar structure, the present study assessed three levels of

categorization in one group of children with ASD, using the sequential touching task in addition

to the generalized imitation and sorting tasks. Previous studies of categorization in ASD have

shown mixed results, with one reason being that a single measure of categorization was used in

one group of children. Therefore, it was believed that using multiple levels, domains, and tasks

in the same group would clarify how children with ASD learn object categories.

59 *Method*

*Participants*

Ten children with ASD (9 males and 1 female) participated in this main experiment.

Their mean chronological age was 4.8 years, ranging from 3 to 6 years. This sample of children

came from a different private school for children with ASD and other developmental disabilities.

Written parental consent was obtained for each child. Since the goal of the study was to

understand early categorization in children with ASD, testing children as young as possible was

preferable (note that the earliest accurate diagnosis of ASD is from 2-3 years of age).

Each child was given the Peabody Picture Vocabulary Test, Third Edition (PPVT-III;

Dunn & Dunn, 1997) or Fourth Edition (PPVT-IV; Dunn & Dunn, 2007). The PPVT was used to

test language comprehension by showing the child a page with four pictures on it and asking the

child to point to the correct item after a label was verbally presented. The number of correct

responses was then scored. Both a norm score (standardized M = 100), and a developmental age-

equivalent score were then derived from the raw score for each child. Mean age-equivalent

PPVT scores were 3.3, ranging from 9 months to 6.5 years. It should be noted that one child had

such low language abilities that he could not achieve a baseline score, and was therefore unable

to get an accurate raw score on the PPVT. Therefore, his language comprehension was estimated

(see Table 4). Each participant was also given three categorization tasks, each of which tested a

superordinate level contrast, a basic level contrast, and a subordinate level contrast. The

objective of this study was to assess categorization skills across a variety of tasks within each

child. There have been no studies using different tasks to assess levels of categorization skills

within the same group with ASD (but see Bornstein and Arteberry [2010], who used this

approach with TD children).

60 The children selected for this experiment represented a spectrum of abilities. The school

administrator did not allow use of a diagnostic instrument, such as the Autism Diagnostic

Observation Schedule (ADOS) or the Autism Diagnostic Interview Revised (ADI-R). Records

were kept by the school but were confidential. The school administrator selected classes with

children on the spectrum for whom the study would be appropriate. Based on the experimenter’s

previous experience working with and studying children with ASD, it was confirmed that these

children were appropriate for the study. Two children’s data were removed from the study after it

was thought that they had language delay rather than ASD. The participants represented a range

of abilities; from low functioning to high functioning and from almost nonverbal language to

sophisticated language abilities.

**Table 4**: Demographic Information and PPVT Scores

Participant CA PPVT raw

score

PPVT standard score

Age- equivalent

Age- equivalent

Age- equivalent

1 6,1 42 66 3,4

2 5,2 \* \* 0,9

3 5,0 52 89 4,1

4 4,5 24 72 1,1

5 4,11 40 81 3,2

6 3,7 51 98 3,6

7 3,4 32 85 2,7

8 3,4 60 108 3,10

9 6,3 65 77 4,1

61 10 6,6 106 99 6,5

MEAN 4,10 52.4 86.1 3,3

Range (3,4 – 6,6) (24 –106)\* (66 – 108)\* (1 – 6,5)

\*Was not able to complete PPVT

*Stimuli* Each task used 3-dimensional scale models of various animals, utensils, and tools in a

variety of colors (see Appendix B and Appendix C). Table 5 lists the properties that were tested.

It should be noted that the category contrasts in the main experiment are different than the ones

used in the pilot study. These category contrasts are hierarchical in nature, such that the

subordinate categories come from the basic categories, which come from the superordinate

categories. See Appendix D for pictures of some of the stimuli.

The generalization properties are also listed in Table 5. For each property tested, the

experimenter demonstrated the action with a modeled prop and the actions were accompanied by

appropriate vocalizations (e.g., “night, night” to demonstrate animals sleeping in the bed). These

actions were modeled using the test prop; for example, by placing the animals on the bed, while

saying “night, night”. The test exemplars were the same for all children, with one exemplar being

the appropriate one (e.g., another animal) and the other being the inappropriate one (e.g., tool).

The order in which the properties were modeled and the placement of modeling and test

exemplars were counterbalanced.

62 **Table 5:** Category Contrasts and Properties Tested

**Superordinate Basic Subordinate**

Typical animals vs. Kitchen utensils Dogs vs. Birds

Spatulas vs. Spoons

Dalmatians vs. Poodles

Slotted spoons vs. Measuring spoons

Atypical animals vs. Tools Insects vs. Frogs

Levels vs. Brushes

Dragonflies vs. Butterflies

Paint brushes vs. Cleaning brushes

Kitchen utensils vs. Tools

**(same categories as above but**

**different contrast)**

Spatulas vs. Spoons

Levels vs. Brushes

**(same as above)**

Slotted spoons vs. Measuring spoons

Slotted spoons vs. Measuring spoons

Paint brushes vs. Cleaning brushes

Paint brushes vs. Cleaning brushes

**(same as above)**

**(same as above)**

*Generalization Properties*

**Superordinate Property Vocalization**

Typical animals vs.

Kitchen utensils

Sleeping in bed vs. Cooking “Night, night” vs. “Cooking”

Atypical animals vs. Tools Drinking from cup vs. Fix a

broken tractor

“Mm, Mm” vs. “Fix it up”

Kitchen utensils vs. Tools Cooking vs. Fix a broken

tractor

“Cooking” vs. “Fix it up”

**Basic**

Dogs vs. Birds Chews a bone vs. Sits in a

nest

“Yum, yum” vs. “Sitting in a

nest”

Spatulas vs. Spoons Flipping cookie vs. Stirring

the cup

“Flip it over” vs. “Stir it up”

63 Insects vs. Frogs Has antennae vs. Swimming

underwater

“Antennae” vs. “Swimming”

Levels vs. Brushes Make it straight vs. Wash out

the bristles

“Hold it straight” vs. “Wash it

out”

**Subordinate**

Dalmatians vs. Poodles Ride a fire truck vs. Uses

clippers to trim fur

“Whee” vs. “Buzz, buzz”

Slotted spoons vs.

Measuring spoons

Drain the veggies vs. Measure

the veggies

“All cooked” vs. “Add water”

Dragonflies vs. Butterflies Eats ants vs. Collects pollen “Yummy ants” vs. “Getting the

pollen”

Paint brushes vs. Cleaning

brushes

Paint the picture vs. Scrub the

tractor

“Clean it up” vs. “Make it

pretty”

*Design and Procedure*

Testing occurred at the child’s school, during the school day and sessions were

videotaped for later scoring. During each session, the child was seated at a table opposite the

experimenter. Each child was seen for multiple sessions (six to seven) and given four to eight

categorization tasks at each session. There were a total of 11 sequential touching tasks, 11

sorting tasks, and 22 generalization tasks for a grand total of 44 tasks per child. The sequential

touching and sorting tasks were administered one after the other; after touching or playing with

the items on the tray for two minutes, the participants were instructed to put away the toys in the

two corresponding boxes.

64 The order of categorization tasks, hierarchical levels, and objects used were

counterbalanced as much as possible. For example, at one session, a child might have been tested

on the following tasks: Dalmatians ride on fire truck (subordinate generalization), wash out the

bristles (basic generalization), atypical animals vs. tools (superordinate) sequential touching and

sorting, paint brushes make a picture (basic generalization), animals drink (superordinate

generalization), and spoons vs. spatulas (basic) sequential touching and sorting.

*Sequential touching task.*

Each participant was tested on 11 sequential touching tasks. Each task had eight objects,

four from one category, and four from another category (see Pilot Study for procedural details).

The order in which the child selected each of the items to touch, examine, or manipulate was

measured. Two coders coded 95% of the data and agreement was based on each object touched.

The percentage of agreement was calculated for each contrast for each child. The overall

reliability between the two raters was 85%.

There were two dependent measures. The first measure of categorization was the MRL

(sequentially touching three or four items from the same category in a row), which was

calculated by dividing the total number of touches a child exhibits by the number of runs. The

second measure was computed using the Monte Carlo program (the number of categorizing runs

based on the total number of touches in the task), which calculated each individual’s

categorization (see page 50 for a description of the Monte Carlo program).

*Sorting task.*

Each participant was also tested on 11 sorting tasks, the same contrasts (and objects) used

in the sequential touching task (see Pilot Study for procedural details). The dependent measure

for this task was the proportion of correct sorting out of eight trials. For example, if the

65 participant was sorting animals and tools, and placed all eight objects in the same container, then

this would be scored as 4/8, or 50%. If the participant placed each of the four objects correctly

into their respective boxes, then this would be scored as 8/8, or 100%. Two coders coded 95% of

the data and mean agreement for percentage correct sorting was 99%.

*Generalized imitation task.*

Each participant was tested on 22 generalization tasks, six from the superordinate level,

and eight from each of the basic and subordinate levels (see Pilot Study for procedural details).

In the main experiment, all of the properties demonstrated across the three levels included an

appropriate and inappropriate exemplar. Each session began with a warm-up task, in which the

participant was encouraged to imitate the experimenter’s action of stacking three soft blocks and

then knocking them over. Each child’s data were included as long as the child could show

evidence of imitation. On the first testing session, one participant was unable to imitate the

warm-up task, because he seemed to be having an off day, so his data on those four

generalization tasks were not included in the study. On all subsequent sessions, his mood

improved and he was able to imitate the experimenter in the warm-up task, so the rest of his data

were included. In addition, due to experimenter error, five of the participants received the wrong

text exemplars on two contrasts (tools fix it up and utensils cooking), so these contrasts were

removed (see Appendix E).

All of the properties chosen by the experimenter were easy to imitate, with a simple

action and an appropriate vocalization (see Table 5). All of the modeled actions were

demonstrated three times, similar to the pilot study, and included vocalizations to ensure that the

participants attended to the action. The child was only required to imitate the action, not the

vocalization. Coding included performance (or nonperformance) of the properties and the

66 exemplars used (Mandler & McDonough, 1996; 1998). Two coders coded 95% of the data and

mean agreement on imitation of the actions and the exemplar used was 89%. When discrepancies

arose, the data from the primary coder were used.

The dependent measure is the proportion of appropriate and the proportion of

inappropriate generalizations at each level of contrast. Proportion scores were used because there

were 6 superordinate and 8 basic and 8 subordinate level tasks. This was designed so that one

could compare generalization within domains at all levels of contrast.

*Results and Discussion*

Results for each of the three tasks will be presented first, followed by a comparison

between tasks, and finally the relationship of language to the categorization tasks will be

discussed.

*Sequential Touching Task: Mean Run Length (Group Analyses)*

The dependent measure of the sequential touching task is the sequential touching of items

from one of the two categories of objects. As stated in the methods section, there are two

measures for analyzing the sequential touching. The first measure, a quantitative measure, is the

MRL, which provides a measure of how children respond as a group. Based on previous

research, the MRL of the group should be statistically above the chance level of 1.75. The

second measure, a qualitative measure, used a Monte Carlo program to assess individual

children’s sequential touching (discussed in next section).

The main research question of this study concerned how children were categorizing

across the three levels. In other words, do children with ASD categorize better at one level of

categorization? Based on traditional categorization views, best performance is expected on basic

level tasks; based on infant research, best performance is expected on superordinate tasks; and

based on the view that children with ASD focus on specific details of objects that could be used

67 to categorize, best performance is expected on subordinate tasks. A repeated measures analysis

of variance was conducted with Category level (superordinate, basic, and subordinate) as the

within-subjects factor. Results do not support or refute any of the views. Overall, one sees that

superordinate (M = 2.32, SE = 0.21), basic (M = 2.06, SE = 0.13) and subordinate categorization

runs (M = 2.10, SE = 0.25) do not significantly differ from each other, F(2,8) = 0.48, p > .10, n.s.

The next question concerned performance compared to chance. Are the means

significantly greater than chance (1.75)? The means, their associated two-tailed *t*-values, and

standard error are shown in Table 6. On the superordinate level, the means were significantly

greater than chance: *t(*9) = 2.74, p < .05. On the basic level, the means were significantly greater

than chance: *t*(9) = 2.42, p < .05. On the subordinate level, the means were not significantly

greater than chance: *t(*9) = 1.39, p > .05, n.s. This suggests that overall categorization is solid at

the superordinate and basic levels, but poor at the subordinate level.

68 **Table 6:** Mean Run Length (MRL), Standard Error, *t*-Test Values, and Percentage of Participants Exhibiting Sequential Touching Greater than Chance According to the Monte Carlo Program

Contrast MRL SE

*t-*test compared to chance (quantitative data)

Monte Carlo program compared to chance (qualitative data) *Superordinate-level* OVERALL MEAN **2.32 .21 2.74\*** 43%

Animate/Inanimate Mean **2.64 .32 2.79\*** 65%

Inanimate/Inanimate Mean 1.70 .11 -0.45 0%

*Basic-level* OVERALL MEAN **2.06 .13 2.42\*** 60%

Animate Mean **2.08 .13 2.53\*** 75%

Inanimate Mean 2.03 .19 1.45 45%

*Subordinate-level* OVERALL MEAN 2.10 .32 1.39 33%

Animate Mean 2.40 .47 1.38 45%

Inanimate Mean 1.81 .11 0.56 20%

**\*p < .05**

The next question of interest was regarding the animate and inanimate MRLs within each

of the three levels. Do the animate/inanimate MRLs show the same pattern within category

level? The MRLs were analyzed according to their animate or inanimate domain. It should be

noted that the superordinate level is different than the basic and subordinate levels, since two of

the contrasts at this level involve both animate and inanimate categories. The following

69 computations were made: the two superordinate animate/inanimate contrasts (typical animals vs.

utensils and atypical animals vs. tools) were averaged together, and compared with tools vs.

utensils, an inanimate contrast. At the basic level, spoons vs. spatulas and brushes vs. levels were

averaged together (basic inanimate level), and compared with the average of the insects vs. frogs

and dogs vs. birds (basic animate level). And finally, within the subordinate level, the average of

measuring spoons vs. slotted spoons and paint brushes vs. cleaning brushes (subordinate

inanimate level) was compared with the average of Dalmatians vs. poodles and dragonflies vs.

butterflies (subordinate animate level). The dependent measure therefore is the MRL for the

animate and inanimate categories, and these means and their associated two-tailed *t-*values are

also shown in Table 6.

Separate repeated measures analyses of variance were conducted on each category level

(superordinate, basic, and subordinate), comparing the MRL to chance. Results show that on the

superordinate level, the means of the contrasts between animate and inanimate domains were

significantly greater than chance: MRL = 2.64 (SE = 0.32), *t*(9) = 2.79, p < .05. The mean of the

contrast within the inanimate domain (tools vs. utensils) did not differ significantly than chance:

MRL = 1.70 (SE = 0.11), *t*(9) = -0.45, p > .10, n.s. On the basic level, the means of the contrasts

within the animate categories were significantly greater than chance: MRL = 2.08 (SE = 0.13),

*t*(9) = 2.53, p < .05. The means of the contrasts within the inanimate domain did not differ

significantly from chance: MRL = 2.03 (SE = 0.19), *t*(9) = 1.45, p > .10, n.s. On the subordinate

level, the means of the contrasts within the animate domain did not significantly differ from

chance: MRL = 2.40 (SE = .47), *t(*9) = 1.38, p > .10, n.s. and the means of the contrasts within

the inanimate domain also did not significantly differ from chance: MRL = 1.81 (SE = .11), *t*(9)

*=* .56, p > .10, n.s. In conclusion, as a group, these children differentiated between animate and